GULF *of* ALASKA

NAVY TRAINING ACTIVITIES

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT/
OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

DECEMBER 2020 - DRAFT
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Gulf of Alaska Navy Training Activities
Draft
Supplemental Environmental Impact Statement/ Overseas Environmental Impact Statement

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DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT/ OVERSEAS ENVIRONMENTAL IMPACT STATEMENT GULF OF ALASKA TRAINING ACTIVITIES

Lead Agency: United States Department of the Navy
Cooperating Agency: National Marine Fisheries Service
Title of the Proposed Action: Gulf of Alaska Training Activities
Designation: Draft Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement

Abstract

The United States Department of the Navy (Navy) prepared this Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS) in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code section 4321 et seq.); the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations sections 1500 et seq. [2019]); Navy Procedures for Implementing NEPA (32 Code of Federal Regulations section 775); and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*. This SEIS/OEIS was prepared to update the Navy's assessment of the potential environmental impacts associated with proposed military readiness activities to be conducted in the Gulf of Alaska (GOA). The activities are consistent with those activities analyzed in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, and are representative of activities the Navy has been conducting in the Gulf of Alaska for decades. The Proposed Action is to conduct an annual exercise, historically referred to as Northern Edge, over a maximum time period of up to 21 consecutive days during the months of April to October.

This SEIS/OEIS evaluates the potential environmental impacts of conducting training activities upon the expiration of the current authorizations and consultations in 2022 in the GOA Temporary Maritime Activities Area (TMAA). The Study Area for this SEIS/OEIS is the TMAA only. Two alternatives were analyzed in this SEIS/OEIS:

- The No Action Alternative represents no Navy training activities at sea or in the airspace associated with the Proposed Action within the TMAA, and presents the resulting environmental effects from taking no action when compared with the effects of the Proposed Action.
- Alternative 1 is the Preferred Alternative. Alternative 1 is a Status Quo Alternative based on the 2016 GOA Final SEIS/OEIS and 2017 GOA Record of Decision. Though the types of activities and level of events are the same as in previous documents (Alternative 1 in both the 2011 GOA Final Environmental Impact Statement/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities (e.g., EA-6B aircraft and frigate, and their associated systems, have been replaced with the EA-18G, Littoral Combat Ship, and Destroyer). Consistent with the previous analysis for Alternative 1, the sinking exercise activities are not part of Alternative 1 for this SEIS/OEIS. In the TMAA, a Status Quo Alternative would allow the Navy to meet current and future training requirements necessary to achieve and maintain fleet readiness.

In this SEIS/OEIS, the Navy analyzed potential impacts on environmental resources resulting from activities under the No Action Alternative and Alternative 1. The resources evaluated include fishes, sea turtles, marine mammals, birds, and socioeconomic resources and environmental justice.

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Acronyms and Abbreviations

Acronym	Definition
°C	Degrees Celsius
°F	Degrees Fahrenheit
ADFG	Alaska Department of Fish and Game
AEP	Auditory Evoked Potential
AMRAAM	Advanced Medium-Range Air-to-Air Missile
ASW	Anti-Submarine Warfare
ATA	Alaska Training Area
BCC	Birds of Conservation Concern
BO	Biological Opinion
C	Candidate
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulation
CH	Critical Habitat
CSG	Carrier Strike Group
CV	Coefficient of Variation
CWT	Coded Wire Tag
dB	Decibel(s)
dB re 1 µPa	Decibels referenced to 1 micropascal
dB re 1 μPa^2	Decibels referenced to 1 micropascal squared
dB re 1 $\mu Pa^2 s$	Decibels referenced to 1 micropascal squared seconds
dBA	A-weighted decibel(s)
DDT	dichlorodiphenyltrichloroethane
DICASS	Directional Command Active Sonobuoy System
DoD	Department of Defense
DOI	Department of Interior
DPS	Distinct Population Segment
E	Endangered
EA	Environmental Assessment
EEZ	Economic Exclusion Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FMP	Fishery Management Plan
FONSI	Finding of No Significant Impact
FR	Federal Register
ft.	Foot/feet
FY	Fiscal Year
GOA	Gulf of Alaska
HAPC	Habitat of Particular Concern
HARM	High Speed Anti-Radiation Missile
HE-ET	High Explosive-Electronic Time
HF	High Frequency
HFAS	High-Frequency Active Sonar
HM	Hull-mounted
Hz	hertz
JPARC	Joint Pacific Alaska Range Complex
kg	Kilogram(s)
kHz	kilohertz
km	Kilometer(s)
lb.	Pound(s)
Lg-cal	Large-Caliber
LOA	Letter of Authorization
m	Meter(s)
MBTA	Migratory Bird Treaty Act
Med-cal	Medium-Caliber
MEM	Military Expended Material
MF	Mid-Frequency
MFAS	Mid-Frequency Active Sonar

Acronym	Definition
mi.	Mile(s)
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
N/A	Not Applicable
Navy	U.S. Department of the Navy
NEPA	National Environmental Policy Act
NEW	Net Explosive Weight
NM	Nautical Mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
NPPSD	North Pacific Pelagic Seabird Database
NTMs	Notice to Mariners
OAP	Ocean Acidification Program
OEIS	Overseas Environmental Impact Statement
OPAREA	Operating Area
Pa-s	Pascal second(s)
PCB	Polychlorinated Biphyenyl
psi	Pounds per square inch
psi-ms	Pounds per square inch per millisecond
PTS	Potential Threshold Shift
ROD	Record of Decision
SAR	Stock Assessment Report
SEIS	Supplemental Environmental Impact Statement
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SINKEX	Sinking Exercise
Sm-cal	Small-Caliber
SoC	Species of Concern
SOCAL	Southern California
SPL	Sound Pressure Level
SPL_{peak}	peak sound pressure level
SRM	Spatial release from masking
SUA	Special Use Airspace
SURTASS LFA	Surveillance Towed Array Sensor System Low Frequency Active
T	Threatened
TMAA	Temporary Maritime Activities Area
TORP	Torpedoes
TS	Threshold Shift
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
UME	Unusual Mortality Event
USCG	United States Coast Guard
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Society
W	Warning Area
yd.	Yard(s)

Executive Summary

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

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ES Executive Summary

ES.1 Introduction

The United States (U.S.) Department of the Navy (Navy) has prepared this Draft Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS) to supplement the impact analysis contained in the Final Gulf of Alaska (GOA) Navy Training Activities Environmental Impact Statement (EIS)/OEIS (U.S. Department of the Navy, 2011) (hereinafter referred to as the 2011 GOA Final EIS/OEIS) and contained in the GOA Final Navy Training Activities SEIS/OEIS (U.S. Department of the Navy, 2016) (hereinafter referred to as the 2016 GOA Final SEIS/OEIS) pursuant to 40 Code of Federal Regulations (CFR) Section 1502.9(c) (2019), and Executive Order 12114. This SEIS/OEIS considers ongoing and future activities conducted at sea, updates training requirements, incorporates new information from an updated acoustic effects model, updates marine mammal density data, and incorporates evolving and emergent best available science. It also supports the issuance of federal regulatory permits and authorizations under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) using the most current and best available science and analytical methods to assess potential environmental impacts on the species covered by those regulations. The at-sea training area in this SEIS/OEIS is referred to as the GOA Temporary Maritime Activities Area (TMAA) (Figure ES-1) and is the same at-sea training area analyzed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. The Proposed Action comprises the military continuing training activities previously conducted and described in the 2016 GOA Final SEIS/OEIS, for which a Record of Decision (ROD) was issued. Although the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities (e.g., EA-6B aircraft and frigate, and their associated systems, have been replaced with the EA-18G, Littoral Combat Ship, and Destroyer). Consistent with the previous analyses for Alternative 1, the sinking exercise activity will not be part of the Proposed Action for this SEIS/OEIS. The Proposed Action is to conduct an annual exercise, historically referred to as Northern Edge, over a maximum time period of up to 21 consecutive days during the months of April to October.

ES.2 Purpose of and Need for Proposed Military Readiness Training Activities

As identified in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, the purpose of the Navy's Proposed Action is to use the TMAA (a portion of the Joint Pacific Alaska Range Complex, previously referred to as the Alaska Training Areas) to support and conduct current, emerging, and future training activities. This action is needed to achieve and maintain fleet readiness to ensure the Navy's continued, effective protection of U.S. national security.

ES.3 Scope and Content of the Environmental Impact Statement/Overseas Environmental Impact Statement

In this SEIS/OEIS, the Navy reevaluated potential impacts from the ongoing military training activities in the GOA TMAA. The GOA TMAA supports opportunistic experimentation and testing activities when conducted as part of training activities and when considered to be consistent with the proposed training activities. These activities could occur as part of large-scale exercises or as independent events. Therefore, there is no separate discussion or analysis for testing activities that may occur as part of the proposed military readiness activities in the TMAA.

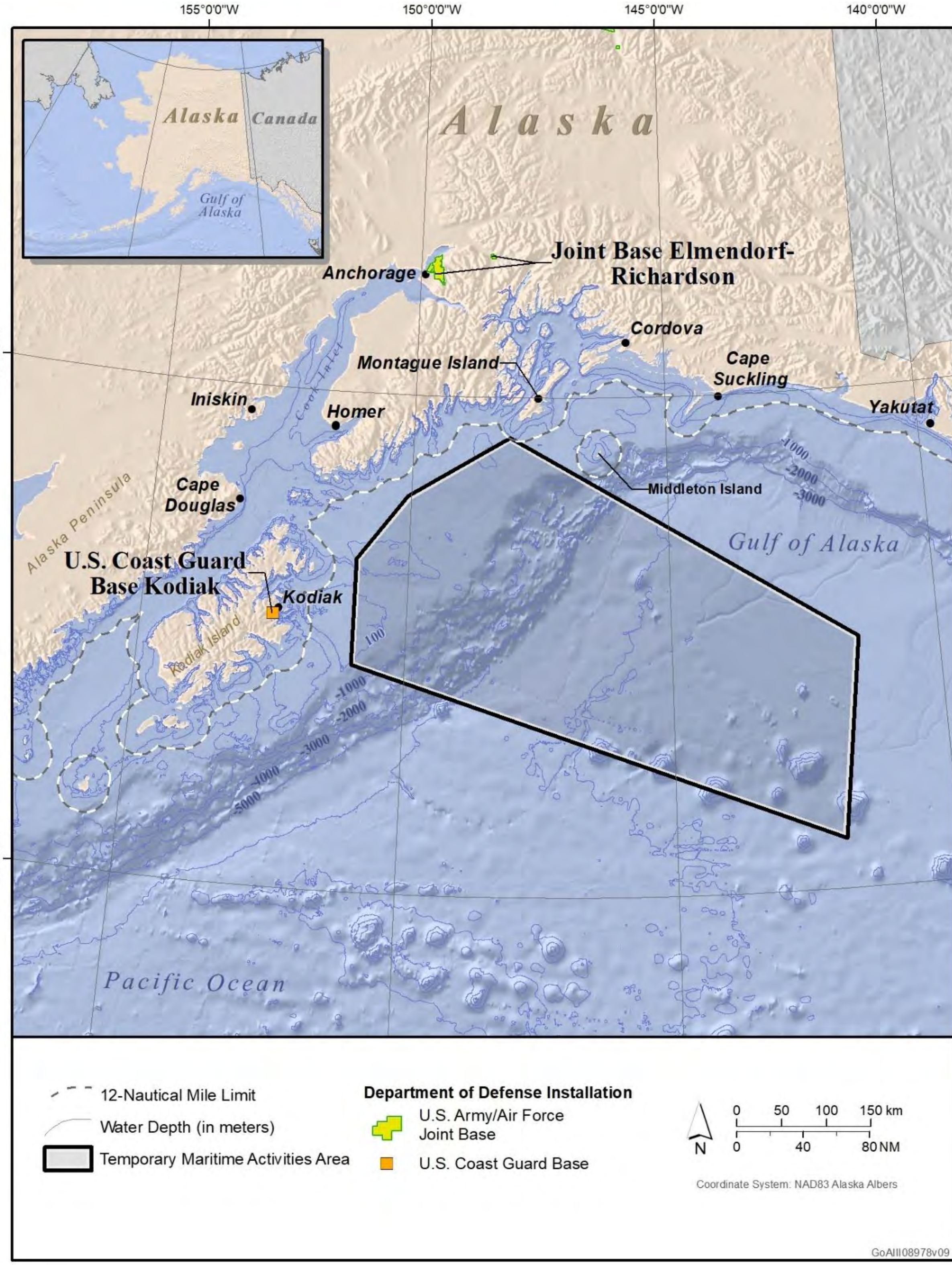

Figure ES-1: Gulf of Alaska Navy Temporary Maritime Activities Area

This Draft SEIS/OEIS assesses potential impacts of the Proposed Action on the environment. The Proposed Action is consistent with the Proposed Action presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, for which a ROD was issued, and entails the military continuing training activities previously conducted and described in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. This Draft SEIS/OEIS assessed potential impacts of the alternatives (Alternative 1 and the No Action Alternative). The resources evaluated include fishes, sea turtles, marine mammals, birds, and socioeconomic resources and environmental justice. Since the completion of the 2016 GOA Final SEIS/OEIS, new information has become available and is incorporated in this analysis. New information specifically addressed in this SEIS/OEIS includes updates to training requirements, an updated acoustic effects model, updated marine mammal density data and sea turtle hearing criteria, and other emergent best available science.

In this SEIS/OEIS, the Navy analyzes acoustic and explosive impacts on marine mammals, fishes, birds, and sea turtles; direct, indirect, cumulative, short-term, and long-term impacts; and the irreversible and irretrievable commitment of resources that may result from the Proposed Action.

The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this SEIS/OEIS. The National Oceanic Atmospheric Administration's National Marine Fisheries Service (NMFS) is serving as a cooperating agency pursuant to 40 CFR Section 1501.6 because of its expertise and regulatory authority over marine resources. Additionally, this document will serve as NMFS' environmental planning documentation for the rule-making process under the MMPA. In accordance with the Council on Environmental Quality (CEQ) Regulations, 40 CFR part 1505.2, the Navy will issue a ROD that provides the rationale for choosing one of the alternatives.

ES.4 Government and Public Involvement

ES.4.1 Scoping Process

In an effort to maximize public participation and ensure the public's input is considered, the Navy conducted scoping for this SEIS/OEIS. Public scoping began with the issuance of the Notice of Intent in the *Federal Register* (FR) on February 10, 2020 (85 FR 7538). To further notify the public of the scoping period, the Navy published advertisements in 5 newspapers, distributed press releases, mailed notification letters (24 tribal chairpersons of federally recognized tribes and 128 federal, state, and local elected officials and government agencies) and postcards (556 individuals, community groups, tribal staff, and nongovernmental organizations) to key stakeholders and parties previously expressing an interest in this project, and provided notification via the project website (https://goaeis.com/) and email.

In accordance with the CEQ regulations for implementing the requirements of the National Environmental Policy Act (NEPA), scoping is not required for an SEIS (40 CFR Section 1502.9(c)(4)). However, in an effort to maximize public participation and ensure the public's concerns are addressed, the Navy chose to conduct a scoping period for this SEIS/OEIS.

Given that the Navy's Proposed Action has not changed, public scoping meetings were not held, but public comments were accepted during the scoping period from February 10, 2020 to March 11, 2020. In total, the Navy received 25 comment submissions from individuals, groups, and agencies. The Navy considered all scoping comments in preparing this SEIS/OEIS.

ES.4.2 Additional Outreach

Prior to the start of the Alaska Command sponsored exercise, Northern Edge 15 (June 2015), the Navy and representatives from Alaska Command conducted a series of town meetings with the Alaskan communities of Cordova, Kodiak, and Homer. During those meetings, concerns were expressed about impacts on fish and the fishing community. The representatives reiterated to the public that the best available science indicated that training activities will not compromise the productivity of fish or affect their habitat. Additionally, it was reemphasized that fishermen will also see little to no change, associated with training activities.

Navy personnel have participated in public outreach and community events since 2016, such as post-Northern Edge coastal community meetings; Navy band events; Alaska Federation of Natives Convention; Alaska Marine Science Symposium; Alaska Forum on the Environment; ComFish; and Pacific Marine Exposition in Anchorage, Cordova, Seward, Kodiak and Fairbanks, Alaska, and Seattle, Washington. Expanded outreach will continue into the foreseeable future to ensure stakeholders are kept informed of the Navy's training activities in the TMAA.

ES.5 Proposed Action and Alternatives

Through this Draft SEIS/OEIS, the Navy:

- Presents the results of the evaluation of relevant new information, which has been incorporated into revised analyses where appropriate. Each resource area analyzed within the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS has been evaluated to determine the need for re-analysis within this SEIS/OEIS.
- Updates environmental analyses with the best available science and most current acoustic analysis methods to evaluate the potential effects of training activities on the marine environment.
- Supports authorization of incidental takes of marine mammals under the MMPA and incidental takes of threatened and endangered marine species under the ESA.

ES.5.1 No Action Alternative

The No Action Alternative is required by CEQ regulations as a baseline against which the impacts of the Proposed Action are compared. CEQ guidance identifies two approaches in developing the No Action Alternative (46 FR 18026). One approach for activities that have been ongoing for long periods of time is for the No Action Alternative to be thought of in terms of continuing the present course of action, or current management direction or intensity, such as the continuing Navy training at sea in the TMAA at current levels, even if renewed authorizations under the MMPA and ESA are required. Under this approach, which was used in the 2016 GOA Final SEIS/OEIS, the analysis compares the effects of continuing current activity levels (i.e., the "status quo") with the effects of the Proposed Action. The second approach depicts a scenario where no authorizations or permits are issued, in which the Proposed Action does not take place, and the resulting environmental effects from taking no action are compared with the effects of implementing the Proposed Action. The Navy applied the second approach in this SEIS/OEIS to further support NMFS' regulatory process by presenting the scenario where no authorization would be issued.

Cessation of military at-sea training activities in the TMAA would mean that the Navy would not meet its statutory requirements and would be unable to properly defend itself and the United States from enemy forces, unable to successfully detect enemy submarines, and unable to safely and effectively use its weapons systems or defensive countermeasures. Navy personnel would essentially not obtain the unique skills or be prepared to safely and effectively use sensors, weapons, and technologies in realistic scenarios required to accomplish the overall mission. Consequently, the No Action Alternative is unreasonable because it does not meet the purpose and need.

ES.5.2 Alternative 1 (Preferred Alternative)

Alternative 1 is the Preferred Alternative. Alternative 1 is a Status Quo Alternative based on the 2016 GOA Final SEIS/OEIS and 2017 GOA ROD. Under this alternative, the Navy would continue the present course of action (continuation of Navy training in the TMAA at current levels documented in the 2017 GOA ROD) even if separate legal authorizations under the MMPA and ESA are required. The Navy could continue to conduct training activities, at the level and scope of activities necessary to fulfill its Title 10 responsibilities described in the Purpose and Need of the Proposed Action. In the GOA TMAA, a Status Quo Alternative would allow the Navy to meet current and future training requirements necessary to achieve and maintain fleet readiness.

ES.6 Summary of Environmental Impacts

Table ES-1 provides a listing of the potential environmental impacts of the Proposed Action. The same resources that were identified and analyzed in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS were considered for reanalysis for this SEIS/OEIS and for reanalysis of cumulative impacts. Those physical resources include air quality, expended materials, water resources, and acoustic environment (airborne). Biological resources considered include marine plants and invertebrates, fish, sea turtles, marine mammals, and birds. Human resources and issues considered include cultural resources, transportation and circulation, socioeconomics, environmental justice and protection of children, and public safety.

For purposes of consistency across all environmental compliance planning conducted under the Navy's At-Sea Policy (see Section 1.2, The Navy's Environmental Compliance and At-Sea Policy), the Navy realigned the resources in this SEIS/OEIS with those of other Navy at-sea projects. The same resources were analyzed, but that analysis in some instances has been shifted into new or renamed resource sections. The following resource sections remain unchanged: Section 3.1 (Air Quality), Section 3.7 (Sea Turtles), Section 3.8 (Marine Mammals), Section 3.9 (Birds), and Section 3.10 (Cultural Resources). See Table 3.0-1 in Section 3.0 of this SEIS/OEIS for a full description of the current organization of resources.

No new Navy training activities are proposed in the TMAA in this SEIS/OEIS, and, for several of the resources, the existing baseline conditions have not changed appreciably. The Navy determined that new research, literature, laws, and regulatory guidance addressed in this SEIS/OEIS resulted in little or no change to the findings of the impact analyses in the 2016 GOA Final SEIS/OEIS. Therefore, the impact assessments from the 2016 GOA Final SEIS/OEIS are incorporated by reference for each of the following resource areas (section numbers and names align with the new organization of sections described above): air quality, sediments and water quality, marine habitats, marine vegetation, marine invertebrates, cultural resources, and public health and safety. These resources are not analyzed further in this SEIS/OEIS and are therefore not included in the summary of impacts in Table ES-1 below.

Table ES-1: Summary of Environmental Impacts for the Proposed Action

Resource Category	*Alternatives*	*Summary of Impacts*	*Explanation of Differences from 2016 SEIS/OEIS*
Fishes	Alt 1	*Impacts from acoustic and explosive stressors:* • Conclusions for fishes made for Alternative 1 that were analyzed in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS remain unchanged in this SEIS/OEIS. • Pursuant to the ESA, the use of explosives, sonar and other transducers, vessel noise, aircraft noise, and weapon noise may affect ESA-listed salmonid species and green sturgeon.	Reanalyzed acoustics and explosives for ESA-listed salmonid species (two new salmonid evolutionarily significant units are candidate species and may become ESA-listed in the near future) and the green sturgeon as new evidence suggests that ESA-listed green sturgeon may be present in the TMAA where they were not previously anticipated to occur.
Sea Turtles	Alt 1	• Overall, due to a low density estimate, zero leatherback sea turtle impacts were estimated to occur from the use of acoustic and explosive sources under Alternative 1 of the Proposed Action.	The Navy Acoustic Effects Model was utilized to estimate impacts on leatherback sea turtles. There was no change to stressors, and modeling indicated no impacts, so the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS analysis remains valid.
Marine Mammals	Alt 1	*Impacts from acoustic and explosive stressors:* • The modeling and post-modeling analyses predict marine mammal exposures to acoustic and explosive sources resulting in Level B harassment and exposures resulting in Level A harassment. • The modeling and post-modeling analyses predict no marine mammal mortalities as a result of explosive sources.	Reanalyzed acoustics and explosives stressors for marine mammals in the TMAA. The Navy determined (U.S. Department of the Navy, 2017) and NMFS agreed (82 FR 19530; 82 FR 24679; National Marine Fisheries Service (2017)) that for Navy activities in the TMAA, only acoustics and explosives could potentially result in the incidental taking of marine mammals.

Table ES-1: Summary of Environmental Impacts for the Proposed Action (continued)

Resource Category	*Alternatives*	*Summary of Impacts*	*Explanation of Differences from 2016 SEIS/OEIS*
Birds	Alt 1	*Impacts from acoustic and explosive stressors:* • Under the Migratory Bird Treaty Act (MBTA) regulations applicable to military readiness activities (50 Code of Federal Regulations [CFR] Part 21), the impacts from explosives, sonar and other transducers, vessel noise, aircraft noise, and weapon noise during training activities described under Alternative 1 would not result in a significant adverse effect on populations of seabirds, shorebirds, and other birds protected under the MBTA.	Updated sound exposure criteria and acoustic effects modeling. Incorporated new information on ESA-listed short-tailed albatross presence in the TMAA, where the species was previously not anticipated to occur.
Socioeconomic Resources and Environmental Justice	Alt 1	• No adverse impacts on commercial/recreational fishing, fisheries research/management, civilian access, or tourism would occur as a result of Alternative 1. • Under Alternative 1, Navy activities were considered and would be consistent with those analyzed in the previous environmental documentation (U.S. Department of the Air Force, 1995, 2007; U.S. Department of the Army, 1999, 2004; U.S. Department of the Navy, 2011, 2016). These documents concluded that no significant impacts related to socioeconomics would occur. • Overflights would not result in adverse effects to commercial shipping, commercial fishing, recreation, or tourism.	No change from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS.

Notes: Alt = Alternative, EIS/OEIS = Environmental Impact Statement/Overseas Environmental Impact Statement, ESA = Endangered Species Act, FR = Federal Register, GOA = Gulf of Alaska, NMFS = National Marine Fisheries Service, SEIS = Supplemental Environmental Impact Statement, TMAA = Temporary Maritime Activities Area.

ES.7 Cumulative Impacts

Marine mammals are the primary resource considered in the cumulative impacts analysis. Marine mammal species occurring in the TMAA may be impacted by multiple ongoing and future actions related to human activities. Explosive detonations and non-impulsive sources such as sonar under Alternative 1 have the potential to disturb or injure marine mammals; however, there are very few injuries and no mortalities expected or predicted by the modeling.

The Proposed Action would contribute to cumulative impacts, but the relative contribution to overall cumulative impacts would be small compared to other human actions, such as commercial ship strikes, bycatch, entanglement, and ocean pollution. The predicted annual takes from the Proposed Action will have no measurable population-level effects when evaluated independently and incrementally with other actions.

For the remaining resource categories, the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS conclusions are still valid. Additionally, as described in Chapter 4 (Cumulative Impacts) of the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, the potential cumulative impacts of the Proposed Action on the remaining resource categories would be negligible or not cumulatively significant.

ES.8 Standard Operating Procedures, Mitigation, and Monitoring

Within the Study Area, the Navy implements standard operating procedures, mitigation measures, and marine species monitoring and reporting. Navy standard operating procedures have the indirect benefit of reducing potential impacts on marine resources. Mitigation measures are designed to help reduce or avoid potential impacts on marine or cultural resources. Marine species monitoring efforts are designed to track compliance with take authorizations under the MMPA and ESA, evaluate the effectiveness of mitigation measures, and improve understanding of the effects training activities have on marine resources.

ES.8.1 Standard Operating Procedures

The Navy currently employs standard practices to provide for the safety of Navy and non-Navy personnel and equipment, including ships and aircraft, as well as the success of the training activities. In many cases there are incidental environmental, socioeconomic, and cultural benefits resulting from standard operating procedures. Standard operating procedures serve the primary purpose of providing for safety and mission success, and are implemented regardless of their secondary benefits. Because standard operating procedures are crucial to safety and mission success, the Navy will not modify them as a way to further reduce effects to environmental resources. Due to their importance for maintaining safety and mission success, standard operating procedures have been considered as part of the Proposed Action, and therefore are included in the Chapter 3 (Affected Environment and Environmental Consequences) environmental analyses for each applicable resource.

ES.8.2 Mitigation

The Navy recognizes that the Proposed Action has the potential to impact the environment. Unlike standard operating procedures, which are established for reasons other than environmental benefit, mitigation measures are modifications to the Proposed Action that are implemented for the sole purpose of reducing a specific potential environmental impact on a particular resource. The Navy is coordinating with NMFS and the U.S. Fish and Wildlife Service (USFWS) on these measures through the consultation and permitting processes. The new Navy ROD will document all mitigation measures the Navy will implement under the Proposed Action. The NMFS ROD, MMPA Regulations and Letter of

Authorization, ESA Biological Opinions, and other applicable consultation documents will include the mitigation measures applicable to the resources for which the Navy consults.

For the purposes of the ESA Section 7 consultation, the mitigation measures proposed in this SEIS/OEIS may be considered by NMFS and USFWS as beneficial actions taken by the Federal agency or applicant (50 CFR 402.14[g][8]). If necessary to satisfy requirements of the ESA, NMFS and USFWS may develop an additional set of measures contained in reasonable and prudent alternatives, reasonable and prudent measures, or conservation recommendations in any Biological Opinion issued for this Proposed Action.

Pursuant to the Navy's government-to-government consultations with federally recognized Alaska Native Tribes, agreements, both formal and informal, on protocols or tribal mitigations may be developed to reduce or eliminate impacts on protected tribal treaty reserved rights and protected tribal resources.

Mitigation measures that the military will implement under the Proposed Action are organized into two categories: procedural mitigation and mitigation areas. Procedural mitigation is mitigation that will be implemented whenever and wherever an applicable military readiness activity takes place within the TMAA. Mitigation areas are geographic locations within the TMAA where the military will implement additional mitigation (i.e., in addition to procedural mitigation) to further avoid or reduce potential impacts on marine mammals and fishery resources from active sonar, explosives, and physical disturbance and strike stressors.

ES.8.3 Mitigation Measures Considered but Eliminated

A number of possible additional mitigation measures were suggested during the public scoping period of this Draft SEIS/OEIS, as well as during comment periods of previous Navy environmental documents. Section 5.5 (Mitigation Measures Considered but Eliminated) contains information on measures that did not meet the appropriate balance between being effective and practical to implement, and therefore will not be implemented under the Proposed Action.

ES.8.4 Monitoring and Reporting

As described in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, the Navy remains committed to demonstrating environmental stewardship while executing its national security mission, complying with the suite of federal environmental laws and regulations, and providing required and relevant reports to appropriate regulatory agencies. Since 2006 across all Navy range complexes (in the Marianas, Pacific, Atlantic, Gulf of Mexico, and Gulf of Alaska), the Navy has produced various reports (Major Exercise Reports, Annual Exercise Reports, and Monitoring Reports) submitted to NMFS. These reports are aimed at understanding the Navy's impact on the environment as it carries out military readiness activities to accomplish its mission. As a complement to the Navy's commitment to avoiding and reducing impacts of the Proposed Action through mitigation, the Navy will undertake monitoring efforts to track compliance with take authorizations, help investigate the effectiveness of implemented mitigation measures, and better understand the impacts of the Proposed Action on marine resources. Taken together, mitigation and monitoring comprise the Navy's integrated approach for reducing environmental impacts from the Proposed Action. The Navy's overall monitoring approach will seek to leverage and build on existing research efforts whenever possible.

Consistent with the cooperating agency agreement with NMFS, mitigation and monitoring measures presented in this SEIS/OEIS focus on the requirements for protection and management of marine resources. Since monitoring will be required for compliance with the Final Rule issued for the Proposed

Action under the MMPA, details of the monitoring program are being developed in coordination with NMFS through the regulatory process.

The Navy developed the Integrated Comprehensive Monitoring Program to serve as the overarching framework for coordinating its marine species monitoring efforts and as a planning tool to focus its monitoring priorities pursuant to ESA and MMPA requirements (U.S. Department of the Navy, 2010). The purpose of the Integrated Comprehensive Monitoring Program is to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of monitoring effort for each range complex based on a set of standardized objectives, regional expertise, and resource availability. Additional information about the U.S. Navy Marine Species Monitoring Program, including an introduction to adaptive management and strategic planning, is provided in Section 5.1.2.2.1 (Marine Species Research and Monitoring Programs).

The Navy is committed to documenting and reporting relevant aspects of its military readiness activities in order to reduce potential environmental impacts and improve future environmental assessments. Initiatives include training activity reporting and incident reporting. Additional information is available on the U.S. Navy Marine Species Monitoring Program website, https://www.navymarinespeciesmonitoring.us/.

ES.8.5 Other Considerations

ES.8.5.1 Consistency with Other Federal, State, and Local Plans, Policies, and Regulations

Based on an evaluation of consistency with statutory obligations, the Navy's proposed training and testing activities would not conflict with the objectives or requirements of federal, state, regional, or local plans, policies, or legal requirements. The Navy is consulting, and will continue to consult, with regulatory agencies as appropriate during the NEPA process and prior to implementation of the Proposed Action to ensure all legal requirements are met.

ES.8.5.2 Relationship Between Short-Term Use of the Human Environment and Maintenance and Enhancement of Long-Term Productivity

In accordance with NEPA, this SEIS/OEIS provides an analysis of the relationship between a project's short-term impacts on the environment and the effects that these impacts may have on the maintenance and enhancement of the long-term productivity of the affected environment. The Proposed Action may result in both short- and long-term environmental effects. However, the Proposed Action would not be expected to result in any impacts that would reduce environmental productivity; permanently narrow the range of beneficial uses of the environment; or pose long-term risks to health, safety, or the general welfare of the public.

ES.8.5.3 Irreversible or Irretrievable Commitment of Resources

For the Proposed Action, most resource commitments are neither irreversible nor irretrievable. Most impacts are short-term and temporary or, if long lasting, are negligible. No habitat associated with threatened or endangered species would be lost as a result of implementation of the Proposed Action. Since there would be no building or facility construction, the consumption of materials typically associated with such construction (e.g., concrete, metal, sand, fuel) would not occur. Energy typically associated with construction activities would not be expended and irreversibly lost.

Implementation of the Proposed Action would require the use of fuels by aircraft and ships. Since fixed- and rotary-wing flight and ship activities would occur but are not expected to increase, this nonrenewable resource would be considered irretrievably lost.

ES.8.5.4 Energy Requirements and Conservation Potential of Alternatives and Mitigation Measures

Resources that will be permanently and continually consumed by project implementation include water, electricity, natural gas, and fossil fuels; however, the amount and rate of consumption of these resources would not result in significant environmental impacts or the unnecessary, inefficient, or wasteful use of resources. Prevention of the introduction of potential contaminants is an important component of mitigation of the Proposed Action's adverse impacts. To the extent practicable, considerations for the prevention of introduction of potential contaminants are included.

Sustainable range management practices are in place that protect and conserve natural and cultural resources and preserve access to training areas for current and future training requirements while addressing potential encroachments that threaten to impact range and training area capabilities.

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Gulf of Alaska Navy Training Activities

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1 Purpose and Need

Gulf of Alaska Navy Training Activities

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1 PURPOSE AND NEED

1.1 Introduction

The United States (U.S.) Department of the Navy (Navy), in cooperation with the National Marine Fisheries Service (NMFS), part of the National Oceanic and Atmospheric Administration, has prepared this supplement to the March 2011 Final Gulf of Alaska (GOA) Navy Training Activities Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (U.S. Department of the Navy, 2011a), hereinafter referred to as the 2011 GOA Final EIS/OEIS, and the July 2016 GOA Final Navy Training Activities Supplemental Environmental Impact Statement (SEIS)/OEIS (U.S. Department of the Navy, 2016), hereinafter referred to as the 2016 GOA Final SEIS/OEIS. The Navy proposes to continue conducting military readiness activities in the Gulf of Alaska. The Navy prepared this SEIS/OEIS to comply with the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions,* by assessing the potential environmental impacts associated with the proposed military readiness activities to be conducted within the Study Area.

The 2011 GOA Final EIS/OEIS Study Area consisted of three components: (1) GOA Temporary Maritime Activities Area (TMAA), (2) U.S. Air Force (Air Force) overland Special Use Airspace (SUA) and air routes over the Gulf of Alaska and State of Alaska, and (3) U.S. Army (Army) training lands. Collectively, for the purposes of this SEIS/OEIS, these areas are referred to as the Joint Pacific Alaska Range Complex (JPARC). The Study Area for this SEIS/OEIS is the TMAA only (Figure 1.1-1). The geographic boundaries of the TMAA have not changed since the completion of the 2011 GOA Final EIS/OEIS. The Air Force SUA and Army training lands were previously analyzed for NEPA purposes under separate environmental documents[1] and are not included in the analysis in this SEIS/OEIS, but environmental analyses from those NEPA documents are incorporated by reference pursuant to 40 Code of Federal Regulations (CFR) section 1502.21 (2019) and listed in Section 1.9 (Related Environmental Documents), as applicable.

This SEIS/OEIS was prepared to update the Navy's assessment of the potential environmental impacts associated with proposed military readiness activities to be conducted in the GOA TMAA. The activities are consistent with those activities analyzed in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, and are representative of activities the Navy has been conducting in the TMAA for decades. These military readiness activities include the use of active sonar and explosives at sea in the TMAA.

New information addressed in this SEIS/OEIS includes a new acoustic effects model, updated marine mammal density data and sea turtle hearing criteria, and other evolving and emergent best available science. Using the updated information, the Navy will seek the reissuance of the federal regulatory permits and authorizations under the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) to support military readiness activities within the TMAA upon the expiration of the current authorizations and consultations in 2022. The Navy will consult with NMFS and the U.S. Fish and Wildlife Service to renew these authorizations and issue appropriate permits.

[1] In the 2011 GOA Final EIS/OEIS, the Navy defined these three training areas as the Alaska Training Areas (ATAs). After the publication of the Record of Decision (ROD) for the 2011 GOA Final EIS/OEIS, the U.S. Departments of the Army and Air Force published a Final EIS, *Modernization and Enhancement of Ranges, Airspace, and Training Areas in the Joint Pacific Alaska Range Complex in Alaska* (June 2013), for which a ROD was approved and signed on August 6, 2013. The EIS included the ATAs, and other training areas, and labeled them the JPARC. As such, the Navy has adopted the term JPARC when referring to the ATAs.

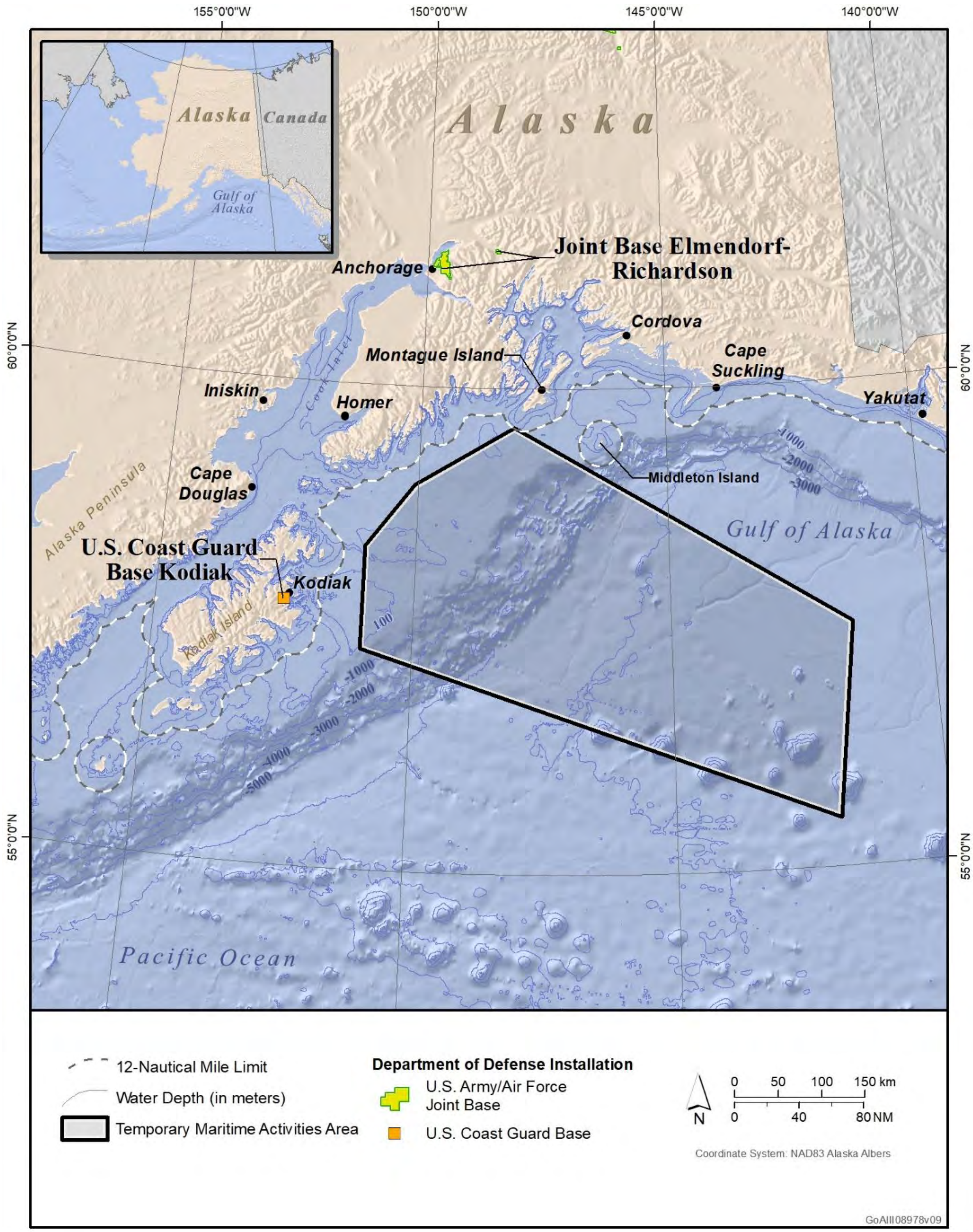

Figure 1.1-1: Gulf of Alaska Navy Training Activities Study Area

The U.S. Navy carries out training activities to be able to protect the United States against its potential adversaries, to protect and defend the rights of the United States and its allies to move freely on the oceans, and to provide humanitarian assistance. Major conflicts, terrorism, lawlessness, and natural disasters all have the potential to threaten the national security of the United States. The security, prosperity, and vital interests of the United States are increasingly tied to other nations because of the close relationships between the United States and other national economies. The U.S. military operates on the world's oceans, seas, and coastal areas—the international maritime domain—on which 90 percent of the world's trade is conducted and two-thirds of its oil transported. The majority of the world's population also lives within a few hundred miles of an ocean.

Although the new information and analytical methods that have emerged since the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS do not present a substantially different picture of the environmental consequences or the significance of impacts resulting from the Navy's proposed action, the Navy has determined that preparing this SEIS/OEIS furthers the purpose of NEPA, pursuant to the Council on Environmental Quality (CEQ) regulations (40 CFR section 1500.1(b) and 40 CFR section 1502.9(c)(2)). This SEIS/OEIS identifies and evaluates new information that could be seen as applicable to the Proposed Action and its environmental impacts.

1.2 The Navy's Environmental Compliance and At-Sea Policy

In 2000, the Navy completed a review of its environmental compliance requirements for exercises and training at sea. The Navy then instituted a policy, known as the "At-Sea Policy," to ensure compliance with applicable environmental regulations and policies, and preserve the flexibility necessary for the Navy and Marine Corps to train and test at sea. This policy directed, in part, that Fleet Commanders develop a programmatic approach to environmental compliance at sea for ranges and Operating Areas (OPAREAs) within their respective geographic areas of responsibility (U.S. Department of the Navy, 2000). Those ranges affected by the "At-Sea Policy" are designated water areas, sometimes containing instrumentation, that are managed and used to conduct training and testing activities.

In 2005, the Navy and the National Oceanic and Atmospheric Administration reached an agreement on a coordinated programmatic strategy for assessing certain environmental effects of military readiness activities at sea. The Navy is currently in the third phase of implementing this programmatic approach.

Phase I of environmental planning. The first phase of the planning program was accomplished by the preparation and completion of individual or separate environmental documents for each range complex and OPAREA. The 2011 GOA Final EIS/OEIS document identified major training activities; analyzed potential environmental impacts; and supported the MMPA incidental take authorization (also known as a "Letter of Authorization"), issued by NMFS, pursuant to Section 101(a)(5) of the MMPA, which was obtained for Navy training activities in the Gulf of Alaska for May 2011 through May 2016.

Phase II of environmental planning. The second phase of the Navy's environmental compliance planning covered activities and existing ranges and OPAREAs previously analyzed in the Phase I NEPA/EO 12114 documents. The 2016 GOA Final SEIS/OEIS was prepared to support the Navy's request to obtain an incidental take authorization under the MMPA from NMFS for the period of April 2017 through April 2022. To support the reissuance of the MMPA authorization, the Navy's re-analysis included consideration of changes since the 2011 GOA Final EIS/OEIS, including new information related to the resources being analyzed, use of a new acoustic effects model, and consideration of evolving and emergent best available science.

Specifically, for the marine mammals analysis, changes included the following:

- Integration of results from a new GOA survey and predictive habitat-based density modeling to derive improved marine mammal density data for the GOA Study Area
- Change in the ESA status of the humpback whale (Hawaii Distinct Population Segment)
- Integration of revised acoustic impact criteria and revised acoustic impact thresholds
- Use of a newly developed standard Navy model for acoustic effects analysis
- Consideration of research published since the 2011 GOA Final EIS/OEIS
- Integration of results from scientific monitoring and research relating to understanding impacts on marine mammals from Navy training activities

For resources other than marine mammals, such as fish and sea turtles, similar consideration of changes since the 2011 GOA Final EIS/OEIS were made through the 2016 analysis to determine if there was a need to re-analyze the potential for impacts accordingly.

Phase III of environmental planning. The third phase of the Navy's environmental compliance planning covers similar types of Navy training activities in the same study area analyzed in Phase II. This SEIS/OEIS is the Navy's third phase of environmental compliance for military readiness activities in the Study Area. The Navy has re-evaluated impacts from these ongoing activities in existing ranges and OPAREAs, and additionally analyzed new or changing military readiness activities into the reasonably foreseeable future based on evolving operational requirements, including those associated with new platforms and systems not previously analyzed. The Navy has thoroughly reviewed and incorporated into this analysis the best available science relevant to analyzing the environmental impacts of the proposed activities. As was done in Phase I and Phase II, the Navy will use this analysis to support regulatory consultations and a request for a letter of authorization under the MMPA and incidental take statements under the ESA.

1.3 Proposed Action

The Navy's Proposed Action is consistent with the Proposed Action presented in the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011a), *Record of Decision for Final Environmental Impact Statement/Overseas Environmental Impact Statement for the Gulf of Alaska Navy Training Activities* (U.S. Department of the Navy, 2011b), the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016), and *Record of Decision for the Gulf of Alaska Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy, 2017). The Proposed Action, described in detail in Chapter 2 (Description of Proposed Action and Alternatives), entails the military continuing training activities previously conducted and described in the 2016 GOA Final SEIS/OEIS, for which a ROD was issued. Although the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities (e.g., EA-6B aircraft and frigate, and their associated systems, have been replaced with the EA-18G, Littoral Combat Ship, and Destroyer). Consistent with the previous analysis for Alternative 1, the sinking exercise activity will not be part of the Proposed Action for this SEIS/OEIS.

1.4 Purpose of and Need for Proposed Military Readiness Training Activities

Title 10 Section 8062 of the U.S. Code provides: "The Navy shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea. It is responsible for the preparation of naval forces necessary for the effective prosecution of war except as otherwise assigned and, in accordance with integrated joint mobilization plans, for the expansion of the peacetime components of the Navy to meet the needs of war."

This is a supplemental document to the 2011 GOA Final EIS/OEIS and ROD (U.S. Department of the Navy, 2011a, 2011b) and the 2016 GOA Final SEIS/OEIS and ROD (U.S. Department of the Navy, 2016, 2017) pursuant to 40 CFR section 1502.9(c)(2), and EO 12114. The Navy and NMFS (as a cooperating agency under the provisions of NEPA) have coordinated from the outset and developed this document to meet each agency's separate and distinct NEPA obligations and support the independent decision making of both agencies. As identified in the 2016 GOA Final SEIS/OEIS, the Navy's purpose for the Proposed Action is to achieve and maintain fleet readiness pursuant to Title 10 Section 8062, using the JPARC, previously referred to as the ATAs in the 2011 GOA Final EIS/OEIS, to support and conduct current, emerging, and future training activities. As stated in Section 1.1 (Introduction), this SEIS/OEIS addresses the Navy's activities in the TMAA.

The Navy will request reauthorization from NMFS to "take" marine mammals incidental to conducting training in the TMAA by Level A and B harassment, serious injury, or mortality. Take under the MMPA is defined as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." For military readiness activities, harassment is defined as "(i) any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment] or (ii) any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered [Level B harassment]."

The purpose of issuing incidental take authorizations is to provide an exception to the take prohibition in the MMPA and to ensure that the Navy's proposed training activities comply with the MMPA and implementing regulations. Incidental take authorizations may be issued as either (1) regulations and associated Letters of Authorization (LOAs) under section 101(a)(5)(A) of the MMPA, or (2) Incidental Harassment Authorizations under section 101(a)(5)(D) of the MMPA. An Incidental Harassment Authorization can be issued only when there is no potential for serious injury or mortality or where any such potential can be negated through required mitigation measures. Because some of the activities under the Proposed Action may create a potential for lethal takes or takes that may result in serious injury that could lead to mortality, the Navy is requesting rulemaking and the issuance of an LOA for this action.

The National Marine Fisheries Service's purpose is to evaluate the Navy's Proposed Action pursuant to NMFS's authority under the MMPA, and to make a determination whether to issue incidental take regulations and an LOA, including any conditions needed to meet the statutory mandates of the MMPA. To authorize the incidental take of marine mammals, NMFS evaluates the best available scientific information to determine whether the take would have a negligible impact on the affected marine mammal species or stocks and an unmitigable impact on their availability for taking for subsistence uses (not relevant here for Navy's Proposed Action). The National Marine Fisheries Service must also prescribe permissible methods of taking, other "means of effecting the least practicable adverse impact" on the affected species or stocks and their habitat, and monitoring and reporting requirements. The National Marine Fisheries Service cannot issue an incidental take authorization unless it can make the required findings. The need for NMFS's action is to consider the impacts of the Navy's activities on marine mammals and meet NMFS' obligations under the MMPA. This SEIS/OEIS analyzes the environmental impacts associated with issuance of the requested authorization of the take of marine mammals incidental to training and testing activities (and their corresponding mitigation measures) within the TMAA. The analysis of mitigation measures considers benefits to species or stocks and their habitat, and analyzes the practicability and efficacy of each measure. This analysis of mitigation measures was used to support requirements pertaining to mitigation, monitoring, and reporting that would be specified in final MMPA regulations and subsequent LOA.

1.4.1 Why the Navy Trains

As described above, the Navy is statutorily mandated to protect U.S. national security by being ready, at all times, to effectively prosecute war and defend the nation by conducting operations at sea. Naval forces must be ready for a variety of military operations—from large-scale conflict to maritime security and humanitarian assistance/disaster relief—to deal with the dynamic social, political, economic, and environmental issues that occur in today's world. The Navy supports these military operations through its continuous presence on the world's oceans; the Navy can respond to a wide range of issues because, on any given day, over one-third of its ships, submarines, and aircraft are deployed overseas. Before deploying, naval forces must train to develop a broad range of capabilities to respond to threats, from full-scale armed conflict in a variety of different geographic areas[2] and environmental conditions to humanitarian assistance and disaster relief efforts.[3] This also prepares Navy personnel to be proficient in operating and maintaining the equipment, weapons, and systems they will use to conduct their assigned missions. The training process provides personnel with an in-depth understanding of their individual limits and capabilities; the training process also helps the testing community improve new weapon systems' capabilities and effectiveness.

Modern weapons bring both unprecedented opportunities and challenges to the Navy. For example, precision (or smart) weapons help the Navy accomplish its mission with far less collateral damage than in past conflicts; however, modern weapons are also very complex to use. Military personnel must train regularly with these weapons to understand the capabilities, limitations, and operations of the platform or system, as well as how to keep them operational under difficult conditions and without readily available technical or logistical assistance. Modern military actions require teamwork among hundreds or thousands of people, across vast geographic areas, and the coordinated use of various equipment, ships, aircraft, and vehicles (e.g., unmanned aerial systems) to achieve success. Personnel increase in skill level by completing basic and specialized individual military training; they then advance to intermediate (e.g., unit-level training) and larger exercise training events.

Military readiness training must be as realistic as possible to provide the experiences vital to success and survival during military operations because simulated training, even in technologically advanced simulators, cannot duplicate the complexity faced by Sailors and Marines in the real world. While

[2] Operation Iraqi Freedom in Iraq and Operation Enduring Freedom in Afghanistan; maritime security operations, including anti-piracy efforts like those in Southeast Asia and the Horn of Africa.
[3] Evacuation of non-combatants from American embassies under hostile conditions, as well as humanitarian assistance/disaster relief like the USNS Mercy and USNS Comfort COVID-19 pandemic response in 2020 and Hurricane Dorian relief in the Bahamas in 2019.

simulators and synthetic training are critical elements that provide early skill repetition and enhance teamwork, there is no substitute for live training in a realistic environment. Just as a pilot would not be ready to fly solo after simulator training, a Navy commander cannot allow military personnel to engage in real combat activities based merely on simulator training.

The large size of the TMAA is essential to allow for realistic training scenarios that prepare Sailors and Marines for real-world operations. Only a large operating area offers the space necessary for operations such as the launch and recovery of aircraft or replenishment maneuvers that require a straight-line course at a fixed speed for a sustained period of time. For example, in light wind conditions, to maintain a safe wind speed over the carrier's deck of 20 knots, flight operations taking 30 minutes to an hour would require traveling in a straight line over a distance of at least 10–20 nautical miles (NM). Aircraft landing on an aircraft carrier must be organized into a holding pattern, typically located 10–50 NM away from the carrier, depending on several factors, including weather conditions, visibility, the number of aircraft waiting to land, and the condition of the aircraft (e.g., fuel remaining). Therefore, to practice this maneuver safely away from civilian airspace, the carrier would need to be 20–50 NM away from any operating area boundary. In short, safe and effective Navy training often requires expansive operating areas due to a number of complex and interrelated factors, and the TMAA meets this requirement.

The Navy also requires extensive areas of ocean to conduct its training in order to properly separate and coordinate different training events so that individual training events do not interfere with each other and do not interfere with public and commercial vessels and aircraft. For example, hazardous activities such as gunnery or missile fire from a vessel in one training event would need to be conducted away from other training events. Additionally, large areas of ocean are required to ensure different training events can be conducted safely while minimizing the risks inherent in military training, such as aircraft flying too closely to one another or to commercial airways. Navy ships must also train to operate at long distances—often hundreds of miles—from each other while still maintaining a common picture of the "battlespace" so that individual Navy units can be coordinated to achieve a common objective. Separation of Navy units may also be required to ensure that participants of other exercises do not experience interference with sensors. This need for expansive sea space makes this area in the Northern Pacific Ocean, which offers a safe cold-water training environment and a unique combination of oceanographic and bathymetric features, even more critical today as the Navy has a renewed emphasis on "sea control." Sea control is the need to secure large areas of oceans from other highly capable naval forces. When the Cold War ended, the Navy emerged unchallenged and dominant. That dominance allowed the Navy to focus on projecting power ashore. The balance between sea control and power projection tipped strongly in favor of the latter, and the Navy's surface force evolved accordingly. During this time, the Navy's proficiency in land-attack and maritime security operations reached new heights, while foundational skills in anti-submarine warfare and anti-surface warfare slowly began to erode. Per the *Chief of Naval Operations Design for Maintaining Maritime Superiority 2.0* (U.S. Department of the Navy, 2018), it has now been decades since the Navy last competed for sea control. Much has changed since the Navy last competed. The emergence of more sophisticated capabilities by our potential adversaries require us to operate further from their coastline in times of conflict, and the modernization of navies able to challenge the U.S. Navy directly means that control of the seas can no longer be assumed. In response, the Navy is developing a model of "distributed lethality," which is intended to enhance the offensive power of individual surface ships. This allows them to deploy in dispersed formations in order to control large areas of the sea (e.g., hundreds of thousands of square miles) from which the Navy can operate seamlessly in times of conflict.

1.5 Overview and Strategic Importance of the Joint Pacific Alaska Range Complex

The JPARC has a unique combination of attributes that make it a strategically important training venue, to include:

- **Location.** The large contingent of Air Force aircraft and Army assets based within a few hundred miles of the TMAA creates the possibility of rare joint training opportunities with Navy forces. The TMAA provides a maritime training venue located within flight range of Joint Base Elmendorf-Richardson, Eielson Air Force Base, Fort Wainwright, Fort Greely, and their associated air and land training ranges. The abundance of commercial vessels in shipping lanes within the Gulf of Alaska provides additional valuable realistic training during exercise scenarios, specifically on avoiding conflicts between military and civilian air and marine traffic.
- **Oceanographic conditions.** The complex bathymetric and oceanographic conditions, including a continental shelf, submarine canyons, numerous seamounts, and fresh water infusions from multiple sources provide a challenging environment for training in the search, detection, and localization of submarines. The TMAA provides a safe, cold-water training environment from April to October.
- **Area of Training Space.** The JPARC is one of the largest air, surface, subsurface, and land training areas in the United States. This vast area provides ample space to support a full range of joint training scenarios.

The 2011 GOA Final EIS/OEIS analyzed Navy activities within the entire JPARC, which included the TMAA, the Air Force SUA, and the Army training lands and associated airspace. For the 2016 GOA Final SEIS/OEIS and this SEIS/OEIS, only actions involving underwater acoustic and explosive impacts within the TMAA were analyzed, because the analysis of SUA and land-based training remains unchanged and was incorporated in the June 2013 JPARC EIS.

TMAA. The TMAA (Figure 1.1-1) is composed of the 42,146 square nautical miles of surface and subsurface OPAREA and overlying airspace that includes the majority of Warning Area (W)-612 located over Blying Sound, towards the northwestern quadrant of the TMAA (see Figure 1-1 in the 2011 GOA Final EIS/OEIS and Figure 1.2-1 in the 2016 GOA Final SEIS/OEIS). A Warning Area is Federal Aviation Administration designated airspace of defined dimensions, which contains activity that may be hazardous to nonparticipating aircraft. The purpose of such Warning Areas is to warn nonparticipating pilots of the potential danger. A Warning Area may be located over domestic or international waters, or both. When not included as part of the TMAA, W-612 provides 2,256 square nautical miles (8,766 square kilometers) of SUA, and is used by the Air Force and the U.S. Coast Guard to fulfill training requirements. Air Force and U.S. Coast Guard activities conducted as part of joint training within the TMAA are included in this EIS/OEIS analysis. No Navy training activities analyzed in this document will occur in the area of W-612 that is outside of the TMAA.

The TMAA is located entirely in International Waters, and is roughly rectangular shaped and oriented from northwest to southeast, approximately 300 NM long by 156 NM wide, situated south of Prince William Sound and east of Kodiak Island. The boundaries of the TMAA were developed to avoid Steller sea lion critical habitat. With the exception of Cape Cleare on Montague Island located over 12 NM away from the northern point of the TMAA, the nearest shoreline (Kenai Peninsula) is approximately 24 NM north of the TMAA northern Boundary. Cordova is approximately 80 NM from the nearest edge of the TMAA, and the center of the TMAA is approximately 170 NM offshore from Cordova. Kodiak is approximately 45 NM from the nearest edge of the TMAA, and the center of the TMAA is approximately 190 NM offshore from Kodiak. Yakutat is approximately 130 NM from the nearest edge of the TMAA, and the center of the TMAA is approximately 240 NM offshore from Yakutat. The TMAA is bounded by the following coordinates: 57° 30'N, 141° 30'W to 29° 36'N, 148° 10'W to 58° 57'N, 150° 04'W to 58° 20'N, 151° 00'W to 57° 16'N, 151° 00'W to 55° 30'N, 142° 00'W. The only Navy training activities that occur outside the TMAA are aircraft flights to and from inland Air Force bases and ranges, which are addressed in the June 2013 JPARC EIS.

Since the 1990s, the Department of Defense has conducted a major joint training exercise in Alaska and off the Alaskan coast that involves the Departments of the Navy, Army, Air Force, and Coast Guard participants reporting to a unified or joint commander who coordinates the activities. These activities are planned to demonstrate and evaluate the ability of the services to engage in a conflict and carry out plans in response to a threat to national security. Due to the severe environmental conditions during the winter months, the exercise occurs between April and October. In 2011 the Navy signed the ROD selecting Alternative 2 from the 2011 GOA Final EIS/OEIS and was issued a permit to conduct two exercises annually during the April to October timeframe. In 2017, the Navy signed the ROD selecting Alternative 1 from the 2016 GOA Final SEIS/OEIS and was issued a permit to conduct one exercise annually during the April to October timeframe. Historically, the exercises, referred to as Northern Edge, have occurred only every other year. To date the Navy has conducted four exercises under these analyses, in June 2011, June 2015, May 2017, and May 2019.

1.6 The Environmental Planning Process

NEPA requires federal agencies to examine the environmental impacts of their proposed actions within the United States and its territories. An EIS/OEIS is a detailed public document that assesses the potential effects that a major federal action might have on the human environment. The Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with applicable laws, regulations, and executive orders.

Pursuant to 40 CFR section 1502.9(c), an SEIS is prepared when the agency makes substantial changes in the proposed action that are relevant to environmental concerns; or there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts. An agency may also supplement a final EIS when the agency determines that the purpose of NEPA will be furthered by doing so. The Navy's original purpose and need and Proposed Action, as identified in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, have not changed and are applicable to this SEIS/OEIS. Although new information and analytical methods have emerged since the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, this new information is not significant and does not present a substantially different picture of the environmental consequences or the significance of impacts resulting from the Navy's Proposed Action. Nonetheless, pursuant to the CEQ regulations (40 CFR section 1500.1(b) and 40 CFR section 1502.9(c)(2)), the Navy has determined that preparing this SEIS/OEIS furthers the purpose of NEPA by updating the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS with new information relevant to the public's concerns. This SEIS/OEIS updates the marine mammal, fishes, birds, and sea turtles sections for acoustic and explosive stressors resource analyses in the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011a) and ROD (U.S. Department of the Navy, 2011b) and the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016) and ROD (U.S. Department of the Navy, 2017).

There is no significant new information relevant to the other resource areas evaluated in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Additionally, there is no additional information that changes the best available science for those resource areas. For these reasons, re-analysis of the alternatives in relation to the other resource areas is not warranted. The alternatives analysis for these resource areas is still valid and is not being re-analyzed in this SEIS/OEIS (refer to Chapter 3, Affected Environment and Environmental Consequences, and the individual resource sections of this SEIS/OEIS for detailed discussions).

1.6.1 National Environmental Policy Act Requirements

The NEPA process for an EIS is displayed in Figure 1.6-1. As was done for the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, the Navy complied with all the NEPA process requirements for this SEIS/OEIS. It should be noted that in accordance with the CEQ regulations for implementing the requirements of NEPA, scoping is not required for an SEIS; however, in an effort to maximize public participation and ensure the public's concerns are addressed, the Navy chose to conduct a scoping period for this SEIS/OEIS. The 30-day scoping process period for this SEIS/OEIS was initiated by publication of the Notice of Intent in the *Federal Register* (February 10, 2020) and local newspapers (*Anchorage Daily News, Cordova Times*, *Juneau Empire*, *Kodiak Daily Mirror*, *and Peninsula Clarion*) (See Appendix F [Public Participation] for more information on the Navy's scoping process for this SEIS/OEIS along with details of outreach efforts the Navy has conducted in support of the training conducted in the Gulf of Alaska).

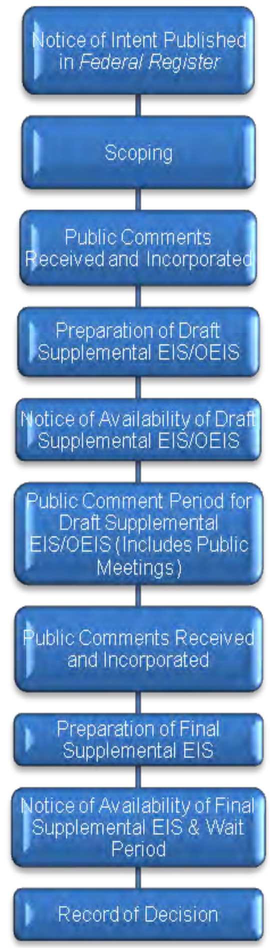

Figure 1.6-1: National Environmental Policy Act Process

1.6.2 Executive Order 12114

Executive Order 12114, *Environmental Impacts Abroad of Major Federal Actions*, directs federal agencies to provide for informed environmental decision-making for major federal actions outside the United States and its territories. Presidential Proclamation 5928, issued on December 27, 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 NM; however, the proclamation expressly provides that it does not extend or otherwise alter existing federal law or any associated jurisdiction, rights, legal interests, or obligations. Thus, as a matter of policy, the Navy analyzes environmental effects and actions within 12 NM under NEPA (an EIS) and those effects occurring beyond 12 NM under the provisions of EO 12114 (an OEIS).

1.6.3 Other Environmental Requirements Considered

The Navy must comply with all applicable federal environmental laws, regulations, and EOs as discussed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. With the exception of acoustic and explosive effects analysis conducted for compliance with the MMPA and the ESA-listed marine mammal, fish, and bird species under NMFS and U.S. Fish and Wildlife Service jurisdiction, there are no detailed re-analysis of the other resource areas from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS analyses. Analysis of impacts under the MMPA and the ESA can be found in Chapter 3 (Affected Environment and Environmental Consequences) of this SEIS/OEIS. Additionally, Chapter 6 (Additional Regulatory Considerations), Table 6.1-1, provides an updated listing of the Navy's compliance status.

1.7 Scope and Content

In this SEIS/OEIS, the Navy reevaluated potential impacts from the ongoing military training activities in the GOA TMAA. The GOA TMAA supports opportunistic experimentation and testing activities when conducted as part of training activities and when considered to be consistent with the proposed training activities. These activities could occur as part of large-scale exercises or as independent events. Therefore, there is no separate discussion or analysis for testing activities that may occur as part of the proposed military readiness activities in the TMAA. Additionally, the alternatives analysis presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS does not change under any resource area except for acoustic and explosive stressors for marine mammals, fish, and birds, taking into account the new information and analytical methods. As such, those other resource areas are not carried forward for re-analysis in this SEIS/OEIS. Through the application of new scientific information and the Navy Acoustic Effects Model, the Navy reanalyzed direct, indirect, cumulative, short-term, long-term, irreversible, and irretrievable impacts that result from the Navy's training activities upon marine mammals in this SEIS/OEIS. This SEIS/OEIS analyzes the impacts on marine mammals under two alternatives—the No Action Alternative and Alternative 1, the selected alternative in the 2017 ROD (U.S. Department of the Navy, 2017).

The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this SEIS/OEIS. The NMFS is a cooperating agency pursuant to 40 CFR section 1501.6, because of its expertise and regulatory authority over marine resources. Additionally, this document will serve as the NMFS's NEPA documentation for the rulemaking process under the MMPA.

At the end of this process, the Navy will issue a ROD that will be based on factors analyzed in this SEIS/OEIS, including military training objectives, best available science and modeling data, potential environmental impacts, and public input.

1.8 Organization of This Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement

To meet the need for decision-making, this SEIS/OEIS is organized as follows:

- Chapter 1 describes the purpose of and need for the Proposed Action.
- Chapter 2 describes the Proposed Action and Alternatives analyzed and presented in the ROD for the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011b) and the ROD for the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2017).
- Chapter 3 describes the existing conditions of the affected environment and potential environmental consequences on those resources requiring additional discussion or analysis beyond what was analyzed in the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011a) and the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016).
- Chapter 4 describes the analysis of cumulative impacts, which are the impacts of the Proposed Action, as described in the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011a) and the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016) when added to past, present, and reasonably foreseeable future actions.
- Chapter 5 describes and focuses on the measures the Navy evaluated that could mitigate impacts on marine resources as well as mitigations beyond those discussed in the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011a) and the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016) for other resource areas.

- Chapter 6 describes other considerations required by the NEPA and describes how the Navy complies with other federal, state, and local plans, policies, and regulations. Additionally, this chapter describes the Navy's government-to-government consultation with federally recognized Alaska Native Tribes in accordance with EO 13175, *Consultation and Coordination with Indian Tribal Governments*.
- Chapter 7 includes a list of the SEIS/OEIS preparers.
- Appendices provide technical information that supports the SEIS/OEIS analyses and its conclusions.

1.9 Related Environmental Documents

The progression of NEPA/EO 12114 documentation for Navy activities has developed from planning individual range complex exercises and testing events to theater assessment planning that spans multiple years and covers multiple range complexes. The following documents are referenced in this SEIS/OEIS where appropriate:

- *Gulf of Alaska Navy Training Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy, 2011a) – This EIS/OEIS is the initial document that analyzes environmental compliance coverage for Navy training activities in the Gulf of Alaska. This document provides the basis for this SEIS/OEIS.
- *Record of Decision for Final Environmental Impact Statement/Overseas Environmental Impact Statement for the Gulf of Alaska Navy Training Activities* (U.S. Department of the Navy, 2011b) – This document, signed on May 11, 2011, is the formal decision document that identifies and explains the reasoning and decision on the selected alternative in the 2011 GOA Final EIS/OEIS.
- *Final Environmental Impact Statement for the Modernization and Enhancement of Ranges, Airspace, and Training Areas in the Joint Pacific Alaska Range Complex* (U.S. Department of Army & Air Force, 2013a) – This EIS analyzes the need to modernize and enhance the range and airspace infrastructure of the training ranges in Alaska to meet Department of Defense Service component training requirements. Current and future Navy training activities are included in this document and it provides environmental coverage for Navy overland activities.
- *Record of Decision for Final Environmental Impact Statement for the Modernization and Enhancement of Ranges, Airspace, and Training Areas in the Joint Pacific Alaska Range Complex* (U.S. Department of Army & Air Force, 2013b) – This document, which was approved and signed on 6 August 2013, provides the reasoning and decision on the selected alternative in the JPARC EIS.
- *Gulf of Alaska Navy Training Activities Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy, 2016) – This is the first supplement to the initial EIS/OEIS.
- *Record of Decision for the Gulf of Alaska Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy, 2017) – This document, signed on April 22, 2017, is the formal decision document that identifies and explains the reasoning and decision on the selected alternative in the 2016 GOA Final SEIS/OEIS.

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2 Description of Proposed Action and Alternatives

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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2 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

The United States (U.S.) Department of the Navy's (Navy's) Proposed Action is a supplement to the 2011 Gulf of Alaska (GOA) Navy Training Activities Final Environmental Impact Statement(EIS)/Overseas Environmental Impact Statement (OEIS) (U.S. Department of the Navy, 2011a), hereinafter referred to as the 2011 GOA Final EIS/OEIS, and Record of Decision (ROD) for the 2011 GOA Final EIS/ (U.S. Department of the Navy, 2011b), and the 2016 GOA Final Supplemental EIS (SEIS)/OEIS (U.S. Department of the Navy, 2016) and ROD for the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2017), pursuant to the guidance of 40 Code of Federal Regulations (CFR) Section 1502.9(c) (2019).

At-sea joint exercises in the GOA, historically referred to as Northern Edge, and described in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, support the training of combat-capable naval forces. The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action analyzed in the previous documents. In this SEIS/OEIS, the Navy reevaluated potential impacts from the ongoing military training activities in the GOA Temporary Maritime Activities Area (TMAA). The GOA TMAA supports opportunistic experimentation and testing activities when conducted as part of training activities and when considered to be consistent with the proposed training activities. These activities could occur as part of large-scale exercises or as independent events. Therefore, there is no separate discussion or analysis for testing activities that may occur as part of the proposed military readiness activities in the TMAA.

2.1 Description of the Joint Pacific Alaska Range Complex

As noted in Section 1.1 (Introduction) of the 2016 GOA Final SEIS/OEIS, the term "Alaska Training Areas" was changed to the "Joint Pacific Alaska Range Complex" (JPARC). The JPARC was described in the 2011 GOA Final EIS/OEIS in Section 2.1 (Description of the Alaska Training Areas). There are no additional changes to the training areas, and this SEIS/OEIS only analyzes activities occurring within the TMAA, a component of the JPARC.

2.1.1 Gulf of Alaska Temporary Maritime Activities Area

The TMAA is depicted in Figure 2.2-1 and is described in Section 2.1.1 (Gulf of Alaska Temporary Maritime Activities Area) of the 2011 GOA Final EIS/OEIS. There are no changes to the TMAA in this SEIS/OEIS. The TMAA is located entirely in international waters and is 12 nautical miles (NM) or greater from bodies of land. A full description of the TMAA is provided in Section 1.5 (Overview and Strategic Importance of the Joint Pacific Alaska Range Complex) of this SEIS/OEIS.

2.2 Primary Mission Areas

The Navy categorizes many of its training activities into functional warfare areas called primary mission areas. The Navy's proposed activities for the GOA TMAA generally fall into the following six primary mission areas:

- air warfare
- surface warfare
- anti-submarine warfare
- electronic warfare
- naval special warfare
- strike warfare

Most activities addressed in this SEIS/OEIS are categorized under one of these primary mission areas; activities that do not fall within one of these areas are listed as "support operations." Each warfare community (aviation, surface, and subsurface) may train in some or all of these primary mission areas.

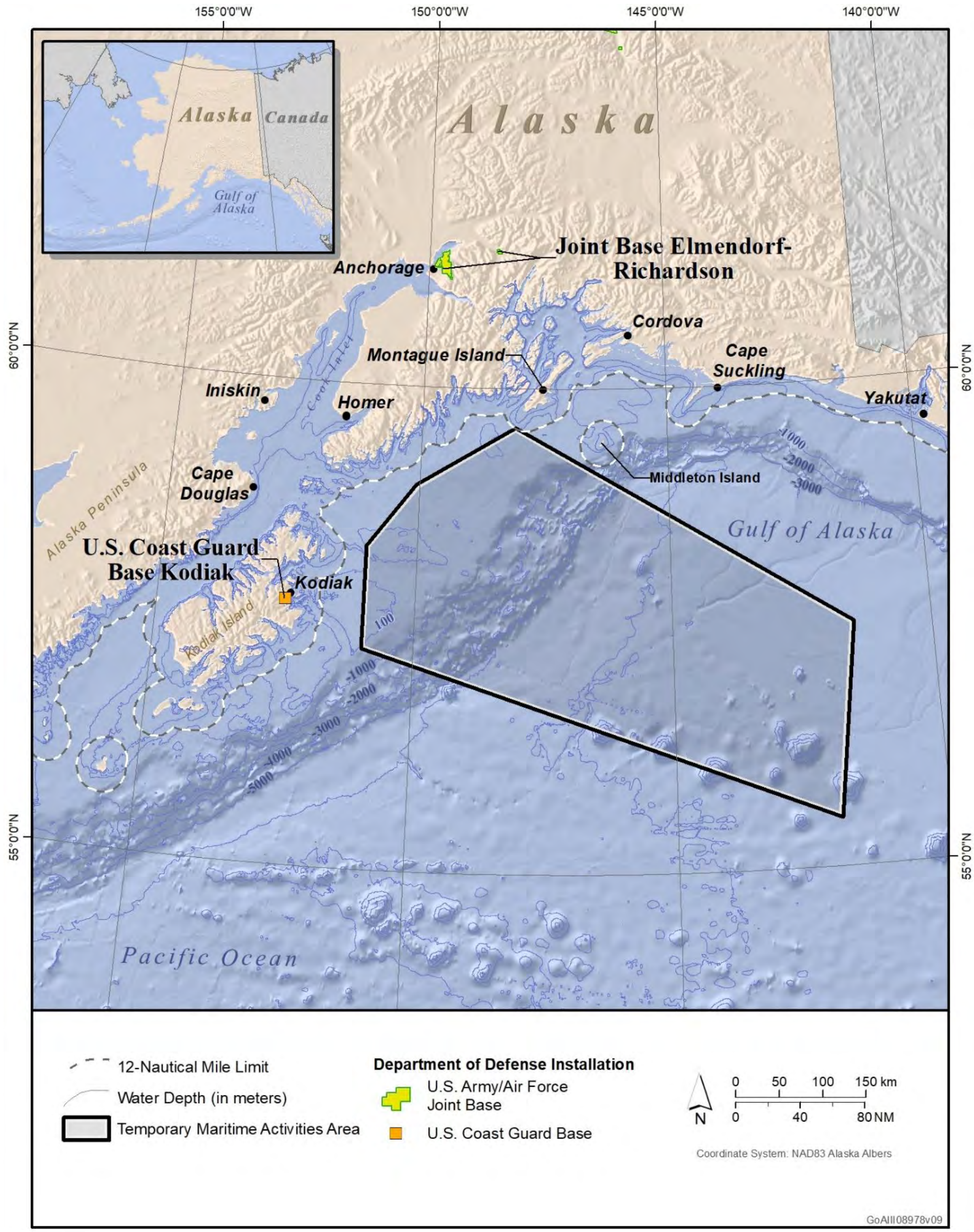

Figure 2.2-1: Gulf of Alaska Temporary Maritime Activities Area

A description of the sonar, munitions, targets, systems and other material used during training activities within these primary mission areas is provided in Appendix A (Navy Activities Descriptions).

2.2.1 Air Warfare

The mission of air warfare (named anti-air warfare in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, but since changed by the Navy to "Air Warfare") is to destroy or reduce enemy air and missile threats (including unmanned airborne threats) and serves two purposes: to protect U.S. forces from attacks from the air and to gain air superiority. Air warfare provides U.S. forces with adequate attack warnings, while denying hostile forces the ability to gather intelligence about U.S. forces.

Aircraft conduct air warfare through radar search, detection, identification, and engagement of airborne threats. Surface ships conduct air warfare through an array of modern anti-aircraft weapon systems such as aircraft detecting radar, naval guns linked to radar-directed fire-control systems, surface-to-air missile systems, and radar-controlled guns for close-in point defense.

2.2.2 Surface Warfare

The mission of surface warfare (named anti-surface warfare in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, but since changed by the Navy to "Surface Warfare") is to obtain control of sea space from which naval forces may operate, and entails offensive action against other surface targets while also defending against enemy forces. In surface warfare, aircraft use guns, air-launched cruise missiles, or other precision-guided munitions; ships employ torpedoes, naval guns, and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles.

Surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, submarine missile or torpedo launch events, and use of other munitions against surface targets.

2.2.3 Anti-Submarine Warfare

The mission of anti-submarine warfare (ASW) (see the 2011 GOA Final EIS/OEIS) is to locate, neutralize, and defeat hostile submarine forces that threaten Navy surface forces. ASW is based on the principle that surveillance and attack aircraft, ships, and submarines all search for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack submarine threats.

ASW training addresses basic skills such as detecting and classifying submarines, as well as evaluating sounds to distinguish between enemy submarines and friendly submarines, ships, and marine life. For a discussion on differentiating sound and noise, see Appendix B (Acoustic and Explosive Concepts), Section B.1.2 (Signal Versus Noise). More advanced training integrates the full spectrum of ASW, from detecting and tracking a submarine to attacking a target using either exercise torpedoes (i.e., torpedoes that do not contain a warhead) or simulated weapons. These integrated ASW training exercises are conducted in coordinated, at-sea training events involving submarines, ships, and aircraft.

2.2.4 Electronic Warfare

The mission of electronic warfare (named Electronic Combat in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, but since changed by the Navy to "Electronic Warfare") is to degrade the enemy's ability to use electronic systems, such as communication systems and radar, and to confuse or deny them the ability to defend their forces and assets. Electronic warfare is also used to detect enemy threats and counter their attempts to degrade the electronic capabilities of the Navy.

Typical electronic warfare activities include threat avoidance training, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices (that block or interfere with other devices) to defeat tracking, navigation, and communications systems.

2.2.5 Naval Special Warfare

Naval special warfare conducts military activities in five Special Operations mission areas: unconventional warfare, direct action, special reconnaissance, foreign internal defense, and counterterrorism.

Naval special warfare training involves specialized tactics, techniques, and procedures, employed in training events that could include insertion/extraction activities using parachutes, rubber boats, or helicopters and other equipment.

2.2.6 Strike Warfare

Strike Warfare addresses combat (or interdiction) activities by air and surface forces against hostile land-based forces and assets. Strike warfare activities include training of fixed-wing fighter/attack aircraft in delivery of precision-guided munitions, nonguided munitions, rockets, and other ordnance against land targets in all weather and light conditions.

Training events typically involve a strike mission with a flight of four or more aircraft. The strike mission practices attacks on long-range targets (i.e., those geographically distant from friendly ground forces), or close air support of targets within close range of friendly ground forces. Laser designators from aircraft or ground personnel may be employed for delivery of precision-guided munitions. Some strike missions involve no-drop events in which prosecution of targets is practiced, but video footage is often obtained by onboard sensors. Strike exercises occur on the land and air training ranges as identified in the Air Force Alaska Military Operations Areas EIS (U.S. Department of the Air Force, 1995), and their impacts are covered under its environmental analysis. The activity in the TMAA is limited to the launch and recovery of aircraft conducting strike training in the land and air training ranges.

2.2.7 Support Operations

Other training (see the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS) is conducted in the TMAA that falls outside of the primary mission areas, but supports overall readiness. Specifically, this includes Deck Landing Qualifications, which provides for helicopter crews to land on ships underway at sea.

2.3 Proposed Activities

Training activities proposed by the Navy in this SEIS/OEIS are identified in Table 2.6-1 at the end of this chapter. This table lists the current name of the activity and a brief description of the activity (Appendix A, Navy Activities Descriptions, includes a full description of each activity). More information about each activity can be found in Appendix A (Navy Activities Descriptions).

2.3.1 Changes to Proposed Activities

The activities analyzed in this SEIS/OEIS are a continuation of activities that have been ongoing and were analyzed previously in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. This SEIS/OEIS includes the analysis of those at-sea activities projected to meet readiness requirements beyond 2022 and into the reasonably foreseeable future and reflects the most up-to-date compilation of training activities deemed necessary to accomplish military readiness requirements. Though the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities (e.g., EA-6B aircraft and frigate, and their associated systems, have been replaced with the EA-18G, Littoral Combat Ship, and Destroyer). Consistent with the previous analysis for Alternative 1, the sinking exercise activity will not be part of the Proposed Action for this SEIS/OEIS.

2.3.2 Standard Operating Procedures

For training to be effective, units must be able to safely use their sensors and weapons systems as they are intended to be used in military missions and combat operations and to their optimum capabilities. Standard operating procedures applicable to training have been developed through years of experience, and their primary purpose is to provide for safety (including public health and safety) and mission success. Because they are essential to safety and mission success, standard operating procedures are part of the Proposed Action and are considered in the Chapter 3 (Affected Environment and Environmental Consequences) environmental analysis for applicable resources.

In many cases, there are benefits to environmental and cultural resources (some of which have high socioeconomic value in the TMAA) resulting from standard operating procedures. Those standard operating procedures that are recognized as providing a benefit to the resources analyzed in this SEIS/OEIS are included in Appendix A (Navy Activities Descriptions), as applicable. The following standard operating procedure categories apply to the Proposed Action and are generally consistent with those included in these specified sections in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of the 2016 GOA Final SEIS/OEIS:

- Section 5.1.1 (General Safety)
- Section 5.1.2 (Vessel Safety)
- Section 5.1.3 (Aircraft Safety)
- Section 5.1.4 (Laser Procedures)
- Section 5.1.5 (Weapons Firing Procedures)
- Section 5.1.6 (Unmanned Aerial Vehicle Procedures)
- Section 5.1.7 (Unmanned Surface Vehicle and Unmanned Underwater Vehicle Procedures)
- Section 5.1.8 (Towed In-Water Device Procedures)
- Section 5.1.9 (Best Management Practices)

Standard operating procedures that apply to the Proposed Action and were not included in, or require a clarification from, the 2016 GOA Final SEIS/OEIS are discussed in the sections below.

2.3.2.1 Sea Space and Airspace Deconfliction

The Navy schedules training activities to minimize conflicts with the use of sea space and airspace throughout the Study Area to ensure the safety of military personnel, the public, commercial aircraft, commercial and recreational vessels, and military assets. The Navy deconflicts its own use of sea space and airspace to allow for the necessary separation of multiple military units to prevent interference with equipment sensors and to avoid interaction with established commercial air traffic routes and commercial shipping lanes. Military aircraft fly in accordance with Federal Aviation Administration

Regulations, Part 91, General Operating and Flight Rules, which govern such flight components as operating near other aircraft, right-of-way rules, aircraft speed, and minimum safe altitudes. These rules include the use of tactical training and maintenance test-flight areas, arrival and departure routes, and airspace restrictions as appropriate to help control air operations.

These standard operating procedures benefit public health and safety (including persons participating in activities that have subsistence benefits and socioeconomic value, such as recreational or commercial fishing) by reducing the potential for interactions with training activities. Additional information on the Navy's communication and cooperation with Tribes and communities is presented in Section 3.14 (Public Safety) of the 2016 GOA Final SEIS/OEIS.

2.3.2.2 Target Deployment and Retrieval Safety

The standard operating procedures for target deployment and retrieval safety apply to weapons firing activities that involve small boats deploying or retrieving targets. These activities are typically conducted in daylight hours in Beaufort Sea state number 4 conditions or better to ensure safe operating conditions during target deployment and recovery. These standard operating procedures benefit public health and safety, marine mammals, sea turtles, and seabirds by increasing the effectiveness of visual observations for mitigation, thereby reducing the potential for interactions with the weapons firing activities associated with the use of applicable deployed targets.

During activities that involve recoverable targets (e.g., aerial drones), the military recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. Recovery of these items helps minimize the amount of materials that remain on the surface or on the seafloor, which could potentially alert enemy forces to the presence of military assets during military missions and combat operations. This standard operating procedure benefits biological resources (e.g., marine mammals, sea turtles, fish, seabirds) by reducing the potential for physical disturbance and strike, entanglement, or ingestion of applicable targets and any associated decelerators/parachutes.

2.3.3 Mitigation Measures

The Navy will implement mitigation measures to avoid or reduce potential impacts from Alternative 1 of the Proposed Action on environmental and cultural resources. Mitigation measures that the Navy will implement under the Proposed Action are organized into two categories: procedural mitigation and mitigation areas. The Navy will implement procedural mitigation measures whenever and wherever applicable training activities take place within the Study Area. Mitigation areas are geographic locations within the Study Area where the Navy will implement additional mitigation during all or part of the year.

A list of the activity categories, stressors, and mitigation areas for which the Navy developed mitigation measures is provided in Table 2.3-1. Chapter 5 (Mitigation) of this SEIS/OEIS provides a full description of each mitigation measure that would be implemented under Alternative 1 of the Proposed Action. It also presents a discussion of how the Navy developed and assessed each measure and includes maps of the mitigation area locations. Mitigation developed for the Proposed Action is generally in line with the type of mitigation included in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of the 2016 GOA Final SEIS/OEIS. The Navy has updated Chapter 5 (Mitigation) of this SEIS/OEIS in its entirety based on its ongoing analysis of the best available science and practicality of implementing potential mitigation measures. Chapter 5 (Mitigation) presents a full analysis of the procedural mitigation and mitigation areas the Navy developed for the TMAA. The Navy ROD will document all mitigation measures the Navy will implement under the Proposed Action. The National Marine Fisheries

Service (NMFS) ROD, Marine Mammal Protection Act (MMPA) Regulations and Letter of Authorization, Endangered Species Act (ESA) Biological Opinion, and other applicable consultation documents will include the mitigation measures applicable to the resources for which the Navy consults.

Table 2.3-1: Overview of Mitigation Categories

Mitigation Category	*Chapter 5 (Mitigation) Section*	*Applicable Activity Category, Stressor, or Mitigation Area*
Procedural Mitigation	Section 5.3.2 (Acoustic Stressors)	Active Sonar Weapon Firing Noise
	Section 5.3.3 (Explosive Stressors)	Explosive Medium-Caliber and Large-Caliber Projectiles Explosive Bombs
	Section 5.3.4 (Physical Disturbance and Strike Stressors)	Vessel Movement Towed In-Water Devices Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions Non-Explosive Bombs
Mitigation Areas	Section 5.4 (Geographic Mitigation to be Implemented)	North Pacific Right Whale Mitigation Area Portlock Bank Mitigation Area Temporary Maritime Activities Area

2.4 Action Alternatives Development

The identification, consideration, and analysis of alternatives are critical components of the National Environmental Policy Act (NEPA) process and contribute to the goal of objective decision-making. The Council on Environmental Quality developed regulations to implement NEPA, and these regulations require the decision maker to consider the environmental effects of the proposed action and a range of alternatives (including the No Action Alternative) to the proposed action (40 CFR section 1502.14). Council on Environmental Quality guidance further provides that an EIS must rigorously and objectively explore all reasonable alternatives for implementing the proposed action and, for alternatives eliminated from detailed study, briefly discuss the reasons for having been eliminated. To be reasonable, an alternative, except for the No Action Alternative, must meet the stated purpose of and need for the proposed action.

The action alternative and the mitigation measures that are incorporated in the action alternative were developed to meet both the Navy's purpose and need to train; and NMFS's independent purpose and need to evaluate the potential impacts of the Navy's activities. In order for NMFS to determine whether incidental take resulting from the Navy's activities would have a negligible impact on affected marine mammal species and stocks, and prescribe measures to affect the least practicable adverse impact on species or stocks and their habitat, the Navy has incorporated these requirements into the analysis of the Proposed Action.

The Navy developed the alternatives considered in this SEIS/OEIS after careful assessment by subject matter experts, including military commands that utilize the ranges, military range management professionals, and Navy environmental managers and scientists.

2.5 Alternatives Eliminated from Further Consideration

This SEIS/OEIS serves as an update to the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Alternatives eliminated from consideration in those documents were re-evaluated to determine if they should be reconsidered for this SEIS/OEIS and are discussed below. After a thorough consideration of each alternative, the Navy once again determined that they did not meet the purpose of and need for the Proposed Action.

2.5.1 Alternative Training Locations

As described in Section 2.3.2.1 (Alternative Locations) in the 2011 GOA Final EIS/OEIS, the proposed locale encompasses existing training areas with unique sizes and capabilities, and training areas that have the continuity and capability to support joint training purposes in Alaska waters. There are no other proximate alternative locations that provide for this capability. As a result, this alternative is neither reasonable nor practicable, does not meet the purpose of and need for the Proposed Action, and has been eliminated from detailed study.

2.5.2 Reduced Training

As described in Section 2.3.2.2 (Reduced Training) in the 2011 GOA Final EIS/OEIS, a reduction or cessation of training would prevent the military services from meeting statutory requirements and adequately preparing forces for operations ranging from disaster relief to armed conflict. Therefore, this alternative does not meet the purpose of and need for the Proposed Action and has been eliminated from detailed study.

2.5.3 Alternate Time Frame

As described in Section 2.3.2.3 (Alternate Time Frame) in the 2011 GOA Final EIS/OEIS, an alternate period in which to hold Navy training in the TMAA, such as in the winter months, would not be feasible. Weather conditions in the GOA preclude conducting an integrated exercise during the winter. Winter sea conditions, storms, fog, fewer daytime hours, and other environmental conditions would lead to navigational safety concerns for both ships and airplanes involved in any winter exercise. Additionally, other services' training requirements prohibit overwater training when the water temperature decreases below a certain level (typical during the winter months in the GOA), as this needlessly jeopardizes the health and safety of exercise participants. Therefore, an alternate time frame would not meet the appropriate weather conditions for safety of maritime training activities at sea, as described in Section 2.3.1 (Alternatives Development) of the 2011 GOA Final EIS/OEIS.

2.5.4 Simulated Training

As described in Section 2.3.2.4 (Simulated Training) in the 2011 GOA Final EIS/OEIS, the Navy continues to use computer simulation and other types of simulation for training activities whenever possible; however, there are limits to the realism that current simulation technology can provide, and its use cannot substitute for live training. Training through simulated means cannot replicate the conditions in which Navy personnel and platforms are required to conduct military operations. While beneficial as a complementing medium to train and test personnel and platforms, simulation alone cannot accurately replicate both the conditions and the stresses that must be placed on personnel and platforms during training. These conditions and stresses are absolutely vital to adequately preparing Naval forces to conduct the broad spectrum of military operations required of them by operational Commanders. Therefore, simulation as an alternative that completely replaces training in the field does not meet the purpose of and need for the Proposed Action and has been eliminated from further analysis.

2.5.5 Training without the Use of Active Sonar

In order to be proficient in detecting and countering potentially hostile submarines, the Navy needs to routinely train using both passive and active sonar. Sonar proficiency is a complex and perishable skill that requires regular, hands-on training in realistic and diverse conditions. Training with active sonar is needed to find and counter newer-generation submarines around the world, which are growing in number and are true threats to global commerce, national security, and the safety of military personnel. As a result, defense against enemy submarines is a top priority for the Navy. The detection and countering of submarines is paramount to national security. Naval forces cannot counter this threat without the use of active sonar. Because the Navy is statutorily responsible to provide combat-ready forces to operational commanders, it must train in a manner in which it will be utilized in military operations. Accordingly, training without active sonar is not a reasonable alternative and will not be carried forward.

2.5.6 Alternatives Including Geographic Mitigation Measures Within the Study Area

The Navy considered, but did not develop, an alternative based solely on geographic mitigation that would impose geographic or temporal restrictions on specific areas in the TMAA, such as areas associated with the presence of specific species. Such an alternative would present a patchwork of areas and time periods in which the Navy could conduct required training, preventing the Navy from conducting the full scope of activities necessary to fulfill its Title 10 responsibilities and running counter to the purpose of and need for the Proposed Action. Thus, such an alternative would not be reasonable. Further, NEPA regulations allow agencies to “Include appropriate mitigation measures not already included in the proposed action or alternatives” (40 CFR 1502.14[f]). The Navy designed its alternatives development and mitigation development processes to ensure the maximum level of mitigation that is practical to implement when balanced against impacts to safety, sustainability, and the ability to continue meeting mission requirements. Under the action alternative, the Navy would implement geographic mitigation that is both biologically effective as well as practical to implement. Mitigation areas developed for the Proposed Action are detailed in Chapter 5 (Mitigation).

2.6 Alternatives Carried Forward

Three alternatives were analyzed in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS: the No Action Alternative, Alternative 1, and Alternative 2. For this SEIS/OEIS, only two Alternatives are being carried forward, the No Action Alternative and Alternative 1 (the Preferred Alternative).

The No Action Alternative in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS consisted of training activities of the types and levels of training intensity as conducted prior to 2011 and did not include ASW training activities involving the use of active sonar. Alternative 1 included all training activities addressed in the No Action Alternative and an increase in training activities. This increase would encompass conducting one large-scale carrier strike group (CSG) exercise, as well as the inclusion of ASW activities and the use of active sonar, occurring over a maximum time period of up to 21 consecutive days during the months of April–October. Alternative 2 included all elements of Alternative 1 plus one additional CSG exercise during the months of April–October. Additionally, Alternative 2 included conducting one sinking exercise per CSG exercise for a total of two exercises per year. Alternative 2 was the Preferred Alternative and was selected in the ROD issued on May 11, 2011, while the ROD issued on April 21, 2017 selected Alternative 1 instead of the preferred Alternative 2.

The Navy’s anticipated level of training activity evolves over time based on numerous factors. Based on the assessment of the training activities in the TMAA and future requirements, the Navy has determined the level of activity analyzed in Alternative 1 from the 2016 GOA Final SEIS/OEIS will continue to meet the Navy's training requirements for the reasonably foreseeable future, and no new training activities are proposed for the Study Area. Therefore, this SEIS/OEIS will only carry forward the No Action Alternative, as described below, and Alternative 1 as described in the 2016 GOA Final SEIS/OEIS and 2017 GOA ROD. Consistent with the previous analysis for Alternative 1, the sinking exercise activity will not be part of the Proposed Action for this SEIS/OEIS.

As previously discussed, in addition to meeting the Navy's purpose and need to train, the action alternative, and in particular the mitigation measures that are incorporated in the action alternative, were developed to meet NMFS's independent purpose and need to evaluate the potential impacts of the Navy's activities; determine whether incidental take resulting from the Navy's activities would have a negligible impact on affected marine mammal species and stocks; and prescribe measures to effect the least practicable adverse impact on species or stocks and their habitat, as well as monitoring and reporting requirements.

2.6.1 No Action Alternative

As mentioned in Section 2.4 (Action Alternatives Development), the Council on Environmental Quality implementing regulations require that a range of alternatives to the Proposed Action, including a No Action Alternative, be analyzed to provide a clear basis for choice among options by the decision maker and the public (40 CFR 1502.14). Council on Environmental Quality guidance identifies two approaches in developing the No Action Alternative (46 FR 18026). One approach is applicable to ongoing, continuing actions as the present course of action under the current management direction or intensity. For example, the continuation of training activities conducted at levels analyzed in the 2011 GOA Final EIS/OEIS could be a viable No Action Alternative, even if separate legal authorizations under the MMPA and ESA are required to continue the activities. Under this approach, which was used in the 2016 GOA Final SEIS/OEIS, the analysis compares the effects of continuing current activity levels (i.e., the "status quo") with the effects of the Proposed Action. The second approach depicts a scenario where no authorizations or permits are issued, in which the Proposed Action does not take place, and the resulting environmental effects from taking no action are compared with the effects of implementing the Proposed Action. The Navy applied the second approach in this SEIS/OEIS as it further supports NMFS' regulatory process by presenting the scenario where no authorization or permits will be issued.

Under the No Action Alternative analyzed in this SEIS/OEIS, the Navy would not conduct the proposed training activities in the GOA TMAA. Consequently, the No Action Alternative of not conducting the proposed live, at-sea training activities in the TMAA is unreasonable in that it does not meet the purpose and need (see Section 1.4, Purpose of and Need for Proposed Military Readiness Training Activities) for the reasons noted below. However, the analysis associated with the No Action Alternative is carried forward in order to compare the magnitude of the potential environmental effects of the Proposed Action with the conditions that would occur if the Proposed Action did not occur (see Section 3.0.1, Approach to Analysis).

From NMFS' perspective, pursuant to its obligation to grant or deny permit applications under the MMPA, the No Action Alternative involves NMFS denying the Navy's application for an incidental take authorization under Section 101(a)(5)(A) of the MMPA. If NMFS were to deny the Navy's application, the Navy would not be authorized to incidentally take marine mammals, and the Navy would not conduct the proposed training activities in the GOA TMAA.

Cessation of proposed Navy at-sea training activities would mean that the Navy would be unable to (1) meet its statutory requirements, (2) adequately prepare to defend itself and the United States from enemy forces, (3) successfully detect enemy submarines, and (4) effectively use its weapons systems or defensive countermeasures due to a lack of training.

2.6.2 Alternative 1 (Preferred Alternative)

Alternative 1 is the Preferred Alternative. Alternative 1 is a Status Quo Alternative based on the 2016 GOA Final SEIS/OEIS and 2017 GOA ROD. Under this alternative, the Navy would continue the present course of action, continuation of Navy training in the TMAA at current levels documented in the 2017 GOA ROD, even if separate legal authorizations under the MMPA and ESA are required. The Navy could continue to conduct training activities, at the level and scope of activities necessary to fulfill its Title 10 responsibilities described in the Purpose and Need of the Proposed Action. In the GOA TMAA, a Status Quo Alternative would allow the Navy to meet current and future training requirements necessary to achieve and maintain fleet readiness.

Table 2.6-1 lists the level of activities of Alternative 1. Although they are consistent with the level of activities addressed in Alternative 1 of the 2016 GOA Final SEIS/OEIS, there have been changes in the platforms and systems used as part of those activities (e.g., EA-6B aircraft and frigate, and their associated systems, have been replaced with the EA-18G, Littoral Combat Ship, and Destroyer). The table describes the activities in terms of the activity name, where in the Study Area the Navy proposes to conduct it, and the number of annual events. The quantity of ordnance and expendables used in the TMAA is consistent with the levels identified for Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Details of each activity, including acoustic and explosive, are presented in Appendix A (Navy Activities Descriptions) of this SEIS/OEIS.

Table 2.6-1: Current and Proposed Training Activities Within the TMAA

Range Activity	*No. of events[2] (annual)*	
	Alternative 1 (2016 Final SEIS/OEIS)	*Alternative 1 (Proposed)*
Air Warfare		
Aircraft Combat Maneuver	300 sorties[2]	300 sorties[2]
Air Defense Exercise	4 events	4 events
Surface-to-Air Gunnery Exercise	3 events	3 events
Air-to-Air Missile Exercise	3 events	3 events
Surface-to-Air Missile Exercise	3 events	3 events
Surface Warfare		
Visit, Board, Search, and Seizure	12 events	12 events
Air-to-Surface Bombing Exercise	18 events	18 events
Air-to-Surface Gunnery Exercise	7 events	7 events
Surface-to-Surface Gunnery Exercise	6 events	6 events
Maritime Interdiction	14 events	14 events
Air-to-Surface Missile Exercise	2 events	2 events
Sea Surface Control	6 events	6 events
Anti-Submarine Warfare (ASW)		
ASW Tracking Exercise – Helicopter	22 events	22 events
ASW Tracking Exercise – Maritime Patrol Aircraft	13 events	13 events
ASW Tracking Exercise – Submarine	2 events	2 events
ASW Tracking Exercise – Surface Ship	2 events	2 events
Electronic Warfare (EW)		
Counter Targeting Exercise	4 events	4 events
Chaff Exercise	2 events	2 events
EW Exercise	5 events	5 events
Naval Special Warfare		
Special Warfare Operations	10 events	10 events
Strike Warfare		
Air-to-Ground Bombing Exercise[1]	150 sorties[2]	150 sorties[2]
Personnel Recovery[1]	4 events	4 events
Support Operations		
Deck Landing Qualification	6 events	6 events

[1]This SEIS/OEIS covers the launch and recovery of aircraft from vessels in the TMAA. The training is conducted in the Air Force Special Use Airspace and Army Training Lands that are covered under separate National Environmental Policy Act analysis.
[2]A sortie is defined as a single activity by one aircraft (i.e., one complete flight from takeoff to landing).
Notes: SEIS = Supplemental Environmental Impact Statement, OEIS = Overseas Environmental Impact Statement, TMAA = Temporary Maritime Activities Area.

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3 Affected Environment and Environmental Consequences

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.0 Introduction

This chapter outlines the United States (U.S.) Department of the Navy's (Navy's) rationale for resource analysis in the Gulf of Alaska (GOA) Navy Training Activities Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS).

In accordance with 40 Code of Federal Regulations (CFR) section 1502.9(c) (2019), Agencies:

> (1) Shall prepare supplements to either draft or final environmental impact statements if:
>
> > (i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or
> >
> > (ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.
>
> (2) May also prepare supplements when the agency determines that the purposes of the Act will be furthered by doing so.
>
> (3) Shall adopt procedures for introducing a supplement into its formal administrative record, if such a record exists.
>
> (4) Shall prepare, circulate, and file a supplement to a statement in the same fashion (exclusive of scoping) as a draft and final statement unless alternative procedures are approved by the Council [on Environmental Quality].

In March 2011, the Navy released the GOA Navy Training Activities Final Environmental Impact Statement (EIS)/OEIS (U.S. Department of the Navy, 2011a), hereafter referred to as the 2011 GOA Final EIS/OEIS, for which a Record of Decision (ROD) was received (*Record of Decision for Final Environmental Impact Statement/Overseas Environmental Impact Statement for the Gulf of Alaska Navy Training Activities* (U.S. Department of the Navy, 2011b) pursuant to the guidance of 40 CFR section 1502.9(c). In July 2016, the Navy released the GOA Navy Training Activities Final SEIS/OEIS (U.S. Department of the Navy, 2016), hereafter referred to as the 2016 GOA Final SEIS/OEIS, for which a ROD was received (*Record of Decision for Final Environmental Impact Statement/Overseas Environmental Impact Statement for the Gulf of Alaska Navy Training Activities* (U.S. Department of the Navy, 2017c)) pursuant to the guidance of 40 CFR Section 1502.9(c). For the 2016 GOA Final SEIS/OEIS, the Navy, in coordination with the National Marine Fisheries Service (NMFS), applied the Navy Acoustic Effects Model to quantitatively analyze potential acoustic effects from Navy training activities. For this SEIS/OEIS, the Navy refined the Navy Acoustic Effects Model (U.S. Department of the Navy, 2018) and updated marine mammal density estimates (U.S. Department of the Navy, 2020), as well as the criteria and activity data inputs used in the acoustic model (U.S. Department of the Navy, 2017a).

This chapter describes existing environmental conditions in the Study Area (the Temporary Maritime Activities Area [TMAA]) as well as the analysis of resources potentially impacted by the Proposed Action described in Chapter 2 (Description of Proposed Action and Alternatives). The TMAA is described in Section 2.2 (Gulf of Alaska Temporary Maritime Activities Area) and depicted in Figure 2-1.

3.0.1 Approach to Analysis

The methods used in this SEIS/OEIS to assess resource impacts associated with the Proposed Action include the procedural steps outlined below:

- Review the 2011 GOA Final EIS/OEIS and ROD.
- Review the existing 2016 GOA Final SEIS/OEIS and ROD.
- Review existing federal and state regulations and standards relevant to resource-specific management or protection.
- Review and apply new literature, to include new surveys; new information on habitat; new information on how resources could be affected by stressors; as well as new literature, laws, regulations, and publications pertaining to the resources identified in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS.
- Describe any changes to existing resource conditions from the 2011 GOA Final EIS/OEIS and ROD and the 2016 GOA Final SEIS/OEIS and ROD.
    - Determine if an existing activity needs to be re-analyzed based upon a change in the activity.
    - Determine if the affected environment has changed.
    - Determine if there is a new method of analysis for the existing activity.
- Identify resource sections for re-analysis within this SEIS/OEIS.
    - Analyze resource-specific impacts for individual stressors.[1]
    - Examine potential population-level impacts.
- Analyze cumulative impacts.
- Consider mitigation measures to reduce identified potential impacts.

3.0.1.1 Navy Compiled and Generated Data

While preparing this document, the Navy used the best available data, science, and information accepted by the relevant and appropriate regulatory and scientific communities to establish a baseline in the environmental analyses for all resources in accordance with the National Environmental Policy Act (NEPA), the Administrative Procedure Act (5 United States Code sections 551–596), and Executive Order 12114.

In support of the environmental baseline and environmental consequences sections for this and other environmental documents, the Navy has sponsored and supported both internal and independent research and monitoring efforts. The Navy's research and monitoring programs, as described below, are largely focused on filling data gaps and obtaining the most up-to-date science.

3.0.1.1.1 Marine Species Monitoring and Research Programs

The Navy has been conducting marine species monitoring for compliance with the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) since 2005, both in association with training and testing events and independently. This also includes marine species monitoring in the Gulf of Alaska from 2011 to 2020. In addition to monitoring activities associated with regulatory compliance, two other U.S. Navy research programs provide extensive investments in basic and applied research: the Office of

[1] The term "stressor" is broadly used in this document to refer to an agent, condition, or other stimulus that causes stress to an organism or alters physical, socioeconomic, or cultural resources.

Naval Research Marine Mammals & Biology program and the Living Marine Resources program. In fact, the U.S. Navy is one of the largest sources of funding for marine mammal research in the world. The most recent of federally funded marine mammal research and conservation conducted by the Marine Mammal Commission found that the Navy was the third-largest source of funding for marine mammal activities at $20.07M (direct project expenditures, as well as associated indirect or support costs) in the United States in 2019, behind only to National Oceanic and Atmospheric Administration Fisheries ($36.60M) and National Science Foundation ($20.23M) (U.S. Marine Mammal Commission, 2020).

The monitoring program has historically focused on collecting baseline data that supports analysis of marine mammal occurrence, distribution, abundance, and habitat use preferences in and around ocean areas in the Atlantic and Pacific where the Navy conducts training and testing. More recently, the priority has begun to shift towards assessing the potential response of individual species to training and testing activities. Data collected through the monitoring program serves to inform the analysis of impacts on marine mammals and ESA-listed fish with respect to species distribution, habitat use, and potential responses to training and testing activities. Monitoring is performed using various methods, including visual surveys from surface vessels and aircraft, passive acoustics, and tagging. Additional information on the program is available on the U.S. Navy's Marine Species Monitoring Program website (https://www.navymarinespeciesmonitoring.us/), which serves as a public online portal for information on the background, history, and progress of the program and also provides access to reports, documentation, data, and updates on current monitoring projects and initiatives.

The two other Navy programs previously mentioned invest in research on the potential effects of sound on marine species and develop scientific information and analytic tools that support preparation of environmental impact statements and associated regulatory processes under the MMPA and ESA, as well as support development of improved monitoring and detection technology and advance overall knowledge about marine species. These programs support coordinated science, technology, research, and development focused on understanding the effects of sound on marine mammals and other marine species, including physiological, behavioral, ecological, and population-level effects. Additional information on these programs and other ocean resources-oriented initiatives can be found on the Living Marine Resources Program page at https://www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc/products_and_services/ev/lmr.html.

3.0.1.1.2 Navy's Quantitative Analysis to Determine Impacts to Sea Turtles and Marine Mammals

The 2011 GOA Final EIS/OEIS used an acoustic modeling methodology, marine mammal density information, and scientific information that was the best available at the time. Following the completion of the 2011 GOA Final EIS/OEIS, the 2016 GOA Final SEIS/OEIS evaluated acoustic impacts using a modeling system known as Navy Acoustic Effects Model, which was developed by the Navy in cooperation with NMFS (as a cooperating agency) to conduct a comprehensive acoustic impact analysis for in-water training activities. The analysis in this SEIS/OEIS continues to utilize relevant new scientific information, the latest marine species density data available, and refinements to the analytical methods and modeling processes for estimating potential effects to marine species.

If proposed Navy activities introduce sound or explosive energy into the marine environment, an analysis of potential impacts on marine species is conducted. Data on the density of animals (number of animals per unit area) of each species and stock is needed, along with criteria and thresholds defining the levels of sound and energy that may cause certain types of impacts. The Navy Acoustics Effects Model takes the density and the criteria and thresholds as inputs and analyzes Navy training activities.

Finally, mitigation and animal avoidance behaviors are considered to determine the number of impacts that could occur. The inputs and process are described below. A detailed explanation of this analysis is provided in the technical report titled *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018).

3.0.1.1.3 Marine Species Density Database

A quantitative analysis of impacts on a species requires data on their abundance and distribution in the potentially impacted area. The most appropriate metric for this type of analysis is density, which is the number of animals present per unit area. Estimating marine species density requires substantial surveys and effort to collect and analyze data to produce a usable estimate. The National Marine Fisheries Service is the primary agency responsible for estimating marine mammal densities within the U.S. Exclusive Economic Zone. Other agencies and independent researchers often publish density data for species in specific areas of interest, including areas outside the U.S. Exclusive Economic Zone. In areas where surveys have not produced adequate data to allow robust density estimates, methods such as model extrapolation from surveyed areas, Relative Environmental Suitability models, or expert opinion are used to estimate occurrence. These density estimation methods rely on information such as animal sightings from adjacent locations, amount of survey effort, and the associated environmental variables (e.g., depth, sea surface temperature).

There is no single source of density data for every area of the world, species, and season because of the fiscal limitations, resources, effort involved in providing survey coverage to sufficiently estimate density, and practical limitations. Therefore, to characterize marine species density for large areas, such as the TMAA, the Navy compiled data from multiple sources and developed a protocol to select the best available density estimates based on species, area, and time (i.e., season). When multiple data sources were available, the Navy ranked density estimates based on a hierarchal approach to ensure that the most accurate estimates were selected. The highest tier included peer-reviewed published studies of density estimates from spatial models, since these provide spatially explicit density estimates with relatively low uncertainty. Other preferred sources included peer-reviewed published studies of density estimates derived from systematic line-transect survey data, the method typically used for the NMFS marine mammal stock assessment reports. In the absence of survey data, information on species occurrence and known or inferred habitat associations have been used to predict densities using model-based approaches, including Relative Environmental Suitability models. Because these estimates inherently include a high degree of uncertainty, they were considered the least preferred data source. In cases where a preferred data source was not available, density estimates were selected based on expert opinion from scientists.

The resulting Geographic Information System database includes seasonal density values for every marine mammal species present within the TMAA. This database is described in the technical report titled *U.S. Navy Marine Species Density Database Phase III for the Gulf of Alaska Study Area* (U.S. Department of the Navy, 2020), hereafter referred to as the Density Technical Report. These data were used as an input into the Navy Acoustic Effects Model.

The Density Technical Report describes the models that were utilized in detail and provides detailed explanations of the models applied to each species density estimate. The list below describes models in order of preference.

1. Spatial density models are preferred and used when available because they provide an estimate with the least amount of uncertainty by deriving estimates for divided segments of the sampling

area. These models (see Becker et al., 2016; Forney et al., 2015) predict spatial variability of animal presence as a function of habitat variables (e.g., sea surface temperature, seafloor depth). This model is developed for areas, species, and, when available, specific timeframes (months or seasons) with sufficient survey data.

2. Stratified design-based density estimates use line-transect survey data with the sampling area divided (stratified) into sub-regions, and a density is predicted for each sub-region (Barlow, 2016; Becker et al., 2016; Bradford et al., 2017; Campbell et al., 2015; Jefferson et al., 2014). While geographically stratified density estimates provide a good indication of a species' distribution within the TMAA, the uncertainty is typically high because each sub-region estimate is based on a smaller stratified segment of the overall survey effort.
3. Design-based density estimations use line-transect survey data from land and aerial surveys designed to cover a specific geographic area (see Carretta et al., 2015). These estimates use the same survey data as stratified design-based estimates, but they are not segmented into sub-regions and instead provide one estimate for a large surveyed area.
4. Although relative environmental suitability models provide estimates for areas of the oceans that have not been surveyed, using information on species occurrence and inferred habitat associations, and have been used in past density databases, these models were not used in the current quantitative analysis.

When interpreting the results of the quantitative analysis, as described in the Density Technical Report, it is important to consider that each model is limited to the variables and assumptions considered by the original data source provider. No mathematical model representation of any biological population is perfect, and with regards to marine mammal biodiversity, any single model will not completely explain the results (U.S. Department of the Navy, 2020). These factors and others described in the Density Technical Report should be considered when examining the estimated impact numbers in comparison to current population abundance information for any given species or stock.

3.0.1.1.4 Developing Acoustic and Explosive Criteria and Thresholds

Information about the numerical sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed to analyze potential impacts on marine species. Revised Phase III criteria and thresholds for quantitative modeling of impacts use the best available existing data from scientific journals, technical reports, and monitoring reports to develop thresholds and functions for estimating impacts on marine species. Working with NMFS, the Navy has developed updated criteria for marine mammals and sea turtles (i.e., leatherback sea turtles). Criteria for estimating impacts on marine fishes are also used in this analysis, which largely follows the *ANSI Sound Exposure Guidelines for Fishes and Sea Turtles* (Popper et al., 2014).

Since the release of the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effect Analysis* in 2012 (U.S. Department of the Navy, 2012b), recent and emerging science has necessitated an update to these criteria and thresholds for assessing potential impacts on marine mammals and sea turtles (i.e., leatherback sea turtles). A detailed description of the Phase III acoustic and explosive criteria and threshold development is included in the supporting technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Impact to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2017a), and details are provided in each resource section. A series of behavioral studies, largely funded by the U.S. Navy, has led to a new understanding of how some species of marine mammals react to military sonar. This understanding resulted in developing new behavioral response functions for estimating alterations in behavior. Additional information on auditory weighting functions has also emerged e.g., (Mulsow et al., 2015), leading to the development of a new methodology to predict auditory weighting functions for each hearing group along with the accompanying hearing loss thresholds. These criteria for predicting hearing loss in marine mammals were largely adopted by NMFS for species within their purview (National Marine Fisheries Service, 2016).

The Navy also uses criteria for estimating effects to fishes and the ranges to which those effects are likely to occur. A working group of experts generated a technical report that provides numerical criteria and relative likelihood of effects to fish within different hearing groups (i.e., fishes with no swim bladder versus fishes with a swim bladder involved in hearing) (Popper et al., 2014). Where applicable, thresholds and relative risk factors presented in the technical report were used to assist in the analysis of effects to fishes from Navy activities. Details on criteria used to estimate impacts on marine fishes are contained within the appropriate stressor section (e.g., sonar and other transducers, explosives) within Section 3.6 (Fish). This panel of experts also estimated parametric criteria for the effects of sea turtle exposure to sources located at “near,” “intermediate,” and “far” distances, assigning “low,” “medium,” and “high” probability to specific categories of behavioral impacts (Popper et al., 2014).

3.0.1.1.5 The Navy Acoustic Effects Model

The Navy Acoustic Effects Model calculates sound energy propagation from sonar and other transducers and explosives during naval activities and the energy or sound received by animat dosimeters. Animat dosimeters are virtual representations of marine mammals and sea turtles (i.e., leatherback sea turtles) distributed in the area around the modeled naval activity; each animat records its individual sound “dose.” The model bases the distribution of animats over the TMAA on the density values in the Navy Marine Species Density Database and distributes animats in the water column proportional to the known time that species spend at varying depths.

The model accounts for environmental variability of sound propagation in both distance and depth when computing the received sound level on the animats. The model conducts a statistical analysis based on multiple model runs to compute the estimated effects on animats. The number of animats that exceed the received threshold for an effect is tallied to provide an estimate of the number of marine mammals or sea turtles (i.e., leatherback sea turtles) that could be affected.

Assumptions in the Navy model intentionally err on the side of overestimation when there are unknowns:

- Naval activities are modeled as though they would occur regardless of proximity to marine mammals and sea turtles (i.e., mitigation and implementation of standard operating procedures that employ protective measures are not modeled) and without any avoidance of the activity by the animal. The final step of the quantitative analysis of acoustic effects is to consider the implementation of mitigation. For sonar and other transducers, the possibility that marine mammals or sea turtles (i.e., leatherback sea turtles) would avoid continued or repeated sound exposures is also considered.
- Many explosions from munitions such as bombs and medium-caliber and large-caliber projectiles actually occur upon impact with targets located on or near the surface of the water. However, for this analysis, sources such as these were modeled as exploding in water. This modeling overestimates the amount of explosive and acoustic energy entering the water.

The model estimates the impacts caused by individual training activities. During any individual modeled event, impacts on individual animats are considered over 24-hour periods. The animats do not represent actual animals, but rather allow for a statistical analysis of the number of instances that marine mammals or sea turtles (i.e., leatherback sea turtles) may be exposed to sound levels resulting in an effect. Therefore, the model estimates the number of instances in which an effect threshold was exceeded over the course of a year, but it does not estimate the number of individual marine mammals that may be impacted over a year (i.e., some marine mammals or sea turtles could be impacted several times, while others would not experience any impact). A detailed explanation of the Navy Acoustic Effects Model is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018).

The Navy Acoustic Effects Model also estimates range to effects by modeling the distance that noise from a sonar or other transducer, or an explosion will need to propagate to reach hearing group-specific exposure thresholds for behavioral response, temporary threshold shift (TTS), permanent threshold shift (PTS), non-auditory injury, and mortality. **Error! Reference source not found.**Figure 3.0-1 provides a hypothetical example of range to effects along one radial from a sonar source for PTS (green), TTS (cyan), behavioral (purple), and no effects (blue) while considering the maximum dive depth of 300 m for species A (white dashed line). Range to effects are bound by a species' maximum dive depth, and only the data less than or equal to a species maximum dive depth are used to estimate impact ranges. For example, only the data less than or equal to 300 m depth are considered for impact ranges for species A, and the point the maximum dive depth line intersects with the edge of a colored impact region depicts the range to those effects (PTS 688 m [green star], TTS, 1,406 m [cyan star], behavioral 1,594 m [purple star]). Since these ranges do not represent a cylinder of effect in the water column, there are portions of the water column within these ranges that would not exceed threshold. For example, from 0 to 300 m in depth, and from 0 to 688 m in range, exposure thresholds for PTS would not be exceeded in regions that are cyan, purple or blue. In some instances, a significant portion of the water column within an impact range may not exceed threshold. These differences in propagation are captured in the actual estimation of takes within the Navy Acoustic Effects Model.

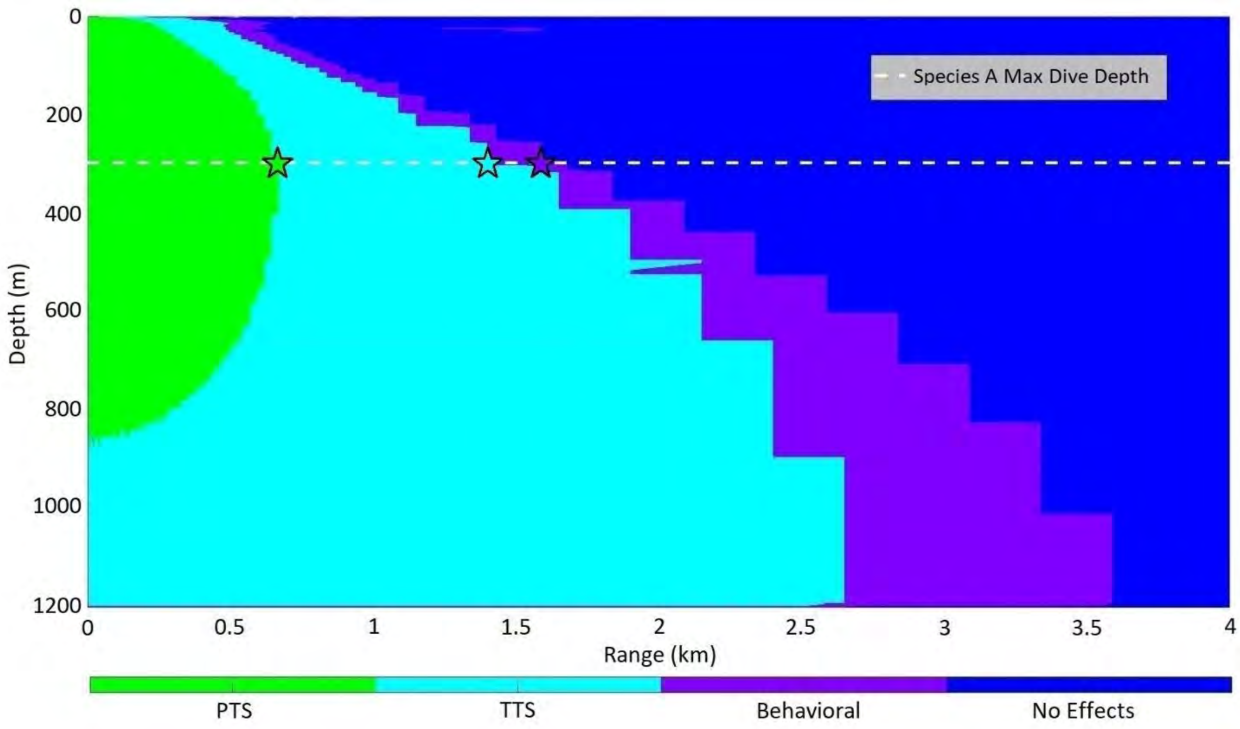

Figure 3.0-1: Hypothetical Range to Effects Example

3.0.1.1.6 Accounting for Mitigation

3.0.1.1.6.1 Sonar and Other Transducers

The Navy implements mitigation measures (described in Section 5.3.2, Acoustic Stressors) including the power-down or shut-down (i.e., power-off) of sonar when a marine mammal or sea turtle (i.e., leatherback sea turtle) is observed in the mitigation zone, during activities that use sonar and other transducers. The mitigation zones encompass the estimated ranges to injury (including PTS) for a given sonar exposure. Therefore, the impact analysis quantifies the potential for mitigation to reduce the risk of PTS. Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018).

In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, some model-estimated PTS is considered mitigated to the level of TTS. The quantitative analysis does not analyze the potential for mitigation to reduce TTS or behavioral effects, even though mitigation could also reduce the likelihood of these effects. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species that may be near or within the mitigation zone.

The ability to observe the range to PTS was estimated for each training event. The ability of Navy Lookouts to detect marine mammals or sea turtles (i.e., leatherback sea turtles) in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as group size or surface-active behavior). The behaviors and characteristics of some species may make them easier to detect. For example, based on small boat surveys between 2000 and 2012 in the Hawaiian Islands, pantropical spotted dolphins and striped dolphins were frequently observed leaping out of the water, and Cuvier's beaked whales (Baird, 2013) and Blainville's beaked whales (HDR, 2012) were occasionally observed breaching. These behaviors are visible from a great distance and likely increase sighting distances and detections of these species. Environmental conditions under which the training activity could take place are also considered, such as the sea surface conditions, weather (e.g., fog or rain), and day versus night.

3.0.1.1.6.2 Explosions

The Navy implements mitigation measures (described in Section 5.3.3, Explosive Stressors) during explosive activities, including delaying detonations when a marine mammal or sea turtle (i.e., leatherback sea turtle) is observed in the mitigation zone. The mitigation zones encompass the estimated ranges to mortality for a given explosive. Navy impact analyses typically consider the potential for procedural mitigation to reduce the risk of mortality due to exposure to explosives; however, the Navy Acoustic Effects Model estimated zero mortality takes for all marine mammal species and sea turtles (i.e., leatherback sea turtles) in the TMAA. Therefore, mitigation for explosives is discussed qualitatively but was not factored into the quantitative analysis for marine mammals or sea turtles under Alternative 1. A detailed explanation of the quantitative analysis process is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018).

3.0.1.1.7 Marine Mammal Avoidance of Sonar and other Transducers

Because a marine mammal is assumed to initiate avoidance behavior (tens of meters away for most species groups) after an initial startle reaction when exposed to relatively high received levels of sound, a marine mammal could reduce its cumulative sound energy exposure over a sonar event with multiple pings. This would reduce risk of both PTS and TTS, although the quantitative analysis conservatively only considers the potential to reduce instances of PTS by accounting for marine mammals swimming away to avoid repeated high-level sound exposures. All reductions in PTS impacts from likely avoidance behaviors are instead considered TTS impacts.

3.0.2 Regulatory Framework

In accordance with the Council on Environmental Quality regulations for implementing the requirements of NEPA, other planning and environmental review procedures are integrated in this SEIS/OEIS to the fullest extent possible. Some of the federal statutes and executive orders described in the 2016 GOA Final SEIS/OEIS (Section 3.0.2.1, Applicable Federal Statutes) have changed since the publishing of the 2016 GOA Final SEIS/OEIS. New, changed, or revoked federal statutes or executive orders are found in Chapter 6 (Additional Regulatory Considerations).

Chapter 6 (Additional Regulatory Considerations) provides a summary listing and status of compliance with the applicable environmental laws, regulations, and executive orders that were considered in preparing this SEIS/OEIS (including those that may be secondary considerations in the resource evaluations).

3.0.3 Resources and Issues Considered for Re-Evaluation in This Document

The same resources that were identified and analyzed in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS were considered for reanalysis for this SEIS/OEIS and for reanalysis of cumulative impacts. Those physical resources include air quality, expended materials, water resources, and acoustic environment (airborne). Biological resources (including threatened and endangered species) considered include marine plants and invertebrates, fish, sea turtles, marine mammals, and birds. Human resources and issues considered in this SEIS/OEIS include cultural resources, transportation and circulation, socioeconomics, environmental justice and protection of children, and public safety.

For purposes of consistency across all environmental compliance planning conducted under the Navy's At-Sea Policy (see Section 1.2, The Navy's Environmental Compliance and At-Sea Policy), the Navy realigned the resources in this SEIS/OEIS with those of other Navy at-sea projects. The same resources continue to be analyzed, but that analysis in some instances may be shifted into new or renamed resource sections as depicted in Table 3.0-1.

As shown in Table 3.0-1, the following resource sections remain unchanged: Section 3.1 (Air Quality), Section 3.7 (Sea Turtles), Section 3.8 (Marine Mammals), Section 3.9 (Birds), and Section 3.10 (Cultural Resources).

Section 3.2 (Expended Materials) and Section 3.3 (Water Resources) are now analyzed in Section 3.2 (Sediments and Water Quality); Section 3.4 (Acoustic Environment) is analyzed in each of the other resource sections, but is primarily analyzed as a stressor to public health (Section 3.12, Public Health and Safety); Section 3.5 (Marine Plants and Invertebrates) is now analyzed as three distinct resources—Section 3.3 (Marine Habitats), Section 3.4 (Marine Vegetation), and Section 3.5 (Marine Invertebrates); Section 3.6 (Fish) remains Section 3.6 and is changed to "Fishes;" Section 3.11 (Transportation), Section 3.12 (Socioeconomics), and Section 3.13 (Environmental Justice) are now analyzed in Section 3.11 (Socioeconomic Resources and Environmental Justice). Section 3.14 (Public Safety) is now Section 3.12 (Public Health and Safety) and includes the analysis of the acoustic environment.

Similar to the 2016 GOA Final SEIS/OEIS, this SEIS/OEIS is being conducted because there is new information and analytical methods to analyze acoustic and explosive impacts on fishes, sea turtles, marine mammals, and birds. In the process of preparing this SEIS/OEIS, the Navy has also taken into account new research, literature, laws, and regulations that have emerged since the publication of the 2016 GOA Final SEIS/OEIS that may affect other resource areas. Subsequently, the Navy used this information to identify and evaluate all the resource areas to determine which ones required reanalysis in this SEIS/OEIS.

Table 3.0-1: Chapter 3 Resource Section Reorganization

2011/2016 Section #	*2011/2016 Section Title*	*Notes*	*2020 Draft SEIS/OEIS Section #*	*2020 Draft SEIS/OEIS Section Title*
3.1	Air Quality	No change	3.1	Air Quality
3.2	Expended Materials	Merged into Sediments and Water Quality	3.2	Sediments and Water Quality
3.3	Water Resources	Merged into Sediments and Water Quality		
3.4	Acoustic Environment	Merged into Public Health and Safety	*See new Section 3.12 Public Health and Safety below*	
3.5	Marine Plants and Invertebrates	Split into three sections	3.3	Marine Habitats
			3.4	Marine Vegetation
			3.5	Marine Invertebrates
3.6	Fish	Changed to Fishes	3.6	Fishes
3.7	Sea Turtles	No change	3.7	Sea Turtles
3.8	Marine Mammals	No change	3.8	Marine Mammals
3.9	Birds	No change	3.9	Birds
3.10	Cultural Resources	No change	3.10	Cultural Resources
3.11	Transportation	Merged into Socioeconomic Resources and Environmental Justice	3.11	Socioeconomic Resources and Environmental Justice
3.12	Socioeconomics			
3.13	Environmental Justice			
3.14	Public Safety	Changed to Public Health and Safety	3.12	Public Health and Safety
3.4	Acoustic Environment	Merged into Public Health and Safety		

3.0.3.1 Resources Not Carried Forward for Reanalysis

No new Navy training activities are proposed in the TMAA in this SEIS/OEIS and, for several of the resources, the existing baseline conditions have not changed appreciably. There have been changes in some platforms and systems (e.g., EA-6B aircraft and frigate, and their associated systems, have been retired) used as part of the proposed activities, but those changes would not affect the analysis or change the conclusions reached in the 2016 GOA Final SEIS/OEIS. The Navy determined that new research, literature, laws, and regulatory guidance addressed in this SEIS/OEIS resulted in little or no change to the findings of the impact analyses in the 2016 GOA Final SEIS/OEIS. Therefore, the impact assessments from the 2016 GOA Final SEIS/OEIS are incorporated by reference for each of the following resource areas (section numbers and names align with the new organization of sections described above) and they are not described further in this SEIS/OEIS:

- 3.1 Air Quality – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action from the 2016 GOA Final SEIS/OEIS. No new activities are being proposed in this SEIS/OEIS that would affect air quality in the TMAA.
- 3.2 Sediments and Water Quality – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action from the 2016 GOA Final SEIS/OEIS. There is new information on existing environmental conditions, including updated Navy regulations, since the analysis in the 2016 GOA Final SEIS/OEIS. However, this new information does not significantly change the affected environment. Based on findings from much more intensively used locations, effects on sediments from the use of explosive munitions during training activities in the Study Area would be negligible by comparison. As a result, explosives and explosives byproducts would have no meaningful effect on sediments or water quality in the Study Area.
- 3.3 Marine Habitats – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action from the 2016 GOA Final SEIS/OEIS. There is no information on existing environmental conditions that significantly changes the affected environment.
- 3.4 Marine Vegetation – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action from the 2016 GOA Final SEIS/OEIS and the existing baseline conditions have not changed appreciably.
- 3.5 Marine Invertebrates – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action from the 2016 GOA Final SEIS/OEIS and the existing baseline conditions have not changed appreciably.
- 3.10 Cultural Resources – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action from the 2016 GOA Final SEIS/OEIS and the existing baseline conditions have not changed appreciably. After consultations with Alaska Native tribes from the Kodiak and Kenai Peninsula region, the Navy confirmed that training events in the TMAA would not involve the use of any explosives in one particular and well-defined fishing area known as Portlock Bank. There are still no relevant subsistence uses of marine mammals implicated by this action. None of the training activities in the Study Area occur where traditional Arctic subsistence hunting exists.
- 3.12 Public Health and Safety – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action from the 2016 GOA Final SEIS/OEIS and the existing baseline conditions have not changed appreciably.

3.0.3.2 Resources Carried Forward for Reanalysis

Fishes (Section 3.6) and Sea Turtles (Section 3.7) were carried forward for reanalysis because new, significant research has become available since 2016. Marine Mammals (Section 3.8) was reanalyzed because of changes to regulations, significant changes to existing conditions, and the availability of new, significant research. Birds (Section 3.9) was reanalyzed because of changes to regulations and the availability of new, significant research. Socioeconomic Resources and Environmental Justice (Section 3.11) was reanalyzed because of changes in the existing conditions, primarily commercial fish harvest.

3.0.4 Stressors-Based Analysis

As stated in the 2016 GOA Final SEIS/OEIS, Navy activities are assessed in this SEIS/OEIS by evaluating the impacts of the various stressors associated with the activities.

The term stressor is broadly used in this document to refer to an agent, condition, or other stimulus that potentially causes stress to an organism or alters physical, socioeconomic, or cultural resources. The

Navy has updated the list of stressors for all of its at-sea planning documents to provide more consistency between documents and to better reflect that certain types of activities affect the environment in the same way.

Table 3.0-2 shows the stressors analyzed in the 2011 Final GOA EIS/OEIS (left-hand column), the new stressor naming convention used in other Navy at-sea projects (center column), and which of the stressors are carried forward in this SEIS/OEIS (right-hand column). There were no appreciable changes in the science or in the occurrence (i.e., location and frequency) of several of the stressors; therefore, those stressors were not reanalyzed.

Table 3.0-2: Updated List of Stressors Considered for Analysis

2011 GOA Final EIS/OEIS	*Updated Stressor List*	*2020 GOA Draft SEIS/OEIS*
Vessel Movements	Vessel Noise	Not reanalyzed
	Vessel Strike	Not reanalyzed
Aircraft Overflights	Aircraft Noise	Not reanalyzed
	Aircraft and Aerial Target Strike (Birds)	Not reanalyzed
Explosive Ordnance	In-Air Explosions	Reanalyzed for Birds
	In-Water Explosions[1]	Reanalyzed for all biological resources
Sonar	Sonar and Other Active Acoustic Sources	Reanalyzed for all biological resources
Weapons Firing Disturbance	Weapons Noise	Not reanalyzed
Expended Materials	Physical Disturbance and Strike	Not reanalyzed
	Entanglement	Not reanalyzed
	Ingestion	Not reanalyzed

[1]All in-water explosions in the TMAA occur at or near the ocean surface.

Other information that was evaluated to identify and analyze stressors included public and agency scoping comments, previous environmental analyses, agency consultations, resource-specific information, and applicable laws, regulations, and executive orders. This stressor-based analysis process was used to focus the information presented and analyzed in the affected environment and environmental consequences sections of this SEIS/OEIS.

As previously mentioned, this SEIS/OEIS analyzed the same warfare areas and activities that produce underwater sound as were analyzed in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. However, in this SEIS/OEIS, the analysis included refinements to the Navy Acoustic Effects Model, new threshold criteria, and updated marine mammal density data as compared to the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Appendix A (Navy Activities Descriptions) identifies the acoustic and explosive stressors for the analysis of marine mammals, birds, and fish.

3.0.4.1 Acoustic Sources

This section describes the characteristics of sounds produced during naval training and the relative magnitude and location of these sound-producing activities. This section provides the basis for analysis of acoustic impacts on fish, marine mammals, and birds in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). Explanations of the terminology and metrics used when describing sound in this SEIS/OEIS are in Appendix B (Acoustic and Explosive Concepts).

Acoustic stressors include acoustic signals emitted into the water from a specific source such as sonar and other transducers (devices that convert energy from one form to another–in this case, to sound waves), as well as incidental sources of broadband sound produced as a byproduct of vessel movement; aircraft transits; and use of weapons or other deployed objects. Explosives also produce broadband sound but are characterized separately from other acoustic sources due to their unique hazardous characteristics (Section 3.0.4.2, Explosive Stressors). Characteristics of each of these sound sources are described in the following sections.

In order to better organize and facilitate the analysis of approximately 300 sources of underwater sound used for training by the Navy including sonars, other transducers, and explosives, a series of source classifications, or source bins, were developed. The source classification bins do not include the broadband noise produced incidental to vessel and aircraft transits and weapons firing.

The use of source classification bins provides the following benefits:

- Provides the ability for new sensors or munitions to be covered under existing authorizations, as long as those sources fall within the parameters of a "bin."
- Improves efficiency of source utilization data collection and reporting requirements anticipated under the MMPA authorizations.
- Ensures a conservative approach to all impact estimates, as all sources within a given class are modeled as the most impactful source (highest source level, longest duty cycle [i.e., the proportion of time signals are emitted in a given period of time], or largest net explosive weight) within that bin.
- Allows analyses to be conducted in a more efficient manner, without any compromise of analytical results.
- Provides a framework to support the reallocation of source usage (hours/explosives) between different source bins, as long as the total numbers of takes remain within the overall analyzed and authorized limits. This flexibility is required to support evolving Navy training requirements, which are linked to military missions and combat operations.

3.0.4.1.1 Sonar and Other Transducers

Active sonar and other transducers emit non-impulsive sound waves into the water to detect objects, safely navigate, and communicate. Passive sonars differ from active sound sources in that they do not emit acoustic signals; rather, they only receive acoustic information about the environment, or listen. In this SEIS/OEIS, the terms sonar and other transducers will be used to indicate active sound sources unless otherwise specified.

The Navy employs a variety of sonars and other transducers to obtain and transmit information about the undersea environment. Some examples are mid-frequency and high-frequency hull-mounted sonars used to find and track potential enemy submarines; high-frequency underwater modems used to transfer data over short ranges; and extremely high frequency (greater than 200 kilohertz [kHz]) Doppler sonars used for navigation, like those used on commercial and private vessels. The characteristics of these sonars and other transducers, such as source level, beam width, directivity, and frequency, depend on the purpose of the source. Higher frequencies can carry or provide more information about objects off which they reflect, but attenuate more rapidly. Lower frequencies attenuate less rapidly, so may detect objects over a longer distance, but with less detail.

Propagation of sound produced underwater is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity. The sound received at a particular location will be different than near the source due to the interaction of many factors, including propagation loss; how the sound is reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher-frequency sounds propagate. The effects of these factors are explained in Appendix B (Acoustic and Explosive Concepts). Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its environmental analyses that consider sound source characteristics and varying ocean conditions across the TMAA.

The sound sources and platforms typically used in naval activities analyzed in this SEIS/OEIS are described in Appendix A (Navy Activities Descriptions). Sonars and other transducers used to obtain and transmit information underwater during Navy training activities generally fall into several categories of use, described below.

3.0.4.1.1.1 Anti-Submarine Warfare Sonar

Sonar used during anti-submarine warfare (ASW) would impart the greatest amount of acoustic energy of any category of sonar and other transducers analyzed in this SEIS/OEIS. Types of sonars used to detect potential enemy vessels include hull-mounted, towed, line array, sonobuoy, helicopter dipping, and torpedo sonars. In addition, acoustic targets and decoys (countermeasures) may be deployed to emulate the sound signatures of vessels or repeat received signals.

Most ASW sonars are mid-frequency (1–10 kHz) because mid-frequency sound balances sufficient resolution to identify targets with distance over which threats can be identified. However, some sources may use higher or lower frequencies. Duty cycles can vary widely, from rarely used to continuously active. Anti-submarine warfare sonars can be wide angle in a search mode or highly directional in a track mode.

Most ASW events occur over a limited area and are completed in less than one day, often within a few hours. Multi-day ASW events requiring coordination of movement and effort between multiple platforms with active sonar over a larger area occur less often, but constitute a large portion of the overall non-impulsive underwater noise from Navy activities, due to periods of concentrated, near-continuous (i.e., 2–8 hours) ASW sonar use by several platforms throughout the duration of the exercise.

3.0.4.1.1.2 Navigation and Safety

Similar to commercial and private vessels, Navy vessels employ navigational acoustic devices including speed logs, Doppler sonars for ship positioning, and fathometers. These may be in use at any time for safe vessel operation. These sources are typically highly directional to obtain specific navigational data.

3.0.4.1.1.3 Communication

Sound sources used to transmit data (such as underwater modems), provide location (pingers), or send a single brief release signal to bottom-mounted devices (acoustic release) may be used throughout the TMAA. These sources typically have low duty cycles and are usually only used when it is desirable to send a detectable acoustic message.

3.0.4.1.1.4 Classification of Sonar and Other Transducers

Sonars and other transducers are grouped into classes that share an attribute, such as frequency range or purpose of use. As detailed below, classes are further sorted by bins based on the frequency or bandwidth; source level; and, when warranted, the application in which the source would be used. Unless stated otherwise, a reference distance of 1 meter (m) is used for sonar and other transducers.

- Frequency of the non-impulsive acoustic source:
  - Low-frequency sources operate below 1 kHz
  - Mid-frequency sources operate at and above 1 kHz, up to and including 10 kHz
  - High-frequency sources operate above 10 kHz, up to and including 100 kHz
  - Very high-frequency sources operate above 100 kHz but below 200 kHz
- Sound pressure level:
  - Greater than 160 decibels (dB) referenced to 1 micropascal (dB re 1 µPa), but less than 180 dB re 1 µPa
  - Equal to 180 dB re 1 µPa and up to and including 200 dB re 1 µPa
  - Greater than 200 dB re 1 µPa
- Application in which the source would be used:
  - Sources with similar functions that have similar characteristics, such as pulse duration, beam pattern, and duty cycle

The bins used for classifying active sonars and transducers that are quantitatively analyzed in the TMAA are shown in Table 3.0-3, including annual bin quantities. While general parameters or source characteristics are shown in the table, actual source parameters are classified.

Table 3.0-3: Sonar and Transducer Sources Quantitatively Analyzed in the Temporary Maritime Activities Area

For Annual Training Activities					
Source Class Category	**Source Class**	**Description**	**Units**	**2011 & 2016 Alternative 1 (Annual)**	**Alternative 1 (Annual)**
Mid-Frequency (MF) Tactical and non-tactical sources that produce signals from 1 to 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-60)	H	271	271
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	24	25
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22)	H	27	27
	MF5	Active acoustic sonobuoys (e.g., DICASS)	I	126	126
	MF6	Active underwater sound signal devices (e.g., MK 84)	I	11	14
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%	H	39	42
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%	H	0	14

Table 3.0-3: Sonar and Transducer Sources Quantitatively Analyzed in the Temporary Maritime Activities Area (continued)

For Annual Training Activities					
Source Class Category	**Source Class**	**Description**	**Units**	**2011 & 2016 Alternative 1 (Annual)**	**Alternative 1 (Annual)**
High-Frequency (HF) Tactical and non-tactical sources that produce signals greater than 10 kHz but less than 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	12	12
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	40	0
Anti-Submarine Warfare (ASW) Tactical sources used during anti-submarine warfare training activities	ASW1	MF systems operating above 200 dB	H	0	14
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)	H	40	42
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	H	273	273
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK3)	I	6	7
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	TORP2	Heavyweight torpedo (e.g., MK 48)	I	0	0

Notes: H = hours; I = count (e.g., number of individual pings or individual sonobuoys).

There are in-water active acoustic sources with narrow beam widths, downward directed transmissions, short pulse lengths, frequencies above known hearing ranges, low source levels, or combinations of these factors, which are not anticipated to result in takes of protected species. These sources are categorized as *de minimis* sources and are qualitatively analyzed to determine the appropriate determinations under NEPA in the appropriate resource impact analyses, as well as under the MMPA and the ESA. When used during routine training activities, and in a typical environment, *de minimis* sources fall into one or more of the following categories:

- Transmit primarily above 200 kHz: Sources above 200 kHz are above the hearing range of the most sensitive marine mammals and far above the hearing range of other protected species in the TMAA.
- Source levels of 160 dB re 1 µPa or less: Low-powered sources with source levels less than 160 dB re 1 µPa are typically hand-held sonars, range pingers, transponders, and acoustic communication devices. Assuming spherical spreading for a 160 dB re 1 µPa source, the sound will attenuate to less than 140 dB re 1 µPa within 10 m and less than 120 dB re 1 µPa within 100 m of the source. Ranges would be even shorter for a source less than 160 dB re 1 µPa source level.
- Acoustic source classes listed in Table 3.0-4: Sources with operational characteristics, such as short pulse length, narrow beam width, downward-directed beam, and low energy release, or

manner of system operation, which exclude the possibility of any significant impact on a protected species (actual source parameters are classified). Even if there is a possibility that some species may be exposed to and detect some of these sources, any response is expected to be short-term and inconsequential.

Table 3.0-4: Sonar and Transducers Qualitatively Analyzed

Source Class Category	Bin	Characteristics
Tracking Pingers (P): Devices that send a ping to identify an object location	P2	• low duty cycles (single pings in some cases) • short pulse lengths (typically 20 milliseconds) • low source levels

3.0.4.1.2 Vessel Noise

Vessel noise, in particular commercial shipping, is a major contributor to underwater anthropogenic noise in the ocean within the TMAA. Naval vessels (e.g., ships and small craft) and civilian vessels (e.g., commercial ships, tugs, work boats, pleasure craft) produce low-frequency, broadband underwater sound, though the exact level of noise produced varies by vessel type. Frisk (2012) reported that between 1950 and 2007 ocean noise in the 25–50 Hertz (Hz) frequency range has increased 3.3 dB per decade, resulting in a cumulative increase of approximately 19 dB over a baseline of 52 dB. The increase in noise is associated with an increase in commercial shipping, which correlates with global economic growth (Frisk, 2012).

Anti-submarine warfare surface platforms are much quieter than Navy oil tankers, for example, which have a smaller presence but contribute substantially more broadband noise (Mintz & Filadelfo, 2011). A variety of smaller craft that vary in size and speed, such as service vessels for routine operations and opposition forces used during training events, would be operating within the TMAA as well.

The quietest Navy warships radiate much less broadband noise than a typical fishing vessel, while the loudest Navy ships during travel are almost on par with large oil tankers (Mintz & Filadelfo, 2011). The average acoustic signature for a Navy vessel is 163 dB re 1 µPa, while the average acoustic signature for a commercial vessel is 175 dB re 1 µPa (Mintz & Filadelfo, 2011). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies (approximately around the one-third octave band centered at 100 Hz) (MacGillivray et al., 2019; Mintz & Filadelfo, 2011; Richardson et al., 1995; Urick, 1983). Ship types also have unique acoustic signatures characterized by differences in dominant frequencies. Bulk carrier noise is predominantly near 100 Hz while container ship and tanker noise is predominantly below 40 Hz (McKenna et al., 2012). Small craft will emit higher-frequency noise (between 1 kHz and 50 kHz) than larger ships (below 1 kHz). Sound produced by vessels will typically increase with speed (MacGillivray et al., 2019; Wladichuk et al., 2019).

The Center for Naval Analyses conducted studies to determine traffic patterns of Navy and non-Navy vessels (Mintz, 2012; Mintz, 2016; Mintz & Filadelfo, 2011; Mintz & Parker, 2006). The most recent analysis covered the period 2011–2015 (Mintz, 2016) and included U.S. Navy surface ship traffic and non-military vessels such as cargo vessels, bulk carriers, commercial fishing vessels, oil tankers, passenger vessels, tugs, and research vessels. Caveats to this analysis include that only vessels over 65 feet (ft.) in length are reported, so smaller Navy vessels and civilian craft are not included, and vessel position records are much more frequent for Navy vessels than for commercial vessels. Therefore, the

Navy is likely overrepresented in the data, and the reported fraction of total energy is likely the upper limit of its contribution (Mintz, 2012; Mintz & Filadelfo, 2011).

Although the aforementioned studies did not include analysis of vessel traffic and associated vessel noise in the TMAA, the conclusions of the studies are relevant to vessel noise in the TMAA. Overall, the contribution of Navy vessel traffic to broadband noise levels was relatively small compared with the contribution from commercial vessel traffic.

3.0.4.1.3 Aircraft Noise

Fixed-wing, tiltrotor, and rotary-wing aircraft are used for a variety of training activities throughout the TMAA, contributing both airborne and underwater sound to the ocean environment. Sounds in air are often measured using A-weighting, which adjusts received sound levels based on human hearing abilities (see Appendix B, Acoustic and Explosive Concepts). Aircraft used in training generally have turboprop or jet engines. Motors, propellers, and rotors produce the most noise, with some noise contributed by aerodynamic turbulence. Aircraft sounds have more energy at lower frequencies and noise levels can vary due to different aircraft and engine types, speeds, heights, and angles (Erbe et al., 2018). Perception of aircraft noise can vary between marine species based on different hearing sensitivities (Erbe et al., 2018). Aircraft may transit to or from vessels at sea throughout the TMAA from established airfields on land. The majority of aircraft noise would be generated at air stations, which are outside the TMAA. Takeoffs and landings occur at established airfields as well as on vessels at sea across the TMAA. Takeoffs and landings from Navy vessels produce in-water noise at a given location for a brief period as the aircraft climbs to cruising altitude. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Table 3.0-5 provides source levels for some typical aircraft used during training in the TMAA and depicts comparable airborne source levels for the F-35A, EA-18G, and F/A-18C/D during takeoff.

3.0.4.1.3.1 Underwater Transmission of Aircraft Noise

Sound generated in air is transmitted to water primarily in a narrow area directly below the source Appendix B (Acoustic and Explosive Concepts). A sound wave propagating from any source must enter the water at an angle of incidence of about 13° or less from the vertical for the wave to continue propagating under the water's surface. At greater angles of incidence, the water surface acts as an effective reflector of the sound wave and allows very little penetration of the wave below the water (Urick, 1983). Water depth and bottom conditions strongly influence how the sound from airborne sources propagates underwater. At lower altitudes, sound levels reaching the water surface would be higher, but the transmission area would be smaller. As the sound source gains altitude, sound reaching the water surface diminishes, but the possible transmission area increases. Estimates of underwater sound pressure level are provided for representative aircraft in Table 3.0-5.

Noise generated by fixed-wing aircraft is transient in nature and extremely variable in intensity. Most fixed-wing aircraft sorties (a flight mission made by an individual aircraft) would occur above 3,000 ft. Air combat maneuver altitudes generally range from 5,000 to 30,000 ft. above ground level, and typical airspeeds range from very low (less than 200 knots) to high subsonic (less than 600 knots). Sound exposure levels (SELs) at the sea surface from most air combat maneuver overflights are expected to be less than 85 A-weighted decibels (based on an F/A-18 aircraft flying at an altitude of 5,000 ft. above ground level and at a subsonic airspeed [400 knots] (U.S. Department of the Navy, 2016)). Exposure to fixed-wing aircraft noise would be brief (seconds) as an aircraft quickly passes overhead.

Table 3.0-5: Representative Aircraft Sound Characteristics

Noise Source	Sound Pressure Level
In-Water Noise Level	
F/A-18 Subsonic at 1,000 ft. (300 m) Altitude	152 dB re 1 µPa at 2 m below water surface[1]
F/A-18 Subsonic at 10,000 ft. (3,000 m) Altitude	128 dB re 1 µPa at 2 m below water surface[1]
H-60 Helicopter Hovering at 82 ft. (25 m) Altitude	Approximately 125 dB re 1 µPa at 1 m below water surface, estimate based on in-air level[2]
Airborne Noise Level	
F/A-18C/D Under Military Power	143 dBA re 20 µPa at 13 m from source[3]
F/A-18C/D Under Afterburner	146 dBA re 20 µPa at 13 m from source[3]
F-35A Under Military Power	145 dBA re 20 µPa at 13 m from source[3]
F-35A Under Afterburner	148 dBA re 20 µPa at 13 m from source[3]
H-60 Helicopter Hovering at 82 ft. (25 m) Altitude	113 dBA re 20 µPa at 25 m from source[2]
F-35A Takeoff Through 1,000 ft. (300 m) Altitude	119 dBA re 20 $\mu Pa^2 s$[4] (per second of duration), based on average sound exposure level
EA-18G Takeoff Through 1,622 ft. (500 m) Altitude	115 dBA re 20 $\mu Pa^2 s$[5] (per second of duration), based on average sound exposure level

Notes: dB re 1 µPa = decibel(s) referenced to 1 micropascal, dBA re 20 µPa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s), ft. = feet, dBA re 20 $\mu Pa^2 s$ = A-weighted decibel(s) referenced to 20 micropascals squared seconds.
Sources: [1]Eller and Cavanagh (2000), [2]Bousman and Kufeld (2005), [3]U.S. Naval Research Advisory Committee (2009), [4]U.S. Department of the Air Force (2016), [5]U.S. Department of the Navy (2012a).

3.0.4.1.3.2 Helicopters

Noise generated from helicopters is transient in nature and extremely variable in intensity. In general, helicopters produce lower-frequency sounds and vibration at a higher intensity than fixed-wing aircraft (Richardson et al., 1995). Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz. Helicopters often radiate more sound forward than backward. The underwater noise produced is generally brief when compared with the duration of audibility in the air and is estimated to be 125 dB re 1 µPa at 1 m below water surface for a UH-60 hovering 82 ft. (25 m) altitude (Bousman & Kufeld, 2005).

Helicopter unit level training typically entails single-aircraft sorties over water that start and end at an air station, although flights may occur from ships at sea. Individual flights typically last about two to four hours. Some events require low-altitude flights over a defined area, such as ASW Tracking Exercise – Helicopter. Most helicopter sorties associated with ASW Tracking Exercise – Helicopter would occur at altitudes as low as 50 ft.

3.0.4.1.3.3 Sonic Booms

An intense but infrequent type of aircraft noise is the sonic boom, produced when an aircraft exceeds the speed of sound. Per Navy Instruction *Naval Air Training and Operating Procedures General Flight and Operating Instructions Manual, Commander Naval Air Forces Manual-3710.7* (U.S. Department of the Navy, 2017b), it is incumbent on every pilot flying aircraft capable of generating sonic booms to reduce such disturbances and damage to the absolute minimum dictated by operational/training requirements. Supersonic flight operations shall be strictly controlled and supervised by operational commanders. Supersonic flight over land or within 30 miles (mi.) offshore shall be conducted in specifically designated areas. Such areas must be chosen to ensure minimum possibility of disturbance. As a general policy, sonic booms shall not be intentionally generated below 30,000 ft. of altitude unless over water and more than 30 mi. from inhabited land areas or islands. Deviations from the foregoing general policy may be authorized only under one of the following conditions:

- Tactical missions that require supersonic speeds;
- Phases of formal training syllabus flights requiring supersonic speeds;
- Research, test, and operational suitability test flights requiring supersonic speeds; or
- When specifically authorized by the Chief of Naval Operations for flight demonstration purposes.

Several factors that influence sonic booms include weight, size, and shape of aircraft or vehicle; altitude; flight paths; and atmospheric conditions. A larger and heavier aircraft must displace more air and create more lift to sustain flight, compared with small, light aircraft. Therefore, larger aircraft create sonic booms that are stronger than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the stronger the shock waves (U.S. Department of the Navy & Department of Defense, 2007). Aircraft maneuvers that result in changes to acceleration, flight path angle, or heading can also affect the strength of a boom. In general, an increase in flight path angle (lifting the aircraft's nose) will diffuse a boom while a decrease (lowering the aircraft's nose) will focus it. In addition, acceleration will focus a boom while deceleration will weaken it. Any change in horizontal direction will focus a boom, causing two or more wave fronts that originated from the aircraft at different times to coincide exactly (U.S. Department of the Navy, 2001). Atmospheric conditions such as wind speed and direction and air temperature and pressure can also influence the sound propagation of a sonic boom.

Of all the factors influencing sonic booms, increasing altitude is the most effective method of reducing sonic boom intensity. The width of the boom "carpet" or area exposed to sonic boom beneath an aircraft is about 1 mi. for each 1,000 ft. of altitude. For example, an aircraft flying supersonic, straight and level at 50,000 ft. can produce a sonic boom carpet about 50 mi. wide. The sonic boom, however, would not be uniform, and its intensity at the water surface would decrease with greater aircraft altitude. Maximum intensity is directly beneath the aircraft and decreases as the lateral distance from the flight path increases until shock waves refract away from the ground or water surface and the sonic boom attenuates. The lateral spreading of the sonic boom depends only on altitude, speed, and the atmosphere and is independent of the vehicle's shape, size, and weight. The ratio of the aircraft length to maximum cross-sectional area also influences the intensity of the sonic boom. The longer and slenderer the aircraft, the weaker the shock waves. The wider and more blunt the aircraft, the stronger the shock waves can be (U.S. Department of the Navy & Department of Defense, 2007).

In air, the energy from a sonic boom is concentrated in the frequency range from 0.1 to 100 Hz. The underwater sound field due to transmitted sonic boom waveforms is primarily composed of low-frequency components (Sparrow, 2002), and frequencies greater than 20 Hz have been found to be difficult to observe at depths greater than 33 ft. (10 m) (Sohn et al., 2000). F/A-18 Hornet supersonic flight was modeled to obtain peak sound pressure levels (SPLs) and energy flux density at the water surface and at depth (U.S. Department of the Air Force, 2000). These results are shown in Table 3.0-6.

Table 3.0-6: Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight

Mach Number*	Aircraft Altitude (km)	Peak SPL (dB re 1 µPa)			Energy Flux Density (dB re 1 µPa²-s)[1]		
		At surface	50 m Depth	100 m Depth	At surface	50 m Depth	100 m Depth
1.2	1	176	138	126	160	131	122
	5	164	132	121	150	126	117
	10	158	130	119	144	124	115
2	1	178	146	134	161	137	128
	5	166	139	128	150	131	122
	10	159	135	124	144	127	119

[1]Equivalent to SEL for a plane wave.
*Mach number equals aircraft speed divided by the speed of sound.
Notes: SPL = sound pressure level, dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 1 µPa²-s = decibel(s) referenced to 1 micropascal squared seconds, m = meter(s).

3.0.4.1.4 Weapon Noise

The Navy trains using a variety of weapons, as described in Appendix A (Navy Activities Descriptions). Depending on the weapon, incidental (unintentional) noise may be produced at launch or firing, while in flight, or upon impact. Other devices intentionally produce noise to serve as a non-lethal deterrent. Not all weapons utilize explosives, either by design or because they are non-explosive practice munitions. Noise produced by explosives, both in air and water, are discussed in Section 3.0.4.2 (Explosive Stressors) below.

Examples of some types of weapon noise are shown in Table 3.0-7. Examples of launch noise are provided in the table. Noise produced by other weapons and devices is described further below.

Table 3.0-7: Example Weapons Noise

Noise Source	*Sound Level*
In-Water Noise Level	
Naval Gunfire Muzzle Blast (5-inch)	Approximately 200 dB re 1 µPa peak directly under gun muzzle at 1.5 m below the water surface[1]
Airborne Noise Level	
Naval Gunfire Muzzle Blast (5-inch)	178 dB re 20 µPa peak directly below the gun muzzle above the water surface[1]
Hellfire Missile Launch from Aircraft	149 dB re 20 µPa at 4.5 m[2]
Advanced Gun System Missile (115-millimeter)	133–143 dBA re 20 µPa between 12 and 22 m from the launcher on shore[3]
RIM 116 Surface-to-Air Missile	122–135 dBA re 20 µPa between 2 and 4 m from the launcher on shore[3]
Tactical Tomahawk Cruise Missile	92 dBA re 20 µPa 529 m from the launcher on shore[3]

Notes: dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 20 µPa = decibel(s) referenced to 20 micropascals, dBA re 20 µPa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s).
Sources: [1]Yagla and Stiegler (2003); [2]U.S. Department of the Army (1999); [3]U.S. Department of the Navy (2013).

3.0.4.1.4.1 Muzzle Blast from Naval Gunfire

Firing a gun produces a muzzle blast in air that propagates away from the gun with strongest directivity in the direction of fire (Figure 3.0-2). Because the muzzle blast is generated at the gun, the noise decays with distance from the gun. The muzzle blast has been measured for the largest gun analyzed in this SEIS/OEIS, the 5-inch large caliber naval gun. At a distance of 3,700 ft. from the gun, which was fired at 10 degrees elevation angle, and at 10 degrees off the firing line, the in-air received level was 124 dB re 20 µPa SPL peak for the atmospheric conditions of the test (U.S. Department of the Navy, 1981). Measurements were obtained for additional distances and angles off the firing line but were specific to the atmospheric conditions present during the testing.

Figure 3.0-2: Gun Blast and Projectile from a MK 45 MOD 2 5-inch/54 Caliber Navy Gun on a Cruiser (top), a MK 45 MOD 2 5-inch/54 Caliber Navy Gun on a Destroyer (bottom left), and a MK 45 MOD 4 5-inch/62 Caliber Navy Gun on a Destroyer (bottom right)

As the pressure from the muzzle blast from a ship-mounted large caliber gun propagates in air toward the water surface, the pressure can be both reflected from the water surface and transmitted into the water. As explained in Appendix B (Acoustic and Explosive Concepts), most sound enters the water in a narrow cone beneath the sound source (within about 13–14 degrees of vertical), with most sound outside of this cone being totally reflected from the water surface. In-water sound levels were measured during the muzzle blast of a 5-inch large caliber naval gun. The highest possible sound level in the water (average peak SPL of 200 dB re 1 µPa, measured 5 ft. below the surface) was obtained when the gun was fired at the lowest angle, placing the blast closest to the water surface (Yagla & Stiegler, 2003). The unweighted SEL would be expected to be 15–20 dB lower than the peak pressure, making the highest possible SEL in the water about 180 to 185 dB re 1 µPa squared seconds (dB re 1 µPa ^{2}-s) directly below the muzzle blast. Configuration of the 5-inch gun on U.S. Navy ships also affects how sound from each muzzle blast could enter the water. On cruisers, when swung out to either side, the barrel of the gun extends beyond the ship deck and over water. On destroyers, when swung out to either side, the barrel of the gun is still over the ship's deck (Figure 3.0-2). Other gunfire arrangements, such as with smaller-caliber weapons or greater angles of fire, would result in less sound entering the water. The sound entering the water would have the strongest directivity directly downward beneath the gun blast, with lower sound pressures at increasing angles of incidence until the angle of incidence is reached where no sound enters the water.

Large-caliber gunfire also sends energy through the ship structure and into the water. This effect was investigated in conjunction with the measurement of 5-inch gun firing described above. The energy transmitted through the ship to the water for a typical round was about 6 percent of that from the muzzle blast impinging on the water (U.S. Department of the Navy, 2000). Therefore, sound transmitted from the gun through the hull into the water is a minimal component of overall weapons firing noise.

3.0.4.1.4.2 Supersonic Projectile Bow Shock Wave

Supersonic projectiles, such as a fired gun shell, create a bow shock wave along the line of fire. A bow shock wave is an impulsive sound caused by a projectile exceeding the speed of sound (for more explanation, see Appendix B [Acoustic and Explosive Concepts]). The bow shock wave itself travels at the speed of sound in air. The projectile bow shock wave created in air by a shell in flight at supersonic speeds propagates in a cone (generally about 65 degrees) behind the projectile in the direction of fire (U.S. Department of the Navy, 1981). Exposure to the bow shock wave is very brief.

Projectiles from a 5-inch/54 caliber gun would travel at approximately 2,600 ft./second, and the associated bow shock wave is subjectively described as a “crack” noise (U.S. Department of the Navy, 1981). Measurements of a 5-inch projectile shock wave ranged from 140 to 147 dB re 20 µPa SPL peak taken at the ground surface at 0.59 nautical miles distance from the firing location and 10 degrees off the line of fire for safety (approximately 190 m from the shell’s trajectory) (U.S. Department of the Navy, 1981).

Like sound from the gun muzzle blast, sound waves from a projectile in flight could only enter the water in a narrow cone beneath the sound source, with in-air sound being totally reflected from the water surface outside of the cone. The region of underwater sound influence from a single traveling shell would be relatively narrow, and the duration of sound influence would be brief at any location.

3.0.4.1.4.3 Launch Noise

Missiles can be rocket or jet propelled, and launches typically occur far offshore in special use airspace such as warning areas, air traffic control assigned airspace, and restricted areas. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket. It rapidly fades as the missile or target reaches optimal thrust conditions and the missile or target reaches a downrange distance where the booster burns out and the sustainer engine continues. Examples of launch noise sound levels are shown in Table 3.0-7.

3.0.4.1.4.4 Impact Noise (Non-Explosive)

Any object dropped in the water would create a noise upon impact, depending on the object’s size, mass, and speed. Sounds of this type are produced by the kinetic energy transfer of the object with the target surface and are highly localized to the area of disturbance. A significant portion of an object’s kinetic energy would be lost to splash, any deformation of the object, and other forms of non-mechanical energy (McLennan, 1997). The remaining energy could contribute to sound generation. Most objects would be only momentarily detectable, if at all, but some large objects traveling at high speeds could generate a broadband impulsive sound upon impact with the water surface. Sound associated with impact events is typically of low frequency (less than 250 Hz) and of short duration.

3.0.4.2 Explosive Stressors

This section describes the characteristics of explosions during naval training. The activities analyzed in this SEIS/OEIS that use explosives are described in Appendix A (Navy Activities Descriptions). This section provides the basis for analysis of explosive impacts on fish, marine mammals, and birds in the remainder of this chapter. Explanations of the terminology and metrics used when describing explosives in this SEIS/OEIS are in Appendix B (Acoustic and Explosive Concepts).

The near-instantaneous rise from ambient to an extremely high peak pressure is what makes an explosive shock wave potentially damaging. Farther from an explosive, the peak pressures decay and the explosive waves propagate as an impulsive, broadband sound. Several parameters influence the effect of an explosive: the weight of the explosive warhead; the type of explosive material; the boundaries and characteristics of the propagation medium; and, in water, the detonation depth. The net explosive weight, the explosive power of a charge expressed as the equivalent weight of trinitrotoluene (TNT), accounts for the first two parameters. The effects of these factors are explained in Appendix B (Acoustic and Explosive Concepts).

3.0.4.2.1 Explosions in Water

In-water explosive detonations during training activities are associated with explosives, including bombs and naval gun shells. For purposes of the analysis for in-water explosives, detonations occurring in air at a height of 33 ft. (10 m) or less above the water surface, and detonations occurring directly on the water surface were modeled to detonate at a depth of 0.3 ft. (0.1 m) below the water surface since there is currently no means to model impacts from in-air detonations. Additional information regarding energy transmission from detonations is discussed in Appendix B (Acoustic and Explosive Concepts). Section 5.3.3 (Explosive Stressors) outlines the procedural mitigation measures for explosive stressors to reduce potential impacts on biological resources.

In order to better organize and facilitate the analysis of Navy training activities using explosives that could detonate in water or near the water surface, explosive classification bins were developed. The use of explosive classification bins provides the same benefits as described for acoustic source classification bins in Section 3.0.4.1 (Acoustic Stressors).

Explosives detonated in water or near the water surface are binned by net explosive weight. The bins of explosives that are proposed for use in the TMAA are shown in Table 3.0-8. This table shows the number of explosive items that could be used in any year under Alternative 1 for training activities.

Propagation of explosive pressure waves in water is highly dependent on environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity, which affect how the pressure waves are reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. In addition, absorption greatly affects the distance over which higher frequency components of explosive broadband noise can propagate. Appendix B (Acoustic and Explosive Concepts) explains the characteristics of explosive detonations and how the above factors affect the propagation of explosive energy in the water. Because of the complexity of analyzing sound propagation in the ocean environment, the Navy relies on acoustic models in its environmental analyses that consider sound source characteristics and varying ocean conditions across the TMAA.

Table 3.0-8: Explosive Sources Used During Training in the Temporary Maritime Activities Area

Explosives (Source Class and Net Explosive Weight) (lb.)	Number of Explosives with the Proposed Action	Representative Underwater Detonation Depth[1]
E5 (> 5–10 lb. NEW)	112	0.3 ft. (0.1 m)
E9 (> 100–250 lb. NEW)	142	0.3 ft. (0.1 m)
E10 (> 250–500 lb. NEW)	32	0.3 ft. (0.1 m)
E12 (> 650–1,000 lb. NEW)	4	0.3 ft. (0.1 m)

[1]Underwater detonation depths listed are those assumed for purposes of acoustic impacts modeling. Detonations assumed to occur at a depth of 0.3 ft. (0.1 m) include detonations that would actually occur at or near the water surface.
Notes: m = meters, NEW = Net Explosive Weight, ft. = feet, lb. = pounds.

3.0.4.2.2 Explosions in Air

Explosions in air include detonations of projectiles and missiles during surface-to-air gunnery and air-to-air missile exercises conducted during air warfare. These explosions typically occur far above the water surface in special use airspace. Some typical types of explosive munitions that would be detonated in air during Navy activities are shown in Bombs and projectiles that detonate at or near the water surface, which are considered for underwater impacts (see Table 3.0-8), would also release some explosive energy into the air. Appendix A (Navy Activities Descriptions) describes where activities with these stressors typically occur.

The explosive energy released by detonations in air has been well studied (see Appendix B, Acoustic and Explosive Concepts), and basic methods are available to estimate the explosive energy exposure with distance from the detonation (U.S. Department of the Navy, 1975). In air, the propagation of impulsive noise from an explosion is highly influenced by atmospheric conditions, including temperature and wind. While basic estimation methods do not consider the unique environmental conditions that may be present on a given day, they allow for approximation of explosive energy propagation under neutral atmospheric conditions. Explosions that occur during air warfare would typically be at a sufficient altitude that a large portion of the sound refracts upward due to cooling temperatures with increased altitude.

Missiles, rockets, projectiles, and other cased weapons will produce casing fragments upon detonation. These fragments may be of variable size and are ejected at supersonic speed from the detonation. The casing fragments will be ejected at velocities much greater than debris from any target due to the proximity of the casing to the explosive material. Unlike detonations on land targets, in-air detonations during Navy training would not result in other propelled materials such as crater debris.

Table 3.0-9. Various missiles, rockets, and medium- and large-caliber projectiles may be explosive or non-explosive, depending on the objective of the training activity in which they are used.

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Table 3.0-9: Typical Air Explosive Munitions During Navy Activities

Weapon Type[1]	Net Explosive Weight (lb.)	Typical Altitude of Detonation (ft.)
Surface-to-Air Missile		
RIM-66 SM-2 Standard Missile	80	> 15,000
RIM-116 Rolling Airframe Missile	39	< 3,000
RIM-7 Sea Sparrow	36	> 15,000 (can be used on low targets)
FIM-92 Stinger	7	< 3,000
Air-to-Air Missile		
AIM-9 Sidewinder	38	> 15,000
AIM-7 Sparrow	36	> 15,000
AIM-120 AMRAAM	17	> 15,000
Air-to-Surface Missile		
AGM-88 HARM	45	< 100
Projectile - Large Caliber[2]		
5"/54 caliber HE-ET	7	< 100
5"/54 caliber Other	8	< 3,000

[1]Mission Design Series and popular name shown for missiles.
[2]Most medium and large caliber projectiles used during Navy training activities do not contain high explosives.
Notes: AMRAAM = Advanced Medium-Range Air-to-Air Missile, HARM = High-Speed Anti-Radiation Missile, HE-ET = High Explosive-Electronic Time, lb. = pound(s), ft. = foot/feet.

3.0.4.3 Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities

This conceptual framework describes the potential effects from exposure to acoustic and explosive activities and the accompanying short-term costs to the animal (e.g., expended energy or missed feeding opportunity). It then outlines the conditions that may lead to long-term consequences for the individual if the animal cannot fully recover from the short-term costs and how these in turn may affect the population. Within each biological resource section (e.g., marine mammals, birds, and fishes) the detailed methods to predict effects on specific taxa are derived from this conceptual framework.

An animal is considered "exposed" to a sound if the received sound level at the animal's location is above the background ambient noise level within a similar frequency band. A variety of effects may result from exposure to acoustic and explosive activities.

The categories of potential effects are:

- ***Injury*** *- Injury to organs or tissues of an animal.*
- ***Hearing loss*** *- A noise-induced decrease in hearing sensitivity, which can be either temporary or permanent and may be limited to a narrow frequency range of hearing.*
- ***Masking*** *- When the perception of a biologically important sound (i.e., signal) is interfered with by a second sound (i.e., noise).*
- ***Physiological stress*** *- An adaptive process that helps an animal cope with changing conditions; however, too much stress can result in physiological problems.*
- ***Behavioral response*** *- A reaction ranging from very minor and brief changes in attentional focus, changes in biologically important behaviors, and avoidance of a sound source or area, to aggression or prolonged flight.*

Figure 3.0-3 is a flowchart that diagrams the process used to evaluate the potential effects to marine animals exposed to sound-producing activities. The shape and color of each box on the flowchart represents either a decision point in the analysis (green diamonds); specific processes such as responses, costs, or recovery (blue rectangles); external factors to consider (purple parallelograms); and final outcomes for the individual or population (orange ovals and rectangles). Each box is labeled for reference throughout the following sections. For simplicity, sound is used here to include not only sound waves but also blast waves generated from explosive sources. Box A1, the Sound-Producing Activity, is the source of this stimuli and therefore the starting point in the analysis.

The first step in predicting whether an activity is capable of affecting a marine animal is to define the stimuli experienced by the animal. The stimuli include the overall level of activity, the surrounding acoustical environment, and characteristics of the sound when it reaches the animal.

Sounds emitted from a sound-producing activity (Box A1) travel through the environment to create a spatially variable sound field. The received sound at the animal (Box A2) determines the range of possible effects. The received sound can be evaluated in several ways, including number of times the sound is experienced (repetitive exposures), total received energy, or highest SPL experienced. Sounds that are higher than the ambient noise level and within an animal's hearing sensitivity range (Box A3) have the potential to cause effects. There can be any number of individual sound sources in a given activity, each with its own unique characteristics. For example, a Navy training exercise may involve several ships and aircraft using several types of sonar. Environmental factors such as temperature and bottom type impact how sound spreads and attenuates through the environment. Additionally, independent of the sounds, the overall level of activity and the number and movement of sound sources are important to help predict the probable reactions.

The magnitude of the responses is predicted based on the characteristics of the acoustic stimuli and the characteristics of the animal (species, susceptibility, life history stage, size, and past experiences). Very high exposure levels close to explosives have the potential to cause injury. High-level, long-duration, or repetitive exposures may potentially cause some hearing loss. All perceived sounds may lead to behavioral responses, physiological stress, and masking. Many sounds, including sounds that are not detectable by the animal, could have no effect (Box A4).

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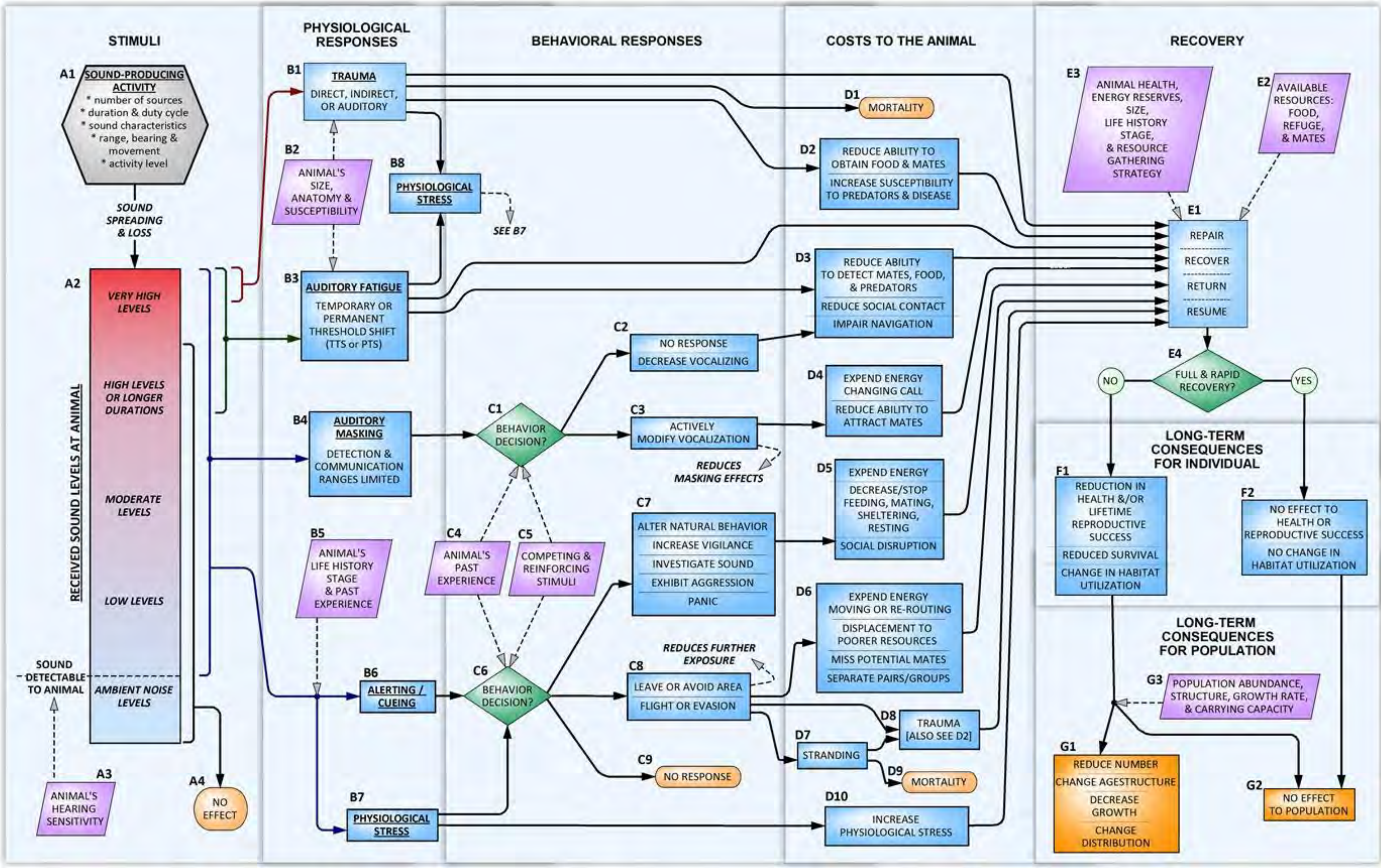

Figure 3.0-3: Flow Chart of the Evaluation Process of Sound-Producing Activities

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3.0.4.3.1 Injury

Injury (Box B1) refers to the direct injury of tissues and organs by shock or pressure waves impinging upon or traveling through an animal's body. Marine animals are well adapted to large, but relatively slow, hydrostatic pressure changes that occur with changing depth. However, injury may result from exposure to rapid pressure changes, such that the tissues do not have time to adequately adjust. Therefore, injury is normally limited to relatively close ranges from explosions. Injury can be mild and fully recoverable or, in some cases, lead to mortality.

Injury includes both auditory and non-auditory injury. Auditory injury is the direct mechanical injury to hearing-related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and injury to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory injury differs from auditory fatigue in that the latter involves the overstimulation of the auditory system at levels below those capable of causing direct mechanical damage. Auditory injury is always injurious but can be temporary. One of the most common consequences of auditory injury is hearing loss.

Non-auditory injury can include hemorrhaging of small blood vessels and the rupture of gas-containing tissues such as the lung, swim bladder, or gastrointestinal tract. After the ear (or other sound-sensing organs), these are usually the organs and tissues most sensitive to explosive injury. An animal's size and anatomy are important in determining its susceptibility to non-auditory injury (Box B2). Larger size indicates more tissue to protect vital organs. Therefore, larger animals should be less susceptible to injury than smaller animals. In some cases, acoustic resonance of a structure may enhance the vibrations resulting from noise exposure and result in an increased susceptibility to injury. The size, geometry, and material composition of a structure determine the frequency at which the object will resonate. Because most biological tissues are heavily damped, the increase in susceptibility from resonance is limited.

Vascular and tissue bubble formation resulting from sound exposure is a hypothesized mechanism of injury to breath-holding marine animals. Bubble formation and growth due to direct sound exposure have been hypothesized (Crum et al., 2005; Crum & Mao, 1996); however, the experimental laboratory conditions under which these phenomena were observed would not be replicated in the wild. Certain dive behaviors by breath-holding animals are predicted to result in conditions of blood nitrogen super-saturation, potentially putting an animal at risk for decompression sickness (Fahlman et al., 2014), although this phenomena has not been observed (Houser et al., 2009). In addition, animals that spend long periods of time at great depths are predicted to have super-saturated tissues that may slowly release nitrogen if the animal then spends a long time at the surface (i.e., stranding) (Houser et al., 2009).

Injury could increase the animal's physiological stress (Box B8), which feeds into the stress response (Box B7) and also increases the likelihood or severity of a behavioral response. Injury may reduce an animal's ability to secure food by reducing its mobility or the efficiency of its sensory systems, making the injured individual less attractive to potential mates, increasing an individual's chances of contracting diseases or falling prey to a predator (Box D2), or increasing an animal's overall physiological stress level (Box D10). Severe injury can lead to the death of the individual (Box D1).

Damaged tissues from mild to moderate injury may heal over time. The predicted recovery of direct injury is based on the severity of the injury, availability of resources, and characteristics of the animal. The animal may also need to recover from any potential costs due to a decrease in resource gathering efficiency and any secondary effects from predators or disease. Severe injuries can lead to reduced survivorship (longevity), elevated stress levels, and prolonged alterations in behavior that can reduce an animal's lifetime reproductive success. An animal with decreased energy stores or a lingering injury may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring produced over its lifetime.

3.0.4.3.2 Hearing Loss

Hearing loss, also called a noise-induced threshold shift, is possibly the best studied type of effect from sound exposures to animals. Hearing loss manifests itself as loss in hearing sensitivity across part of an animal's hearing range, which is dependent upon the specifics of the noise exposure. Hearing loss may be either PTS, or TTS. If the threshold shift eventually returns to zero (the animal's hearing returns to pre-exposure value), the threshold shift is a TTS. If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 3.0-4 shows one hypothetical threshold shift that completely recovers, a TTS; and one that does not completely recover, leaving some PTS.

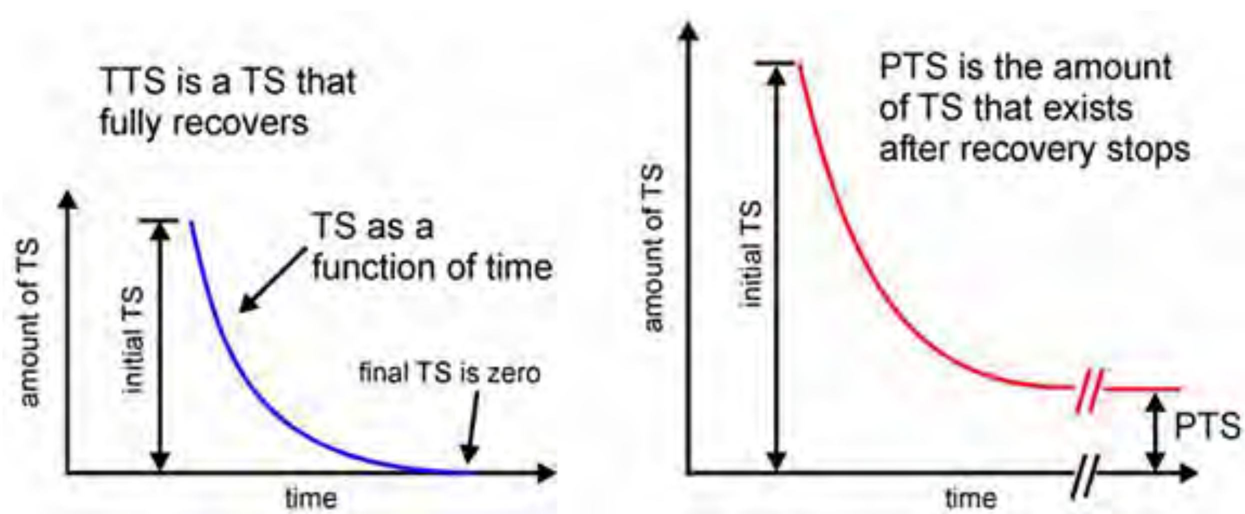

Figure 3.0-4: Two Hypothetical Threshold Shifts

The characteristics of the received sound stimuli are used and compared to the animal's hearing sensitivity and susceptibility to noise (Box A3) to determine the potential for hearing loss. The amplitude, frequency, duration, and temporal pattern of the sound exposure are important parameters for predicting the potential for hearing loss over a specific portion of an animal's hearing range. Duration is particularly important because hearing loss increases with prolonged exposure time. Longer exposures with lower sound levels can cause more threshold shift than a shorter exposure using the same amount of energy overall. The frequency of the sound also plays an important role. Experiments show that animals are most susceptible to hearing loss (Box B3) within their most sensitive hearing range. Sounds outside of an animal's audible frequency range do not cause hearing loss.

The mechanisms responsible for hearing loss may consist of a variety of mechanical and biochemical processes in the inner ear, including physical damage or distortion of the tympanic membrane (not including tympanic membrane rupture, which is considered auditory injury), physical damage or distortion of the cochlear hair cells, hair cell death, changes in cochlear blood flow, and swelling of cochlear nerve terminals (Henderson et al., 2006; Kujawa & Liberman, 2009). Although the outer hair cells are the most prominent target for fatigue effects, severe noise exposures may also result in inner hair cell death and loss of auditory nerve fibers (Henderson et al., 2006).

The relationship between TTS and PTS is complicated and poorly understood, even in humans and terrestrial mammals, where numerous studies failed to delineate a clear relationship between the two. Relatively small amounts of TTS (e.g., less than 40–50 dB measured two minutes after exposure) will recover with no apparent permanent effects; however, terrestrial mammal studies revealed that larger amounts of threshold shift can result in permanent neural degeneration, despite the hearing thresholds returning to normal (Kujawa & Liberman, 2009). The amounts of threshold shift induced by Kujawa and Liberman (2009) were described as being "at the limits of reversibility." It is unknown whether smaller amounts of threshold shift can result in similar neural degeneration, or if effects would translate to other species such as marine animals.

Hearing loss can increase an animal's physiological stress (Box B8), which feeds into the stress response (Box B7). Hearing loss can increase the likelihood or severity of a behavioral response and increase an animal's overall physiological stress level (Box D10). Hearing loss reduces the distance over which animals can communicate and detect other biologically important sounds (Box D3). Hearing loss could also be inconsequential for an animal if the frequency range affected is not critical for that animal to hear within, or the hearing loss is of such short duration (e.g., a few minutes) that there are no costs to the individual.

Small to moderate amounts of hearing loss may recover over a period of minutes to days, depending on the amount of initial threshold shift. Severe noise-induced hearing loss may not fully recover, resulting in some amount of PTS. An animal whose hearing does not recover quickly and fully could suffer a reduction in lifetime reproductive success. An animal with PTS may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring it can produce over its lifetime.

3.0.4.3.3 Masking

Masking occurs if the noise from an activity interferes with an animal's ability to detect, understand, or recognize biologically relevant sounds of interest (Box B4). In this context noise refers to unwanted or unimportant sounds that mask an animal's ability to hear sounds of interest. Sounds of interest include those from conspecifics such as offspring, mates, and competitors; echolocation clicks; sounds from predators; natural, abiotic sounds that may aid in navigation; and reverberation, which can give an animal information about its location and orientation within the ocean. The probability of masking increases as the noise and sound of interest increase in similarity and the masking noise increases in level. The frequency, received level, and duty cycle of the noise determines the potential degree of auditory masking. Masking only occurs during the sound exposure.

A behavior decision (either conscious or instinctive) is made by the animal when the animal detects increased background noise, or possibly, when the animal recognizes that biologically relevant sounds are being masked (Box C1). An animal's past experiences can be important in determining the behavioral response when dealing with masking (Box C4). For example, an animal may modify its vocalizations to reduce the effects of masking noise. Other stimuli present in the environment can influence an animal's behavior decision (Box C5), such as the presence of predators, prey, or potential mates.

An animal may exhibit a passive behavioral response when coping with masking (Box C2). It may simply not respond and keep conducting its current natural behavior. An animal may also stop calling until the background noise decreases. These passive responses do not present a direct energetic cost to the animal; however, masking will continue, depending on the acoustic stimuli.

An animal may actively compensate for masking (Box C3). An animal can vocalize more loudly to make its signal heard over the masking noise. An animal may also shift the frequency of its vocalizations away from the frequency of the masking noise. This shift can actually reduce the masking effect for the animal and other animals that are listening in the area.

If masking impairs an animal's ability to hear biologically important sounds (Box D3), it could reduce an animal's ability to communicate with conspecifics or reduce opportunities to detect or attract more distant mates, gain information about their physical environment, or navigate. An animal that modifies its vocalization in response to masking could also incur a cost (Box D4). Modifying vocalizations may cost the animal energy, interfere with the behavioral function of a call, or reduce a signaler's apparent quality as a mating partner. For example, songbirds that shift their calls up an octave to compensate for increased background noise attract fewer or less-desirable mates, and many terrestrial species advertise body size and quality with low-frequency vocalizations (Slabbekoorn & Ripmeester, 2007). Masking may also lead to no measurable costs for an animal. Masking could be of short duration or intermittent such that biologically important sounds that are continuous or repeated are received by the animal between masking noise.

Masking only occurs when the sound source is operating; therefore, direct masking effects stop immediately upon cessation of the sound-producing activity. Masking could have long-term consequences for individuals if the activity was continuous or occurred frequently enough.

3.0.4.3.4 Physiological Stress

Marine animals naturally experience physiological stress as part of their normal life histories. The physiological response to a stressor, often termed the stress response, is an adaptive process that helps an animal cope with changing external and internal environmental conditions. Sound-producing activities have the potential to cause additional stress. However, too much of a stress response can be harmful to an animal, resulting in physiological dysfunction.

If a sound is detected (i.e., heard or sensed) by an animal, a stress response can occur (Box B7). The severity of the stress response depends on the received sound level at the animal (Box A2), the details of the sound-producing activity (Box A1), the animal's life history stage (e.g., juvenile or adult, breeding or feeding season), and past experience with the stimuli (Box B5). An animal's life history stage is an important factor to consider when predicting whether a stress response is likely (Box B5). An animal's life history stage includes its level of physical maturity (i.e., larva, infant, juvenile, sexually mature adult) and the primary activity in which it is engaged such as mating, feeding, or rearing/caring for young. Prior experience with a stressor may be of particular importance because repeated experience with a stressor may dull the stress response via acclimation (St. Aubin & Dierauf, 2001) or increase the response via sensitization. Additionally, if an animal suffers injury or hearing loss, a physiological stress response will occur (Box B8).

The generalized stress response is characterized by a release of hormones (Reeder & Kramer, 2005) and other chemicals (e.g., stress markers) such as reactive oxidative compounds associated with noise-induced hearing loss (Henderson et al., 2006). Stress hormones include norepinephrine and epinephrine (i.e., the catecholamines), which produce elevations in the heart and respiration rate, increase awareness, and increase the availability of glucose and lipid for energy. Other stress hormones are the glucocorticoid steroid hormones cortisol and aldosterone, which are classically used as an indicator of a stress response and to characterize the magnitude of the stress response (Hennessy et al., 1979).

An acute stress response is traditionally considered part of the startle response and is hormonally characterized by the release of the catecholamines. Annoyance type reactions may be characterized by the release of either or both catecholamines and glucocorticoid hormones. Regardless of the physiological changes that make up the stress response, the stress response may contribute to an animal's decision to alter its behavior.

Elevated stress levels may occur whether or not an animal exhibits a behavioral response (Box D10). Even while undergoing a stress response, competing stimuli (e.g., food or mating opportunities) may overcome any behavioral response. Regardless of whether the animal displays a behavioral response, this tolerated stress could incur a cost to the animal. Reactive oxygen compounds produced during normal physiological processes are generally counterbalanced by enzymes and antioxidants; however, excess stress can lead to damage of lipids, proteins, and nucleic acids at the cellular level (Berlett & Stadtman, 1997; Sies, 1997; Touyz, 2004).

Frequent physiological stress responses may accumulate over time, increasing an animal's chronic stress level. Each component of the stress response is variable in time, and stress hormones return to baseline levels at different rates. Elevated chronic stress levels are usually a result of a prolonged or repeated disturbance. Chronic elevations in the stress levels (e.g., cortisol levels) may produce long-term health consequences that can reduce lifetime reproductive success.

3.0.4.3.5 Behavioral Reactions

Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. These types of reactions are not mutually exclusive, and many overall reactions may be combinations of behaviors or a sequence of behaviors. Severity of behavioral reactions can vary drastically between minor and brief reorientations of the animal to investigate the sound, to severe reactions such as aggression or prolonged flight. The type and severity of the behavioral response will determine the cost to the animal. The total number of vehicles and platforms involved, the size of the activity area, the distance between the animal and activity, and the duration of the activity are important considerations when predicting the initial behavioral responses.

A physiological stress response (Box B7) such as an annoyance or startle reaction, or cueing or alerting (Box B6) may cause an animal to make a behavior decision (Box C6). Any exposure that produces an injury or hearing loss is also assumed to produce a stress response (Box B7) and increase the severity or likelihood of a behavioral reaction. Both an animal's experience (Box C4) and competing and reinforcing stimuli (Box C5) can affect an animal's behavior decision. The decision can result in three general types of behavioral reactions: no response (Box C9), area avoidance (Box C8), or alteration of a natural behavior (Box C7).

An animal's past experiences can be important in determining what behavior decision it may make when dealing with a stress response (Box C4). Habituation is the process by which an animal learns to ignore or tolerate stimuli over some period and return to a normal behavior pattern, perhaps after being exposed to the stimuli with no negative consequences. Sensitization is when an animal becomes more sensitive to a set of stimuli over time, perhaps as a result of a past, negative experience that could result in a stronger behavioral response.

Other stimuli (Box C5) present in the environment can influence an animal's behavioral response. These stimuli may be conspecifics or predators in the area or the drive to engage in a natural behavior. Other stimuli can also reinforce the behavioral response caused by acoustic stimuli. For example, the awareness of a predator in the area coupled with the sound-producing activity may elicit a stronger reaction than the activity alone would have.

An animal may reorient, become more vigilant, or investigate if it detects a sound-producing activity (Box C7). These behaviors all require the animal to divert attention and resources, therefore slowing or stopping their presumably beneficial natural behavior. This can be a very brief diversion, or an animal may not resume its natural behaviors until after the activity has concluded. An animal may choose to leave or avoid an area where a sound-producing activity is taking place (Box C8). A more severe form of this comes in the form of flight or evasion. Avoidance of an area can help the animal avoid further effects by avoiding or reducing further exposure. An animal may also choose not to respond to a sound-producing activity (Box C9).

An animal that alters its natural behavior in response to stress or an auditory cue may slow or cease its natural behavior and instead expend energy reacting to the sound-producing activity (Box D5). Natural behaviors include feeding, breeding, sheltering, and migrating. The cost of feeding disruptions depends on the energetic requirements of individuals and the potential amount of food missed during the disruption. Alteration in breeding behavior can result in delaying reproduction. The costs of a brief interruption to migrating or sheltering are less clear.

An animal that avoids a sound-producing activity may expend additional energy moving around the area, be displaced to poorer resources, miss potential mates, or have social interactions affected (Box D6). The amount of energy expended depends on the severity of the behavioral response. Missing potential mates can result in delaying reproduction. Groups could be separated during a severe behavioral response such as flight, and offspring that depend on their parents may die if they are permanently separated. Splitting up an animal group can result in a reduced group size, which can have secondary effects on individual foraging success and susceptibility to predators.

Some severe behavioral reactions can lead to stranding (Box D7) or secondary injury (Box D8). Animals that take prolonged flight, a severe avoidance reaction, may injure themselves or strand in an environment for which they are not adapted. Some injury is likely to occur to an animal that strands (Box D8). Injury can reduce the animal's ability to secure food and mates, and increase the animal's susceptibility to predation and disease (Box D2). An animal that strands and does not return to a hospitable environment may die (Box D9).

3.0.4.3.6 Long-Term Consequences

The potential long-term consequences from behavioral responses are difficult to discern. Animals displaced from their normal habitat due to an avoidance reaction may return over time and resume their natural behaviors. This is likely to depend upon the severity of the reaction and how often the activity is repeated in the area. In areas of repeated and frequent acoustic disturbance, some animals may habituate to the new baseline; conversely, species that are more sensitive may not return, or return but not resume use of the habitat in the same manner. For example, an animal may return to an area to feed but no longer rest in that area. Long-term abandonment or a change in the utilization of an area by enough individuals can change the distribution of the population. Frequent disruptions to natural behavior patterns may not allow an animal to recover between exposures, which increases the probability of causing long-term consequences to individuals.

The magnitude and type of effect and the speed and completeness of recovery (i.e., return to baseline conditions) must be considered in predicting long-term consequences to the individual animal (Box E4). The predicted recovery of the animal (Box E1) is based on the cost to the animal from any reactions, behavioral or physiological. Available resources fluctuate by season, location, and year and can play a major role in an animal's rate of recovery (Box E2). Recovery can occur more quickly if plentiful food resources, many potential mates, or refuge or shelter is available. An animal's health, energy reserves, size, life history stage, and resource gathering strategy affect its speed and completeness of recovery (Box E3). Animals that are in good health and have abundant energy reserves before an effect takes place will likely recover more quickly.

Animals that recover quickly and completely are unlikely to suffer reductions in their health or reproductive success, or experience changes in habitat utilization (Box F2). No population-level effects would be expected if individual animals do not suffer reductions in their lifetime reproductive success or change their habitat utilization (Box G2). Animals that do not recover quickly and fully could suffer reductions in their health and lifetime reproductive success; they could be permanently displaced or change how they use the environment; or they could die (Box F1). These long-term consequences to the individual can lead to consequences for the population (Box G1), although population dynamics and abundance play a role in determining how many individuals would need to suffer long-term consequences before there was an effect on the population.

Long-term consequences to individuals can translate into consequences for populations dependent upon population abundance, structure, growth rate, and carrying capacity. Carrying capacity describes the theoretical maximum number of animals of a particular species that the environment can support. When a population nears its carrying capacity, its growth is naturally limited by available resources and predator pressure. If one, or a few animals, in a population are removed or gather fewer resources, then other animals in the population can take advantage of the freed resources and potentially increase their health and lifetime reproductive success. Abundant populations that are near their carrying capacity (theoretical maximum abundance) that suffer consequences on a few individuals may not be affected overall. Populations that exist well below their carrying capacity may suffer greater consequences from any lasting consequences to even a few individuals. Population-level consequences can include a change in the population dynamics, a decrease in the growth rate, or a change in geographic distribution.

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3.6 Fishes

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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3.6.1 Introduction

As presented in Chapter 1 (Purpose and Need), the United States (U.S.) Department of the Navy (Navy) analysis presented in this document supplements both the 2011 Gulf of Alaska (GOA) Final Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (U.S. Department of the Navy, 2011a) and the 2016 GOA Final Supplemental EIS (SEIS)/OEIS (U.S. Department of the Navy, 2016). The Proposed Action is to conduct an annual exercise, historically referred to as Northern Edge, over a maximum time period of up to 21 consecutive days during the months of April to October. Though the types of activities and level of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. Consistent with the previous analysis for Alternative 1, the sinking exercise activity will not be part of the Proposed Action for this SEIS/OEIS. As was also the case for the previous analysis, the National Marine Fisheries Service (NMFS) is a cooperating agency with the Navy for this supplemental analysis, specifically where it relates to fish and other marine resources under that agency's regulatory purview.

The purpose of the fishes section in this SEIS/OEIS is to provide any new or changed information since the 2016 GOA Final SEIS/OEIS that is relevant to an analysis of potential impacts on fish and their habitat associated with the continuation of Navy training activities in the Temporary Maritime Activities Area (TMAA) beyond May 2022. The TMAA is 12 nautical miles (NM) or greater from shore, outside of the U.S. Territorial Sea. The current National Marine Fisheries Service (2017) Biological Opinion for Navy training in the TMAA is effective from April 26, 2017, through April 26, 2022, at which time NMFS plans to update the environmental baseline and reassess any changes in fish species status.

The organizational structure of the fish affected environment section varies slightly from that presented in the 2016 GOA Final SEIS/OEIS. Background information in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS for the fish species that occur in the TMAA will not be repeated in this section unless necessary for context in support of new information and emergent relevant best available science. This supplement includes fish status updates, recent GOA fish research studies, new groundfish harvest data, and amendments to Fishery Management Plans (FMPs) and related Essential Fish Habitat (EFH) designations since the 2016 GOA Final SEIS/OEIS. This information is presented in the subsections that follow.

3.6.2 Affected Environment

The predominant fish species and habitat types known to occur in the TMAA have not changed since they were described in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. The TMAA supports two primary categories of fishes: anadromous salmonids (genus *Oncorhynchus*; hereafter referred to as salmonids) and groundfishes. Salmonids found within the Gulf of Alaska include Chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), sockeye salmon (*O. nerka*), and steelhead (*O. mykiss*). The life histories of the dominant species of salmonids and groundfishes occurring in the Gulf of Alaska are described in the 2011 GOA Final EIS/OEIS, with some updated information on salmonid distribution and migration patterns provided herein.

In the subsequent sections, updated information has been incorporated on the distribution and management status of these fishes within the Gulf of Alaska and TMAA. Further, a discussion of the Endangered Species Act (ESA)-listed Southern Distinct Population Segment (DPS) of green sturgeon (*Acipenser medirostris*) has been included based on additional information suggesting that it may occur within the continental shelf portion of the TMAA. This SEIS/OEIS describes a few species status changes and fisheries management updates that have occurred since the 2016 GOA Final SEIS/OEIS. With the exception of these changes, the information and analysis presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remains valid.

The TMAA overlaps a portion of the continental shelf/slope but is mostly located within offshore pelagic (open ocean) habitats that include the abyssal plain and various seamounts. These habitats are influenced by the Alaska Coastal Current and the Alaska Gyre. With the exception of Montague Island located over 12 NM from the northern point of the TMAA, the nearest shoreline (Kenai Peninsula) is located approximately 24 NM north of the TMAA's northern boundary (Figure 3.6-1). The GOA shelf is dominated by gravel, sand, silt, and mud, punctuated by areas of hard rock (Fautin et al., 2010). There are numerous banks and reefs with coarse, rocky bottoms, but much of the shelf is covered by glacial silt from the Copper River and the Bering and Malaspina glaciers (Mundy, 2005). Habitat types and their characteristics within the TMAA were described in the 2011 GOA Final EIS/OEIS.

3.6.2.1 General Background

3.6.2.1.1 Endangered Species Act-Listed Species in the Temporary Maritime Activities Area

Many ESA-listed fish species (including various salmonids and green sturgeon) from the U.S. West Coast may occur within the TMAA. Following a review of Federal Register (FR) publications (National Marine Fisheries Service, 2020b) since the 2016 GOA Final SEIS/OEIS, the most current federal status of threatened, endangered, and candidate fish species is presented in Table 3.6-1. Abundance data and trends for all Pacific salmonid Evolutionarily Significant Units (ESUs)/DPSs are incorporated by reference in National Marine Fisheries Service (2016b). Candidate species are any species that are undergoing a status review that NMFS has announced through an FR notice (71 FR 61022). Candidate species do not carry any procedural or substantive protections under the ESA (71 FR 61022). Table 3.6-1 indicates ESA-listed salmonid species that originate from rivers in Washington, Oregon, and California that have been confirmed to be, or may be, present in the TMAA during certain periods of their life cycle. Salmon and steelhead that originate from Alaskan rivers may be present in the TMAA, but since they are not listed under the ESA, they are not included in the table.

In addition, green sturgeon have occasionally been documented in Alaskan waters as far north as Unalaska Island, and two fish from the ESA-listed southern DPS have been identified at Graves Harbor in Southeast Alaska (Environmental Protection Information Center et al., 2001) (74 FR 52300). Although a few green sturgeon have been documented in the Gulf of Alaska, they were not identified to a DPS so it is unclear whether they were part of the ESA-listed Southern DPS. However, based on their migration patterns, it is possible that ESA-listed green sturgeon could be present within the on-shelf portion of the TMAA. However, as described in Section 3.6.2.8.2 (Distribution), they are not expected to be found within the offshore portion.

On October 4, 2019, NMFS announced that they plan to initiate five-year reviews of 28 Pacific salmonid species listed under the ESA (84 FR 53117). The purpose of these reviews is to ensure the accuracy of their listing classifications. The five-year reviews will be based on the best scientific and commercial data available at the time of the reviews; NMFS accepted comments until March 27, 2020. Based on the results of these five-year reviews, NMFS will make the requisite determinations under the ESA.

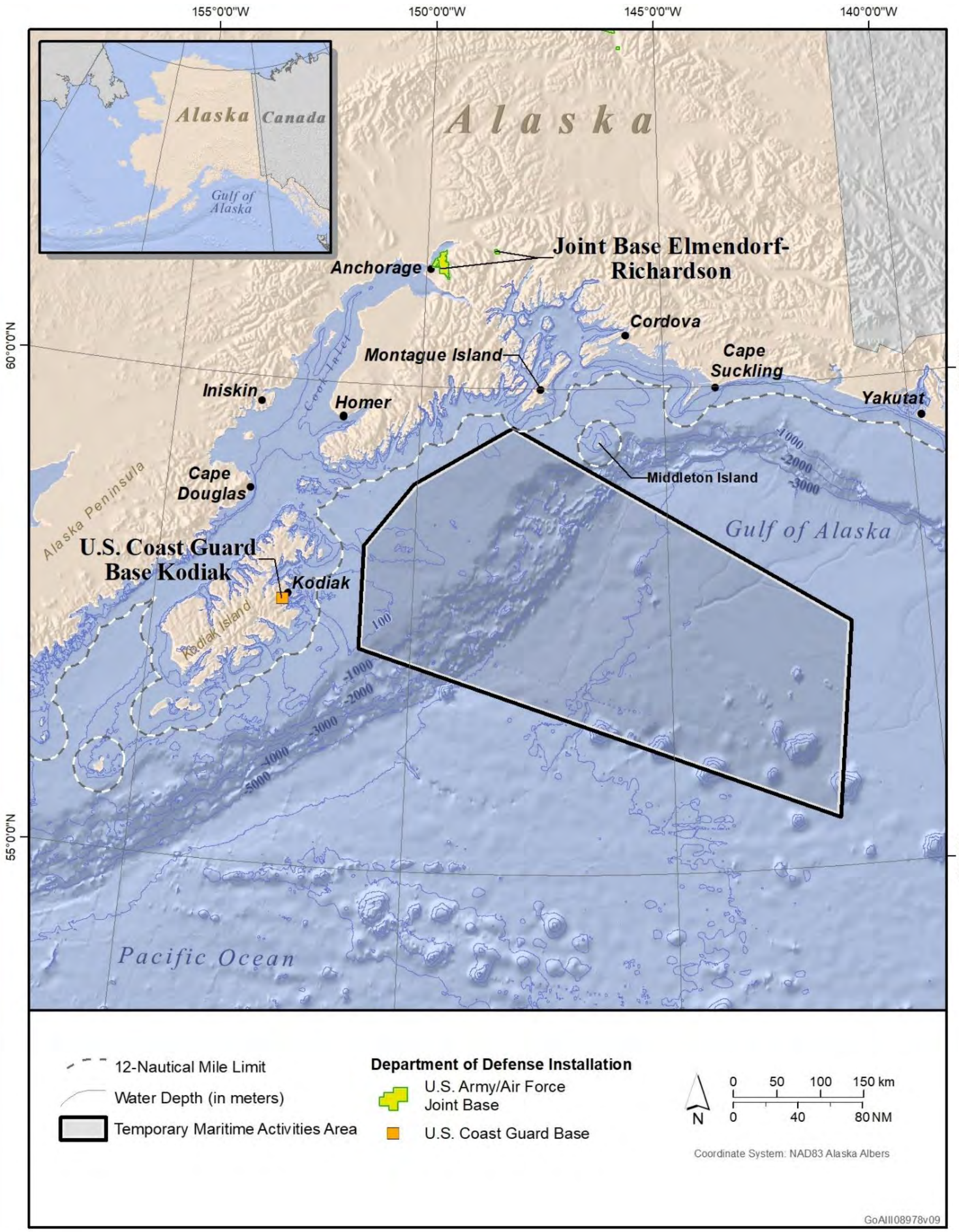


Figure 3.6-1: Gulf of Alaska Navy Training Activities Study Area

Table 3.6-1: Status and Presence of ESA-Listed Fish Species and their Designated Critical Habitat and Candidate Species Found in the TMAA within the Gulf of Alaska

Species and Regulatory Status				*Presence in the GOA and TMAA*	
Common Name (Scientific Name)	***Distinct Population Segment (DPS)/ Evolutionarily Significant Unit (ESU)***	***Federal Status***	***Critical Habitat Designation***	***Documented Presence in the GOA/TMAA[1]***	***Likelihood of Presence in the TMAA***
Chinook Salmon (*Oncorhynchus tshawytscha*)	Puget Sound ESU	T	Designated (Not in TMAA)	X/X	Confirmed
	Upper Columbia River Spring-run ESU	E	Designated (Not in TMAA)	X/X	Confirmed
	Lower Columbia River ESU	T	Designated (Not in TMAA)	X/X	Confirmed
	Snake River Spring/Summer-run ESU	T	Designated (Not in TMAA)	X/X	Confirmed
	Snake River Fall-run ESU	T	Designated (Not in TMAA)	X/X	Confirmed
	Upper Willamette River ESU	T	Designated (Not in TMAA)	X/X	Confirmed
	Oregon Coast Spring-Run ESU[2]	C	Not Designated	-/-	Potential
	Upper Klamath-Trinity River ESU[2]	C	Not Designated	-/-	Potential
	California Coastal ESU	T	Designated (Not in TMAA)	-/-	Potential
	Sacramento River Winter-run ESU	E	Designated (Not in TMAA)	-/-	Potential
	Central Valley Spring-run ESU	T	Designated (Not in TMAA)	X/-	Potential
Coho Salmon (*Oncorhynchus kisutch*)	Lower Columbia River ESU	T	Designated (Not in TMAA)	X/X	Confirmed
	Oregon Coast ESU	T	Designated (Not in TMAA)	X/X	Confirmed
	Southern Oregon/Northern California Coasts ESU	T	Designated (Not in TMAA)	-/-	Potential
	Central California Coast ESU	E	Designated (Not in TMAA)	-/-	Potential
Chum Salmon (*Oncorhynchus keta*)	Hood Canal Summer-run ESU	T	Designated (Not in TMAA)	-/-	Likely
	Columbia River ESU	T	Designated (Not in TMAA)	-/-	Likely

Table 3.6-1: Status and Presence of ESA-Listed Fish Species and their Designated Critical Habitat and Candidate Species Found in the TMAA within the Gulf of Alaska (continued)

Species and Regulatory Status				*Presence in the GOA and TMAA*	
Common Name (Scientific Name)	***Distinct Population Segment (DPS)/ Evolutionarily Significant Unit (ESU)***	***Federal Status***	***Critical Habitat Designation***	***Documented Presence in the GOA/TMAA[1]***	***Likelihood of Presence in the TMAA***
Sockeye Salmon (*Oncorhynchus nerka*)	Snake River ESU	E	Designated (Not in TMAA)	-/-	Likely
	Ozette Lake ESU	T	Designated (Not in TMAA)	-/-	Likely
Steelhead (*Oncorhynchus mykiss*) ~~(continued)~~	Puget Sound DPS	T	Designated (Not in TMAA)	X/-	Likely
	Upper Columbia River DPS	T	Designated (Not in TMAA)	X/-	Likely
	Middle Columbia River DPS	T	Designated (Not in TMAA)	X/-	Likely
	Lower Columbia River DPS	T	Designated (Not in TMAA)	X/-	Likely
	Snake River Basin DPS	T	Designated (Not in TMAA)	X/-	Likely
	Upper Willamette River DPS	T	Designated (Not in TMAA)	X/-	Likely
	Northern California DPS	T	Designated (Not in TMAA)	-/-	Potential
	Northern California Summer-Run DPS[2]	C	Not Designated	-/-	Potential
	California Central Valley DPS	T	Designated (Not in TMAA)	-/-	Potential
	Central California Coast DPS	T	Designated (Not in TMAA)	X/-	Potential
	South-Central California Coast DPS	T	Designated (Not in TMAA)	-/-	Potential
	Southern California DPS	E	Designated (Not in TMAA)	-/-	Unlikely
Green Sturgeon (*Acipenser medirostris*)	Southern DPS	T	Designated (Not in TMAA)	-/-	Potential

[1] Presence based on coded wire tag studies (see Section 3.6.2.7, Site-Specific Information on Endangered Species Act-Listed Salmonids in the Gulf of Alaska and Temporary Maritime Activities Area)
[2] New/updated species status since the 2016 GOA Final SEIS/OEIS.
Notes: Federal Status: C = Candidate, E = Endangered, T = Threatened; "X" = Documented; "-" = Not Documented
Sources: (National Marine Fisheries Service, 2016a, 2020b)

3.6.2.1.2 Endangered Species Act-Listed Species Unlikely to be Present in the Temporary Maritime Activities Area

The Southern California Steelhead DPS is the only ESA-listed fish species addressed in this document that is considered unlikely to be present in the TMAA. In their southern range, steelhead tend to migrate north and south along the continental shelf, a pattern that may be related to the shorter time these stocks spend in saltwater (Barnhart, 1991; Busby et al., 1996; Moyle et al., 2017). There is no evidence suggesting that these fish migrate as far north as the Gulf of Alaska. Many steelhead stocks in the northern range are known to make extensive offshore migrations. For example, Oregon, Washington, and British Columbia steelhead are commonly captured in Alaskan waters (Barnhart, 1991). Although California stocks were not previously known to occur in the Gulf of Alaska, coded wire tag (CWT) data indicates that some individuals from the Central California Coast Steelhead DPS and Central Valley spring-run Chinook Salmon ESU have been found in the Gulf of Alaska and may occur in the TMAA (Hayes et al., 2011). Thus, there is potential for ESA-listed fish from Washington south to Central California to occur in the TMAA.

3.6.2.1.3 Hearing and Vocalization

A summary of fish hearing and vocalizations is described in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Due to the availability of new literature, including revised sound exposure criteria, the information provided below will supplant the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS for fishes.

All fishes have two sensory systems that can detect sound in the water: the inner ear, which functions similarly to the inner ear in other vertebrates, and the lateral line, which consists of a series of receptors along the body of a fish (Popper & Schilt, 2008). The lateral line system is sensitive to external particle motion arising from sources within a few body lengths of an animal. The lateral line detects particle motion at low frequencies from below 1 hertz (Hz) up to at least 400 Hz (Coombs & Montgomery, 1999; Hastings & Popper, 2005; Higgs & Radford, 2013; Webb et al., 2008). Generally, the inner ears of fish contain three types of dense otoliths (i.e., small calcareous bodies) that sit atop many delicate mechanoelectric hair cells within the inner ear, similar to the hair cells found in the mammalian ear. Underwater sound waves pass through the fish's body and vibrate the otoliths. This causes a relative motion between the dense otoliths and the surrounding tissues, causing a deflection of the hair cells, which is sensed by the nervous system.

Although a propagating sound wave contains pressure and particle motion components, particle motion is most significant at low frequencies (up to at least 400 Hz) and is most detectible at high sound levels or very close to a sound source. The inner ears of fishes are directly sensitive to acoustic particle motion rather than acoustic pressure (acoustic particle motion and acoustic pressure are discussed in Appendix B, Acoustic and Explosive Concepts). Historically, studies that have investigated hearing in, and effects to, fishes have been carried out with sound pressure metrics. Although particle motion may be the more relevant exposure metric for many fish species, there is little data available that actually measures it due to a lack of standard measurement methodology and experience with particle motion detectors (Hawkins et al., 2015; Martin et al., 2016). In these instances, particle motion can be estimated from pressure measurements (Nedelec et al., 2016a).

Some fishes possess additional morphological adaptations or specializations that can enhance their sensitivity to sound pressure, such as a gas-filled swim bladder (Astrup, 1999; Popper & Fay, 2010). The swim bladder can enhance sound detection by converting acoustic pressure into localized particle motion, which may then be detected by the inner ear (Radford et al., 2012). Fishes with a swim bladder generally have greater hearing sensitivity and can detect higher frequencies than fishes without a swim bladder (Popper & Fay, 2010; Popper et al., 2014). In addition, structures such as gas-filled bubbles near the ear or swim bladder, or even connections between the swim bladder and the inner ear, also increase sensitivity and allow for higher frequency hearing capabilities and better sound pressure detection.

Although many researchers have investigated hearing and vocalizations in fish species, hearing capability data only exist for just over 100 of the currently known 34,000 marine and freshwater fish species (Eschmeyer & Fong, 2016). Therefore, fish hearing groups are defined by species that possess a similar continuum of anatomical features, which result in varying degrees of hearing sensitivity (Popper & Fay, 2010; Popper & Hastings, 2009b). Categories and descriptions of hearing sensitivities are further defined in this document (modified from Popper et al., 2014) as the following:

- Fishes without a swim bladder—hearing capabilities are limited to particle motion detection at frequencies well below 2 kilohertz (kHz).
- Fishes with a swim bladder not involved in hearing—species lack notable anatomical specializations and primarily detect particle motion at frequencies below 2 kHz.
- Fishes with a swim bladder involved in hearing—species can detect frequencies below 2 kHz, possess anatomical specializations to enhance hearing, and are capable of sound pressure detection up to a few kHz.
- Fishes with a swim bladder and high-frequency hearing—species can detect frequencies below 2 kHz, possess anatomical specializations, and are capable of sound pressure detection at frequencies up to 10 kHz to over 100 kHz (not present in Study Area).

The quantitative literature review conducted by Wiernicki et al. (2020), the x-ray and image processing performed by Schulz-Mirbach et al. (2020), and hearing measurements and dissections of black sea bass by Stanley et al. (2020) continue to support the above hearing group classifications. Additional research is still needed to better understand species-specific frequency detection capabilities and overall sensitivity to sound.

Data suggest that most species of marine fish either lack a swim bladder (e.g., sharks and flatfishes) or have a swim bladder not involved in hearing and can only detect sounds below 1 kHz. Some marine fishes (Clupeiformes) with a swim bladder involved in hearing are able to detect sounds to about 4 kHz (Colleye et al., 2016; Mann et al., 2001; Mann et al., 1997). One subfamily of clupeids (i.e., Alosinae or shads) can detect high- and very high-frequency sounds (i.e., frequencies from 10 to 100 kHz, and frequencies above 100 kHz, respectively), although auditory thresholds at these higher frequencies are elevated and the range of best hearing is still in the low-frequency range (below 1 kHz) similar to other fishes. Mann et al. (1998; 1997) theorize that this subfamily may have evolved the ability to hear relatively high sound levels at these higher frequencies in order to detect echolocations of nearby foraging dolphins. For fishes that have not had their hearing tested, such as deep sea fishes, the suspected hearing capabilities are based on the structure of the ear, the relationship between the ear and the swim bladder, and other potential adaptations such as the presence of highly developed areas of the brain related to inner ear and lateral line functions (Buran et al., 2005; Deng et al., 2011, 2013). It is believed that most fishes have their best hearing sensitivity from 100 to 400 Hz (Popper, 2003).

ESA-listed species with the potential to occur within the TMAA include various salmonid species, as well as green sturgeon (see Table 3.6-1 for details). There are no available data on the hearing capabilities of these specific ESA-listed populations. Instead, each species is considered to be part of a hearing group described above based on data from similar species, and knowledge of that species' physiology. As discussed above, most marine fishes investigated to date lack hearing capabilities greater than 1,000 Hz. Notably, this includes sturgeon and salmonid species, fishes with a swim bladder that is not involved in hearing. Although it is assumed that sturgeon and salmon species can detect frequencies up to 1,000 Hz, available hearing data has only tested these species up to about 600 Hz (Hawkins & Johnstone, 1978; Kane et al., 2010; Lovell et al., 2005; Meyer et al., 2010). There are no ESA-listed species that occur in the TMAA that have a swim bladder that is involved in hearing, or that have high-frequency hearing (the two most sensitive hearing groups).

Many fishes are known to produce sound. Bony fishes can produce sounds in a number of ways and use them for a variety of behavioral functions (Ladich, 2008, 2014). Over 30 families of fishes are known to use vocalizations in aggressive interactions, and over 20 families are known to use vocalizations in mating (Ladich, 2008). Sounds generated by fishes as a means of communication are generally below 500 Hz (Slabbekoorn et al., 2010). The air in the swim bladder is vibrated by the sound-producing structures (often muscles that are integral to the swim bladder wall) and radiates sound into the water (Zelick et al., 1999). Sprague and Luczkovich (2004) calculated that silver perch, of the family Sciaenidae, can produce drumming sounds ranging from 128 to 135 decibels referenced to 1 micropascal (dB re 1 μPa). Female midshipman fish detect and locate the "hums" (approximately 90 to 400 Hz) of vocalizing males during the breeding season (McIver et al., 2014; Sisneros & Bass, 2003). Sciaenids produce a variety of sounds, including calls produced by males on breeding grounds (Ramcharitar et al., 2001), and a "drumming" call produced during chorusing that suggests a seasonal pattern to reproductive-related function (McCauley & Cato, 2000). Other sounds produced by chorusing reef fishes include "popping," "banging," and "trumpet" sounds; altogether, these choruses produce sound levels 35 decibels (dB) above background levels, at peak frequencies between 250 and 1,200 Hz, and source levels between 144 and 157 dB re 1 μPa (McCauley & Cato, 2000).

Additional research using visual surveys (such as baited underwater video and monitoring by divers) and passive acoustic monitoring continue to reveal new sounds produced by fishes, both in the marine and freshwater environments, and allow for specific behaviors to be paired with those sounds (Radford et al., 2018; Rountree et al., 2018; Rowell et al., 2020; Rowell et al., 2018).

3.6.2.1.4 General Threats

General threats to fish species within the TMAA were not addressed in the 2011 GOA Final EIS/OEIS or the 2016 GOA Final SEIS/OEIS. The major threats to fish species that were described in the 2015 Biological Evaluation and 2017 GOA Biological Opinion are summarized and updated below. Much of the Climate Change discussion below was summarized from Johnson (2016).

Climate Change

The Intergovernmental Panel on Climate Change's Fifth Assessment Synthesis Reports conclude that climate change is unequivocal (Intergovernmental Panel on Climate Change, 2013, 2014). The reports indicate that oceans have warmed, with the greatest warming occurring near the surface. Over the last 60 years Alaska has warmed more than twice as rapidly as most of the United States. The U.S. Environmental Protection Agency reports that average annual temperatures in Alaska have risen 3.4 degrees Fahrenheit (°F) (winter temperatures have risen 6.2°F) during that period, and some projections call for another 2–4°F increase by the middle of this century (Chapin III et al., 2014; Johnson, 2016). It is expected that long-term warming trends will override inter-annual or multi-decadal climate variability (Johnson, 2016).

Potential consequences of climate change on fish in the Gulf of Alaska include temperature and salinity stratification; changes to primary productivity and prey base; ocean acidification; decreased ocean oxygen levels; invasive species; and harmful algal blooms (Johnson, 2016). Climate change has the potential to impact species abundance, geographic distribution (both laterally and vertically), migration patterns, timing of seasonal activities (Intergovernmental Panel on Climate Change, 2014), and species viability into the future.

Climate change may affect food web processes in the Gulf of Alaska through changes in oceanic stratification. Phytoplankton form the basis of the oceanic food web and require sunlight energy and nutrient mixing to support a phytoplankton bloom. If summer temperatures are too warm thermal stratification occurs, which blocks deeper nutrients from reaching phytoplankton near the surface. Timing and intensity of phytoplankton blooms must match the abundance of zooplankton, and the eggs and larvae of fish and crustaceans, for maximum fisheries productivity (Johnson, 2016). Further, a warming climate may cause winter precipitation to shift from a snow to rain-dominated system on the Gulf of Alaska coast. As such, the spring phytoplankton bloom may occur earlier and may not be available to zooplankton, which would reduce zooplankton productivity and result in a subsequent decrease in fisheries production (Johnson, 2016).

Studies indicate that sustained periods of warming can elevate metabolic costs to organisms, reduce available energy to higher trophic level fishes, and ultimately change the trophic structure of the ecosystem (Anderson & Piatt, 1999; Brodeur & Daly, 2019; Clark et al., 2010; Johnson, 2016; National Oceanic and Atmospheric Administration, 2020a; Overland & Wang, 2007; Schwing et al., 2010; von Biela et al., 2019; Zador et al., 2019). The 1977 shift to a warmer climate regime in the North Pacific (Pacific Decadal Oscillation) was accompanied by an increase in zooplankton, salmon, cod, and pollock production, but it also brought steep declines in forage fish, crab, and shrimp (Johnson, 2016). For many years, these type of Pacific Decadal Oscillation regime shifts served as useful indices for understanding climate variability and predicting fish productivity and distribution patterns. However, as described below, climate change appears to be causing more extreme variations of ocean temperatures and wind patterns and are making correlations between Pacific Decadal Oscillation regime changes and biological variables more difficult to predict (National Oceanic and Atmospheric Administration, 2020b).

Over the past several years, the mass of warm water in the Gulf of Alaska (called the “Blob”) that impacted marine fish species and ecosystems the entire length of the U.S. West Coast, reduced the availability of phytoplankton and zooplankton. Scientists have associated a marked absence of pollock larvae surviving into late summer with those portions of the Gulf of Alaska affected by the Blob (Johnson, 2016). Although some scientists believe that the Blob could be associated with a particularly warm Pacific Decadal Oscillation phase, based on the different mechanism involved it is more likely a factor of human-caused climate change and potentially representative of future climate change impacts (Freedman & Tierney, 2019; Liang et al., 2017). The warm surface waters inhibit nutrients from being mixed into the surface layer to fuel production of phytoplankton. Furthermore, warm-water currents off the Pacific Coast bring southern varieties of zooplankton, particularly copepods, which have low lipid (fat) content and are less nutritious to fish and birds than the normally available northern varieties of copepods and krill. Increases in euphausiid (krill) abundance have been strongly correlated with cold temperatures in the Bering Sea (National Oceanic and Atmospheric Administration, 2019; Ressler et al., 2014), but not in the Gulf of Alaska (Simonsen et al., 2016). However, “cold water” copepods have been found to be more abundant during cold-water periods (Keister et al., 2011), so it remains to be seen how climate change will affect the production of northern copepods and krill in the Gulf of Alaska that provide high-energy nutrition to pollock and salmon.

The Blob has also significantly reduced the Pacific cod *(Gadus microcephalus)* population in the Gulf of Alaska through an increase in metabolic demand and reduced prey supply (Gisclair, 2019). With cod stocks falling, the North Pacific Fishery Management Council (NPFMC) set an 80 percent reduction in the catch limit in 2018 and an additional reduction of 5 percent in 2019. The NPFMC completely closed the directed fishery in 2020 and reduced cod bycatch limits for other fisheries. These rules were enacted to reduce overfishing, avoid long-term population-level effects, and protect Steller sea lions, which rely on cod for prey (Gisclair, 2019).

Ocean acidification, a climate change related process where increasing atmospheric carbon dioxide concentrations are reducing ocean pH and carbonate ion concentrations, may have serious impacts on fish development and behavior (Raven et al., 2005). Ocean acidification is expected to progress faster and more severely in Alaska than lower latitudes because cold Alaskan waters hold more carbon dioxide year-round and have a high baseline concentration of carbon dioxide (Alaska Ocean Acidification Network, 2019). Acidification of seawater reduces the amount of calcium carbonate minerals needed for shell-building organisms to build and maintain their shells, which poses a danger for species such as crab, clams, pelagic calcifying snails (pteropods) and some types of zooplankton. Changes in ocean chemistry can also affect fish. For instance, higher acidity water has been shown to reduce the ability for some fish to detect predators (Alaska Ocean Acidification Network, 2019).

Pteropods are a key food source for salmon, herring, and other fish in the Gulf of Alaska (Alaska Ocean Acidification Network, 2019; Johnson, 2016). Extensive shell dissolution has been documented in pteropods in both the Gulf of Alaska and the Bering Sea (Alaska Ocean Acidification Network, 2019). It has been estimated that a 10 percent decrease in pteropods could cause a 20 percent decrease in body weight of adult pink salmon (Chapin III et al., 2014; Johnson, 2016).

Azumaya and Urawa (2019) found that the distribution of chum salmon in the North Pacific in summer has shifted northward and the area of chum distribution has decreased approximately 5 percent during the last 36 years due to recent warming trends. A National Oceanic and Atmospheric Administration study found that Pacific cod shift abundance to deeper water in warm years (Johnson, 2016). Predation, competition, and disease are likely to have a greater negative impact as northern seas warm. While researchers have found that naturally occurring salmon sharks *(Lamna ditropis)* regularly contribute to high mortality rates of Chinook salmon in the Bering Sea (Seitz et al., 2019), more southern species of sharks (e.g., great white sharks [*Carcharodon carcharias*], common thresher sharks (*Alopias vulpinus*]) tend to occur more frequently in the Gulf of Alaska during particularly warm years and are very effective predators on salmon and herring (Johnson, 2016). Pacific pomfret (*Brama japonica*), and possibly Pacific mackerel (*Scomber japonicus*), have appeared in Alaska waters; they prey on juvenile salmonids and are aggressive competitors for the same prey resources (Johnson, 2016).

Due to the dynamic factors associated with climate change, effects on salmonids are difficult to predict. Studies and modeling have shown that climate change could result in a range of beneficial and adverse effects. The impacts on climate change on West Coast freshwater spawning and rearing habitats have been studied thoroughly and are expected to present significant challenges for salmonids (Crozier & Siegel, 2017). However, salmonids that use the Gulf of Alaska may benefit from increased primary productivity in the ocean, even though results of some research suggest that higher quality prey, like the more lipid-rich copepods that predominate during cooler water phases, tend to produce higher juvenile salmon survival. This is particularly the case if migration timing and plankton bloom timing are in phase (Johnson, 2016).

Since the 1977 regime shift to a warmer phase, pink, chum, and sockeye have been more productive, while coho and Chinook did not respond so positively. This is likely because these salmonids migrate to the ocean early in their life when they are small and, thus, feed on lower trophic levels for a longer period of time than do Chinook and coho. Therefore, almost all their biomass is accumulated in the marine environment (Irvine & Fukuwaka, 2011). Some stocks may spread into or become more firmly established in arctic waters with warming temperatures. For example, Larson et al. (2013) used genetic stock identification to show that a significant portion of stocks from California to Southeast Alaska overwinter in the Gulf of Alaska, then travel northward to the continental shelf region of the eastern Bering Sea during spring and summer. This migration pattern is thought to be driven by warm summer temperatures in the Gulf of Alaska, which promote northward movement towards the cooler and more productive Alaskan continental shelf. With temperatures rising in the Gulf of Alaska due to climate change, it is possible that this region will become even less hospitable to salmonids during the summer months, increasing the proportion of salmon stocks that spend the summer in the Bering Sea (Abdul-Aziz et al., 2011; Myers et al., 2007). Future research incorporating similar data could provide direct evidence of shifting salmonid migration patterns in response to climate change.

High-seas salmon have also shown the ability to adapt to climate-induced changes in their prey resources by switching their diets either within or between trophic levels (Brodeur & Daly, 2019; Fergusson et al., 2019; Kaeriyama et al., 2004). However, on the other hand, an extreme interpretation of models based on climate change scenarios predicts that by 2100 the ocean winter habitat of Pacific Northwest sockeye salmon would decrease by 38 percent and summer habitat for Chinook by 86 percent, sockeye by 45 percent, 30 percent for coho, 30 percent for pink, and 29 percent for chum (Abdul-Aziz et al., 2011; Johnson, 2016). Projected losses would be greatest in the Gulf of Alaska and may include nearly complete loss of habitat for sockeye (Abdul-Aziz et al., 2011). Recent and ongoing field work and modeling by the National Oceanic and Atmospheric Administration suggests that the manifestations of warming in the Gulf of Alaska will continue, highlighting the need for continued research and monitoring of conditions and biological responses to these changes (National Oceanic and Atmospheric Administration, 2020a; Zador et al., 2019).

Commercial and Recreational Fishing

For information on updated data for commercial and recreational fishing in the state of Alaska see Section 3.11 (Socioeconomic Resources and Environmental Justice). Commercial and recreational fishing can adversely affect fish populations, other species, and habitats. Potential impacts of fishing include overfishing of targeted species, bycatch, entanglement, and habitat modification. Bycatch is the capture of fish, marine mammals, sea turtles, seabirds, and other nontargeted species that occur incidentally to normal fishing operations. Fisheries bycatch has been identified as a primary driver of population declines in several marine species, including sharks, mammals, seabirds, and sea turtles (Wallace et al., 2010). Use of mobile fishing gear such as bottom trawls disturb the seafloor and may reduce habitat structural complexity. Indirect impacts of trawls were described in the 2011 Final GOA EIS/OEIS and include increased turbidity, alteration of surface sediment, removal of prey (leading to declines in predator abundance), and removal of predators (Hamilton Jr., 2000). Lost gill nets, purse seines, and long-lines may foul and disrupt bottom habitats and have the potential to entangle or be ingested by marine animals (National Marine Fisheries Service, 2017).

In addition to being subject to capture in fisheries closer to their natal rivers, federally listed salmonids are caught in several fisheries that operate in GOA waters. These fisheries include the following: groundfish fisheries managed by NMFS under the FMP for Groundfish of the Gulf of Alaska (North Pacific Fishery Management Council, 2019); salmon fisheries under the FMP for the Salmon Fisheries in the Exclusive Economic Zone (EEZ) off Alaska (North Pacific Fishery Management Council et al., 2018); Pacific salmon fisheries that operate under the Pacific Salmon Treaty between the United States and Canada (Pacific Salmon Commission, 2020); and State of Alaska-managed commercial, recreational (personal use), sport, and subsistence fisheries for Pacific salmon that operate in the Gulf of Alaska. State fisheries do not operate in the TMAA so are not further discussed. Updates to the FMPs are provided in Section 3.6.2.9 (Essential Fish Habitat).

Groundfish fisheries do occur in the TMAA and are known to incidentally capture ESA-listed salmonids (Dorn et al., 2019; Guthrie III et al., 2019; Guthrie III et al., 2020; Masuda, 2019; Masuda et al., 2019; Schnaittacher & Narita, 2019, 2020). Annual prohibited species catch limits in groundfish fisheries are established by the NPFMC for Chinook salmon in the central and western GOA. The National Marine Fisheries Service (2017b) has indicated that only a small percentage of these fish would be expected to be from ESA-listed populations.

Marine Debris and Pollution

Marine debris is any anthropogenic object intentionally or unintentionally discarded, disposed of, or abandoned in the marine environment. Common types of marine debris include various forms of plastic and abandoned fishing gear, as well as clothing, metal, glass, and other debris. Marine debris degrades marine habitat quality and poses ingestion and entanglement risks to marine life (National Marine Fisheries Service, 2006).

Plastic marine debris is a major concern because it degrades slowly and many plastics float, allowing the debris to be transported by currents throughout the oceans. Currents in the oceanic convergence zone in the North Pacific Subtropical Gyre act to accumulate the floating plastic marine debris. These debris-carrying currents include the south-flowing California Current and the north-flowing GOA Current. These currents distribute debris throughout the TMAA.

A major concern associated with plastic waste is degradation into microplastics, which are consumed by zooplankton and various filter feeders (e.g., oysters) and then bioaccumulate. Some fish and marine organisms have been shown to fill up their stomachs with indigestible material and then starve to death because they feel full but haven’t received the nutrition they require (Jambeck, 2018; Prinz & Korez, 2019). Microplastics can also alter the behavior of fish, with those that ingest the pollutants likely to be bolder, more active, and swim in risky areas, which can lead to mortality (McCormick et al., 2020).

Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyl (PCB) and dichlorodiphenyltrichloroethane (DDT), which accumulate up to one million times more in plastic than in ocean water (Mato et al., 2001). Marine animals can mistakenly consume these wastes, which contain elevated levels of toxins, instead of their prey. In the North Pacific Subtropical Gyre, it is estimated that the fishes in this area are ingesting 12,000–24,000 U.S. tons (10,886,216–21,772,433 kilograms) of plastic debris a year (Davison & Asch, 2011).

Debris that sinks to the seafloor is also a concern for ingestion and entanglement of fish and contributes to marine habitat degradation. West Coast groundfish bottom trawl surveys in 2007/2008 found anthropogenic debris at depths of 55–1,280 m, and the density increased with depth. The majority of debris was plastic and metallic while the rest was composed of fabric and glass (Keller et al., 2010).

Offshore petroleum production and local, transitory pollution events such as oil spills pose some degree of risk. Offshore petroleum production and large-scale transport of petroleum occurs in the Alaska EEZ, although at this time there is no offshore production of petroleum in the commercial troll area of the EEZ (North Pacific Fishery Management Council et al., 2018). Offshore oil and gas development and transport will inevitably result in some oil entering the environment at levels exceeding background amounts. The Exxon Valdez oil spill was shown to have direct effects on the survival, fitness, and habitats of pink salmon and herring (Rosen, 2017). The herring population in Prince William Sound crashed in 1993, just four years after the Exxon Valdez oil spill, and has yet to recover. Scientists have not been able to determine if and how the spill played a role in the collapse of the herring population (Robertson & Pegau, 2018; Rosen, 2017). Chinook salmon were not directly affected, because of their different habitat utilization in the spill area (North Pacific Fishery Management Council, 2018b). In general, the early life history stages of fish are more susceptible to oil pollution than juveniles or adults (North Pacific Fishery Management Council, 2018b).

3.6.2.2 Chinook Salmon (*Oncorhynchus tshawytscha*)

3.6.2.2.1 Status and Management

Since the 2016 GOA Final SEIS/OEIS, NMFS has responded to petitions to list the Upper Klamath-Trinity River Chinook Salmon ESU (83 FR 8410) and Oregon Coast spring-run Chinook Salmon ESU (85 FR 20476) as threatened or endangered species under the ESA (Table 3.6-1). NMFS determined that the petitions present substantial scientific information indicating that the petitioned actions may be warranted and plans to conduct status reviews of both Chinook salmon ESUs. There have been no other listing status changes to ~~other~~ Chinook salmon ESUs since 2016.

3.6.2.2.2 Distribution

Chinook salmon distribution in marine waters varies seasonally and inter-annually due to a variety of environmental factors (Pacific Fishery Management Council, 2014). However, there are general migration and ocean distribution patterns characteristic of populations in specific geographic areas (North Pacific Fishery Management Council et al., 2018). Chinook populations originating from river systems north of Cape Blanco, Oregon, tend to migrate north and westward along the Pacific coast, whereas those originating south of Cape Blanco tend to migrate west and south to forage in waters off Oregon and California (Masuda, 2019; North Pacific Fishery Management Council, 2018b; Quinn & Myers, 2005; Sharma, 2009b). As such, southern stocks (south of Cape Blanco) are less likely to use habitats in the Gulf of Alaska than northern stocks. However, as described in Section 3.6.2.7 (Site-Specific Information on Listed Salmonids in the Gulf of Alaska and Temporary Maritime Activities Area), juveniles from southern ESUs have been documented in the Gulf of Alaska, so it is possible that some individuals from southern populations could migrate into the TMAA.

Listed spring-run Chinook salmon from northern West Coast ESUs that originate from the Columbia River Basin are more likely to migrate into the Gulf of Alaska and the TMAA than other listed Chinook salmon. Upper Columbia River spring-run and Snake River spring/summer-run ESUs are more common off the continental shelf and in the open ocean during their marine residence (Masuda, 2019; Quinn, 2018; Sharma, 2009a), whereas other spring-run ESUs are primarily distributed on the shelf (Sharma, 2009a).

Listed fall- and summer-run Chinook salmon from West Coast ESUs tend to be primarily distributed along the continental shelf during their marine residence, remaining in coastal water throughout their ocean life (Sharma, 2009b). After emigrating from their natal streams, juveniles spend several months rearing in nearshore estuarine habitat, before moving onto the continental shelf. A recent study has shown that most juvenile Chinook captured off the Southeast Alaska coast originate from Columbia River spring-run stocks (Van Doornik et al., 2019). Columbia River fall Chinook generally undertake a rapid northward migration, but very few are recovered north of Vancouver Island (Trudel et al., 2009).

The vast majority of juvenile Chinook salmon in the Gulf of Alaska occur on the continental shelf, mostly in the inside waters of the Alexander Archipelago (Echave et al., 2012; National Marine Fisheries Service, 2017), although some Chinook move offshore by late summer (Brodeur et al., 2003). Immature Chinook salmon are also predominantly found on the continental shelf in the Gulf of Alaska, though they are distributed more widely throughout the Gulf of Alaska than juveniles (Echave et al., 2012; National Marine Fisheries Service, 2017). Most mature adults in the Gulf of Alaska are found along the outer coast and inside waters of the Alexander Archipelago. Echave et al. (2012) reported a relatively high abundance of mature Chinook salmon within Southeast Alaska waters (outside of the TMAA), likely because the surveys were conducted when the Chinook were returning to spawn. The offshore distribution off the southern end of the Archipelago was observed during winter sampling, when mature fish are more likely to be offshore in oceanic habitats.

Chinook salmon do not concentrate at the surface, as do other Pacific salmon, but are most abundant at depths of 30–70 meters (m) (North Pacific Fishery Management Council et al., 2018). However, juvenile Chinook salmon tend to be more abundant than adults near the surface, most frequently found at depths of less than 30 m (Fisher & Pearcy, 1995; Orsi & Wertheimer, 1995). Juvenile salmonids are not known to congregate in large schools in marine habitats (Moulton, 1997; Pearcy & Fisher, 1990). Preliminary evidence from the 2019 GOA Expedition suggests that adult salmonids may congregate in schools during the winter months (International Year of the Salmon, 2019).

Site-specific presence of ESA-listed Chinook salmon ESUs in the Gulf of Alaska, including CWT recoveries, is described in Section 3.6.2.7 (Site-Specific Information on ESA-Listed Salmonids in the Gulf of Alaska and Temporary Maritime Activities Area). With the exception of the two new candidate ESUs under review, some updated information on Chinook distribution and migratory patterns, and the site-specific presence information, the information presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remains valid. Table 3.6-2 shows the temporal patterns and horizontal/vertical distribution of ESA-listed fish species in the TMAA.

3.6.2.3 Coho Salmon (*Oncorhynchus kisutch*)

3.6.2.3.1 Status and Management

There has been no change in the status or management of coho salmon ESUs since the 2016 GOA Final SEIS/OEIS.

3.6.2.3.2 Distribution

After leaving their natal rivers, juvenile coho tend to use the cool, upwelled waters of the continental shelf for migration and feeding (Bellinger et al., 2015). In the Gulf of Alaska, juvenile coho predominantly occur in coastal waters, throughout the continental shelf and slope (Echave et al., 2012), with some coho moving offshore by late summer (Brodeur et al., 2003; North Pacific Fishery Management Council et al., 2018). Morris et al. (2007) found that juvenile coho from the lower Columbia River and coastal Oregon were recovered in or near the TMAA. Coho juveniles are generally found within the upper 30 m of the water column, with the majority in the top 10–15 m, which is shallower than most Chinook juveniles (North Pacific Fishery Management Council et al., 2018; Orsi & Wertheimer, 1995).

Table 3.6-2: Temporal Patterns and Horizontal/Vertical Distribution of ESA-Listed Fish Species in the Gulf of Alaska and the TMAA

Common Name (Scientific Name)	*Temporal Patterns*	*Horizontal Distribution*	*Vertical Distribution*
Chinook Salmon (*Oncorhynchus tshawytscha*)	Juveniles: Mid-summer to early fall	Juveniles: Majority distributed on continental shelf, mostly in the inside waters of SE Alaska. Smaller abundances found throughout inner and outer shelf waters off Montague Island.	Juveniles: More abundant than adults near the surface, typically at depths less than 30 m (Fisher & Pearcy, 1995; Orsi & Wertheimer, 1995).
	Immature Adults: Year-round	Immature Adults: Mostly distributed on the shelf to just beyond the outer shelf. More widely distributed than juveniles.	Immature Adults: Same as maturing adults.
	Maturing Adults: Mature fish leave in September.	Maturing Adults: Majority within outer coast and inside waters of SE Alaska. Higher relative abundance in SE Alaska waters in summer. More likely to use offshore habitats in winter.	Maturing Adults: Less surface oriented than other Pacific salmon. Deeper depths than juveniles (typically 30–70 m).
Coho Salmon (*Oncorhynchus kisutch*)	Juveniles: June to September	Juveniles: Predominantly occur in coastal waters, throughout the continental shelf and slope. Move offshore by late summer.	Juveniles: Generally shallower than Chinook with majority found at depths of 10–15 m (North Pacific Fishery Management Council, 2018a; Orsi & Wertheimer, 1995).
	Immature/Maturing Adults: Year-round. Mature fish leave in late summer	Immature/Maturing Adults: Continental shelf and beyond into offshore waters.	Immature/Maturing Adults: Primarily within upper 30 m (Walker et al., 2007).
Chum Salmon (*Oncorhynchus keta*)	Juveniles: July to September	Juveniles: Distributed throughout the inner and middle shelf. By the end of their first fall at sea, most fish have moved into offshore waters.	Juveniles: Mostly in top 15 m of water column (Beamish et al., 2007b).
	Immature/Maturing Adults: Year-round. Mature fish leave in early fall.	Immature/Maturing Adults: Distributed throughout the outer portion of the shelf and as far offshore as the U.S. EEZ boundary.	Immature/Maturing Adults: Majority found at 0–30 m depths (Walker et al., 2007).

Table 3.6-2: Temporal Patterns and Horizontal/Vertical Distribution of ESA-Listed Fish Species in the Gulf of Alaska and the TMAA (continued)

Common Name (Scientific Name)	***Temporal Patterns***	***Horizontal Distribution***	***Vertical Distribution***
Sockeye Salmon (*Oncorhynchus nerka*)	Juveniles: Early summer to late winter	Juveniles: Distribution generally contained to the continental shelf.	Juveniles: Shallowest depths of any salmonids (Walker et al., 2007). Mostly found within top 15 m of water column (Beamish et al., 2007a) and within top 5 m in some areas (Walker et al., 2007).
	Immature: Year-round	Immature: Distributed from nearshore waters to the U.S. EEZ boundary.	Immature: Surface-oriented
	Adults: Mature fish leave in early August	Adults: Occur in relatively low abundances extending out to the U.S. EEZ boundary.	Adults: Generally surface oriented (upper 10 m) (Walker et al., 2007).
Steelhead (*Oncorhynchus mykiss*)	Juveniles: Summer to fall	Juveniles: Offshore migration through North Pacific to the western Gulf of Alaska.	Juveniles: Same as adults
	Immature/Maturing Adults: Year-round. Spawners leave in spring/summer	Immature/Maturing Adults: Offshore, widely distributed across North Pacific. May pass through the Gulf of Alaska but migrate south of TMAA when returning to spawn (Light et al., 1989).	Immature/Maturing Adults: Surface-oriented (0–10 m) (Light et al., 1989).
Green Sturgeon (*Acipenser medirostris*)	Subadults and adults: Fall and winter	Subadults and adults: Likely widely distributed over the continental shelf (if present).	Subadults and adults: <200 m depth (primarily 40–110 m) (Erickson & Hightower, 2007; Huff et al., 2012).

Notes: SE = Southeast, EEZ = Exclusive Economic Zone, GOA = Gulf of Alaska, m = meter(s), TMAA = Temporary Maritime Activities Area
Sources: (Echave et al., 2012); (North Pacific Fishery Management Council et al., 2018); (National Marine Fisheries Service, 2017) (unless specified otherwise)

Immature and mature coho in the Gulf of Alaska occur along the continental shelf but also occur in offshore oceanic waters beyond the shelf break (Echave et al., 2012). The 2019 GOA Expedition found relatively high abundances of coho adults in the Gulf of Alaska offshore habitats (International Year of the Salmon, 2019). Immature and mature adults are generally found within the top 50 m but more typically occur at depths shallower than 20 m (Walker et al., 2007).

Updated information on site-specific presence of ESA-listed coho salmon ESUs in the Gulf of Alaska is described in Section 3.6.2.7 (Site-Specific Information on Endangered Species Act-Listed Salmonids in the Gulf of Alaska and Temporary Maritime Activities Area). With the exception of the inclusion of updated distribution and migratory patterns and site-specific presence data, the information presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remains valid.

3.6.2.4 Chum Salmon (*Oncorhynchus keta*)

3.6.2.4.1 Status and Management

There have been no listing status changes to chum salmon ESUs since 2016. In 2017, NMFS received a petition to list the winter-run Puget Sound chum salmon in the Nisqually River system and Chambers Creek as a threatened or endangered ESU under the ESA. Following a review completed in 2017, NMFS determined that winter-run chum salmon from these river systems do not qualify as an ESU and was not eligible for listing under the ESA (82 FR 33064).

3.6.2.4.2 Distribution

Chum generally move north and west along the coast upon entering saltwater and move offshore by the end of their first ocean year (Byron & Burke, 2014; Quinn, 2018). Some data suggest that Puget Sound chum, including those in the Hood Canal summer-run ESU, may not make an extended migration into northern British Columbian and Alaskan waters, but instead may travel directly offshore into the north Pacific Ocean (Hartt & Dell, 1986). Myers et al. (1996) documented maturing chum salmon from Washington and the Columbia River in offshore areas of the Gulf of Alaska, though only a small number of coded-wire tag recoveries were observed.

Within the Gulf of Alaska, juvenile chum salmon are distributed throughout the inner and middle shelf along the Gulf coastline between July and September (Echave et al., 2012), but that by the end of their first fall at sea, most fish have moved off the continental shelf into open waters (Quinn, 2018). Immature and mature chum salmon are distributed widely throughout the outer portion of the continental shelf and over oceanic waters as far offshore as the U.S. EEZ boundary (Echave et al., 2012).

Juvenile chum salmon are surface oriented and typically found within the top 15 m of the water column (Beamish et al., 2007b). In Southeast Alaska, juvenile chum salmon were observed near the surface as small aggregations (10–50 fish) but not in large schools (Moulton, 1997). However, immature and mature chum salmon have a deeper vertical distribution (second only to Chinook salmon). The majority are found at 0–30 m depths, but they have been captured as deep as 120 m in the Bering Sea (Walker et al., 2007).

Updated information on site-specific presence of ESA-listed chum salmon ESUs in the Gulf of Alaska is described in Section 3.6.2.7 (Site-Specific Information on Endangered Species Act-Listed Salmonids in the Gulf of Alaska and Temporary Maritime Activities Area). With the exception of the inclusion of updated distribution and migratory patterns and site-specific presence data, the information presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remains valid.

3.6.2.5 Sockeye Salmon (*Oncorhynchus nerka*)

3.6.2.5.1 Status and Management

There has been no change in the status or management of sockeye salmon ESUs since the 2016 GOA Final SEIS/OEIS.

3.6.2.5.2 Distribution

Sockeye tend to follow a similar migration pattern as chum once they enter the ocean, moving north and west along the coast, and may move offshore or stay inshore at the end of their first ocean year (Beacham et al., 2014; Byron & Burke, 2014; Quinn, 2018). In the Gulf of Alaska, the distribution of juvenile sockeye salmon is generally contained to the continental shelf (Echave et al., 2012). Immature sockeye are distributed from the nearshore waters to the U.S. EEZ boundary throughout the entire Gulf of Alaska (Echave et al., 2012). Similarly, mature sockeye occur in relatively low abundances extending from coastal waters to the U.S. EEZ boundary (Echave et al., 2012). Myers et al. (1996) documented maturing sockeye salmon from Washington and the Columbia River in offshore areas of the Gulf of Alaska.

Juvenile sockeye are generally found in the top 15 m of the water column (Beamish et al., 2007a). An analysis of juvenile salmonids from 2,968 sets between 0 and 60 m in depth in coastal BC showed that 80–87 percent of sockeye salmon were captured in the top 15 m (Beamish et al., 2007a). Depth data from a limited number of data storage tags in the North Pacific Ocean indicated that sockeye juveniles had the shallowest vertical distribution of any salmonids (regularly found within the top 5 m of the water column) (Walker et al., 2007). Immature and mature sockeye are generally surface oriented (upper 10 m) but have been found up to 80 m in the Bering Sea (Ogura & Ishida, 1995; Quinn et al., 1989; Walker et al., 2007).

The information regarding sockeye salmon presented in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS remains valid. Therefore, no additional updates are required.

3.6.2.6 Steelhead (*Oncorhynchus mykiss*)

3.6.2.6.1 Status and Management

There have been no steelhead listing status changes since the 2016 GOA Final SEIS/OEIS was issued. In February 2020, NMFS responded to a petition to list the Northern California summer-run steelhead as an endangered DPS under the ESA (85 FR 6527) (Table 3.6-1). Based on the best scientific and commercial data available, including the DPS configuration review report, NMFS determined that: (1) listing Northern California summer-run steelhead as an endangered DPS was not warranted; and (2) summer-run steelhead do not meet the criteria to be considered a separate DPS from winter-run steelhead (85 FR 6527). There have been no listing status changes to other steelhead DPSs since 2016.

3.6.2.6.2 Distribution

Steelhead are thought to rely heavily on offshore marine waters for feeding, with high seas tagging programs indicating steelhead make more extensive migrations offshore in their first year than any other Pacific salmonids (Quinn & Myers, 2005). Juveniles migrate rapidly through estuaries, bypass coastal migration routes of other salmonids, and move into oceanic offshore feeding (Daly et al., 2014; Quinn & Myers, 2005). McKinnell et al. (2011) assessed the distribution of North American hatchery steelhead stock in the Gulf of Alaska and Aleutian Islands using CWT mark and recapture data from 1981 through 1994. These data showed that tagged steelhead from hatcheries in the upper, middle, and lower Columbia River, the Snake River basin, coastal Washington, and Puget Sound were recaptured in offshore waters of the northern and southern Gulf of Alaska and the Aleutian Islands.

Tagging and diet studies indicate that adult and juvenile steelhead are surface oriented, spending most of their time in the top 10 m of the surface in oceanic feeding grounds off the continental shelf (Light et al., 1989). Steelhead adults may migrate within 1 m of the surface when returning over the shelf to their natal stream (Light et al., 1989).

Site-specific presence of ESA-listed steelhead DPSs in the Gulf of Alaska is described in Section 3.6.2.7 (Site-Specific Information on Endangered Species Act-Listed Salmonids in the Gulf of Alaska and Temporary Maritime Activities Area). With the exception of the inclusion of updated distribution and migratory patterns and site-specific presence data, the information presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remains valid.

3.6.2.7 Site-Specific Information on Endangered Species Act-Listed Salmonids in the Gulf of Alaska and Temporary Maritime Activities Area

Salmon Bycatch in the Groundfish Fishery

Chinook salmon incidentally taken in the pollock fishery historically account for the greatest proportion of Chinook salmon taken in the GOA groundfish fisheries (Schnaittacher & Narita, 2019, 2020). Chum salmon typically account for over 95 percent of the non-Chinook salmon catch, with the remainder consisting of smaller abundances of coho, pink, and sockeye salmon (Schnaittacher & Narita, 2019). These salmonids may comprise ESA-listed and nonlisted fish from Oregon and Washington as well as non-listed fish from British Columbia or Alaska.

Prior to 1998, salmon bycatch was identified to species. Since then, annual estimates of non-Chinook salmon have been combined (Schnaittacher & Narita, 2019). Salmon bycatch generally occurs on vessels fishing with trawl gear. Other gear used to harvest groundfish, such as longline and pot, generally do not catch many salmonids. In the Gulf of Alaska, the majority of salmon bycatch occurs in the pollock trawl fishery, although other target fisheries for flatfish, rockfish, and Pacific cod also can capture Chinook salmon. The incidental harvest of Chinook salmon from federally managed groundfish fisheries in the Gulf of Alaska averaged 21,389 salmon per year from 1990 to 2019, ranging from a low of 8,475 individuals in 2009 to a peak of 54,696 in 2010 (Schnaittacher & Narita, 2019). Comparatively, the number of "other" salmon captured in the GOA groundfish fisheries is relatively low (North Pacific Fishery Management Council, 2020). Over the past six years, non-Chinook bycatch in the Gulf of Alaska ranged from 1,320 (in 2015) to 9,149 (in 2018) salmon and averaged approximately 4,700 salmon (National Marine Fisheries Service, 2020a).

In 2018, the pollock trawl fishery contributed the largest component to Chinook salmon bycatch in the Gulf of Alaska with an estimated 14,820 fish. An additional 2,364 fish from the rockfish trawl and other fisheries increased the Chinook salmon bycatch total to an estimated 17,184 fish (Guthrie III et al., 2019). In 2019, the total incidental catch of Chinook salmon in the Gulf of Alaska from the groundfish fishery was 23,893 individuals and the incidental catch of non-Chinook salmon was 6,407 (Schnaittacher & Narita, 2019).

The estimated prohibited species catch of chum salmon in the Gulf of Alaska (National Marine Fisheries Service, 2016c) is one to two orders of magnitude lower than in the Bering Sea and has been a lower management priority than the typically larger catches of Chinook salmon (Guthrie III et al., 2017). In 2016, chum salmon samples were collected in the Gulf of Alaska, primarily from the pollock trawl fishery, which caught about 56 percent of the chum salmon prohibited species catch. The majority of chum salmon from the non-pollock fisheries were caught in the arrowtooth flounder, sablefish, rockfish, and halibut fisheries (Whittle et al. 2018).

For several years, the Bering Sea pollock industry has been working on developing a Chinook salmon excluder device for trawl gear, which allows salmon to escape from the trawl net underwater, while retaining pollock. The success of such devices relies on the different swimming behaviors and sensory capacities of pollock and Chinook salmon. Through experimental fishery permits authorized by the NPFMC and NMFS, various iterations have been tested, and their voluntary use by pollock skippers is increasing. Recently, the Gulf of Alaska pollock industry has begun to consider how the Bering Sea Chinook salmon excluder might be adapted for the smaller GOA pollock fleet (North Pacific Fishery Management Council, 2020).

In 2012, NMFS implemented Amendment 93 to the GOA Groundfish FMP, which required retention of salmon by all vessels in the GOA pollock fisheries until the catch is delivered to a processing facility where an observer can collect genetic samples and screen for CWTs (77 FR 42629) (National Marine Fisheries Service, 2019). Genetic and CWT data are used for many purposes, including stock contribution studies, in order to better manage harvest rates for conservation of the resource and provide documentation of ESA-listed fish to support ESA Section 7 consultations (Nandor et al., 2010).

Genetic Sampling

In 2013, NMFS restructured the North Pacific Observer Program when it implemented Amendment 76 to the GOA Groundfish FMP. Observer coverage and deployment are no longer based on vessel length and processing capacity; rather, NMFS now has the flexibility to decide when and where to deploy observers based on a scientifically defensible sampling design. The design of the new program serves to reduce sources of bias that jeopardized the statistic reliability of catch and bycatch data collected by the North Pacific Observer Program (Schnaittacher & Narita, 2019).

North Pacific fisheries observers enumerate all non-target species bycatch (including salmon) using a whole-haul or systematic subsampling process, as appropriate. Starting in 2013, the Alaska Groundfish Data Bank implemented a census approach whereby genetic samples and biological information were collected from every Chinook salmon encountered as bycatch in the rockfish trawl fisheries. In 2014, the North Pacific Observer Program implemented a simple random sampling protocol for the collection of genetic Chinook salmon samples for the trawl fisheries for walleye pollock in the Gulf of Alaska (Faunce et al., 2014). Since then, there have been many iterations of the sampling design (Faunce, 2015). Now, observers are required to collect a genetic sample from every Chinook and chum specimen encountered in the pollock fishery (Alaska Fisheries Science Center, 2019). The majority of the Chinook and chum salmon bycatch genetic tissue samples are derived from the bottom and midwater pollock trawl fishery (Guthrie III et al., 2020; Whittle et al., 2018).

In 2018, 15 percent of the estimated Chinook salmon bycatch from the pollock fishery were successfully genotyped (Guthrie III et al., 2020). During this year, bycatch samples were collected from trawling conducted off Kodiak Island, just west of the TMAA. Based on analysis of 2,226 Chinook salmon samples from a total bycatch of 14,820 fish, British Columbia (43 percent; 6,433), U.S. West Coast (33 percent; 4,846), and Coastal Southeast Alaska (18 percent; 2,728) stock groups comprised the largest regional contributions. In 2016, 473 chum salmon samples were analyzed from the GOA groundfish fisheries; the highest proportion was from Eastern Gulf of Alaska/Pacific Northwest (93 percent) stocks, similar to previous years (Whittle et al., 2018).

Genetic samples from the GOA rockfish fishery bycatch were also collected in 2018 (Guthrie III et al., 2020). Based on the genotyping of 504 Chinook salmon bycatch samples collected from this fishery in NMFS Statistical Area 630 (central Gulf of Alaska area that overlaps the shelf portion of the TMAA), the U.S. West Coast region had the largest contribution (53 percent: 264) with smaller contributions from British Columbia (28 percent; 141), and Coastal Southeast Alaska (11 percent; 54) regions. The 2018 GOA stock composition estimates for Chinook salmon bycatch in both the trawl and rockfish fisheries follow a similar trend observed in recent years with most (>90 percent) Chinook salmon encountered originating from three large southern regions between coastal Southeast Alaska and northern California. This pattern also holds for samples collected across finer-scale time and area strata within the Gulf of Alaska (Guthrie III et al., 2020).

Two primary factors dictate the observed trends in genetic stock composition of trawl fishery bycatch in the Gulf of Alaska. First, British Columbia and U.S. West Coast systems produce orders of magnitude more Chinook salmon each year than Alaska systems, yielding the much greater proportion of these stocks. Second, the timing of the fisheries may also drive some of these trends. British Columbia and U.S. West Coast stocks have both spring and fall runs of Chinook salmon, which may lead to the presence of greater overlap with trawl fisheries in the Gulf of Alaska, as compared to Alaskan stocks, which are dominated by a spring out-migration of smolts, reducing periods of potential overlap with trawl fleets (Zador et al., 2018).

Recent CWT Studies

CWT studies were reviewed to examine the potential for salmon bycatch captured in the Gulf of Alaska groundfish fishery to include ESA-listed fish (Masuda, 2019; Masuda et al., 2019). In 2019, NMFS prepared an annual report on the stock of origin and CWT data from incidental catch of salmon in 2018 (Masuda, 2019). The report included maps showing the ocean distribution of CWT Chinook salmon from ESA-listed ESUs from the Pacific Northwest. These maps were compiled from the historical database of CWT recoveries (1981–2018) from high seas commercial fisheries and research surveys: GOA groundfish fisheries, GOA rockfish trawl fishery, at-sea Pacific hake trawl fishery off the U.S. West Coast, and the West Coast groundfish trawl fishery, as well as domestic and foreign research surveys in the North Pacific Ocean and the Gulf of Alaska (Masuda, 2019). It should be noted that these fisheries are predominantly on-shelf and, while they may overlap a portion of the nearshore portion of the TMAA, the data will be biased toward those areas where these groundfish fisheries occur, thus providing an incomplete representation of salmonid occurrence in the TMAA.

Since the late 1960s, CWTs have been used in the greater Pacific region (Alaska, British Columbia, Washington, Idaho, Oregon, and California) to mark anadromous salmonids (Nandor et al., 2010). Over 50 million Pacific salmonids with CWTs are released yearly by 54 federal, provincial, state, tribal, and private entities (North Pacific Fishery Management Council, 2018b). Although some tagging of wild stocks occurs (mainly in Alaska), CWTs are used mostly for tagging of hatchery fish. As such, wild stocks of Chinook salmon are generally under-represented by CWTs, especially outside of Alaska.

Despite region-wide usage, CWT sampling coverage does have some limitations (Nandor et al., 2010). Chinook and coho salmon are the only species sampled in commercial and sport fisheries on a coastwide basis. Some sampling does occur for chum, sockeye, pink salmon, and steelhead, but it is much more limited. In such cases, it typically involves agency-specific management objectives in marine terminal areas or limited freshwater areas. Nevertheless, CWTs remain the only stock identification tool that is Pacific coastwide in scope and provides unparalleled information about ocean distribution patterns, fishery impacts, and survival rates for listed Pacific salmon (Nandor et al., 2010). Table 3.6-3 is a summary of CWT recoveries for various adult and juvenile salmonids in the Gulf of Alaska.

As expected, most of the CWT recoveries in the Gulf of Alaska consist of spring-run Chinook from northern West Coast ESUs. The most frequently detected CWT Chinook salmon recovered in the GOA groundfish fisheries have originated from the Upper Willamette River ESU (n=200) and the Lower Columbia River ESU (n=38) (Table 3.6-3). These Chinook have been detected throughout the northern GOA, including offshore areas off Kodiak Island, along the Aleutian Islands, and into the Bering Sea (Masuda, 2019). Relatively high abundances of Snake River spring/summer-run Chinook have also been detected in U.S. research surveys (Table 3.6-3). It was somewhat surprising to find a relatively large number of Snake River fall-run Chinook in the GOA, along with a rare individual from the Central Valley spring-run Chinook ESU. It was not surprising to find a few coho migrating through the Gulf of Alaska, as they tend to utilize offshore areas during their marine residence.

Table 3.6-3: CWT Recoveries of ESA-Listed Salmonids in the Gulf of Alaska

Species	ESU	Federal Status	Adult or Juvenile	Number	Type of Study	Survey Year	Reference
Chinook Salmon	Puget Sound ESU	T	Adult	1	Rockfish trawl fishery	2013–2018	(Masuda, 2019)
			Juvenile	1	NMFS research surveys	1996–2017	(Masuda, 2019)
	Upper Columbia River Spring-run ESU	E	Adult	1	Groundfish fisheries	1981–2018	(Masuda, 2019)
				1	Rockfish trawl fishery	2013–2018	(Masuda, 2019)
			Juvenile	27	NMFS research surveys	1996–2017	(Masuda, 2019)
	Lower Columbia River ESU	T	Adult	38	Groundfish fisheries	1981–2018	(Masuda, 2019)
				2	Rockfish trawl fishery	2013–2018	(Masuda, 2019)
			Juvenile	11	NMFS research surveys	1996–2017	(Masuda, 2019)
	Snake River Spring/Summer-run ESU	T	Adult	1	Groundfish fisheries	1981–2018	(Masuda, 2019)
				2	Rockfish trawl fishery	1981–2018	(Masuda, 2019)
			Juvenile	41	NMFS research surveys	1996–2017	(Masuda, 2019)
	Snake River Fall-run ESU	T	Adult	7	Groundfish fisheries	1981–2018	(Masuda, 2019)
				6	Rockfish trawl fishery	2013–2018	(Masuda, 2019)
			Juvenile	6	NMFS research surveys	1996–2017	(Masuda, 2019)
	Upper Willamette River ESU	T	Adult	200	Groundfish fisheries	1981–2018	(Masuda, 2019)
				28	NMFS research surveys	1996–2017	(Masuda, 2019)
			Juvenile	8	Rockfish trawl fishery	2013–2018	(Masuda, 2019)
	Central Valley Spring-run ESU	T	Adult	3	Groundfish fisheries	1995–1999	(Myers et al., 1999)

Table 3.6-3: CWT Recoveries of ESA-Listed Salmonids in the GOA (continued)

Species	ESU	Federal Status	Adult or Juvenile	Number	Type of Study	Survey Year	Reference
Coho salmon	Lower Columbia River ESU	T	Juvenile	1	NMFS research surveys	1996–2017	(Masuda, 2019)
				17	Fisheries and Oceans Canada and NMFS research surveys	1995–2004	(Morris et al., 2007)
	Oregon Coast ESU	T	Juvenile	2	Canadian Research surveys	1981–2005	(Myers et al., 2005)
				3	Fisheries and Oceans Canada and NMFS research surveys	1995–2004	(Morris et al., 2007)
Steelhead	Puget Sound DPS	T	Mixed	NA	Groundfish fisheries	1956–1989	(Burgner et al., 1992)
	Upper Columbia River DPS	T	Mixed	NA	Groundfish fisheries	1956–1989	(Burgner et al., 1992)
	Middle Columbia River DPS	T	Mixed	NA	Groundfish fisheries	1956–1989	(Burgner et al., 1992)
	Lower Columbia River DPS	T	Mixed	NA	Groundfish fisheries	1956–1989	(Burgner et al., 1992)
	Snake River Basin DPS	T	Adult	1	Canadian Research surveys	1981–2005	(Myers et al., 2005)
	Upper Willamette River DPS	T	Mixed	NA	Groundfish fisheries	1956–1989	(Burgner et al., 1992)
	Central California Coast DPS	T	Adult	3	Archival tagging study	2004–2008	(Hayes et al., 2011)

Notes: DPS = Distinct Population Segment, ESU = Evolutionarily Significant Unit, NA= not available, E = Endangered, T = Threatened

Although chum and sockeye were not identified in the Gulf of Alaska (likely due to few CWT fish), it is likely that some fish from listed West Coast ESUs may be present in the Gulf of Alaska in low numbers. Studies have shown that steelhead from Washington and the Columbia River Basin are distributed throughout the high seas fishery with the distribution varying by season and age class, but the studies do not provide origins of individually tagged fish (Burgner et al., 1992; Myers et al., 2005). Since Oregon only tags Columbia River Basin steelhead, no Oregon Coast steelhead were detected in the Gulf of Alaska. There were no apparent differences in distribution in the Gulf of Alaska between coastal and interior stocks of steelhead.

Although Oregon and Washington steelhead are well represented in the Gulf of Alaska, California steelhead are not (Burgner et al., 1992; Light et al., 1989). California uses CWTs extensively for hatchery-released steelhead; however, no CWT recoveries from California steelhead have been reported in the Gulf of Alaska (Burgner et al., 1992; Masuda, 2019). The only presumed California steelhead presence in the Gulf of Alaska was based on archival tags (using water temperature data), which determined that Scott Creek kelts (from the Central California Coast DPS) migrated into the Gulf of Alaska (Hayes et al., 2011). Hayes et al. (2011) suggested that steelhead from the larger Sacramento-San Joaquin basin stay in coastal waters, while fish from the central to north California coast may be well represented in the high seas, but just not bearing CWTs. Southern steelhead populations tend to have a more southern offshore distribution. It is not surprising that no ESA-listed Southern California steelhead CWTs have been detected in the Gulf of Alaska. These stocks have very low abundance, few historically marked fish, and rarely leave the continental shelf of California (Barnhart, 1991). As such, the probability that Southern California stocks would be present in the Gulf of Alaska and the TMAA is very low.

2019 International GOA Expedition

Scientists estimate that one-third of all Pacific salmon overwinter in the Gulf of Alaska (International Year of the Salmon, 2019). Since there have been limited surveys, the factors influencing the declines and booms are not well known. In February–March 2019, Dr. Richard Beamish led an international research team to study the mechanisms affecting salmon in the Gulf of Alaska (International Year of the Salmon, 2019; Pakhomov et al., 2019). The primary goal of the International GOA Expedition was to evaluate whether salmon abundance is mostly determined by the end of the first ocean winter, as fish that grow faster in their first year tend to survive better. The expedition used DNA technology to identify the stock-specific rearing areas for all five species of salmon and determine their abundances and condition.

The initial findings are summarized below (International Year of the Salmon, 2019; Pakhomov et al., 2019):

- A preliminary abundance estimate calculated 55 million salmon in the Expedition study area.
- The study area ranged geographically from 47 degrees North (°N) to 57°N; the northern part of the study area overlapped the far southern, offshore portion of the TMAA.
    - Salmon species differed substantially in their distributions with some showing potential links to environmental conditions. Trawl net surveys captured a total of 425 salmon throughout the study area. The frequency of occurrence in trawl catches for all salmon species was 83 percent and individually as follows: chum (64 percent), coho (38 percent), sockeye (31 percent), pink (17 percent), and Chinook (5 percent).
    - Using a tested abundance catchability coefficient of 0.3 for adult salmon, the study estimated the following abundances: chum (27.7 million), coho (13.6 million), sockeye (9 million), pink (4.2 million), and Chinook (0.4 million).
    - Sockeye in the northern portion of the study area were associated with cooler waters compared to pink salmon that were captured in southern, warmer waters. Catches of sockeye were somewhat lower than expected. It is possible that some sockeye salmon over-winter farther west of the study area.
    - The GOA survey covered roughly 12 percent of potential pink salmon wintering area, but estimated abundance reached only 0.3 percent of estimated total pink salmon abundance. Radchenko (2020) speculates that pink salmon may be overwintering in the South Bering Sea which has experienced warmer ocean waters in recent years.

  - Chum salmon were most broadly distributed and caught in the majority of sets. Chum salmon were represented by all marine-age groups including fish of first marine year. It is likely that many of these fish originated from Asia (Dunagan, 2019).
  - Coho salmon were found at relatively high abundances and captured over 1,000 kilometers (km) (621 miles) offshore; they were previously thought to have a more coastal distribution.
  - Few Chinook salmon were captured, presumably because these fish are found in deeper waters than where trawling typically occurs(Dunagan, 2019).
  - It is likely that no steelhead were captured because they tend to be more surface oriented, and the trawl nets were deployed at depths too deep to capture them.
  - Fish condition varied over the study area and even within a single set. Fish condition was positively related to stomach fullness. Chum exhibited a range of conditions (from skinny to robust) within a single set. DNA analysis will help determine if the variability is due to stock origin.
- At sea-genetic sequencing provided real-time stock composition. Coho caught ranged from SE Alaska to the Columbia River, with the majority originating from British Columbia.
- Trawl net videos provided preliminary evidence indicating that some adult salmon tend to exhibit schooling rather than solitary feeding behavior, which was previously thought to be more prevalent in the Gulf of Alaska during the winter months.
- Stomach analyses to examine diet was conducted on all salmon captured during the survey. Key diet categories (by volume) included euphausiids, pteropods, larval fish, and squid.
- Few salmon predators were observed during the 2019 GOA Expedition, which is consistent with previous winter surveys; eDNA results will indicate whether major predators were present but not captured during the trawl surveys (Weitkamp, 2020).
- In the Gulf of Alaska, squid are particularly important in the diet of higher trophic level species (coho, Chinook, steelhead), while occupying an important trophic position as intra-guild prey of pink and sockeye salmon (Katugin et al., 2019). During the 2019 GOA Expedition spring trawl surveys, several pelagic squid species were regularly encountered but at different abundance levels. One potentially abundant species (*Okutania anonycha*) was absent from trawl catches, but it occurred exclusively in salmon stomachs, indicating that the surveys may have occurred too late in the season or at depths that were too shallow (Katugin et al., 2019). The 2019 GOA Expedition also found large aggregations of northern sea nettles (*Chrysaora melanaster*), a scyphozoan jellyfish, in the Gulf of Alaska, including the southern portion of the TMAA (Hunt, 2019). This is the first documented occurrence of *Chrysaora* in the Gulf of Alaska, which is notable because they may present competition for food resources for juvenile salmonids.
- Although the February–March study timeframe of this expedition doesn’t overlap with the timing of the proposed activity (April to October), the study does encompass a portion of the TMAA and provides baseline information on salmonid stock presence and relative abundance within deep water offshore habitats similar to those found in the TMAA.

In March 2020, researchers continued their study on the winter ecology of Pacific salmon by returning to the Gulf of Alaska for a second expedition (International Year of the Salmon, 2020). A similar trawl net was used for this study to ensure comparable results across expeditions. The 2020 Expedition was more focused on the southern GOA (outside the TMAA) but found generally higher abundances of salmon than in 2019. Surveys are planned to continue in 2021 throughout the entire North Pacific Ocean (International Year of the Salmon, 2020).

GOA Integrated Ecosystem Research Program – Salmon Studies

Although the 2010–2014 North Pacific Research Board GOA Integrated Ecosystem Research Program was focused on studying GOA groundfish (as further described in Section 3.6.2.9, Essential Fish Habitat), the researchers collected incidental information on salmonids as well. Ecologically important juvenile groundfishes and salmon co-occur in the upper water column of the eastern Gulf of Alaska during the summer, a period when growth is critical to their survival. Daly et al. (2019a) quantified fine-scale spatial and trophic overlap of juvenile groundfishes (arrowtooth flounder [*Atheresthes stomias*], Pacific cod [*Gadus macrocephalus*], walleye pollock [*Gadus chalcogrammus*], and rockfish) and salmon (piscivorous coho and Chinook as well as planktivorous pink, chum, and sockeye) to examine trophic structuring and potential survival bottlenecks for these fishes in the Gulf of Alaska. Fine-scale diet overlap between juvenile groundfishes and planktivorous juvenile salmon species (pink, chum, and sockeye) ranged from 0 percent to 78 percent and was typically higher than that with piscivorous juvenile salmon (coho and Chinook). The researchers did not find a significant resource bottleneck between the species groups regarding availability of zooplankton. Juvenile groundfishes were directly consumed by juvenile salmon and were less frequently caught at stations where the highest catches of juvenile piscivorous salmon occurred. The study suggested that competition for resources by groundfish and salmon was likely when food resources are low in the Gulf of Alaska.

Further, Daly et al. (2019b) studied diet habits of the five Pacific salmon species caught in the marine waters of the eastern and central regions of the Gulf of Alaska. The central Gulf of Alaska region encompassed the shelf portion of the TMAA. The groundfish study incidentally captured over 52,000 juvenile salmon (most [53 percent] were pink) and 10,000 adult salmon (most [80 percent] were chum) and conducted a diet analysis on over 6,500 juvenile and adult salmon (Daly et al., 2019b). Twice as many juvenile and adult salmon (and five times as many juvenile focal groundfish) were caught in the central Gulf of Alaska than the eastern Gulf of Alaska. Focal groundfish include Pacific cod, walleye pollock, arrowtooth flounder, sablefish (*Anoplopoma fimbria*), and Pacific Ocean perch (*Sebastes alutus*). The study found that Chinook and coho salmon primarily consumed fish, cephalopods, euphausiids (adults), and decapods, whereas sockeye, chum, and pink salmon relied on euphausiids, amphipods, pteropods, and copepods (Daly et al., 2019b). The findings suggest that juvenile, immature, and maturing salmon growth and condition can be influenced by bottom-up forces in the ocean, which may ultimately affect run timing and survival rate.

Forage Fishes

Forage fish species in the Gulf of Alaska, such as age-0 walleye pollock, capelin (*Mallotus villosus*), Pacific herring (*Clupea pallasii*), and mesopelagic fishes (e.g., *Myctophidae*), are ecologically important as both consumers of zooplankton, and as prey for fish, seabirds, and marine mammals (McGowan et al., 2019). Bishop (2018) found that herring move from the Gulf of Alaska into Prince William Sound during the fall and spring, suggesting that fish spawning in the Sound migrate out into the Gulf of Alaska. As part of the Gulf of Alaska Integrated Ecosystem Research Program, an acoustic-trawl survey was conducted in the summer and fall of 2011 and 2013 to quantify variability in species composition, density, and distributions of forage fish over the continental shelf and slope in the central and eastern regions of the Gulf of Alaska (McGowan et al., 2019).

The forage fish community in 2011 was characterized by the absence of age-0 pollock and lower densities of capelin, herring, and mesopelagics compared to observations in 2013 (McGowan et al., 2019). Age-0 pollock were abundant across both regions in summer 2013 but were rarely observed in fall. In contrast, summer observations of herring were rare, while aggregations of herring were observed over the eastern GOA shelf in fall of both years. Seasonal changes in community composition are attributed to the transport of age-0 pollock from offshore waters in summer to nearshore waters in fall, and to immigration of herring to the eastern GOA shelf in fall. Eulachon (*Thaleichthys pacificus*) and Pacific sand lance (*Ammodytes personatus* are important forage fishes in the North Pacific Ocean but are more common outside of the TMAA. Sand lance typically occur in shallow, coastal, and intertidal waters (< 50 m depth) (McGowan et al., 2019). Spatial and temporal variability in community composition and distributions of forage fish species may potentially impact predator foraging in the Gulf of Alaska.

3.6.2.8 Green Sturgeon (*Acipenser medirostris*)

3.6.2.8.1 Status and Management

The Southern DPS of green sturgeon was listed as threatened under the ESA in 2006 (71 FR 17757). Critical habitat was designated for this DPS in 2009, but it does not include the Gulf of Alaska (74 FR 52300). In 2003, NMFS determined that green sturgeon along the West Coast consist of two DPSs: (1) a northern DPS comprising populations in coastal watersheds northward of and including the Eel River ("Northern DPS"); and (2) a southern DPS consisting of coastal and Central Valley populations south of the Eel River, with the only known population occurring in the Sacramento River ("Southern DPS") (71 FR 17757). Only the Southern DPS is ESA-listed. The Northern DPS was found to be "not warranted" for listing and remains a federal Species of Concern.

3.6.2.8.2 Distribution

Green sturgeon are long-lived, slow-growing fish and the most marine-oriented of the sturgeon species. They range along the Pacific coast from Baja California to the Aleutian Islands. Green sturgeon spend the majority of their lives in nearshore oceanic waters, bays, and estuaries. They are anadromous, with adults returning to freshwater to spawn. In marine waters, adults and subadults primarily occur at depths of 40–110 m (Erickson & Hightower, 2007), with most found at depths of 20–80 m (Payne et al., 2015a). They are rarely found deeper than 200 m (Huff et al., 2012). Only a small portion (15 percent) of the TMAA overlaps with shelf areas shallower than the 200 m isobath.

Green sturgeon have been occasionally observed in coastal, nearshore, and estuarine habitats from southeast Alaska through the Gulf of Alaska to the northwest side of Unalaska Island in the Aleutian Chain (Environmental Protection Information Center et al., 2001). Southern DPS fish are confirmed to occur from Graves Harbor, Alaska, to Monterey Bay, California (73 FR 52300). Green sturgeon observed northwest of Graves Harbor have not been identified to DPS. Two tagged Southern DPS green sturgeon were detected at the hydroacoustic monitor in Graves Harbor, indicating that Southern DPS green sturgeon do migrate further north than the 58th parallel, which transects the northern portion of the TMAA.

To evaluate green sturgeon marine migration patterns, researchers tagged 213 subadult and adult sturgeon along the U.S. West Coast (Lindley et al., 2008). Green sturgeon exhibited an annual migration along the continental shelf from U.S. to Canadian waters in the fall and an apparent return migration in the spring. Large numbers of green sturgeon were detected on northwest Vancouver Island, British Columbia, during May to June and October to November. However, only a single fish was detected in southeast Alaska in December, suggesting that use of the Bering Sea and Aleutian archipelago is uncommon for North American green sturgeon.

In 2019, the Northwest Fisheries Science Center conducted a study to characterize the distribution of salmonids within the Northwest Training and Testing area along the coast of Washington state (Smith &

Huff, 2020). The study was conducted in support of the U.S. Navy's 2019 Annual Marine Species Monitoring Report for the Pacific. The study deployed 107 stationary acoustic receivers in a grid pattern along the coast to detect tagged fish. In addition to gaining information on salmonid distribution, the study managed to detect 124 tagged green sturgeon, with sturgeon detected at most of the receiver locations. The study found that green sturgeon were highly distributed along the coastline (between 3 NM and 12 NM offshore) between May and September 2019. Nearly all green sturgeon were found nearshore of the 200 m depth contour when migrating off the coast of Washington, which is consistent with other studies indicating their preference for nearshore habitats (Smith & Huff, 2020).

Historical fisheries records of Alaskan groundfish catches dating back to the 1960s and fisheries observer records from 1986 to 2006 did not contain any records of green sturgeon, and few records have been reported in other databases from these waters (Huff et al., 2012). In 2006, Colway and Stevenson (2007) noted the presence of two unidentified green sturgeon specimens in the Bering Sea and the western Gulf of Alaska. Since then, fishery observers in the Bering Sea have encountered four additional green sturgeon specimens, including three in the past two years (Stevenson & Hunt, 2020). It is unclear whether these fish were part of the Northern or Southern DPS. In contrast, green sturgeon have been regularly captured in groundfish bottom trawls off Oregon and Washington (Erickson & Hightower, 2007).

In marine habitats, green sturgeon regularly occur over flat, sandy substrate (Payne et al., 2015a) but can also be found near complex hard-bottom areas (Huff et al., 2012). An Oregon coastal study found that green sturgeon, on average, spent a longer duration in areas with high seafloor complexity, especially where a greater proportion of the substrate consists of boulders (Hinckley et al., 2019). Sturgeon in this study may have been using complex seafloor habitat because it coincides with the distribution of benthic prey taxa or provides refuge from predators. Huff et al. (2012) found that sturgeon overwintering aggregations are sheltered in rocky, high-relief areas less than 200 m deep and are associated with ephemeral, yet abundant, standing stocks of plankton that support rich benthic communities.

The Gulf of Alaska shelf and continental slope consist of complex bathymetric features, including gulleys and canyons, rocky nearshore habitat, elevated pinnacles, flat muddy areas, and channels with high current flow (Baker et al., 2019). The shelf is dominated by gravel, sand, silt, and mud, punctuated by areas of hard rock. There are numerous banks and reefs with coarse, rocky bottoms, but much of the shelf is covered by glacial silt from the Copper River and the Bering and Malaspina glaciers (Mundy, 2005). Although sand and silt substrate in the TMAA may be used by green sturgeon, it may not provide preferred habitat to support high quality foraging and predator avoidance. Baker et al. (2019) modelled Gulf of Alaska trawlable areas using benthic terrain and oceanographic variables. The researchers found higher rugose substrates along the southern extent of the Kenai Peninsula and the southern coastline of Kodiak Island (within the shelf portion of the TMAA), which may provide more suitable green sturgeon habitat.

Although Gulf of Alaska trawling and observer data indicate few documented green sturgeon, these fishing activities tend to be performed over flat/sandy habitats to minimize gear damage. Further, green sturgeon don't tend to consume bait as easily as white sturgeon, and are best targeted using on-bottom gill nets (which are not typically deployed in the Gulf of Alaska), which may all contribute to the lack of green sturgeon observations. It is possible that green sturgeon are selectively using more rugose habitat within the TMAA within untrawlable areas so they are not detected by research surveys or as groundfish bycatch. Green sturgeon may also migrate through the Gulf of Alaska to access Alaska Peninsula and

Bering Sea habitats. Since green sturgeon have been documented as far north as Graves Harbor (in the eastern Gulf of Alaska) (73 FR 52300), it is possible that Southern DPS fish could be present in the Gulf of Alaska and the onshelf portion of the TMAA. However, it is more likely that any green sturgeon in the Gulf of Alaska originate from the non-listed Northern DPS fish.

Cold temperatures, perhaps in combination with other factors related to the danger of dispersing far from spawning grounds, may be another reason why green sturgeon are rare visitors north of 54°N latitude (Huff et al., 2012). Although there is a chance that green sturgeon may be seasonally present (fall/winter) in shallower, more rugose portions of the Gulf of Alaska continental shelf (<200 m deep), these areas represent a very small portion of the TMAA (Huff et al., 2020). Thus, the probability that listed Southern DPS green sturgeon would be present in the TMAA is very low, particularly during periods of the year when training activities are proposed. Further investigations are needed to determine presence, distribution, and habitat preferences of Southern DPS fish in the Gulf of Alaska.

3.6.2.9 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act requires that the regional Fishery Management Councils, in cooperation with NMFS, delineate EFH for all federally managed fisheries. The NPFMC has two FMPs in effect for fishes, groundfish and salmon fisheries in the Gulf of Alaska. Information on invertebrate fisheries, such as the scallop fishery in the TMAA, are presented in Section 3.6.2.9 (Essential Fish Habitat). EFH descriptions were presented in the 2011 GOA Final EIS/OEIS and updated in the 2016 GOA Final SEIS/OEIS. This SEIS/OEIS addresses the same activities within the TMAA as was discussed in the previous documents.

The NPFMC and NMFS are required to review the EFH components within each FMP every five years. The 2015 EFH five-year Review was completed in 2017 and implemented in 2018, and hereafter referred to as the "2017 Review." The next five-year review is scheduled for 2022. Based on the 2017 Review, new habitat and life history information was used to revise the Groundfish and Salmon EFH descriptions and maps in the FMPs. Although the Groundfish and Salmon FMPs have been updated since the 2016 GOA Final SEIS/OEIS was issued, the analyses previously presented remains valid. However, updates to each FMP are summarized below, by species group. Designated EFH for each life stage that occurs within the TMAA are provided in Table 3.6-4 and Table 3.6-5.

Table 3.6-4: Groundfish Species with EFH Designated in the TMAA

Fishery Management Plan	Species	Eggs	Larvae	Early Juvenile	Late Juvenile	Adult
Groundfish	Alaska plaice	X	X	-	X	X
	Arrowtooth flounder	X	X	-	X	X
	Atka mackerel	X	-	-	X	X
	Dover sole	X	X	-	X	X
	Dusky rockfish	X	X	-	X	X
	Flathead sole	X	X	-	X	X
	Northern rockfish	X	X	X	X	X
	Octopus	--	-	-	-	X
	Other rockfish	X	-	-	X	X
	Pacific cod	-	X	X	X	X
	Pacific ocean perch	X	X	X	X	X
	Rex sole	X	X	-	X	X
	Rock sole (Northern/Southern)	X	X	-	X	X
	Rougheye/Blackspotted rockfish	X	X	X	X	X
	Sablefish	-	X	X	X	X
	Sculpins	-	-	-	-	X
	Sharks	-	-	-	-	-
	Shortraker rockfish	X	X	X	X	X
	Skates	X	-	X	X	X
	Squid	-	-		X	X
	Shortspine thornyhead rockfish	-	-	X	X	X
	Walleye pollock	X	X	X	X	X
	Yelloweye rockfish	X	X	X	X	X
	Yellowfin sole	X	X	-	X	X

Sources: (North Pacific Fishery Management Council, 2014, 2019)

Table 3.6-5: Salmon Species with EFH Designated in the TMAA

Fishery Management Plan	Species	Eggs and Larvae	Freshwater Juveniles	Estuarine Juveniles	Marine Juveniles	Marine Immature/ Maturing Adults	Freshwater Adults
Salmon	Chinook	-	-	-	X	X	-
	Chum	-	-	-	X	X	-
	Coho	-	-	-	X	X	-
	Pink	-	-	-	X	X	-
	Sockeye	-	-	-	X	X	-

Source: (North Pacific Fishery Management Council et al., 2018)

3.6.2.9.1 Groundfish Fishery Management Plan

The Fishery Management Plan for Groundfish of the Gulf of Alaska was originally described in the 2011 GOA Final EIS/OEIS, and updates were provided in the 2016 GOA Final SEIS/OEIS. In August 2019, the North Pacific Fishery Management Council (2019) published an updated Groundfish FMP for the Gulf of

Alaska. This Groundfish FMP describes additional amendments that have been implemented since the 2016 GOA Final SEIS/OEIS was prepared:

- Amendment 103 was implemented on September 12, 2016. This amendment allows NMFS to reapportion unused Chinook prohibited species catch within and among specific trawl sectors.
- Amendment 104 was implemented on September 7, 2017, and authorizes NMFS to place electronic monitoring systems for collecting at-sea data on vessels.
- Amendment 105 was implemented on July 5, 2018 and included the following components:
    - Revised EFH description and identification by species; and updated life history, distribution, and habitat association information.
    - Updated the model used to determine fishing effects on EFH and the description of EFH impacts from fishing activities.
    - Updated description of EFH impacts from non-fishing activities and EFH conservation recommendations for non-fishing activities.
- Amendment 106 was implemented on August 6, 2018 and prohibited directed fishing for the squid species complex (squids) by federally permitted groundfish fishermen, moved squid to the Ecosystem Component category, and specified a squid retention limit in the GOA groundfish fisheries.

Since the 2019 FMP was published, NMFS has proposed or implemented two additional amendments to the GOA Groundfish FMP:

- Amendment 107 was implemented on February 20, 2020 (85 FR 9687). This amendment requires that the operator of a federally permitted catcher vessel using hook-and-line, pot, or jig gear in the Gulf of Alaska retain and land all rockfish species caught while fishing for groundfish or Pacific halibut.
- Amendment 108 was implemented on December 20, 2019 (84 FR 70064). This amendment prohibits replaced Amendment 80 catcher/processer vessels from receiving and processing Pacific cod harvested and delivered by catcher vessels directed fishing for Pacific cod in the Gulf of Alaska.
- Amendment 109 was proposed by NMFS on February 28, 2020 (85 FR 11939). This amendment would reduce operational and management inefficiencies in the GOA Pacific cod fisheries by changing seasonal Pacific cod apportionments to allow greater harvest opportunities earlier in the year.
- Amendment 110 was proposed by NMFS on March 23, 2020 (85 FR 16310). This amendment would reclassify sculpins into the non-target ecosystem component category, prohibit directed fisheries for sculpins, and limit the retention and commercial exchange of sculpins.

Since these amendments were proposed or implemented to help facilitate a sustainable groundfish fishery did not significantly change the environmental baseline, the analyses presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remain valid.

Groundfish Species

Groundfish species in the Gulf of Alaska include flatfishes, rockfishes, other roundfishes, skates, sharks, and chimeras. In 2017, as part of an ongoing sampling series, NMFS conducted a bottom trawl survey in the Gulf of Alaska, which overlapped with portions of the TMAA (Von Szalay & Raring, 2018). The survey captured a total of 161 fish and 364 invertebrate species during summer 2017. Species with the highest total catch abundance (by weight) over the entire survey area were: Pacific ocean perch, arrowtooth flounder, walleye pollock, Pacific halibut (*Hippoglossus stenolepis*), flathead sole (*Hippoglossoides elassodon*), giant grenadier (*Coryphaenoides pectoralis*), northern rockfish (*Sebastes polyspinis*), and sablefish.

From 2010 to 2014, the North Pacific Research Board led a large multidisciplinary ecological study that examined the physical and biological mechanisms that determine survival of juvenile groundfishes in the Gulf of Alaska (North Pacific Research Board, 2020). Researchers studied the “gauntlet” faced by groundfishes (specifically walleye pollock, Pacific cod, Pacific Ocean perch, sablefish, and arrowtooth flounder) during their first year of life as these fish are transported from offshore areas where they are spawned to nearshore nursery areas. The studies were structured around two GOA study regions (eastern and western) primarily on the continental shelf, ranging from Chatham Strait to Kodiak Island, with the dividing boundary at Prince William Sound. The western portion of the study area encompasses the continental shelf of the TMAA, and the eastern study area is mostly shoreward of the TMAA. The continental shelf within the TMAA is broad, with high demersal fish biomass but low species diversity (North Pacific Research Board, 2020). The following summarizes some of the pertinent findings from the Gulf of Alaska Integrated Ecosystem Research Program.

Siddon et al. (2019) found that Pacific cod and walleye pollock larvae were more abundant over the shelf and slope in the western Gulf of Alaska, reflecting preferred habitat for spawning adults and settling juvenile fish. Conversely, sablefish larvae were more abundant near areas of deeper water in the eastern Gulf of Alaska, such as Yakutat Canyon. Rockfish larvae (predominantly persistent organic pollutants in spring) were ubiquitous across the region. Larval Pacific ocean perch were associated with the slope, troughs, and canyons intersecting the slope, and the outer shelf. Arrowtooth flounder larval abundances varied by region and year. These larvae were collected primarily along the slope and near canyons and troughs. Deep-water features such as troughs and canyons that bisect the shelf appear to be “hot spots” for rockfish, sablefish, and arrowtooth flounder larvae originating from slope or basin spawning habitat.

Goldstein et al. (2019) found that the large number of groundfish species spawning in late winter and spring leads to high spring diversity and distinct eastern versus western larval fish assemblages. Most larval assemblages were found on the shelf in the west portion of the TMAA during spring, with fewer assemblages detected in summer. Assemblage patterns were largely driven by regional spring spawning events and only minimally influenced by temperature, salinity, and bottom depth over the shelf. For most groundfish species, the emergence of larvae is timed to coincide with the spring phytoplankton bloom, with early-phenology species associated with deep water and slope habitats and late-phenology species occupying primarily coastal and shelf habitats. Exceptions are the deep-water larvae of rex sole (*Glyptocephalus zachirus*), dover sole (*Solea solea*), and rockfishes that are most abundant in spring through summer. Species that are most abundant in winter (e.g., arrowtooth flounder and Pacific halibut) are spawned in deep water and the primary larval habitat is over the slope. These fishes appear to have adapted to the temporal and spatial complexity of the Gulf of Alaska ecosystem (Doyle et al., 2019).

For more specific information on groundfish status, distribution, and ecology in the Gulf of Alaska, please refer to the following publications:

- Arrowtooth flounder (Debenham et al., 2019; Doyle et al., 2018; Stockhausen et al., 2019)
- Sablefish (Gibson et al., 2019)
- Pacific cod (Hinckley et al., 2019)

- Walleye pollock (Parada et al., 2015)
- Pacific Ocean perch (National Oceanic and Atmospheric Administration, 2020a)
- All groundfish (Pirtle et al., 2017)

Information on groundfish harvest and harvest updates are presented in Section 3.11.1.1.2 (Commercial and Recreational Fishing). Although Pacific halibut are an important component to fisheries within the Study Area, this species is not managed under the groundfish fishery management plan.

3.6.2.9.2 Salmon Fishery Management Plan

The FMP for the Salmon Fisheries in the EEZ off Alaska was originally described in the 2011 GOA Final EIS/OEIS, and updates were provided in the 2016 GOA Final SEIS/OEIS. In October 2018, the North Pacific Fishery Management Council (2018b) published an updated Salmon FMP. This Salmon FMP describes one additional amendment that has been implemented since the 2016 GOA Final SEIS/OEIS was prepared:

- Amendment 13 was approved on July 5, 2018 (83 FR 31340). Based on the salmon five-year EFH review, Amendment 13 updated the description of EFH for all five species of Pacific salmon, replaced the maps of marine EFH for all five species of Pacific salmon, and updated the analysis of fishing and non-fishing impacts on salmon habitat in areas that are considered salmon EFH. The updated EFH descriptions reduced the area of designated EFH for Pacific salmon by 71.3 percent on average (Echave et al., 2012).

Salmon EFH is still currently designated within the Gulf of Alaska, including the TMAA, but does not extend out to the limits of the U.S. EEZ (Echave et al., 2012). Juvenile salmon EFH generally consist of the water over the continental shelf within the Bering Sea extending north to the Chukchi Sea, and over the continental shelf throughout the Gulf of Alaska and within the inside waters of the Alexander Archipelago. Within the TMAA, the continental shelf ranges from 150 to 200 m. Immature and mature Pacific salmon EFH include nearshore and oceanic waters, often extending well beyond the shelf break, with fewer areas within the inside waters of the Alexander Archipelago and Prince William Sound (National Marine Fisheries Service, 2018b).

Since this amendment just refined the geographic scope of EFH for Pacific salmon in marine waters off Alaska and did not propose any new restrictions on the habitat or the species, the analyses presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remains valid.

3.6.3 Environmental Consequences

As presented in Section 1.3 (Proposed Action), there are no changes to the current Proposed Action from that presented in the 2016 GOA Final SEIS/OEIS. This SEIS/OEIS analyzes the impacts on fish under two alternatives, the No Action Alternative and Alternative 1 (the Proposed Action).

This section presents changes since the 2016 GOA Final SEIS/OEIS and evaluates how and to what degree the activities described in Proposed Action could impact fish in the TMAA. The stressors analyzed for impacts on fish in the TMAA in included the following:

- Acoustic Stressors (sonar and other transducers, vessel noise, aircraft noise, weapons noise)
- Explosive Stressors

3.6.3.1 Acoustic Stressors

The analysis of effects to fishes follows the concepts outlined in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). This section begins with a summary of relevant data regarding acoustic impacts on fishes in Section 3.6.3.1.1 (Background). This is followed by an analysis of estimated impacts on fishes due to sonar and other transducers. Additional explanations of the acoustic terms and sound energy concepts used in this section are found in Appendix B (Acoustic and Explosive Concepts).

The Navy will rely on the previous 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS analysis of vessel, aircraft, and weapon noise, as there has been no substantive or otherwise meaningful change in the action, although new applicable and emergent science in regard to these sub-stressors is presented in the sections that follow. Due to available new literature, adjusted sound exposure criteria, and new acoustic effects modeling, the analysis provided in Section 3.6.3.1.2 (Impacts from Sonar and Other Transducers) of this SEIS/OEIS supplants the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS for fishes, and may change estimated impacts for some species since the 2016 GOA Final SEIS/OEIS. In addition, this analysis includes the consideration of ESA-listed green sturgeon not previously analyzed.

3.6.3.1.1 Background

Effects of human-generated sound on fishes have been examined and summarized in numerous publications (de Jong et al., 2020; Hastings & Popper, 2005; Hawkins et al., 2015; Ladich & Popper, 2004; Lindseth & Lobel, 2018; Mann, 2016; Mickle & Higgs, 2018; National Research Council, 1994, 2003; Neenan et al., 2016; Popper & Hawkins, 2019; Popper, 2003, 2008; Popper et al., 2016; Popper & Hastings, 2009b; Popper & Hawkins, 2018; Popper et al., 2014). The potential impacts from Navy activities are based on the analysis of available literature related to each type of effect. Where applicable, interim criteria and thresholds and relative risk factors presented in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) were used to assist in the analysis of effects on fishes from Navy activities.

There are limited studies of fish responses to aircraft and weapon noise. Based on the general characteristics of these sound types, for stressors where data is lacking (such as aircraft noise), studies of the effects of similar non-impulsive/continuous noise sources (such as sonar or vessel noise) are used to inform the analysis of fish responses. Similarly, studies of the effects from impulsive sources (such as air guns or pile driving) are used to inform fish responses to other impulsive sources (such as weapon noise). Non-impulsive or continuous sources may be presented as a proxy source to better understand potential reactions from fish where data from sonar and vessel noise exposures are limited. Additional information on the acoustic characteristics of these sources can be found in Appendix B (Acoustic and Explosive Concepts).

Although air guns and pile driving are not used during GOA training activities, the analysis of some explosive impacts (Section 3.6.3.2, Explosive Stressors) will in part rely on data from fishes exposed to impulsive sources where appropriate. Therefore, background information on impulsive sources are provided below.

3.6.3.1.1.1 Injury

Injury refers to the direct effects on the tissues or organs of a fish. Moderate- to low-level noise from vessels, aircraft, and weapons use are described in Section 3.0.4.1 (Acoustic Sources) and lacks the amplitude and energy to cause any direct injury. Section 3.0.4.3 (Conceptual Framework for Assessing

Effects from Acoustic and Explosive Activities) provides additional information on injury and the framework used to analyze this potential impact.

Injury due to Impulsive Sound Sources

Impulsive sounds, such as those produced by seismic air guns and impact pile driving, may cause injury or mortality in fishes. Although air guns and pile driving would not occur as part of this proposed action, this information aids in the analysis of other impulsive sources (i.e., weapons noise or in some cases, explosions). Mortality and potential damage to the cells of the lateral line have been observed in fish larvae, fry, and embryos after exposure to single shots from a seismic air gun within close proximity to the sound source (0.1–6 m) (Booman et al., 1996; Cox et al., 2012). However, exposure of adult fish to a single shot from an air gun array (four air guns) within similar ranges (6 m), has not resulted in any signs of mortality within seven days after exposure (Popper et al., 2016). Although injuries occurred in adult fishes, they were similar to injuries seen in control subjects (i.e., fishes that were not exposed to the air gun) so there is little evidence that the air gun exposure solely contributed to the observed effects.

Injuries, such as ruptured swim bladders, hematomas, and hemorrhaging of other gas-filled organs, have been reported in fish exposed to a large number of simulated impact pile driving strikes with cumulative sound exposure levels up to 219 decibels referenced to 1 micropascal squared seconds (dB re 1 μPa^2-s) under highly controlled settings where fish were unable to avoid the source (Casper et al., 2013a; Casper et al., 2012b; Casper et al., 2013b; Halvorsen et al., 2012a; Halvorsen et al., 2011, 2012b). However, it is important to note that these studies exposed fish to 900 or more strikes as the studies aimed to evaluate the equal energy hypothesis, which suggests that the effects of a large single pulse of energy is equivalent to the effects of energy received from many smaller pulses (as discussed in Smith & Gilley, 2008). Halvorsen et al. (2011) and Casper et al. (2017) found that the equal energy hypothesis does not apply to effects of pile driving; rather, metrics relevant to injury could include, but not be limited to, cumulative sound exposure level, single strike sound exposure level, and number of strikes (Halvorsen et al., 2011). Furthermore, Casper et al. (2017) found the amount of energy in each pile strike and the number of strikes determines the severity of the exposure and the injuries that may be observed. For example, hybrid striped bass (white bass *Morone chrysops* x striped bass *M. saxatilis*) exposed to fewer strikes with higher single strike sound exposure values resulted in a higher number of, and more severe, injuries than bass exposed to an equivalent cumulative sound exposure level that contained more strikes with lower single strike sound exposure values. This is important to consider when comparing data from pile driving studies to potential effects from an explosion. Although single strike peak sound pressure levels were measured during these experiments (at average levels of 207 dB re 1 µPa), the injuries were only observed during exposures to multiple strikes; therefore, it is anticipated that a peak value much higher than the reported values would be required to lead to injury in fishes exposed to a single strike or explosion.

These studies included species both with and without swim bladders. The majority of fish that exhibited injuries were those with swim bladders. Lake sturgeon (*Acipenser fulyescens*), a physostomous fish, was found to be less susceptible to injury from impulsive sources than Nile tilapia (*Oreochromis niloticus*) or hybrid striped bass, physoclistous fishes (Casper et al., 2017; Halvorsen et al., 2012a). As reported by Halvorsen et al. (2012a), the difference in results is likely due to the type of swim bladder in each fish. Physostomous fishes have an open duct connecting the swim bladder to their esophagus and may be able to quickly adjust the amount of gas in their body by gulping or releasing air. Physoclistous fishes do not have this duct; instead, special tissues or glands regulate gas pressure in the swim bladder. There were no mortalities reported during these experiments, and in the studies where recovery was observed, the majority of exposure related injuries healed within a few days in a laboratory setting. In many of these controlled studies, neutral buoyancy was determined in the fishes prior to exposure to the simulated pile driving. However, fishes with similar physiology to those described in these studies that are exposed to actual pile driving activities may show varying levels of injury depending on their state of buoyancy.

By exposing caged juvenile European sea bass (*Dicentrarchus labrax*) to actual pile driving operations, Debusschere et al. (2014) confirmed the results discussed in the paragraph above. No differences in mortality were found between control and experimental groups at similar levels tested in the experiments described in the paragraph above (sound exposure levels up to 215–222 dB re 1 μPa^2-s), and many of the same types of injuries occurred (Casper et al., 2013a; Casper et al., 2012b; Casper et al., 2013b; Halvorsen et al., 2012a; Halvorsen et al., 2011, 2012b). Fishes with injuries from impulsive sources such as these may not survive in the wild due to harsher conditions and risk of predation.

Other potential effects from exposure to impulsive sound sources include potential bubble formation and neurotrauma. It is speculated that high sound pressure levels may also cause bubbles to form from micronuclei in the blood stream or other tissues of animals, possibly causing embolism damage (Hastings & Popper, 2005). Fishes have small capillaries where these bubbles could be caught and lead to the rupturing of the capillaries and internal bleeding. It has also been speculated that this phenomena could take place in the eyes of fish due to potentially high gas saturation within the eye tissues (Popper & Hastings, 2009b). Additional research is necessary to verify if these speculations apply to exposures to non-impulsive sources such as sonars. These phenomena have not been well studied in fishes and are difficult to recreate under real-world conditions.

As summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), exposure to high intensity and long duration impact pile driving or air gun shots did not cause mortality, and fishes typically recovered from injuries in controlled laboratory settings. Species tested to date can be used as viable surrogates for investigating injury in other species exposed to similar sources (Popper et al., 2014).

Injury due to Sonar and Other Transducers

Non-impulsive sound sources (e.g., sonar, acoustic modems, and sonobuoys) have not been known to cause direct injury or mortality to fish under conditions that would be found in the wild (Halvorsen et al., 2012a; Kane et al., 2010; Popper et al., 2007). Potential direct injuries (e.g., barotrauma, hemorrhage or rupture of organs or tissue) from non-impulsive sound sources, such as sonar, are unlikely because of slow rise times,[1] lack of a strong shock wave such as that associated with an explosive, and relatively low peak pressures. General categories and characteristics of Navy sonar systems are described in Section 3.0.4.1.1 (Sonar and Other Transducers).

The effects of mid-frequency sonar-like signals (1.5–6.5 kHz) on larval and juvenile Atlantic herring (*Clupea harengus*), Atlantic cod (*Gadus morhura*), saithe (*Pollachius virens*), and spotted wolffish

[1] Rise time: the amount of time for a signal to change from static pressure (the ambient pressure without the added sound) to high pressure. Rise times for non-impulsive sound typically have relatively gradual increases in pressure where impulsive sound has near-instantaneous rise to a high peak pressure. For more detail, see Appendix B (Acoustic and Explosive Concepts).

(*Anarhichas minor*) were examined by Jørgensen et al. (2005). Researchers investigated potential effects on survival, development, and behavior in this study. Among fish kept in tanks and observed for one to four weeks after sound exposure, no significant differences in mortality or growth-related parameters between exposed and unexposed groups were observed. Examination of organs and tissues from selected herring experiments did not reveal obvious differences between unexposed and exposed groups. However, two (out of 42) of the herring groups exposed to sound pressure levels of 189 dB re 1 µPa and 179 dB re 1 µPa had a post-exposure mortality of 19 and 30 percent, respectively. It is not clear if this increased mortality was due to the received level or to other unknown factors, such as exposure to the resonance frequency of the swim bladder. Jørgensen et al. (2005) estimated a resonant frequency of 1.8 kHz for herring and saithe ranging in size from 6.3 to 7.0 centimeters, respectively, which lies within the range of frequencies used during sound exposures and therefore may explain some of the noted mortalities.

Past research has demonstrated that fish species, size, and depth influences the resonant frequency of the swim bladder (Løvik & Hovem, 1979; McCartney & Stubbs, 1971). For example, lower frequencies (i.e., generally below 1 kHz) are expected to produce swim bladder resonance in adult fishes from about 10 to 100 centimeters (McCartney & Stubbs, 1971); higher frequencies, greater than 1 kHz, could produce swim bladder resonance in smaller fishes. At resonance, the swim bladder may absorb much of the acoustic energy in the impinging sound wave. It was hypothesized that the resulting oscillations may cause mortality, or harm the auditory organs or the swim bladder (Jørgensen et al., 2005; Kvadsheim & Sevaldsen, 2005). However, damage to the swim bladder and to tissues surrounding the swim bladder was not observed in fishes exposed to multiple sonar pulses from approximately 165–195 dB re 1 µPa at their presumed swim bladder resonant frequency (Jørgensen et al., 2005). Fishes may be more susceptible to injury from swim bladder resonance when exposed to continuous signals within the resonant frequency range; although, based on the above studies, injury or mortality from swim bladder resonance under real-world conditions is unlikely.

Hastings (1991; 1995) tested the limits of acoustic exposure on two freshwater fish species. Hastings found "acoustic stunning" (loss of consciousness) in blue gouramis (*Trichogaster trichopterus*) following an eight-minute continuous exposure in captivity to a 150 Hz pure tone with a sound pressure level of 198 dB re 1 µPa (Hastings, 1995). This species of fish has an air bubble in the mouth cavity directly adjacent to the animal's braincase that may have caused this injury. Hastings (1991; 1995) also found that goldfish (*Carassius auratus*), exposed to a 250 Hz continuous wave sound with peak pressures of 204 dB re 1 µPa for two hours, and blue gourami exposed to a 150 Hz continuous wave sound at a sound pressure level of 198 dB re 1 µPa for 0.5 hour did not survive. These studies illustrate the highest known levels tested on fishes with hearing specializations. These high levels of noise were also projected for relatively long durations of time and in a small tank test environment, therefore direct comparisons to results in natural settings should be treated with caution. Stunning and mortality due to exposure to non-impulsive sound exposure has not been observed in other studies.

Three freshwater species of fish, the rainbow trout (*Oncorhynchus mykiss,* also known as steelhead), channel catfish (*Ictalurus punctatus*), and the hybrid sunfish (*Lepomis* sp.), were exposed to both low- and mid-frequency sonar (Kane et al., 2010; Popper et al., 2007). Low-frequency exposures with received sound pressure levels of 193 dB re 1 µPa occurred for either 324 or 648 seconds. Mid-frequency exposures with received sound pressure levels of 210 dB re 1 µPa occurred for 15 seconds. No fish mortality resulted from either experiment, and during necropsy after test exposures, both studies found that none of the subjects showed signs of tissue damage related to exposure (Kane et al., 2010; Popper et al., 2007).

As summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), although fish have been injured and killed due to intense, long-duration, non-impulsive sound exposures, fish exposed under more realistic conditions have shown no signs of injury. Those species tested to date can be used as viable surrogates for estimating injury in other species exposed to similar sources.

3.6.3.1.1.2 Hearing Loss

Researchers have examined the effects on hearing in fishes from sonar-like signals, tones, and different impulsive noise sources. Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on hearing loss and the framework used to analyze this potential impact.

Exposure to high-intensity sound can cause hearing loss, also known as a noise-induced threshold shift, or simply a threshold shift (Miller, 1974). A temporary threshold shift (TTS) is a temporary, recoverable loss of hearing sensitivity. A TTS may last several minutes to several weeks, and the duration may be related to the intensity of the sound source and the duration of the sound exposure (including multiple exposures). A permanent threshold shift (PTS) is non-recoverable, results from the destruction of tissues within the auditory system, permanent loss of hair cells, or damage to auditory nerve fibers (Liberman, 2016), and can occur over a small range of frequencies related to the sound exposure. As with TTS, the animal does not become deaf but requires a louder sound stimulus, relative to the amount of PTS, to detect a sound within the affected frequencies. For example, if 5 dB of PTS occurs at a certain frequency, then a sound at that same frequency would need to be 5 dB louder for the animal to detect it. However, the sensory hair cells of the inner ear in fishes are regularly replaced over time when they are damaged, unlike in mammals where sensory hair cells loss is permanent (Lombarte et al., 1993; Popper et al., 2014; Smith et al., 2006). Consequently, PTS has not been known to occur in fishes, and any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2014; Popper et al., 2005; Smith et al., 2006). Although available data for some terrestrial mammals have shown signs of nerve damage after severe threshold shifts (e.g., Kujawa & Liberman, 2009; Lin et al., 2011), it is not known if damage to auditory nerve fibers could also occur in fishes, and if so, whether fibers would recover during this process. One example that demonstrated a lack of damage to sensory receptors when TTS occurred was in a study on hearing loss in zebrafish (*Danio rerio,* a freshwater species with a swim bladder involved in hearing). This was one of the first studies to look at both auditory threshold shifts and potential physical effects on the inner ear. However, marine species have yet to be tested, and future research should evaluate other potential mechanisms of cellular or structural damage if in fact physical damage occurs in fishes with the onset of a threshold shift (Breitzler et al., 2020).

Hearing Loss due to Impulsive Sound Sources

Popper et al. (2005) examined the effects of a seismic air gun array on a fish with a swim bladder that is involved in hearing, the lake chub (*Couesius plumbeus*); and two species that have a swim bladder that is not involved in hearing, the northern pike (*Esox lucius*) and the broad whitefish (*Coregonus nasus*), a salmonid. In this study, the lowest received cumulative sound exposure level at which effects were noted was 186 dB re 1 µPa^2-s (five shots with a mean sound pressure level of 177 dB re 1 µPa). The results showed temporary hearing loss for both lake chub and northern pike to both 5 and 20 air gun shots, but not for the broad whitefish. Hearing loss was approximately 20–25 dB at some frequencies for both species, and full recovery of hearing took place within 18 hours after sound exposure. Examination of the sensory surfaces of the ears after allotted recovery times (one hour for five shot exposures, and up to 18 hours for 20 shot exposures) showed no damage to sensory hair cells in any of the fish from these exposures (Song et al., 2008).

McCauley et al. (2003) and McCauley and Kent (2012) showed loss of a small percent of sensory hair cells in the inner ear of caged fish exposed to a towed air gun array simulating a passing seismic vessel. Pink snapper (*Pargus auratus*), a species that has a swim bladder that is not involved in hearing, were exposed to multiple air gun shots for up to one and one-half hours (McCauley et al., 2003) where the maximum received sound exposure levels exceeded 180 dB re 1 μPa^2-s. The loss of sensory hair cells continued to increase for up to at least 58 days post exposure to 2.7 percent of the total cells. Gold band snapper (*Pristipomoides multidens*) and sea perch (*Lutjanus kasmira*), both fishes with a swim bladder involved in hearing, were also exposed to a towed air gun array simulating a passing seismic vessel (McCauley & Kent, 2012). Although received levels for these exposures have not been published, hair cell damage increased as the range of the exposure (i.e., range to the source) decreased. Again, the amount of damage was considered small in each case (McCauley & Kent, 2012). It is not known if this hair cell loss would result in hearing loss since fish have tens or even hundreds of thousands of sensory hair cells in the inner ear and only a small portion were affected by the sound (Lombarte & Popper, 1994; Popper & Hoxter, 1984). A reason McCauley and Kent (2012) found damage to sensory hair cells, while Popper et al. (2005) did not, may be in their distinct methodologies. Their studies had many differences, including species and the precise sound source characteristics.

Hastings et al. (2008) exposed a fish with a swim bladder that is involved in hearing, the pinecone soldierfish (*Myripristis murdjan*); and three species that have a swim bladder that is not involved in hearing, the blue green damselfish (*Chromis viridis*), the saber squirrelfish (*Sargocentron spiniferum*), and the bluestripe seaperch (*Lutjanus kasmira*), to an air gun array. Fish in cages were exposed to multiple air gun shots with a cumulative sound exposure level of 190 dB re 1 μPa^2-s. The authors found no hearing loss in any fish examined up to 12 hours after the exposures.

In an investigation of another impulsive source, Casper et al. (2013b) found that some fishes may actually be more susceptible to barotrauma (e.g., swim bladder ruptures, herniations, and hematomas) than hearing effects when exposed to simulated impact pile driving. Hybrid striped bass (white bass x striped bass) and Mozambique tilapia (*Oreochromis mossambicus*), two species with a swim bladder not involved in hearing, were exposed to sound exposure levels between 213 and 216 dB re 1 μPa^2-s. The subjects exhibited barotrauma, and although researchers began to observe signs of inner ear hair cell loss, these effects were small compared to the other non-auditory injuries incurred. Researchers speculated that injury might occur prior to signs of hearing loss or TTS. These sound exposure levels may present the lowest threshold at which hearing effects may begin to occur.

Overall, PTS has not been known to occur in fishes tested to date. Any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2014; Popper et al., 2005; Smith et al., 2006). The lowest sound exposure level at which TTS has been observed in fishes with a swim bladder involved in hearing is 186 dB re 1 μPa^2-s. As reviewed in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), fishes without a swim bladder, or fishes with a swim bladder that is not involved in hearing, would be less susceptible to hearing loss (i.e., TTS) than fishes with swim bladders involved in hearing, even at higher levels and longer durations.

Hearing Loss due to Sonar and Other Transducers

Several studies have examined the effects of the sound exposures from low-frequency sonar on fish hearing (i.e., Halvorsen et al., 2013; Kane et al., 2010; Popper et al., 2007). Hearing was measured both immediately post exposure and for up to several days thereafter (Halvorsen et al., 2013; Kane et al., 2010; Popper et al., 2007). Maximum received sound pressure levels were 193 dB re 1 µPa for 324 or 648 seconds (a cumulative sound exposure level of 218 or 220 dB re 1 μPa^2-s, respectively) at frequencies ranging from 170 to 320 Hz (Kane et al., 2010; Popper et al., 2007) and 195 dB re 1 µPa for 324 seconds (a cumulative sound exposure level of 215 dB re 1 μPa^2-s) in a follow-on study (Halvorsen et al., 2013). Two species with a swim bladder not involved in hearing, the largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*), showed no loss in hearing sensitivity from sound exposure immediately after the test or 24 hours later. Channel catfish, a fish with a swim bladder involved in hearing; and some specimens of rainbow trout, a fish with a swim bladder not involved in hearing, showed a threshold shift (up to 10–20 dB of hearing loss) immediately after exposure to the low-frequency sonar when compared to baseline and control animals. Small thresholds shifts were detected for up to 24 hours after the experiment in some channel catfish. Although some rainbow trout in one test group showed signs of hearing loss, rainbow trout in another group showed no hearing loss. The different results between rainbow trout test groups are difficult to understand, but may be due to development or genetic differences in the various groups of fish. Catfish hearing returned to, or close to, normal within about 24 hours after exposure to low-frequency sonar. Examination of the inner ears of the fish during necropsy revealed no differences from the control groups in ciliary bundles or other features indicative of hearing loss. The maximum time fish were held post exposure before sacrifice was 96 hours (Kane et al., 2010).

The same investigators examined the potential effects of mid-frequency active sonar on fish hearing and the inner ear (Halvorsen et al., 2012c; Kane et al., 2010). The maximum received sound pressure level was 210 dB re 1 µPa at a frequency of 2.8 to 3.8 kHz for a total duration of 15 seconds (cumulative sound exposure level of 220 dB re 1 μPa^2-s). Out of the species tested (rainbow trout and channel catfish), only one test group of channel catfish showed any hearing loss after exposure to mid-frequency active sonar. The investigators tested catfish during two different seasons and found that the group tested in October experienced TTS, which recovered within 24 hours, but fish tested in December showed no effect. It was speculated that the difference in hearing loss between catfish groups might have been due to the difference in water temperature during the testing period or due to differences between the two stocks of fish (Halvorsen et al., 2012c). Any effects on hearing in channel catfish due to sound exposure appeared to be short term and non-permanent (Halvorsen et al., 2012c; Kane et al., 2010).

Some studies have suggested that there may be some loss of sensory hair cells due to high intensity sources, indicating a loss in hearing sensitivity; however, none of those studies concurrently investigated the subjects' actual hearing range after exposure to these sources. Enger (1981) found loss of ciliary bundles of the sensory cells in the inner ears of Atlantic cod following one to five hours of exposure to pure tone sounds between 50 and 400 Hz with a sound pressure level of 180 dB re 1 µPa. Hastings (1995) found auditory hair-cell damage in goldfish, a freshwater species with a swim bladder that is involved in hearing. Goldfish were exposed to 250 Hz and 500 Hz continuous tones with maximum peak sound pressure levels of 204 dB re 1 µPa and 197 dB re 1 µPa, respectively, for about two hours. Similarly, Hastings et al. (1996) demonstrated damage to some sensory hair cells in oscars (*Astronotus ocellatus*) observed one to four days following a one-hour exposure to a pure tone at 300 Hz with a sound pressure level of 180 dB re 1 µPa, but no damage to the lateral line was observed. Both studies found a relatively small percentage of total hair cell loss from hearing organs despite long duration exposures. Effects from long-duration noise exposure studies are generally informative; however, they are not necessarily a direct comparison to intermittent short-duration exposures produced during Navy activities involving sonar and other transducers.

As noted in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), some fish species with a swim bladder that is involved in hearing may be more susceptible to TTS from high-intensity non-impulsive sound sources, such as sonar and other transducers, depending on the duration and frequency content of the exposure. Fishes with a swim bladder involved in hearing and fishes with high-frequency hearing may exhibit TTS from exposure to low- and mid-frequency sonar, specifically at cumulative sound exposure levels above 215 dB re 1 µPa^2-s. However, fishes without a swim bladder and fishes with a swim bladder that is not involved in hearing would be unlikely to detect mid- or other high-frequency sonars and would likely require a much higher sound exposure level to exhibit the same effect from exposure to low-frequency active sonar.

Hearing Loss due to Vessel Noise

Little data exist on the effects of vessel noise on hearing in fishes. However, TTS has been observed in fishes exposed to elevated background noise and other non-impulsive sources (e.g., white noise). Caged studies on pressure sensitive fishes (i.e., fishes with a swim bladder involved in hearing and those with high-frequency hearing) show some hearing loss after several days or weeks of exposure to increased background sounds, although the hearing loss seems to recover (e.g., Breitzler et al., 2020; Scholik & Yan, 2002a; Smith et al., 2006; Smith et al., 2004a). Smith et al. (2006; 2004a) exposed goldfish, to noise with a sound pressure level of 170 dB re 1 µPa and found a clear relationship between the amount of hearing loss and the duration of exposure until maximum hearing loss occurred at about 24 hours of exposure. A 10-minute exposure resulted in 5 dB of TTS, whereas a three-week exposure resulted in a 28 dB TTS that took over two weeks to return to pre-exposure levels (Smith et al., 2004a). Recovery times were not measured by investigators for shorter exposure durations. It is important to note that these exposures were continuous and subjects were unable to avoid the sound source for the duration of the experiment.

Scholik and Yan (2001) demonstrated TTS in fathead minnows (*Pimephales promelas*) after a 24-hour continuous exposure to white noise (0.3–2.0 kHz) at 142 dB re 1 µPa that took up to 14 days post-exposure to recover. This is the longest recorded time for a threshold shift to recover in a fish. The same authors also found that the bluegill sunfish (*Lepomis macrochirus*), a species that primarily detects particle motion and lacks specializations for hearing, did not show significant elevations in auditory thresholds when exposed to the same stimulus (Scholik & Yan, 2002b). This demonstrates again that fishes with a swim bladder involved in hearing and those with high-frequency hearing may be more sensitive to hearing loss than fishes without a swim bladder or those with a swim bladder not involved in hearing.

Breitzler et al. (2020) exposed zebrafish (a freshwater species with a swim bladder involved in hearing) to 24 hours of white noise at various frequencies and sound levels. This is one of the first studies that measured hearing thresholds, physical damage (e.g., loss of hair cells) and recovery post-exposure. Overall, results were similar to those from previous studies. As the noise level increased, the amount of TTS observed in zebrafish also increased, and frequencies that were most affected were those within the fish's best hearing sensitivity. Breitzler et al. (2020) also observed an increase in response latency in fish with TTS (i.e., the fish were slower to respond to auditory stimuli during hearing tests). Threshold shifts in fish exposed to sound pressure levels of 130 dB and 140 dB re 1 µPa recovered within three days, whereas it took up to 14 days for fish exposed to the highest sound pressure level (150 dB re 1 µPa) to return to pre-exposure levels. Similarly, response latency was time dependent and sometimes took up to 14 days to recover to pre-exposure levels. The highest threshold shifts recorded also resulted in significant hair cell loss, whereas lower exposure levels did not. Similar to the other effects measured in this study, hair cell loss attributed to the highest exposure level returned to baseline levels within seven days post-exposure. This further demonstrates the ability for fish to rejuvenate hair cells and for hearing thresholds to recover to baseline levels (lacking evidence of PTS).

Butler et al. (2020) presented playbacks of pure tones ranging from 100 to 2,000 Hz to African cichlids (*Astatotilapia burtoni*), a freshwater species with a swim bladder involved in hearing, stationed in a small aquarium to investigate the effects on hearing. Playbacks were presented at a sound pressure level of 140 dB re 1 µPa for three hours. After review of the playback, the authors noted that the sound source was more broadband than intended and therefore may not be analogous to other tonal sources (such as sonar), but rather could be more comparable to vessel noise playbacks or an example of elevated background levels. Observed threshold shifts were only significantly different than controls in lower frequencies (200 and 300 Hz), which corresponds to the species' best range of sensitivity. Recovery of hearing thresholds was not measured during this study.

When reviewing results from the above studies, it is important to note that the fish were unable to avoid the sound source (e.g., held stationary in tubs or tanks) and were subjected to long, continuous duration exposures (e.g., days to weeks). A direct comparison of these results to fish exposed to continuous sound sources in natural settings should be treated with caution. For example, fishes that are exposed to noise produced by a vessel passing by in their natural environment, even in areas with high levels of vessel movement, would only be exposed for short durations (e.g., seconds or minutes) and therefore relatively low sound exposure levels as vessels pass by. As evidence suggests that fish can recover from hearing loss (both threshold sensitivity and actual physical damage) even after long duration exposures in a confined space, it also indicates similar results to lower level and shorter duration exposures. Therefore, overall effects would not likely rise to the level of impact demonstrated in the summarized laboratory studies.

As noted in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), some fish species with a swim bladder that is involved in hearing may be more susceptible to TTS from long duration continuous noise, such as broadband[2] white noise, depending on the duration of the exposure (thresholds are proposed based on continuous exposure of 12 hours). However, it is not likely that TTS would occur in fishes with a swim bladder not involved in hearing or in fishes without a swim bladder.

3.6.3.1.1.3 Masking

Masking refers to the presence of a noise that interferes with a fish's ability to hear biologically important sounds including those produced by prey, predators, or other fishes. Masking occurs in all vertebrate groups and can result in a reduction in communication and listening space, effectively limiting the distance over which an animal can communicate and detect biologically relevant sounds (Pine et al., 2020). Human-generated continuous sounds (e.g., some sonar, vessel noise, and vibratory

[2] A sound or signal that contains energy across multiple frequencies.

pile driving) have the potential to mask sounds that are biologically important to fishes. Researchers have studied masking in fishes using continuous masking noise, but masking due to intermittent, short-duty cycle sounds has not been studied. Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on masking and the framework used to analyze this potential impact.

Masking is likely to occur in most fishes due to varying levels of ambient or natural noise in the environment such as wave action, precipitation, or other animal vocalizations (Popper et al., 2014). Ambient noise during higher sea states in the ocean has resulted in elevated thresholds in several fish species (Chapman & Hawkins, 1973; Ramcharitar & Popper, 2004). Although the overall intensity or loudness of ambient or human-generated noise may result in masking effects in fishes, masking may be most problematic when human-generated signals or ambient noise levels overlap the frequencies of biologically important signals (Buerkle, 1968, 1969; Popper et al., 2014; Tavolga, 1974).

Wysocki and Ladich (2005) investigated the influence of continuous white noise exposure on the auditory sensitivity of three freshwater fishes: the goldfish and the lined Raphael catfish (*Platydoras costatus*), fishes with notable hearing specializations for sound pressure detection; and the pumpkinseed sunfish (*Lepomis gibbosus*), a freshwater fish without notable specializations. For the goldfish and catfish, baseline thresholds were lower than masked thresholds. Continuous white noise with a sound pressure level of approximately 130 dB re 1 µPa at 1 m resulted in an elevated threshold of 23–44 dB within the subjects' region of best sensitivity between 500 and 1,000 Hz. There was less evidence of masking in the sunfish during the same exposures with only a shift of 11 dB. Wysocki and Ladich (2005) suggest that ambient sound regimes may limit acoustic communication and orientation, especially in animals with notable hearing specializations for sound pressure detection.

Masking could lead to potential fitness costs depending on the severity of the reaction and the animal's ability to adapt or compensate during an exposure (de Jong et al., 2020; Radford et al., 2014; Slabbekoorn et al., 2010). For example, masking could result in changes in predator-prey relationships potentially inhibiting a fish's ability to detect predators and therefore increase its risk of predation (Astrup, 1999; Mann et al., 1998; Simpson et al., 2015; Simpson et al., 2016). Masking may also limit the distance over which fish can communicate or detect important signals (Alves et al., 2016; Codarin et al., 2009; Ramcharitar et al., 2006; Ramcharitar et al., 2001; Stanley et al., 2017), including vocalizations made during reproductive phases or sounds emitted from a reef for navigating larvae (de Jong et al., 2020; Higgs, 2005; Neenan et al., 2016). If the masking signal is brief (a few seconds or less), biologically important signals may still be detected, resulting in little effect to the individual. If the signal is longer in duration (minutes or hours) or overlaps with important frequencies for a particular species, more severe consequences may occur such as the inability to attract a mate and reproduce. Holt and Johnston (2014) were the first to demonstrate the Lombard effect in one species of fish, a potentially compensatory behavior where an animal increases the source level of its vocalizations in response to elevated noise levels. The Lombard effect is currently understood to be a reflex that may be unnoticeable to the animal, or it could lead to increased energy expenditure during communication.

The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) highlights a lack of data that exists for masking by sonar but suggests that the narrow bandwidth and intermittent nature of most sonar signals would result in only a limited probability of any masking effects. In addition, most sonars (mid-, high-, and very high-frequency) are above the hearing range of most marine fish species, eliminating the possibility of masking for these species. In most cases, the probability of masking would further decrease with increasing distance from the sound source.

In addition, no data are available on masking by impulsive signals (e.g., impact pile driving and air guns) (Popper et al., 2014). Impulsive sounds are typically brief, lasting only fractions of a second, where masking could occur only during that brief duration of sound. Biological sounds can typically be detected between pulses within close distances to the source unless those biological sounds are similar to the masking noise, such as impulsive or drumming vocalizations made by some fishes (e.g., cod or haddock). Masking could also indirectly occur because of repetitive impulsive signals where the repetitive sounds and reverberations over distance may create a more continuous noise exposure.

Although there is evidence of masking as a result of exposure to vessel noise, the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) does not present numeric thresholds for this effect. Instead, relative risk factors are considered and it is assumed the probability of masking occurring is higher at near to moderate distances from the source (up to hundreds of meters) but decrease with increasing distance (Popper et al., 2014).

3.6.3.1.1.4 Physiological Stress

Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on physiological stress and the framework used to analyze this potential impact. A fish must first be able to detect a sound above its hearing threshold and above the ambient noise level before a physiological stress reaction can occur. The initial response to a stimulus is a rapid release of stress hormones into the circulatory system, which may cause other responses such as elevated heart rate and blood chemistry changes. Increases in background sound have been shown to cause stress in humans and animals, which also includes the measurement of biochemical responses by fishes to acoustic stress (e.g., Goetz et al., 2015; Madaro et al., 2015; Remage-Healey et al., 2006; Smith et al., 2004b; Wysocki et al., 2007; Wysocki et al., 2006). However, results from these studies have varied. Stimuli that have been used to study physiological stress responses in fishes include predator vocalizations, non-impulsive or continuous, and impulsive noise exposures.

A stress response that has been observed in fishes includes the production of cortisol (a stress hormone) when exposed to sounds such as boat noise, tones, or predator vocalizations. Nichols et al. (2015) found that giant kelpfish (*Heterostichus rostratus*) had increased levels of cortisol with increased sound level and intermittency of boat noise playbacks. Cod exposed to a short-duration upsweep (a tone that sweeps upward across multiple frequencies) across 100–1,000 Hz had increases in cortisol levels, which returned to normal within one hour post-exposure (Sierra-Flores et al., 2015). Remage-Healey et al. (2006) found elevated cortisol levels in Gulf toadfish (*Opsanus beta*) exposed to low-frequency bottlenose dolphin sounds, but observed no physiological change when they exposed toadfish to low-frequency “pops” produced by snapping shrimp.

A sudden increase in sound pressure level (i.e., presentation of a sound source) or an increase in overall background noise levels can increase hormone levels and alter other metabolic rates indicative of a stress response, such as increased ventilation and oxygen consumption (Pickering, 1981; Popper & Hastings, 2009a; Radford et al., 2016; Simpson et al., 2015; Simpson et al., 2016; Smith et al., 2004a, 2004b; Spiga et al., 2017). Similarly, reef fish embryos exposed to boat noise have demonstrated changes in morphological development and increases in heart rate, another indication of a physiological stress response, although survival rates were unchanged (Fakan & McCormick, 2019; Jain-Schlaepfer et al., 2018). Although results have varied, it has been shown that chronic or long-term (days or weeks) exposures of continuous man-made sounds can lead to a reduction in embryo viability (Sierra-Flores et al., 2015) and decreased growth rates (Nedelec et al., 2015).

Mills et al. (2020) observed the hormonal effects of motorboat noise on orange-fin anemonefish (*Amphiprion chrysopterus*) over short-term (30 minutes) and longer-term (48 hours) periods. Cortisol levels did not differ significantly between the periods for either sex. Testosterone levels were significantly higher in males exposed to motorboat-noise playback and 11-ketotestosterone (11-KT) levels were significantly higher in males during the short-term experiment and in both sexes during the longer-term experiment.

Kusku et al. (2020) measured respiratory changes as secondary indicators of stress in Nile tilapia (*Oreochromis niloticus*) to determine potential effects of long-term exposure to underwater sound playback, including shipping noise. Fish exposed to noise showed as much as a two-fold increase in respiratory indicators (opercular beat rate and pectoral wing rate) after 10 minutes of sound exposure as compared to controls and pre-exposure rates. Over the next 120 days of continuous sound exposure, respiratory indicators declined steadily and returned to baseline. The authors conclude that the data support habituation of fish to chronic noise exposure.

However, not all species show these reactions. Smith et al. (2004b) found no increase in corticosteroid, a class of stress hormones, in goldfish exposed to a continuous, band-limited noise (0.1–10 kHz) with a sound pressure level of 170 dB re 1 µPa for one month. Wysocki et al. (2007) exposed rainbow trout to continuous band-limited noise with a sound pressure level of about 150 dB re 1 µPa for nine months with no observed stress effects. Growth rates and effects on the trout's immune systems were not significantly different from control animals held at a sound pressure level of 110 dB re 1 µPa. In addition, although there was a difference of 10 dB in overall background level and boat activity between test sites, reef fish, *Halichoeres bivittatus,* showed similar levels of whole-body cortisol (Staaterman et al., 2020). This suggests that boat noise, in this context, was not as stressful as handling of the fish for this particular experiment and contradicts previous conclusions that follow similar study designs.

Fishes may have physiological stress reactions to sounds that they can hear. Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources, such as predator vocalizations, or the sudden onset of impulsive signals rather than from non-impulsive or continuous sources such as vessel noise or sonar. If an exposure is short, the stress responses are typically brief (a few seconds to minutes). In addition, research shows that fishes may habituate (i.e., learn to tolerate) to the noise that is being presented after multiple exposures or longer duration exposures that prove to be non-threatening. However, exposure to chronic noise sources can lead to more severe impacts over time, such as reduced growth rates which can lead to reduced survivability for an individual. It is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

3.6.3.1.1.5 Behavioral Reactions

Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on behavioral reactions and the framework used to analyze this potential impact. Behavioral reactions in fishes have been observed due to a number of different types of sound sources. The majority of research has been performed using air guns (including large-scale seismic surveys), sonar, and vessel noise. Fewer observations have been made on behavioral reactions to impact pile driving noise, although fish are likely to show similar behavioral reactions to any impulsive noise within or outside the zone for hearing loss and injury.

As with masking, a fish must first be able to detect a sound above its hearing threshold and above the ambient noise level before a behavioral reaction can occur. Most fishes can only detect low-frequency sounds, with the exception of a few species that can detect some mid and high frequencies (above 1 kHz).

Fish studies have identified the following behavioral reactions to sound: alteration of natural behaviors (e.g., startle or alarm), and avoidance (LGL Ltd Environmental Research Associates et al., 2008; McCauley et al., 2000; Pearson et al., 1992). In the context of this SEIS/OEIS, and to remain consistent with available behavioral reaction literature, the terms “startle,” “alarm,” “response,” and “reaction” will be used synonymously.

In addition, observed behavioral effects to fish could include disruption to or alteration of natural activities such as swimming, schooling, feeding, breeding, and migrating. Sudden changes in sound level can cause fish to dive, rise, or change swimming direction. However, some fish either do not respond, learn to tolerate or habituate to repeated exposures, or learn to tolerate noise that does not seem threatening (e.g., Bruintjes et al., 2016; Currie et al., 2020; Hubert et al., 2020; Nedelec et al., 2016b; Radford et al., 2016).

Research on behavioral reactions can be difficult to understand and interpret. For example, behavioral responses often vary depending on the type of exposure and sound source present. Changes in sound intensity may be more important to a fish’s behavior than the maximum sound level. Some studies show that sounds that fluctuate in level or have intermittent pulse rates tend to elicit stronger responses from fish than even stronger sounds with a continuous level (Currie et al., 2020; Neo et al., 2014; Schwarz & Greer, 1984). It has also been suggested that unpredictable sounds that last for long durations may have the largest impact on behavioral responses (de Jong et al., 2020). Interpreting behavioral responses can also be difficult due to species-specific behavioral tendencies, motivational state (e.g., feeding or mating), an individual’s previous experience, how resilient a species is to changes in their environment, and whether or not the fish are able to avoid the source (e.g., caged versus free-swimming subjects). Results from caged studies may not provide a clear understanding of how free-swimming fishes may react to the same or similar sound exposures (Hawkins et al., 2015).

Behavioral Reactions due to Impulsive Sound Sources

It is assumed that most species would react similarly to impulsive sources such as weapons noise and explosions. However, it is important to note that most data on behavioral reactions to impulsive sources is collected from studies using air guns and impact pile driving, sources that do not occur in the TMAA. Reactions include startle or alarm responses and increased swim speeds at the onset of impulsive sounds (Fewtrell & McCauley, 2012; Pearson et al., 1992; Roberts et al., 2016a; Spiga et al., 2017). Data on fish behavioral reactions exposed to impulsive sound sources is mostly limited to studies using caged fishes and seismic air guns (Løkkeborg et al., 2012). Several species of rockfish (*Sebastes* species) in a caged environment exhibited startle or alarm reactions to seismic air gun pulses between peak-to-peak sound pressure levels of 180 dB re 1 µPa and 205 dB re 1 µPa (Pearson et al., 1992). More subtle behavioral changes were noted at lower sound pressure levels, including decreased swim speeds. At the presentation of the sound, some species of rockfish settled to the bottom of the experimental enclosure and reduced swim speed. Trevally (*Pseudocaranx dentex*) and pink snapper (*Pagrus auratus*) also exhibited alert responses as well as changes in swim depth, speed, and schooling behaviors when exposed to air gun noise (Fewtrell & McCauley, 2012). Both trevally and pink snapper swam faster and closer to the bottom of the cage at the onset of the exposure. However, trevally swam in tightly cohesive groups at the bottom of the test cages while pink snapper exhibited much looser group cohesion. These behavioral responses were seen during sound exposure levels as low as 147 up to

161 dB re 1 µPa^2-s but habituation occurred in all cases, either within a few minutes or within 30 minutes after the final air gun shot (Fewtrell & McCauley, 2012; Pearson et al., 1992).

Some studies have shown a lack of behavioral reactions to air gun noise. Herring exposed to an approaching air gun survey (from 27 to 2 km over 6 hours), resulting in single pulse sound exposure levels of 125 to 155 dB re 1 µPa^2-s, did not react by changing direction or swim speed (Pena et al., 2013). Although these levels are similar to those tested in other studies which exhibited responses (Fewtrell & McCauley, 2012), the distance of the exposure to the test enclosure, the slow onset of the sound source, and a strong motivation for feeding may have affected the observed response (Pena et al., 2013). In another study, Wardle et al. (2001) observed marine fish on an inshore reef before, during, and after an air gun survey at varying distances. The air guns were calibrated at a peak level of 210 dB re 1 µPa at 16 m and 195 dB re 1 µPa at 109 m from the source. Other than observed startle responses and small changes in the position of pollack, when the air gun was located within close proximity to the test site (within 10 m), they found no substantial or permanent changes in the behavior of the fish on the reef throughout the course of the study. Behavioral responses to impulsive sources are more likely to occur within near and intermediate (tens to hundreds of meters) distances from the source as opposed to far distances (thousands of meters) (Popper et al., 2014).

Unlike the previous studies, Slotte et al. (2004) used fishing sonar (38 kHz echo sounder) to monitor behavior and depth of blue whiting (*Micromesistius poutassou*) and Norwegian spring herring (*Clupea harengus L.*) spawning schools exposed to air gun signals. They reported that fishes in the area of the air guns appeared to go to greater depths after the air gun exposure compared to their vertical position prior to the air gun usage. Moreover, the abundance of animals 30–50 km away from the air guns increased during seismic activity, suggesting that migrating fish left the zone of seismic activity and did not re-enter the area until the activity ceased. It is unlikely that either species was able to detect the fishing sonar. However, it should be noted that these behavior patterns may have also been influenced by other variables such as motivation for feeding, migration, or other environmental factors (e.g., temperature, salinity) (Slotte et al., 2004).

Bruce et al. (2018) investigated the potential behavioral effects of sharks exposed to a seismic survey. In the first part of the study, researchers attached acoustic and accelerometer tags to swell sharks (*Cephaloscyllium laticeps)*, gummy sharks (*Mustelus antarcticus)*, and tiger flathead (*Neoplatycephalus richardsoni*) in order to monitor their behavior during seismic surveys. Although tagging was successful and provided a large sample size for two out of the three species, most tagged individuals moved out of range of the experimental site where autonomous acoustic receivers were placed or sporadically returned to the monitoring site throughout the duration of the survey. This made it difficult to correlate displacement from the area with the actual survey. In the second part of the study, modeled predicted catch rates within the experimental site were compared to actual catch per unit effort data collected from local fisheries. Of the nine species analyzed, only three of them showed reductions in catch rates following the seismic survey. Contrary to past findings and assumptions, catch rates for six species actually increased after the survey. Although these findings are interesting and, in some ways, may contradict prior conclusions, there are some improvements that should be made to similar studies in the future to better understand the true effects of seismic surveys on fish behavior and catch rates.

Alterations in natural behavior patterns due to exposure to pile driving noise have not been studied as thoroughly, but reactions noted thus far are similar to those seen in response to seismic surveys. These changes in behavior include startle responses, changes in depth (in both caged and free-swimming subjects), increased swim speeds, changes in ventilation rates, changes in attention and anti-predator behaviors, and directional avoidance (e.g., Hawkins et al., 2014; Mueller-Blenkle et al., 2010; Neo et al., 2015; Roberts et al., 2016a; Spiga et al., 2017). The severity of response varied greatly by species and received sound pressure level of the exposure. For example, some minor behavioral reactions such as startle responses were observed during caged studies with a sound pressure level as low as 140 dB re 1 µPa (Neo et al., 2014). However, only some free-swimming fishes avoided pile driving noise at even higher sound pressure levels between 152 and 157 dB re 1 µPa (Iafrate et al., 2016). In addition, Roberts et al. (2016a) observed that although multiple species of free swimming fish responded to simulated pile driving recordings, not all responded consistently. In some cases, only one fish would respond while the others continued feeding from a baited remote underwater video. In other instances, various individual fish would respond to different strikes. The repetition rate of pulses during an exposure may also have an effect on what behaviors were noted and how quickly these behaviors recovered as opposed to the overall sound pressure or exposure level (Neo et al., 2014). Neo et al. (2014) observed slower recovery times in fishes exposed to intermittent sounds (similar to pile driving) compared to continuous exposures.

As summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), species may react differently to the same sound source depending on a number of variables, such as the animal's life stage or behavioral state (e.g., feeding, mating). Without specific data, it is assumed that fishes react similarly to all impulsive sounds outside the zone for hearing loss and injury. Observations of fish reactions to large-scale air gun surveys are informative, but not necessarily directly applicable to analyzing impacts from the short-term, intermittent use of all impulsive sources. It is assumed that fish have a high probability of reacting to an impulsive sound source within near and intermediate distances (tens to hundreds of meters), and a decreasing probability of reaction at increasing distances (Popper et al., 2014).

Behavioral Reactions due to Sonar and Other Transducers

Behavioral reactions to sonar have been studied both in caged and free-swimming fish, although results can often-times be difficult to interpret depending on the species tested and the study environment. Jørgensen et al. (2005) showed that caged cod and spotted wolf fish (*Anarhichas minor*) lacked any response to simulated sonar between 1 and 8 kHz. However, within the same study, reactions were seen in juvenile herring. It is likely that the sonar signals were inaudible to the cod and wolf fish (species that lack notable hearing specializations), but audible to herring (a species that has hearing capabilities in the frequency ranges tested).

Doksæter et al. (2009; 2012) and Sivle et al. (2014; 2012) studied the reactions of both wild and captive Atlantic herring to the Royal Netherlands Navy's experimental mid-frequency active sonar ranging from 1 to 7 kHz. The behavior of the fish was monitored in each study either using upward looking echosounders (for wild herring) or audio and video monitoring systems (for captive herring). The source levels used within each study varied across all studies and exposures with a maximum received sound pressure level of 181 dB re 1 µPa and maximum cumulative sound exposure level of 184 dB re 1 $\mu Pa^2 \cdot s$. No avoidance or escape reactions were observed when herring were exposed to any sonar sources. Instead, significant reactions were noted at lower received sound levels of different non-sonar sound types. For example, dive responses (i.e., escape reactions) were observed when herring were exposed to killer whale feeding sounds at received sound pressure levels of approximately 150 dB re 1 µPa (Sivle et al., 2012). Startle responses were seen when the cages for captive herring were hit with a wooden stick and with the ignition of an outboard boat engine at a distance of one meter from the test pen (Doksaeter et al., 2012). It is possible that the herring were not disturbed by the sonar, were more motivated to continue other behaviors such as feeding, or did not associate the sound as a threatening stimulus. Based on these results (Doksaeter et al., 2009; Doksaeter et al., 2012; Sivle et al., 2012), Sivle et al. (2014) created a model in order to report on the possible population-level effects on Atlantic herring from active naval sonar. The authors concluded that the use of naval sonar poses little risk to populations of herring regardless of season, even when the herring populations are aggregated and directly exposed to sonar.

There is evidence that elasmobranchs (cartilaginous fish including sharks and rays) also respond to human-generated sounds. A number of researchers conducted experiments in which they played back sounds (e.g., pulsed tones below 1 kHz) and attracted a number of different shark species to the sound source (e.g., Casper et al., 2012a; Myrberg et al., 1976; Myrberg et al., 1969; Myrberg et al., 1972; Nelson & Johnson, 1972). The results of these studies showed that sharks were attracted to irregularly pulsed low-frequency sounds (below several hundred Hz), in the same frequency range of sounds that might be produced by struggling prey. However, abrupt and irregularly pulsed human-generated noise (0.2-–kHz, with most energy below 1 kHz) resulted in withdrawal responses of certain shark species (Chapuis et al., 2019). Sharks are not known to be attracted to continuous signals or higher frequencies that they presumably cannot hear (Casper & Mann, 2006; Casper & Mann, 2009).

Only a few species of marine fishes can detect sonars above 1 kHz (see Section 3.6.2.1.3, Hearing and Vocalization), meaning that most fishes would not detect most mid-, high-, or very high-frequency Navy sonars. The few marine species that can detect above 1 kHz and have some hearing specializations may be able to better detect the sound and would therefore be more likely to react. However, researchers have found little reaction by adult fish in the wild to sonars within the animals' hearing range (Doksaeter et al., 2009; Doksaeter et al., 2012; Sivle et al., 2012). The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) suggests that fish able to hear sonars would have a low probability of reacting to the source within near or intermediate distances (within tens to hundreds of meters) and a decreasing probability of reacting at increasing distances.

Behavioral Reactions due to Vessel Noise

Vessel traffic also contributes to the amount of noise in the ocean and has the potential to affect fishes. Several studies have demonstrated and reviewed avoidance responses by fishes (e.g., herring and cod) to the low-frequency sounds of vessels (De Robertis & Handegard, 2013; Engås et al., 1995; Handegard et al., 2003). Misund (1997) found fish ahead of a ship that showed avoidance reactions did so at ranges of 50 to 150 m. When the vessel passed over them, some species of fish responded with sudden escape responses that included lateral avoidance or downward compression of the school.

As mentioned above, behavioral reactions are quite variable depending on a number of factors such as (but not limited to) the type of fish, its life history stage, behavior, time of day, location, the sound source (e.g., type of vessel or motor vs. playback of broadband sounds), and the sound propagation characteristics of the water column (Popper et al., 2014; Schwarz & Greer, 1984). Reactions to playbacks of continuous noise or passing vessels generally include basic startle and avoidance responses, as well as evidence of distraction and increased decision-making errors. Other observed responses include increased group cohesion; increased distractions or evidence of modified attention; changes in vertical distribution in the water column, swim speeds, distance traveled, and feeding efficacy such as reduced foraging/hunting attempts and increased mistakes (i.e., lowered discrimination between food and non-food items) (e.g., Bracciali et al., 2012; De Robertis & Handegard, 2013; Gendron et al., 2020; Handegard et al., 2015; Jimenez et al., 2020; Mauro et al., 2020; McCormick et al., 2019; Nedelec et al., 2017a; Nedelec et al., 2015; Neo et al., 2015; Payne et al., 2015b; Purser & Radford, 2011; Roberts et al., 2016a; Sabet et al., 2016; Simpson et al., 2015; Simpson et al., 2016; Voellmy et al., 2014a; Voellmy et al., 2014b). Furthermore, both playbacks and actual noise from nearby boats have resulted in alterations in reproductive and nesting behaviors, such as changes in visual displays; signaling and aggression towards potential mates, competitors, and conspecifics; diminished territorial interactions; and reduced parental care behaviors such as egg fanning and vigilance (Butler & Maruska, 2020; McCloskey et al., 2020). In addition to physiological stress responses discussed in Section 3.6.3.1.1.4, Mills et al. (2020) observed the behavioral effects of motorboat noise on orange-fin anemonefish (*Amphiprion chrysopterus*) over short-term (30 minutes) and longer-term (48 hours) periods. Significant behavioral effects included increased hiding, reduction in distance from anemone, and increased aggressive behavior toward heterospecifics over both time periods.

Behavioral responses may also be dependent on the type of vessel to which a fish is exposed. For example, juvenile damselfish (*Pomacentrus wardi*) exposed to sound from a two-stroke engine resulted in startle responses, reduction in boldness (increased time spent hiding, less time exhibiting exploratory behaviors) and space use (maximum distance ventured from shelter or traveled within the test enclosure), as well as slower and more conservative reactions to visual stimuli analogous to a potential predator. However, damselfish exposed to sound from a four-stroke engine generally displayed similar responses as control fish exposed to ambient noise (e.g., little or no change in boldness) (McCormick et al., 2018; McCormick et al., 2019). Although the two sound sources were very similar, the vessels powered by the four-stroke engine were of lower intensity compared to vessels powered by the two-stroke engine, which may explain the overall reduced response to this engine type. Vessel noise has also led to changes in anti-predator response, but these responses vary by species. During exposures to vessel noise, juvenile Ambon damselfish (*Pomacentrus amboinensis*) and European eels showed slower reaction times and lacked startle responses to predatory attacks, and subsequently showed signs of distraction and increased their risk of predation during both simulated and actual predation experiments (Simpson et al., 2015; Simpson et al., 2016). Furthermore, juvenile Ambon damselfish showed a reduction in learned anti-predator behaviors likely as a result of distraction which could lead to an increased risk of survival (Ferrari et al., 2018). Spiny chromis (*Acanthochromis polyacanthus*) exposed to chronic boat noise playbacks for up to 12 consecutive days spent less time feeding and interacting with offspring, and displayed increased defensive acts. In addition, offspring survival rates were also lower at nests exposed to chronic boat noise playbacks versus those exposed to ambient playbacks (Nedelec et al., 2017b). This suggests that chronic or long-term exposures could have more severe consequences than brief exposures.

In contrast, larval Atlantic cod showed a stronger anti-predator response and were more difficult to capture during simulated predator attacks (Nedelec et al., 2015). There are also observations of a general lack of response to shipping and pile driving playback noise by grey mullet (*Chelon labrosus*) and the two spotted goby (*Gobiusculus flavescens*) (Roberts et al., 2016b) as well as no effect of boat noise or presence on round goby (*Neogobius melanostomus)* calling behaviors (Higgs & Humphrey, 2019). Mensinger et al. (2018) found that Australian snapper (*Pagrus auratus*) located in a protected area showed no change in feeding behavior or avoidance during boat passes, whereas snapper in areas where fishing occurs startled and ceased feeding behaviors during boat presence. This supports that location and past experience also have an influence on whether fishes react.

Although behavioral responses such as those listed above were often noted during the onset of most sound presentations, most behaviors did not last long and animals quickly returned to baseline behavior patterns. In fact, in one study, when given the chance to move from a noisy tank (with sound pressure levels reaching 120–140 dB re 1 µPa) to a quieter tank (sound pressure levels of 110 dB re 1 µPa), there was no evidence of avoidance. The fish did not seem to prefer the quieter environment and continued to swim between the two tanks comparable to control sessions (Neo et al., 2015). However, many of these reactions are difficult to extrapolate to real-world conditions due to the captive environment in which testing occurred.

To investigate potential avoidance on a larger scale, Ivanova et al. (2020) tagged Arctic cod and recorded movement and behavior during exposure to noise produced by cargo and cruise ship traffic. Overall, cod increased their horizontal movement outside of their estimated home range when vessels were either present or moving, compared to periods where vessels were absent indicating periods of potential avoidance. In addition, changes in feeding, travel, and search behaviors were observed when comparing each sound condition. The authors note that future studies should continue to investigate whether these observed effects are prolonged or how quickly fish may return to their home range and baseline behaviors.

Most fish species should be able to detect vessel noise due to its low-frequency content and their hearing capabilities (see Section 3.6.2.1.3, Hearing and Vocalization). The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) suggests that fishes have a high to moderate probability of reacting to nearby vessel noise (i.e., within tens of meters) with decreasing probability of reactions with increasing distance from the source (hundreds or more meters).

3.6.3.1.1.6 Long-Term Consequences

Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on potential pathways for long-term consequences. Mortality removes an individual fish from the population and injury reduces the fitness of an individual. Few studies have been conducted on any long-term consequences from repeated hearing loss, stress, or behavioral reactions in fishes due to exposure to loud sounds (Hawkins et al., 2015; Popper & Hastings, 2009a; Popper et al., 2014). Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with costs that can accumulate over time to cause long-term consequences for the individual. These long-term consequences may affect the survivability of the individual, or if impacting enough individuals may have population-level effects, including alteration from migration paths, avoidance of important habitat, or even cessation of foraging or reproductive behavior (Hawkins et al., 2015). Conversely, some animals habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past has not accompanied any overt threat. In fact, Sivle et al. (2016) predicted that exposures to sonar at the maximum levels tested would only result in short-term disturbance and would not likely affect the overall population in sensitive fishes such as Atlantic herring.

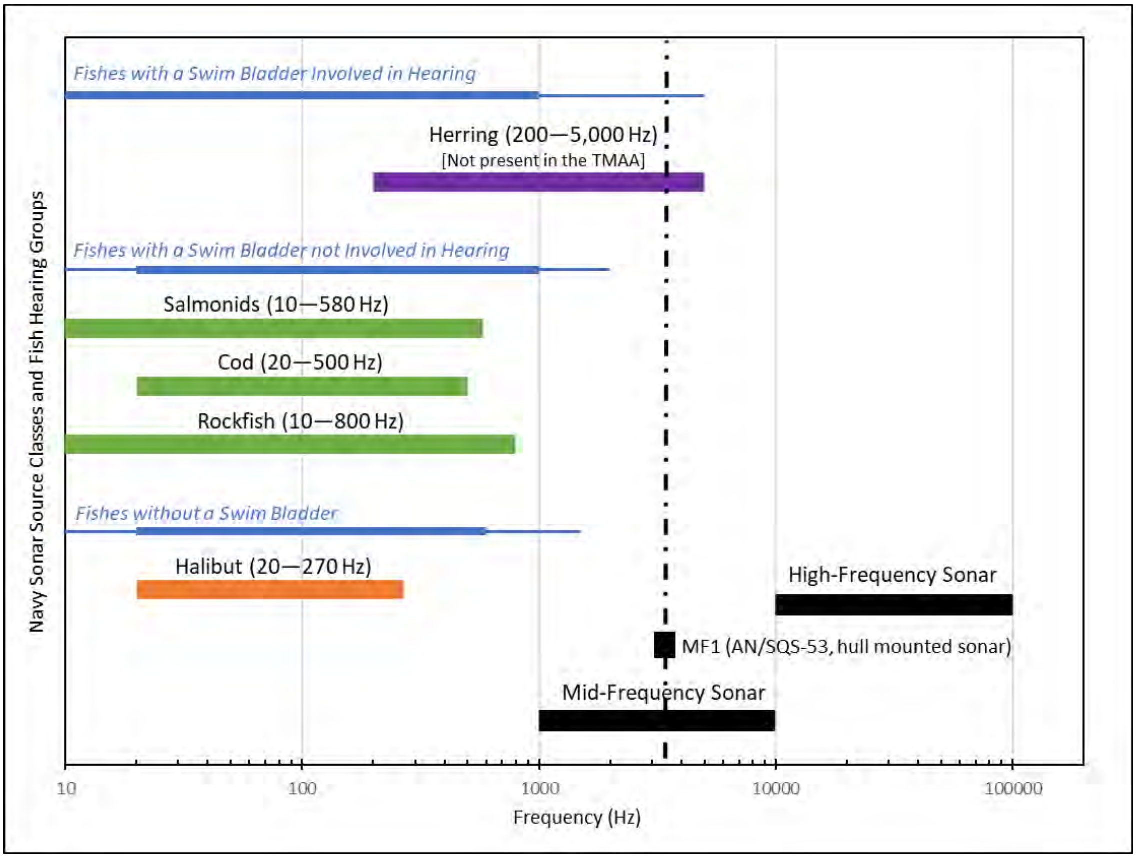
3.6.3.1.2 Impacts from Sonar and Other Transducers

Sonar and other transducers proposed for use could be used throughout the TMAA. Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of these systems are described in Section 3.0.4.1 (Acoustic Sources).

As described under Section 3.6.3.1.1.1 (Injury), direct injury from sonar and other transducers is highly unlikely because injury has not been documented in fish exposed to sonar (Halvorsen et al., 2013; Halvorsen et al., 2012c; Popper et al., 2007) and therefore is not considered further in this analysis.

Fishes are not equally sensitive to noise at all frequencies. Fishes must first be able to hear a sound in order to be affected by it. As discussed in Section 3.6.2.1.3 (Hearing and Vocalization), many marine fish species tested to date hear primarily below 1 kHz. For the purposes of this analysis, fish species were grouped into one of four fish hearing groups based on either their known hearing ranges (i.e., audiograms) or physiological features that may be linked to overall hearing capabilities (i.e., swim bladder with connection with, or in close proximity to, the inner ear).

Figure 3.6-2 provides a general summary of hearing threshold data from available literature (e.g., Casper & Mann, 2006; Deng et al., 2013; Kéver et al., 2014; Mann et al., 2001; Ramcharitar et al., 2006) to demonstrate the potential overall range of frequency detection for each hearing group.



Notes: Thin blue lines represent the estimated minimum and maximum range of frequency detection for the hearing group. All hearing groups are assumed to detect frequencies down to 10 Hz regardless of available data. Thicker portions of each blue line represent the estimated minimum and maximum range of best sensitivity for that group. Thick colored lines (purple, green, orange) below each hearing group represent example hearing data for specific species. Not all fishes within a hearing group would be able to detect all frequencies. For example, flatfish such as halibut can only detect frequencies up to 270 Hz, although other fishes in the same hearing group can detect much higher frequencies (e.g., bull sharks [not present in the TMAA] can detect up to 1,500 Hz, the upper limit of the hearing group). Each sonar source class that occurs in the TMAA is represented graphically by the horizontal black bars. Not all sources within each class would operate at all the displayed frequencies and may not overlap all fish hearing groups as demonstrated by the dotted black line. Hz = hertz, MF1 = 3,500 Hz.

Sources: (Casper & Mann, 2006; Chapman & Hawkins, 1973; Chapman & Sand, 1974; Hawkins & Johnstone, 1978; Mann et al., 2005; Popper, 2008; Popper et al., 2007; Tavolga & Wodinsky, 1963)

Figure 3.6-2: Fish Hearing Group and Navy Sonar Bin Frequency Ranges

Due to data limitations, these estimated hearing ranges may be overly conservative in that they may extend beyond what some species within a given fish hearing group may actually detect. For example, although most sharks are most sensitive to lower frequencies, well below 1 kHz, the bull shark (a species not known to occur in the TMAA) has been tested and can detect frequencies up to 1.5 kHz (Kritzler & Wood, 1961; Myrberg, 2001), representing the uppermost known limit of frequency detection for this hearing group. These upper bounds of each fish hearing groups' frequency range are outside of the range of best sensitivity for the majority of fishes within that group. As a result, fishes within each group would only be able to detect those upper frequencies at close distances to the source, and from sources with relatively high source levels.

Figure 3.6-2 is not a composite audiogram but rather displays the basic overlap in potential frequency content for each hearing group with Navy defined sonar classes (i.e., mid- and high-frequency) as discussed under Section 3.0.4.1.1 (Sonar and Other Transducers).

Systems within the low-frequency sonar class present the greatest potential for overlap with fish hearing, although these sonars are not used as part of the proposed action. Some mid-frequency sonars and other transducers may also overlap some species' hearing ranges, but to a much lesser extent than low-frequency sonars. For example, the only hearing groups that have the potential to detect mid-frequency sources within bins MF1, MF4 and MF5 are fishes with a swim bladder involved in hearing and with high-frequency hearing. It is anticipated that most marine fishes would not hear, or be affected by, most mid-frequency Navy sonars or other transducers with operating frequencies greater than about 1–4 kHz. Only a few fish species (i.e., fish with a swim bladder and high-frequency hearing specializations) can detect, and therefore be potentially affected by, high- and very high-frequency sonars and other transducers, although none of these species (subfamily Alosinae [menhaden, shad]) are known to be present in the TMAA.

The most probable impacts from exposure to sonar and other transducers are TTS (for more detail see Section 3.6.3.1.1.2, Hearing Loss), masking (for more detail see Section 3.6.3.1.1.3, Masking), physiological stress (for more detail see Section 3.6.3.1.1.4, Physiological Stress), and behavioral reactions (for more detail see Section 3.6.3.1.1.5, Behavioral Reactions). Analysis of these effects are provided below.

3.6.3.1.2.1 Methods for Analyzing Impacts from Sonar and Other Transducers

The Navy performed a quantitative analysis to estimate the range to TTS for fishes exposed to sonar and other transducers used during Navy training activities. Inputs to the quantitative analysis included sound propagation modeling in the Navy Acoustic Effects Model to the sound exposure criteria and thresholds presented below to predict ranges to effects. Although ranges to effect are predicted, density data for fish species within the TMAA are not available; therefore, it is not possible to estimate the total number of individuals that may be affected by sound produced by sonar and other transducers.

Criteria and thresholds to estimate impacts from sonar and other transducers are presented below in Table 3.6-6. Thresholds for hearing loss are typically reported in cumulative sound exposure level so as to account for the duration of the exposure. Therefore, thresholds reported in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) that were presented in other metrics were converted to sound exposure level based on the signal duration reported in the original studies (see Halvorsen et al., 2013; Halvorsen et al., 2012c; Kane et al., 2010; Popper et al., 2007). General research findings from these studies can be reviewed in Section 3.6.3.1.1.2 (Hearing Loss).

Table 3.6-6: Sound Exposure Criteria for TTS from Mid-Frequency Sonar

Fish Hearing Group	TTS from Mid-Frequency Sonar (SEL_{cum})
Fishes without a swim bladder	NC
Fishes with a swim bladder not involved in hearing	NC
Fishes with a swim bladder involved in hearing	220

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), NC = effects from exposure to sonar is considered to be unlikely, therefore no criteria are reported, > indicates that the given effect would occur above the reported threshold.

For mid-frequency sonars, fishes with a swim bladder involved in hearing have shown signs of hearing loss because of mid-frequency sonar exposure at a maximum received sound pressure level of 210 dB re 1 µPa for a total duration of 15 seconds. To account for the total duration of the exposure, the threshold for TTS is a cumulative sound exposure level of 220 dB re 1 μPa^2-s (Halvorsen et al., 2012c; Kane et al., 2010). TTS has not been observed in fishes with a swim bladder that is not involved in hearing exposed to mid-frequency sonar. Fishes within this hearing group do not sense pressure well and typically cannot hear at frequencies above 1 kHz (Halvorsen et al., 2012c; Popper et al., 2014). Therefore, no criteria were proposed for fishes with a swim bladder that is not involved in hearing from exposure to mid-frequency sonars as it is considered unlikely for TTS to occur. Fishes without a swim bladder are even less susceptible to noise exposure; therefore, TTS is unlikely to occur, and no criteria are proposed for this group either.

Criteria for high- and very-high-frequency sonar were not presented in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014); however, only species with a swim bladder involved in hearing and with high-frequency specializations in the subfamily Alosinae could potentially be affected. As stated previously, these fish species are not present in the TMAA.

3.6.3.1.2.2 Impact Ranges for Sonar and Other Transducers

The following section provides ranges to specific effects from sonar and other transducers. Ranges are calculated using criteria from Table 3.6-7 and the Navy Acoustic Effects Model. Only ranges to TTS were predicted based on available data. Sonar durations of 1, 30, 60 and 120 seconds were used to calculate the ranges below. However, despite the variation in exposure duration, ranges were almost identical across these durations and therefore were combined and summarized by bin in the table below. General source levels, durations, and other characteristics of these systems are described in Section 3.0.4.1 (Acoustic Sources).

Table 3.6-7: Ranges to Temporary Threshold Shift from Three Representative Sonar Bins

Fish Hearing Group	*Range to Effects (meters)*		
	Sonar Bin MF1	*Sonar Bin MF4*	*Sonar Bin MF5*
	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)	*Helicopter-deployed dipping sonars (e.g., AN/AQS-22)*	*Active acoustic sonobuoys (e.g., DICASS)*
Fish without a swim bladder	NR	NR	NR
Fish with a swim bladder not involved in hearing	NR	NR	NR
Fish with a swim bladder involved in hearing	7 (5–10)	0	0

Notes: (1) Ranges to TTS represent modeled predictions in different areas and seasons within the Study Area. The average range to TTS is provided as well as the minimum to the maximum range to TTS in parenthesis. Where only one number is provided the average, minimum, and maximum ranges to TTS are the same.
(2) MF = mid-frequency, NR = no criteria are available and therefore no range to effects are estimated.

3.6.3.1.2.3 Impacts from Sonar and Other Transducers Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur in the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.6.3.1.2.4 Impacts from Sonar and Other Transducers Under Alternative 1

The Navy's Proposed Action is consistent with the Proposed Action presented in the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011a), *Record of Decision for Final Environmental Impact Statement/Overseas Environmental Impact Statement for the Gulf of Alaska Navy Training Activities* (U.S. Department of the Navy, 2011b), the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016), and *Record of Decision for the Gulf of Alaska Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy, 2017). The Proposed Action, described in detail in Chapter 2 (Description of Proposed Action and Alternatives), entails the military continuing training activities previously conducted and as described in the 2016 GOA Final SEIS/OEIS, for which a Record of Decision was issued. Though the types of activities and level of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been minor changes in the platforms and systems used as part of those activities.

Sonar and other transducers proposed for use are typically transient and temporary because activities that involve sonar and other transducers take place at different locations and many platforms are generally moving throughout the TMAA. In addition, the Proposed Action would occur over a maximum time period of up to 21 consecutive days during the months of April–October, further limiting the total potential time sonar and other transducers may impact fishes within the TMAA. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training under Alternative 1 are described in Section 3.0.4.1.1 (Sonar and Other Transducers). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). The proposed use of sonar for training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Although the existing conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, a detailed re-analysis of Alternative 1 with respect to fishes is provided here to supplant previous analyses based on available new literature, adjusted sound exposure criteria, and new acoustic effects modeling.

All marine fishes detect low-frequency sound. However, low-frequency sources would not be used as part of this proposed action and therefore are not analyzed further. As shown in Figure 3.6-2, the majority of marine fish species present within the TMAA are not expected to detect sounds in the mid-frequency range above a few kHz. The fish species that are known to detect mid-frequencies up to a few kHz (i.e., those with swim bladders, including some sciaenids [drum], most clupeids [herring], and potentially deep-water fish such as myctophids [lanternfish]) do not have their best sensitivities in the range of the operational sonars. Thus, these species may only detect the most powerful systems, such as hull-mounted sonar, within a few kilometers; and most other, less powerful mid-frequency sonar systems, for a kilometer or less. Fishes with a swim bladder involved in hearing are more susceptible to hearing loss due to exposure to mid-frequency sonars; however, the maximum estimated range to TTS for fish within this hearing group is equal to or less than 10 m for the most powerful sonar bin. Fishes within this hearing group would have to be very close to the source and the source levels would have to be relatively high in order to experience TTS. Most marine species lack these hearing specializations and therefore would be unable to detect sound greater than approximately 1 kHz and likewise would not be susceptible to TTS from these sound sources.

Most mid-frequency active sonars used in the TMAA would not have the potential to substantially mask key environmental sounds or produce sustained physiological stress or behavioral reactions due to the limited time of exposure resulting from the moving sound sources and variable duty cycles. However, it is important to note that some mid-frequency sonars have a high duty cycle or are operated continuously. This may increase the risk of masking, but only for important biological sounds that overlap with the frequency of the sonar being operated. Furthermore, although some species may be able to produce sound at higher frequencies (greater than 1 kHz), vocal marine fishes, such as sciaenids, largely communicate below the range of mid-frequency levels used by most sonars. Any such masking effects would be temporary and infrequent as a vessel operating mid-frequency sonar transits an area.

Fishes that are able to detect sonar and other transducers above a few kHz within near (tens of meters) to far (thousands of meters) distances of the source would be more likely to experience: mild physiological stress or behavioral reactions such as startle or avoidance responses, although risk would be low even close to the source; or no reaction. Based on the information provided in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), the relative risk of these effects at any distance are expected to be low. Due to the transient nature of most sonar operations, impacts, if any, would be localized and infrequent, only lasting a few seconds or minutes. As such, mid-frequency sonar use is unlikely to impact individuals or impacts would likely be insignificant. Based on the low level and short duration of potential exposure to sonar and other transducers and the limited number of days the Proposed Action would occur in a given year (21 consecutive days), long-term consequences for fish populations are not expected.

Various ESA-listed populations of salmonids (Chinook salmon, coho salmon, chum salmon, sockeye salmon, and steelhead) migrate north to mature in the Gulf of Alaska and may occur in the TMAA. As discussed in Table 3.6-2, juvenile salmonids predominantly occur in coastal waters on the continental shelf and along the slope with the exception of juvenile chum and steelhead salmon which could occur in portions of the TMAA farther offshore. Immature and maturing adult salmonids may occur throughout the TMAA (near and offshore) with seasonal and interannual variability depending on the species and population of interest. In addition, the Southern DPS of green sturgeon (not previously analyzed), although rare, has the potential to occur in the TMAA. If green sturgeon are present within the TMAA, it is more likely that they would occur in coastal areas on the shelf rather than in the open ocean. Sonar and other transducers would be used throughout the TMAA and therefore may overlap areas where any of these ESA-listed species could occur.

As discussed previously in Section 3.6.2.1.3 (Hearing and Vocalization) and as shown in Figure 3.6-2, all ESA-listed salmonids and green sturgeon are capable of detecting sound produced by some mid-frequency sonars and other transducers. Specifically, ESA-listed salmonids and green sturgeon have a swim bladder not involved in hearing and may be able to detect some mid-frequency sources operating below 2 kHz, but they are not particularly sensitive to these frequencies. In addition, there are only a few sources utilized within the TMAA that would potentially overlap frequencies ESA-listed fishes could detect, limiting the overall impact from exposure. Furthermore, due to the short-term, infrequent and localized nature of these activities, ESA-listed fishes are unlikely to be exposed multiple times within a short period. Physiological and behavioral reactions would be expected to be brief (seconds to minutes) and infrequent based on the low probability of co-occurrence between training activities and these species. Therefore, impacts from sonar and other transducers would be minor and insignificant for all ESA-listed species.

Although ESA-listed salmonids and green sturgeon have designated critical habitat, none of the designated critical habitat occurs within the TMAA; therefore, critical habitat for these species would not be impacted.

As described above, there is new information that applies to the analysis of impacts of sonar and other transducers on fishes. Though the types of activities and level of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. However, this new information does not substantively change the affected environment, which forms the environmental baseline of the analysis in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Additionally, no new Navy training activities are being proposed in this SEIS/OEIS that would affect fishes in the TMAA. Therefore, conclusions for fishes made for Alternative 1 that were analyzed in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS remain unchanged in this SEIS/OEIS. For a summary of effects of the action alternative on fishes under both the National Environmental Policy Act (NEPA) and EO 12114, please refer to Table 3.6-11 in the 2011 GOA Final EIS/OEIS.

In addition, new evidence suggests that ESA-listed green sturgeon may be present in the TMAA where they were not previously anticipated to occur. Therefore, conclusions based on the present analysis are also made for green sturgeon.

Pursuant to the ESA, the use of sonar and other transducers during training activities, as described under Alternative 1, may affect ESA-listed salmonids and green sturgeon. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

3.6.3.1.3 Impacts from Vessel Noise

3.6.3.1.3.1 Impacts from Vessel Noise Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur in the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.6.3.1.3.2 Impacts from Vessel Noise Under Alternative 1

Training activities within the TMAA involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels). Fishes may be exposed to noise from vessel movement throughout the TMAA. A detailed description of the acoustic characteristics and typical sound levels of vessel noise are in Section 3.0.4.1 (Acoustic Sources). Proposed training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS.

Although ESA-listed salmonids and green sturgeon have designated critical habitat, none of the designated critical habitat occurs within the TMAA; therefore, critical habitat for these species would not be impacted.

Alternative 1 for this SEIS/OEIS remains consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Because the existing baseline conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to fishes is not warranted.

However, new evidence suggests that ESA-listed green sturgeon may be present in the TMAA, where they were not previously anticipated to occur. Therefore, conclusions based on the previous analysis are also made for green sturgeon as the potential impacts from vessel noise would not differ between all previously analyzed ESA-listed fishes.

Pursuant to the ESA, vessel noise produced during training activities, as described under Alternative 1, may affect ESA-listed salmonids and green sturgeon. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

3.6.3.1.4 Impacts from Aircraft Noise

3.6.3.1.4.1 Impacts from Aircraft Noise Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur in the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.6.3.1.4.2 Impacts from Aircraft Noise Under Alternative 1

Training activities within the TMAA involve maneuvers by various types of fixed, rotary-wing, and tilt-rotor aircraft (collectively referred to as aircraft). Most aircraft noise would be concentrated around airbases and fixed ranges within the range complex, especially in the waters immediately surrounding aircraft carriers at sea during takeoff and landing. Other aircraft overflights include commercial air traffic in addition to U.S. Navy aircraft. Fishes may be exposed to noise from aircraft overflights. A detailed description of the acoustic characteristics and typical sound levels of aircraft overflights are in Section 3.0.4 (Stressors-Based Analysis). Proposed training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS.

The amount of sound entering the ocean from aircraft would be very limited in duration, sound level, and affected area. Due to the low level of sound that could enter the water from aircraft, hearing loss is not considered further as a potential effect. Potential impacts considered are masking of other biologically relevant sounds, physiological stress, and changes in behavior. Reactions by fishes to these specific stressors have not been recorded, however fishes would be expected to react to aircraft noise as they would react to other transient sounds (e.g., vessel noise).

Although ESA-listed salmonids and the green sturgeon have designated critical habitat, none of the designated critical habitat occurs within the TMAA; therefore, critical habitat for these species would not be impacted.

Alternative 1 for this SEIS/OEIS remains consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Because the existing conditions have not changed appreciably, and no new Navy training activities are being proposed for use in the TMAA in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to fishes is not warranted.

However, new evidence suggests that ESA-listed green sturgeon may be present in the TMAA, where they were not previously anticipated to occur. Therefore, conclusions based on the previous analysis are also made for green sturgeon as the potential impacts from aircraft noise would not differ between all previously analyzed ESA-listed fishes.

Pursuant to the ESA, aircraft noise produced during training activities, as described under Alternative 1, may affect ESA-listed salmonids and green sturgeon. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

3.6.3.1.5 Impacts from Weapon Noise

3.6.3.1.5.1 Impacts from Weapons Noise Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur in the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.6.3.1.5.2 Impacts from Weapon Noise Under Alternative 1

Fishes may be exposed to sounds caused by the firing of weapons, objects in flight, and impact of non-explosive munitions on the water's surface, which are described in Section 3.0.4.1 (Acoustic Sources). In general, these are impulsive sounds (such as those discussed under Section 3.0.4.2, Explosive Stressors) generated in close vicinity to or at the water surface, with the exception of items that are launched underwater. The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated in air by firing a gun (muzzle blast) and a crack sound due to a low amplitude shock wave generated by a supersonic projectile flying through the air. Most in-air sound would be reflected at the air-water interface. Underwater sounds would be strongest just below the surface and directly under the firing point. Any sound that enters the water only does so within a narrow cone below the firing point or path of the projectile. Vibration from the blast propagating through a ship's hull, the sound generated by the impact of an object with the water surface, and the sound generated by launching an object underwater are other sources of impulsive sound in the water. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange. Due to the transient nature of most activities that produce weapon noise, overall effects would be localized and infrequent, only lasting a few seconds or minutes. Reactions by fishes to these specific stressors have not been recorded, however fishes would be expected to react to weapon noise as they would react to other transient impulsive sounds. Proposed training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS.

Although ESA-listed salmonids and the green sturgeon have designated critical habitat, none of the designated critical habitat occurs within the TMAA; therefore, critical habitat for these species would not be impacted.

Alternative 1 for this SEIS/OEIS remains consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Because the existing conditions have not changed appreciably, and no new Navy training activities are being proposed for use in the TMAA in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to fishes is not warranted.

However, new evidence suggests that ESA-listed green sturgeon may be present in the TMAA, where they were not previously anticipated to occur. Therefore, conclusions based on the previous analysis are also made for green sturgeon as the potential impacts from weapon noise would not differ between all previously analyzed ESA-listed fishes.

Pursuant to the ESA, weapon noise produced during training activities, as described under Alternative 1, may affect ESA-listed salmonids and green sturgeon. The Navy will consult with NMFS as required by Section 7(a)(2).

3.6.3.2 Explosive Stressors

Explosions in the water or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. However, unlike other acoustic stressors, explosives release energy at a high rate producing a shock wave that can be injurious and even deadly. Therefore, explosive impacts on fishes are discussed separately from other acoustic stressors, even though the analysis of explosive impacts will in part rely on data for fish impacts due to impulsive sound exposure where appropriate.

Explosives are usually described by their net explosive weight, which accounts for the weight and type of explosive material. Additional explanation of the acoustic and explosive terms and sound energy concepts used in this section is found in Appendix B (Acoustic and Explosive Concepts).

This section begins with a summary of relevant data regarding explosive impacts on fishes in Section 3.6.3.2.1 (Background). The ways in which an explosive exposure could result in immediate effects or lead to long-term consequences for an animal are explained in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), and this section follows that framework.

Due to available new literature, adjusted sound exposure criteria, and new acoustic effects modeling, the analysis provided in Section 3.6.3.2.2 (Impacts from Explosives) of this FSEIS supplants the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS for fishes, and may change estimated impacts for some species since the 2016 GOA Final SEIS/OEIS. In addition, this analysis includes the consideration of ESA-listed green sturgeon not previously analyzed.

3.6.3.2.1 Background

The effects of explosions on fishes have been studied and reviewed by numerous authors (Keevin & Hempen, 1997; O'Keeffe, 1984; O'Keeffe & Young, 1984; Popper et al., 2014). A summary of the literature related to each type of effect forms the basis for analyzing the potential effects from Navy activities. The sections below include a survey and synthesis of best-available-science published in peer-reviewed journals, technical reports, and other scientific sources pertinent to impacts on fishes potentially resulting from Navy training activities. Fishes could be exposed to a range of impacts depending on the explosive source and context of the exposure. In addition to acoustic impacts including temporary or permanent hearing loss, auditory masking, physiological stress, or changes in behavior, potential impacts from an explosive exposure can include non-lethal injury and mortality.

3.6.3.2.1.1 Injury

Injury refers to the direct effects on the tissues or organs of a fish. The blast wave from an in-water explosion is lethal to fishes at close range, causing massive organ and tissue damage (Keevin & Hempen, 1997). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors including fish size, body shape, depth, physical condition of the fish, and perhaps most importantly, the presence of a swim bladder (Dahl et al., 2020; Keevin & Hempen, 1997; Wright, 1982; Yelverton & Richmond, 1981; Yelverton et al., 1975). At the same distance from the source, larger fishes are generally less susceptible to death or injury, elongated forms that are round in cross-section are less at risk than deep-bodied forms, and fishes oriented sideways to the blast suffer the greatest impact (Edds-Walton & Finneran, 2006; O'Keeffe, 1984; O'Keeffe & Young, 1984; Wiley et al., 1981; Yelverton et al., 1975). Species with a swim bladder are much more susceptible to blast injury from explosives than fishes without one (Gaspin, 1975; Gaspin et al., 1976; Goertner et al., 1994).

If a fish is close to an explosive detonation, the exposure to rapidly changing high pressure levels can cause barotrauma. Barotrauma is injury due to a sudden difference in pressure between an air space inside the body and the surrounding water and tissues. Rapid compression followed by rapid expansion of airspaces, such as the swim bladder, can damage surrounding tissues and result in the rupture of the airspace itself. As the largest air-filled organ in the body of most fishes with one, the swim bladder is the primary site of damage from explosives (Dahl et al., 2020; Wright, 1982; Yelverton et al., 1975). Gas-filled swim bladders resonate at different frequencies than surrounding tissue and can be torn by rapid oscillation between high- and low-pressure waves (Goertner, 1978). Swim bladders are a characteristic of most bony fishes, with the notable exception of flatfishes (e.g., halibut). Sharks and rays are examples of cartilaginous fishes without a swim bladder. Small airspaces, such as micro-bubbles that may be present in gill structures, could also be susceptible to oscillation when exposed to the rapid pressure increases caused by an explosion. This may have caused the bleeding observed on gill structures of some fish exposed to explosions (Goertner et al., 1994). Sudden very high pressures can also cause damage at tissue interfaces due to the way pressure waves travel differently through tissues with different densities. Rapidly oscillating pressure waves might rupture the kidney, liver, spleen, and sinus and cause venous hemorrhaging (Keevin & Hempen, 1997).

Several studies have exposed fish to explosives and examined various metrics in relation to injury susceptibility. Sverdrup (1994) exposed Atlantic salmon (1–1.5 kilograms [2–3 pounds]) in a laboratory setting to repeated shock pressures of around 2 megapascals (300 pounds per square inch [psi]) without any immediate or delayed mortality after a week. Hubbs and Rechnitzer (1952) showed that fish with swim bladders exposed to explosive shock fronts (the near-instantaneous rise to peak pressure) were more susceptible to injury when several feet below the water surface than near the bottom. When near the surface, the fish began to exhibit injuries around peak pressure exposures of 40–70 psi. However, near the bottom (all water depths were less than 100 feet [ft.]) fish exposed to pressures over twice as high exhibited no sign of injury. Yelverton et al. (1975) similarly found that peak pressure was not correlated to injury susceptibility; instead, injury susceptibility of swim bladder fish at shallow depths (10 ft. or less) was correlated to the metric of positive impulse (pascal seconds [Pa-s]), which takes into account both the positive peak pressure, the duration of the positive pressure exposure, and the fish mass, with smaller fish being more susceptible.

Dahl et al. (2020) reported the effects of underwater explosions on one species of Clupeiform fish, Pacific sardines (*Sardinops sagax*), with a physostomous swim bladder (an open swim bladder with direct connection to the gut via the pneumatic duct). Fish were stationed at various distances prior to each explosion, in addition to a control group that was not exposed. Necropsies following explosions observed significant injuries, including fat hematoma, kidney rupture, swim bladder rupture, and reproductive blood vessel rupture. While most significant injuries were consistently present at close range (<50 m), there were inconsistent findings at the 50–125 m range, suggesting possible acoustic refraction effects, including waveform paths that were bottom reflected, surface reflected, or a combination of both. Ranges at which injuries were observed within the present study are similar to those estimated by the Navy's Acoustic Effects Model for fishes with a swim bladder for detonations modeled in Southern California (where the study took place, for ranges see U.S. Department of the Navy, 2018b). The Navy continues to fund similar projects, including survival studies and those examining other types of fish (such as physoclists, species with a closed swim bladder), as they are crucial to consider before extrapolating findings to other fish species.

Gaspin et al. (1976) exposed multiple species of fish with a swim bladder, placed at varying depths, to explosive blasts of varying size and depth. Goertner (1978) and Wiley (1981) developed a swim bladder oscillation model, which showed that the severity of injury observed in those tests could be correlated to the extent of swim bladder expansion and contraction predicted to have been induced by exposure to the explosive blasts. Per this model, the degree of swim bladder oscillation is affected by ambient pressure (i.e., depth of fish), peak pressure of the explosive, duration of the pressure exposure, and exposure to surface rarefaction (negative pressure) waves. The maximum potential for injury is predicted to occur where the surface reflected rarefaction (negative) pressure wave arrives coincident with the moment of maximum compression of the swim bladder caused by exposure to the direct positive blast pressure wave, resulting in a subsequent maximum expansion of the swim bladder. Goertner (1978) and Wiley et al. (1981) found that their swim bladder oscillation model explained the injury data in the Yelverton et al. (1975) exposure study and their impulse parameter was applicable only to fishes at shallow enough depths to experience less than one swim bladder oscillation before being exposed to the following surface rarefaction wave.

O'Keeffe (1984) provides calculations and contour plots that allow estimation of the range to potential effects of in-water explosions on fish possessing swim bladders using the damage prediction model developed by Goertner (1978). O'Keeffe's (1984) parameters include the charge weight, depth of burst, and the size and depth of the fish, but the estimated ranges do not take into account unique propagation environments that could reduce or increase the range to effect. In general, fish at greater depths and near the surface are predicted to be less likely to be injured because geometries of the exposures would limit the amplitude of swim bladder oscillations. In contrast, detonations at or near the surface (i.e., similar to most Navy activities that utilize bombs and missiles) would result in energy loss at the water-air interface, resulting in lower overall ranges to effect than those predicted here.

In contrast to fish with swim bladders, fishes without swim bladders have been shown to be more resilient to explosives (Gaspin, 1975; Gaspin et al., 1976; Goertner et al., 1994). For example, some small (average 116 millimeter length; approximately 1 ounce) hogchokers (*Trinectes maculatus*) exposed less than 5 ft. from a 10 pound pentolite charge immediately survived the exposure with slight to moderate injuries, and only a small number of fish were immediately killed; however, most of the fish at this close range did suffer moderate to severe injuries, typically of the gills or around the otolithic structures (Goertner et al., 1994).

Studies that have documented caged fishes killed during planned underwater explosions indicate that most fish that die do so within one to four hours, and almost all die within a day (Yelverton et al., 1975). Mortality in free-swimming (uncaged) fishes may be higher due to increased susceptibility to predation. Fitch and Young (1948) found that the type of free-swimming fish killed changed when blasting was repeated at the same location within 24 hours of previous blasting. They observed that most fish killed on the second day were scavengers, presumably attracted by the victims of the previous day's blasts.

Fitch and Young (1948) also investigated whether a significant portion of fish killed would have sunk and not been observed at the surface. Comparisons of the numbers of fish observed dead at the surface and at the bottom in the same affected area after an explosion showed that fish found dead on the bottom comprised less than 10 percent of the total observed mortality. Gitschlag et al. (2000) conducted a more detailed study of both floating fishes and those that were sinking or lying on the bottom after explosive removal of nine oil platforms in the northern Gulf of Mexico. Results were highly variable. They found that 3–87 percent (46 percent average) of the red snapper killed during a blast might float to the surface. Currents, winds, and predation by seabirds or other fishes may be some of the reasons that the magnitude of fish mortality may not have been accurately captured.

There have been few studies of the impact of underwater explosives on early life stages of fish (eggs, larvae, juveniles). Fitch and Young (1948) reported mortality of larval anchovies exposed to underwater blasts off California. Nix and Chapman (1985) found that anchovy and smelt larvae died following the detonation of buried charges. Similar to adult fishes, the presence of a swim bladder contributes to shock wave-induced internal damage in larval and juvenile fish (Settle et al., 2002). Explosive shock wave injury to internal organs of larval pinfish and spot exposed at shallow depths was documented by Settle et al. (2002) and Govoni et al. (2003; 2008) at impulse levels similar to those predicted by Yelverton et al. (1975) for very small fish. Settle et al. (2002) provide the lowest measured received level that injuries have been observed in larval fish. Researchers (Faulkner et al., 2006; Faulkner et al., 2008; Jensen, 2003) have suggested that egg mortality may be correlated with peak particle velocity exposure (i.e., the localized movement or shaking of water particles, as opposed to the velocity of the blast wave), although sufficient data from direct explosive exposures is not available.

Rapid pressure changes could cause mechanical damage to sensitive ear structures due to differential movements of the otolithic structures. Bleeding near otolithic structures was the most commonly observed injury in non-swim bladder fish exposed to a close explosive charge (Goertner et al., 1994).

As summarized by the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), exposure to explosive energy poses the greatest potential threat for injury and mortality in marine fishes. Fishes with a swim bladder are more susceptible to injury than fishes without a swim bladder. The susceptibility also probably varies with size and depth of both the detonation and the fish. Fish larvae or juvenile fish may be more susceptible to injury from exposure to explosives.

3.6.3.2.1.2 Hearing Loss

There are no direct measurements of hearing loss in fishes due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds such as those produced by air guns. PTS in fish has not been known to occur in species tested to date and any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Popper et al., 2014; Popper et al., 2005; Smith et al., 2006).

As reviewed in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), fishes without a swim bladder, or fishes with a swim bladder not involved in hearing, would be less susceptible to hearing loss (i.e., TTS), even at higher level exposures. Fish with a swim bladder involved in hearing may be susceptible to TTS within very close ranges to an explosive. General research findings regarding TTS in fishes as well as findings specific to exposure to other impulsive sound sources are discussed in Section 3.6.3.1.1.2 (Hearing Loss).

3.6.3.2.1.3 Masking

Masking refers to the presence of a noise that interferes with a fish's ability to hear biologically important sounds including those produced by prey, predators, or other fish in the same species (Myrberg, 1980; Popper et al., 2003). This can take place whenever the noise level heard by a fish exceeds the level of a biologically relevant sound. As discussed in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Masking may lead to a change in vocalizations or a change in behavior (e.g., cessation of foraging, leaving an area).

There are no direct observations of masking in fishes due to exposure to explosives. The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) highlights a lack of data that exist for masking by explosives but suggests that the intermittent nature of explosions would result in very limited probability of any masking effects and if masking were to occur it would only occur during the duration of the sound. General research findings regarding masking in fishes due to exposure to sound are discussed in detail in Section 3.6.3.2.1.3 (Masking). Potential masking from explosives is likely to be similar to masking studied for other impulsive sounds such as air guns.

3.6.3.2.1.4 Physiological Stress

Fishes naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on physiological stress and the framework used to analyze this potential impact.

Research on physiological stress in fishes due to exposure to explosive sources is limited. Sverdrup et al. (1994) studied levels of stress hormones in Atlantic salmon after exposure to multiple detonations in a laboratory setting. Increases in cortisol and adrenaline were observed following the exposure, with adrenaline values returning to within normal range within 24 hours. General research findings regarding physiological stress in fishes due to exposure to acoustic sources are discussed in detail in this section. Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources such as predator vocalizations or the sudden onset of impulsive signals. Stress responses may be brief (a few seconds to minutes) if the exposure is short or if fishes habituate or learn to tolerate the noise. It is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

3.6.3.2.1.5 Behavioral Reactions

As discussed in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), any stimuli in the environment can cause a behavioral response in fishes, including sound and energy produced by explosions. Alterations in natural behavior patterns due to exposure to explosions have not been studied as thoroughly, but reactions are likely to be similar to reactions studied for other impulsive sounds such as those produced by air guns (e.g., startle response, changes in swim speed and depth). Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle or avoidance responses. General research findings regarding behavioral reactions from fishes due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail in this section.

As summarized by the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), species may react differently to the same sound source depending on a number of variables, such as the animal's life stage or behavioral state (e.g., feeding, mating). Without data that are more specific it is assumed that fishes with similar hearing capabilities react similarly to all impulsive sounds outside or within the zone for hearing loss and injury. Observations of fish reactions to large-scale air gun surveys are informative, but not necessarily directly applicable to analyzing impacts from the short-term, intermittent use of all impulsive sources. Fish have a higher probability of reacting when closer to an impulsive sound source (within tens of meters), and a decreasing probability of reaction at increasing distances (Popper et al., 2014).

3.6.3.2.1.6 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. For additional information on the determination of long-term consequences, see Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and temporary hearing impairment or chronic masking, which could affect navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions, masking and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for fish species that live for multiple seasons or years. For example, a lost reproductive opportunity could be a measurable cost to the individual; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences.

3.6.3.2.2 Impacts from Explosives

This section analyzes the impacts on fishes due to in-water and in-air explosives that would be used during Navy training activities, synthesizing the background information presented above. The proposed use of explosives for training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details), with one exception. Consistent with the previous analyses for Alternative 1, the sinking exercise activity will not be part of the proposed action for this SEIS/OEIS, and therefore the explosive use associated with that activity is no longer part of this proposed action.

As discussed above, sound and energy from underwater explosions are capable of causing mortality, injury, temporary hearing loss, masking, physiological stress, or a behavioral response, depending on the level and duration of exposure. The death of an animal would eliminate future reproductive potential, which is considered in the analysis of potential long-term consequences to the population. Exposures that result in non-auditory injuries may limit an animal's ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or affect its ability to reproduce. TTS can also impair an animal's abilities, although the individual may recover quickly with little significant effect.

3.6.3.2.2.1 Methods for Analyzing Impacts from Explosives

The Navy performed a quantitative analysis to estimate ranges to effect for fishes exposed to underwater explosives during Navy training activities. Inputs to the quantitative analysis included sound propagation modeling in the Navy's Acoustic Effects Model to the sound exposure criteria and thresholds presented below. Density data for fish species within the TMAA are not currently available; therefore, it is not possible to estimate the total number of individuals that may be affected by explosive activities.

Criteria and Thresholds used to Estimate Impacts on Fishes from Explosives

Mortality and Injury from Explosives

Criteria and thresholds to estimate impacts from sound and energy produced by explosive activities are presented below in Table 3.6-8. In order to estimate the longest range at which a fish may be killed or mortally injured, the Navy based the threshold for mortal injury on the lowest pressure that caused mortalities in the study by Hubbs and Rechnitzer (1952), consistent with the recommendation in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014). As described in Section 3.6.3.2.1.1 (Injury), this threshold likely over-estimates the potential for mortal injury. The potential for mortal injury has been shown to be correlated to fish size, depth, and geometry of exposure, which are not accounted for by using a peak pressure threshold. However, until fish mortality models are developed that can reasonably consider these factors across multiple environments, use of the peak pressure threshold allows for a conservative estimate of maximum impact ranges.

Due to the lack of detailed data for onset of injury in fishes exposed to explosives, thresholds from impact pile driving exposures (Halvorsen et al., 2012a; Halvorsen et al., 2011, 2012b) were used as a proxy for the analysis in the Atlantic Fleet and Hawaii-Southern California Training and Testing Draft EIS/OEISs (U.S. Department of the Navy, 2018a, 2018b). Upon re-evaluation during consultation with NMFS, the Navy determined that pile driving data was not appropriate and over conservative for use in the analysis of explosive effects on fishes. The Navy recommended a different peak pressure threshold derived from explosive literature be utilized in the analysis. Consequently, this threshold was later used and published in the Navy's Final EIS/OEISs (U.S. Department of the Navy, 2018a, 2018b) and is recommended for future analyses until better information can be obtained to inform explosive sound exposure criteria. Although NMFS agreed to evaluate the use of the Navy's proposed threshold in future consultations (National Marine Fisheries Service, 2018a), NMFS does not currently have a formal criteria established for explosive thresholds effects on fishes. Therefore, the Navy's injury criteria have been revised as follows.

Thresholds for the onset of injury from exposure to an explosion are not currently available and recommendations in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) only provide qualitative criteria for consideration. Therefore, available data from existing explosive studies were reviewed to provide a conservative estimate for a threshold to the onset of injury (Gaspin, 1975; Gaspin et al., 1976; Hubbs & Rechnitzer, 1952; Settle et al., 2002; Yelverton et al., 1975).

Table 3.6-8: Sound Exposure Criteria for Mortality and Injury from Explosives for All Fishes

Onset of Mortality	***Onset of Injury***
SPL_{peak}	***SPL_{peak}***
229	220

Note: SPLpeak = Peak sound pressure level.

It is important to note that some of the available literature is not peer-reviewed and there may be some caveats to consider when reviewing the data (e.g., issues with controls, limited details on injuries observed) but this information may still provide a better understanding of where injurious effects would begin to occur specific to explosive activities. The lowest threshold at which injuries were observed in each study were recorded and compared for consideration in selecting criteria. As a conservative measure, the absolute lowest peak sound pressure level recorded that resulted in injury, observed in exposures of larval fishes to explosions (Settle et al., 2002), was selected to represent the threshold to injury.

The injury threshold is consistent across all fish regardless of hearing groups due to the lack of rigorous data for multiple species. As discussed throughout Section 3.6.3.2.1.1 (Injury), it is important to note that these thresholds may be overly conservative, as there is evidence that fishes exposed to higher thresholds than those in Table 3.6-8 have shown no signs of injury (depending on variables such as the weight of the fish, size of the explosion, and depth of the cage (Gaspin, 1975; Gaspin et al., 1976; Hubbs & Rechnitzer, 1952; Settle et al., 2002; Yelverton et al., 1975). It is likely that adult fishes and fishes without a swim bladder would be less susceptible to injury than more sensitive hearing groups (i.e., fishes with a swim bladder) and larval fish.

The number of fish killed by an in-water explosion would depend on the population density near the blast, as well as factors discussed throughout Section 3.6.3.2.1.1 (Injury) such as net explosive weight, depth of the explosion, and fish size. For example, if an explosion occurred in the middle of a dense school of fish, a large number of fish could be killed. However, the probability of this occurring is low based on the patchy distribution of dense schooling fish. Stunning from pressure waves could also temporarily immobilize fish, making them more susceptible to predation.

Fragments produced by exploding munitions at or near the surface may present a high-speed strike hazard for an animal at or near the surface. In water, however, fragmentation velocities decrease rapidly due to drag (Swisdak & Montanaro, 1992). Because blast waves propagate efficiently through water, the range to injury from the blast wave would likely extend beyond the range of fragmentation risk.

Hearing Loss from Explosives

Criteria and thresholds to estimate TTS from sound produced by explosive activities are presented below in Table 3.6-9. Direct (measured) TTS data from explosives are not available. Criteria used to define TTS from explosives is derived from data on fishes exposed to seismic air gun signals (Popper et al., 2005) as summarized in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014). TTS has not been documented in fishes without a swim bladder from exposure to other impulsive sources (pile driving and air guns). Although it is possible that fishes without a swim bladder could receive TTS from exposure to explosives, fishes without a swim bladder are typically less susceptible to hearing impairment than fishes with a swim bladder. If TTS occurs in fishes without a swim bladder, it would likely occur within the range of injury; therefore, no thresholds for TTS are proposed. General research findings regarding hearing loss in fishes as well as findings specific to exposure to other impulsive sound sources are discussed in Section 3.6.3.2.1.2 (Hearing Loss).

Table 3.6-9: Sound Exposure Criteria for Hearing Loss from Explosives

Fish Hearing Group	***TTS (SEL_{cum})***
Fishes with a swim bladder not involved in hearing	> 186
Fishes with a swim bladder involved in hearing	186

Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa^2-s]), > indicates that the given effect would occur above the reported threshold.

As discussed below Section 3.6.3.1.1.2 (Hearing Loss, Hearing Loss due to Impulsive Sound Sources), exposure to sound produced from seismic air guns at a cumulative sound exposure level of 186 dB re 1 μPa^2-s has resulted in TTS in fishes with a swim bladder involved in hearing (Popper et al., 2005). TTS has not occurred in fishes with a swim bladder not involved in hearing and would likely occur above the given threshold in Table 3.6-9.

3.6.3.2.2.2 Impact Ranges for Explosives

The following section provides estimated range to effects for fishes exposed to sound and energy produced by explosives. Ranges are calculated using criteria from Table 3.6-10 and Table 3.6-11 and the Navy Acoustic Effects Model. All detonations conducted during Navy activities would occur at or near the surface. Specifically, as discussed in Section 3.0.4.2.1 (Explosions in Water), detonations occurring in air at a height of 33 ft. (10 m) or less above the water surface, and detonations occurring directly on the water surface, were modeled to detonate at a depth of 0.3 ft. (0.1 m) below the water surface since there is currently no means to model impacts from in-air detonations. The Navy Acoustic Effects Model cannot account for the highly non-linear effects of cavitation and surface blow off; therefore, some estimated ranges may be overly conservative. In addition, not all fish present within these ranges would be predicted to receive the associated effect as there are portions of the water column within these ranges that would not exceed the threshold (see Figure 3.0-1 for details). Ranges may vary greatly depending on factors such as the location, water depth, and season of the event.

Table 3.6-10 provides range to mortality and injury for all fishes. Only one table (Table 3.6-11) is provided for range to TTS for fishes with a swim bladder. Ranges to TTS for fishes with a swim bladder not involved in hearing and those without a swim bladder would be shorter than those reported because this effect has not been observed in fishes within those hearing groups.

Table 3.6-10: Range to Mortality and Injury for All Fishes from Explosives

Bin[1]	Range to Effects (meters)	
	Onset of Mortality 229 SPL_{peak}	Onset of Injury 220 SPL_{peak}
E5	175 (170–180)	445 (440–450)
E9	500 (500–500)	1,025 (1,025–1,025)
E10	638 (625–650)	1,400 (1,275–1,525)
E12	800 (800–800)	1,775 (1,775–1,775)

[1]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: (1) NEW = net explosive weight, SPL_{peak} = Peak sound pressure level. (2) Range to effects represent modeled predictions in different areas and seasons within the Action Area.
Each cell contains the estimated average, minimum and maximum range to the specified effect. Minimal variability in modeled environmental parameters (e.g., low variation in sound speed profile between simulations, deep water/lack of bottom reflections) can lead to low variation between the estimated average, minimum, and maximum ranges for a given bin and threshold, or cases where these ranges are identical.

Table 3.6-11: Range to TTS for Fishes with a Swim Bladder from Explosives

Bin[1]	Cluster Size	Range to Effects (meters)
		TTS
		SEL_{cum}
E5	1	155 (150–160)
	7	365 (360–370)
E9	1	450 (440–460)
E10	1	563 (550–575)
E12	1	711 (700–750)

[1]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650– 1,000)
Notes: (1) NEW = net explosive weight, SELcum = Cumulative sound exposure level, TTS = Temporary Threshold Shift. (2) Range to effects represent modeled predictions in different areas and seasons within the Action Area.
Each cell contains the estimated average, minimum and maximum range to the specified effect. Minimal variability in modeled environmental parameters (e.g., low variation in sound speed profile between simulations, deep water/lack of bottom reflections) can lead to low variation between the estimated average, minimum, and maximum ranges for a given bin and threshold.

3.6.3.2.2.3 Impacts from Explosives Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur in the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.6.3.2.2.4 Impacts from Explosives Under Alternative 1

The Navy's Proposed Action is consistent with the Proposed Action presented in the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011a), *Record of Decision for Final Environmental Impact Statement/Overseas Environmental Impact Statement for the Gulf of Alaska Navy Training Activities* (U.S. Department of the Navy, 2011b), the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016), and *Record of Decision for the Gulf of Alaska Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy, 2017). The Proposed Action, described in detail in Chapter 2 (Description of Proposed Action and Alternatives), entails the military continuing training activities previously conducted and as described in the 2016 GOA Final SEIS/OEIS, for which a Record of Decision was issued. Though the types of activities and level of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been minor changes in the platforms and systems used as part of those activities.

Training activities under Alternative 1 would use surface or near-surface detonations and explosive ordnance. The use of explosives would occur throughout the TMAA, the same location as analyzed under the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, and are typically dispersed in space and time. The number and type (i.e., source bin) of explosives that would be used during training under Alternative 1 are described in Section 3.0.4.2 (Explosive Stressors). Activities using explosives would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). The proposed use of explosives for training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) with one exception. Consistent with the previous analyses for Alternative 1, the sinking exercise activity will not be part of the proposed action for this SEIS/OEIS. Although the existing conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, a detailed re-analysis of Alternative 1 with respect to fishes is provided here to supplant previous analyses based on available new literature, adjusted sound exposure criteria, and new acoustic effects modeling.

To avoid or reduce potential impacts from explosive training activities on marine species, and as described in Chapter 5 (Mitigation), the Navy will implement mitigation to not use in-water explosives June through September in the North Pacific Right Whale Mitigation Area and April through October in the Portlock Bank Mitigation Area. Mitigation will help the Navy avoid or reduce potential impacts on fish and fishery resources in these important habitat areas in the TMAA.

Sound and energy from explosions could result in mortality and injury, on average, for hundreds to even thousands of meters from some of the largest explosions. Exposure to explosions could also result in temporary hearing loss in nearby fishes. The estimated range to each of these effects based on explosive bin size is provided in Table 3.6-10 and Table 3.6-11. Generally, explosives that belong to larger bins (with large net explosive weights) produce longer ranges within each effect category. However, some ranges vary depending upon a number of other factors (e.g., number of explosions in a single event, depth of the charge). Fishes without a swim bladder, adult fishes, and larger species would generally be less susceptible to injury and mortality from sound and energy associated with explosive activities than small, juvenile or larval fishes. Fishes that experience hearing loss could miss opportunities to detect predators or prey, or show a reduction in interspecific communication. However, the Proposed Action would only occur over a maximum time period of up to 21 consecutive days during the months of April–October, further limiting the total potential time explosives may impact fishes throughout the TMAA.

If an individual fish were repeatedly exposed to sound and energy from underwater explosions that caused alterations in natural behavioral patterns or physiological stress, these impacts could lead to long-term consequences for the individual such as reduced survival, growth, or reproductive capacity. If detonations occurred close together (within a few seconds), there could be the potential for masking to occur but this would likely happen at farther distances from the source where individual detonations might sound more continuous. Training activities involving explosions are generally dispersed in space and time. Consequently, repeated exposure of individual fishes to sound and energy from in-water explosions over the course of a day or multiple days is not likely and most behavioral effects are expected to be short-term (seconds or minutes) and localized. Exposure to multiple detonations over the course of a day would most likely lead to an alteration of natural behavior or the avoidance of that specific area.

Various ESA-listed populations of salmonids (Chinook salmon, coho salmon, chum salmon, sockeye salmon, and steelhead) migrate north to mature in the Gulf of Alaska and may occur in the TMAA. As discussed in Table 3.6-2, juvenile salmonids predominantly occur in coastal waters on the continental shelf and along the slope with the exception of juvenile chum salmon and steelhead which could occur in portions of the TMAA farther offshore. Immature and maturing adult salmonids may occur throughout the TMAA (both near and offshore) with seasonal and interannual variability depending on the species and population of interest. In addition, the Southern DPS of green sturgeon (not previously analyzed), although rare, has the potential to occur in the TMAA. If green sturgeon are present within the TMAA, it is more likely that they would occur in coastal areas on the shelf rather than in the open ocean. Each of these ESUs could only be exposed to explosive activities during the time they are present in the TMAA and during the same 21 consecutive days in which the Proposed Action would occur. Generally, surface-oriented fishes and those that occur in the top tens of meters of the water column, such as some ESA-listed salmonids, have a higher potential of being exposed to and affected by detonations at or above the water's surface. There would be little to no potential for species such as sturgeon, which typically occur at greater depths or on the seafloor, for exposure to sound and energy produced by detonations at or above the surface.

As discussed previously in Section 3.6.2.1.3 (Hearing and Vocalization), all ESA-listed fish species that occur in the TMAA are capable of detecting sound produced by explosives. Impacts on ESA-listed fishes, if they occur, would be similar to impacts on fishes in general. Due to the short-term, infrequent and localized nature of these activities, ESA-listed fishes are unlikely to be exposed multiple times within a short period. In addition, physiological and behavioral reactions would be expected to be brief (seconds to minutes) and infrequent based on the low probability of co-occurrence between training activities and these species. Although individuals may be impacted, long-term consequences for populations would not be expected.

Although ESA-listed salmonids and the green sturgeon have designated critical habitat, none of the designated critical habitat occurs within the TMAA; therefore, critical habitat for these species would not be impacted.

As described above, there is new information that applies to the analysis of impacts of explosives on fishes. Though the types of activities and level of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. However, this new information does not substantively change the affected environment, which forms the environmental baseline of the analysis in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Additionally, no new Navy training activities are being proposed in this SEIS/OEIS that would affect fishes in the TMAA. Therefore, conclusions for fishes made for Alternative 1 analyzed in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS remain unchanged in this SEIS/OEIS. For a summary of effects of the action alternative on fishes under both the NEPA and Executive Order (EO) 12114, please refer to Table 3.6-11 in the 2011 GOA Final EIS/OEIS.

In addition, new evidence suggests that ESA-listed green sturgeon may be present in the TMAA where they were not previously anticipated to occur. Therefore, conclusions based on the present analysis are also made for green sturgeon.

Pursuant to the ESA, the use of explosives during training activities, as described under Alternative 1, may affect ESA-listed salmonids and green sturgeon. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

3.6.4 Summary of Stressor Assessment (Combined Impacts of All Stressors) on Fish

As described above, there is new information on fish stock assessment reports, tagging studies, and fish hearing since the 2016 GOA Final SEIS/OEIS was prepared. However, this new information does not significantly change the affected environment, which forms the environmental baseline of the fish analysis in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Additionally, no new Navy training activities are being proposed in this SEIS/OEIS that would affect fishes in the TMAA. Therefore, conclusions for impacts on fish species made for the stressors that were not re-analyzed in this SEIS/OEIS remain unchanged from the conclusions under Alternative 1 analyzed in the 2011 GOA Final EIS/OEIS, and training activities do not compromise productivity of fishes or impact their habitats. For a summary of effects due to other stressors not reanalyzed in this SEIS/OEIS for Alternative 1 on fishes under both NEPA and EO 12114, please refer to Table 3.6-11 in the 2011 GOA Final EIS/OEIS.

Essential Fish Habitat Determinations

According to 50 Code of Federal Regulations Section 600.920(a), a supplemental consultation for EFH is required for renewals, reviews, or substantial revisions of actions if these actions may adversely affect EFH. There are no changes to Navy activities or designated EFH in the TMAA that are substantial in nature and that may adversely affect EFH previously analyzed. The Navy is corresponding with the NMFS regarding new species and life stages for scallop and groundfish species and other EFH to ensure concurrence. The analysis previously captured in Appendix C (Regulatory Consultations) of the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011a) remains unchanged.

Endangered Species Act

As part of the SEIS/OEIS, the Navy is consulting under section 7 of the ESA with NMFS for the ESA-listed fishes and will continue to rely on the prior analysis from the 2011 GOA Final EIS/OEIS, as reviewed and amended by this SEIS/OEIS, and Biological Evaluation, as they remain valid. Specifically, there has not been an exceedance of incidental take for listed fishes under the current Biological Opinion; there is no new information that reveals new effects to listed fish species or critical habitat for listed fishes that were not previously considered; and Navy training activities in the TMAA are not being substantially modified in a manner that would affect listed fish species or their critical habitat that was not previously considered. Two new salmonid ESUs are being considered for listing under the ESA, and NMFS is proposing to issue new species status reviews in the near future. However, the proposed project would not affect any future listed salmonids differently than those already evaluated in the 2016 GOA Final SEIS/OEIS or Biological Evaluation. Due to new information on ESA-listed salmonid occurrence and the presence of the southern DPS of green sturgeon, this SEIS/OEIS and Biological Assessment have expanded the number of potentially-occurring ESA-listed fishes addressed from the 2016 GOA Final SEIS/OEIS.

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3.7 Sea Turtles

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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3.7 Sea Turtles

3.7.1 Introduction

For purposes of this Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS), the Study Area remains the same as that identified in the March 2011 Gulf of Alaska (GOA) United States (U.S.) Department of the Navy (Navy) Training Activities Final Environmental Impact Statement (EIS)/OEIS and the July 2016 GOA Navy Training Activities Final SEIS/OEIS. The Study Area includes the Temporary Maritime Activities Area (TMAA). The TMAA is beyond 12 nautical miles (NM) from shore and outside of the U.S. Territorial Sea. The Proposed Action would occur over a maximum time period of up to 21 consecutive days during the months of April–October.

3.7.2 Affected Environment

This section references the Navy's 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016), which included updates to the affected environment description presented in the 2011 analysis. Similar to the Navy's 2011 GOA Final EIS/OEIS, this section provides an overview of sea turtle distribution and occurrence within the TMAA, with any relevant updates to the affected environment since the completion of the Navy's 2016 GOA Final SEIS/OEIS.

3.7.2.1 General Background

Only the leatherback sea turtle (*Dermochelys coriacea*), a cold-water adapted species, is included for analysis in this SEIS/OEIS. Recent information on population structure (through genetic studies) and distribution (through telemetry, tagging, genetic studies, and population modeling) has led to an increased understanding and refinement of the global stock structure (Clark et al., 2010; Gaspar & Lalire, 2017). This effort is critical to focus efforts to protect the species, because the status of individual stocks varies widely across the world. Unlike populations in the Caribbean and Atlantic Ocean, which are generally stable or increasing, western Pacific leatherbacks have declined more than 80 percent and eastern Pacific leatherbacks have declined by more than 97 percent since the 1980s (Kobayashi et al., 2016). Because the threats to these subpopulations have not ceased, the International Union for Conservation of Nature has predicted a decline of 96 percent for the western Pacific subpopulation and a decline of nearly 100 percent for the eastern Pacific subpopulation by 2040 (Nachtigall et al., 2016; Wallace et al., 2016). Even though new information is available regarding population structure and dynamics, the general density estimate for Pacific leatherback sea turtles used for the analysis of potential impacts (0.00001 leatherbacks/square kilometer) is used in this SEIS/OEIS, and is the same estimate used in the Navy's 2016 GOA Final SEIS/OEIS. Although this SEIS/OEIS includes updated information related to leatherback population dynamics, the new research is generally in agreement with the information provided in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS.

Since the release of the Navy's 2016 GOA Final SEIS/OEIS, the Navy has conducted a literature search for recent information that would warrant updating the description of the affected environment for sea turtles in this SEIS/OEIS (see Section 3.0.3, Resources and Issues Considered for Re-Evaluation in This Document). The following sections provide new information since the Navy's 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS for sea turtle diving abilities, as well as for hearing and vocalizations for sea turtles, with specific updates for leatherback sea turtles where species-specific information has appeared in new literature.

Although additional information relating to existing environmental conditions was found, the new information does not indicate an appreciable change to the existing environmental conditions as described in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Leatherback sea turtles would still be considered rare in the TMAA, as only 19 sightings have occurred of the species in the GOA since 1960 (National Marine Fisheries Service, 2017).

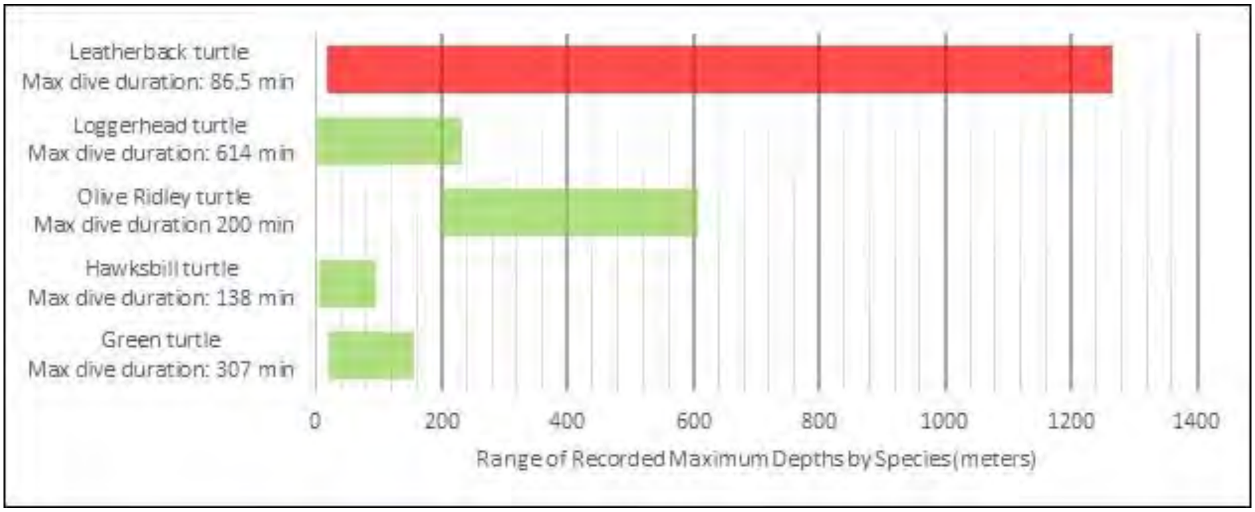
3.7.2.1.1 Species Unlikely to be Present in the Temporary Maritime Activities Area

As noted in the Navy's 2011 Final GOA EIS/OEIS (U.S. Department of the Navy, 2011a), and the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016), the Navy conducted a literature search for additional information that would warrant inclusion of the loggerhead sea turtle (*Caretta caretta*), olive ridley sea turtle (*Lepidochelys olivacea*), and green sea turtle (*Chelonia mydas*) in the analysis. One recent reference reported photographic evidence of loggerhead sea turtles in nearshore waters of British Columbia (Halpin et al., 2018). This sighting was considered rare, as would any sighting of Cheloniidae sea turtles, in alignment with previous conclusions presented in the Navy's 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Although sightings of sea turtles from the Cheloniidae family have been documented in the TMAA, most of these involve individuals that were either cold stressed, likely to become cold stressed, or already deceased (Hodge & Wing, 2000). Thus, the TMAA is considered to be outside the normal range for sea turtle species of the Cheloniidae family (National Marine Fisheries Service, 2017), and these species are not considered further for analysis in this SEIS/OEIS.

3.7.2.1.2 Diving

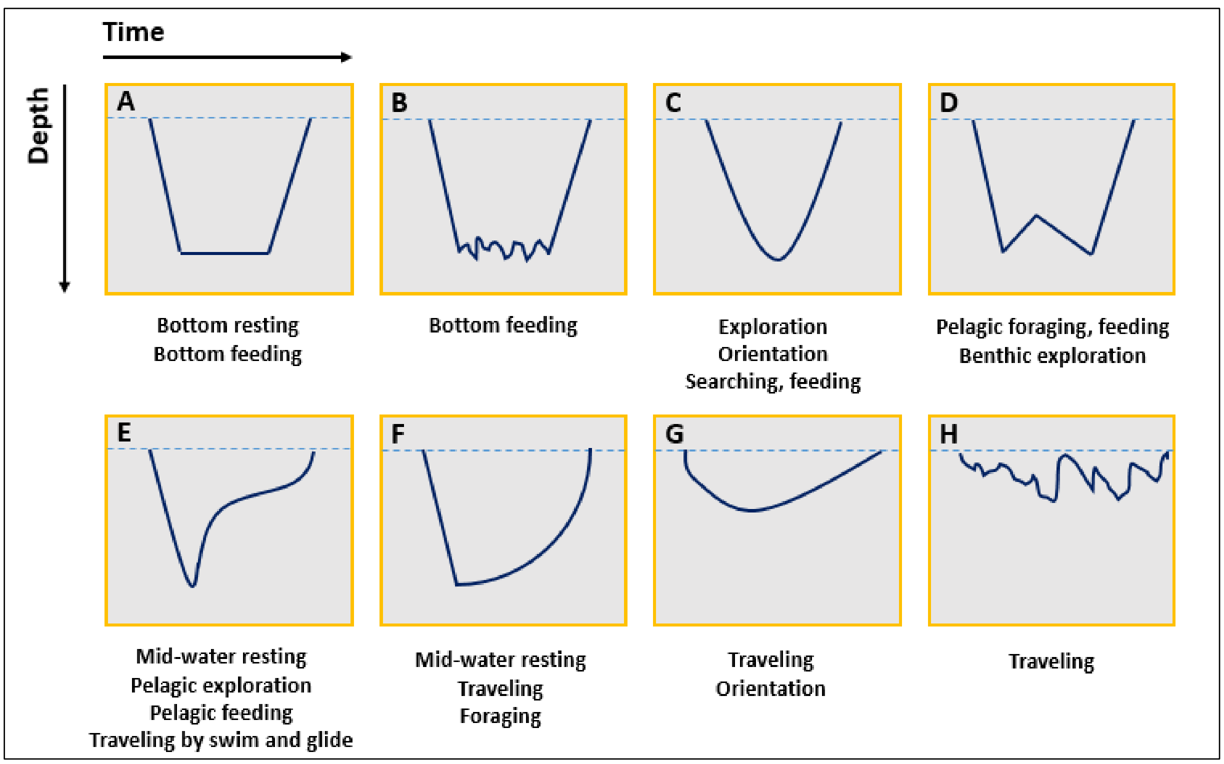
Sea turtle dive depth and duration varies by species, the age of the animal, the location of the animal, and the activity (foraging, resting, and migrating). The leatherback is the deepest diving sea turtle, with a recorded maximum depth of 4,200 feet (ft.) (1,280 meters [m]) (Houghton et al., 2008), although most dives are much shallower (usually less than 820 ft. [250 m]) (Hays et al., 2004b; Hays et al., 2004c; Sale et al., 2006; Wallace et al., 2015). Diving activity (including surface time) is influenced by a suite of environmental factors (e.g., water temperature, availability and vertical distribution of food resources, bathymetry) that result in spatial and temporal variations in dive behavior (James et al., 2006; Sale et al., 2006; Wallace et al., 2016).

Hochscheid (2014) has completed a species-specific summary for sea turtles within the Study Area that was not included in the 2016 GOA Final SEIS/OEIS. Hochscheid (2014) collected data from 57 studies published between 1986 and 2013, which summarized depths and durations of dives of datasets including an overall total of 538 sea turtles. Figure 3.7-1 presents the ranges of maximum dive depths for different sea turtle species that shows the unique diving capabilities of leatherback sea turtles compared to other sea turtle species. This summary can improve the exposure analysis for stressors analyzed in Section 3.7.3 (Environmental Consequences). Hochscheid (2014) also collected information on generalized dive profiles, with correlations to specific activities, such as bottom resting, bottom feeding, orientation and exploration, pelagic foraging and feeding, mid-water resting, and traveling during migrations. Generalized dive profiles compiled from 11 different studies show eight distinct profiles tied to specific activities. These profiles and activities are shown in Figure 3.7-2.



Sources: Hochscheid (2014), Sakamoto et al. (1993), Rice and Balazs (2008), Gitschlag (1996), Salmon et al. (2004)

Figure 3.7-1: Dive Depth and Duration Summaries for Sea Turtle Species



Sources: Hochscheid (2014); Rice and Balazs (2008), Sakamoto et al. (1993), Houghton et al. (2003), Fossette et al. (2007), Salmon et al. (2004), Hays et al. (2004a); Southwood et al. (1999).

Notes: Profiles A-H, as reported in the literature and compiled by Hochscheid (2014). The depth and time arrows indicate the axis variables, but the figure does not represent true proportions of depths and durations for the various profiles. In other words, the depths can vary greatly, but behavioral activity seems to dictate the shape of the profile. Profiles G and H have only been described for shallow dives (less than 5 m).

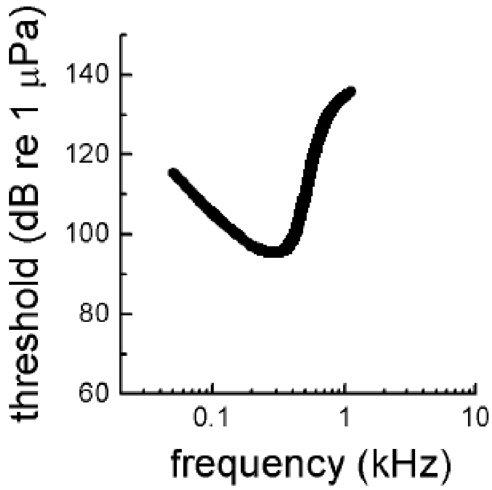
Figure 3.7-2: Generalized Dive Profiles and Activities Described for Sea Turtles

3.7.2.1.3 Hearing and Vocalization

Since the release of the Navy's 2016 GOA Final SEIS/OEIS, the Navy's literature search has found additional sources to improve the understanding of sea turtle hearing and vocalization. Sea turtle ears are adapted for hearing underwater and in air, with auditory structures that may receive sound via bone conduction (Lenhardt et al., 1985), via resonance of the middle ear cavity (Willis et al., 2013), or via standard tympanic middle ear path (Hetherington, 2008). Studies of hearing ability show that sea turtles' ranges of in-water hearing detection generally lie between 50 and 1,600 hertz (Hz), with maximum sensitivity between 100 and 400 Hz, and that hearing sensitivity drops off rapidly at higher frequencies. Sea turtles are also limited to low frequency hearing in air, with hearing detection in juveniles possible between 50 to 800 Hz, and a maximum hearing sensitivity around 300–400 Hz (Bartol & Ketten, 2006; Piniak et al., 2016). Hearing abilities have primarily been studied with sub-adult, juvenile, and hatchling subjects in four sea turtle species, including green (Bartol & Ketten, 2006; Ketten & Moein-Bartol, 2006; Piniak et al., 2016; Ridgway et al., 1969; Yudhana et al., 2010), olive ridley (Bartol & Ketten, 2006), loggerhead (Bartol et al., 1999; Lavender et al., 2014; Martin et al., 2012), and leatherback (Dow Piniak et al., 2012). Only one study examined the auditory capabilities of an adult sea turtle (Martin et al., 2012); the hearing range of the adult loggerhead sea turtle was similar to other measurements of juvenile and hatchling sea turtle hearing ranges. Using existing data on sea turtle hearing sensitivity, the Navy developed a composite sea turtle audiogram for underwater hearing (Figure 3.7-3), as described in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a).

The role of underwater hearing in sea turtles is unclear. Sea turtles may use acoustic signals from their environment as guideposts during migration and as cues to identify their natal beaches (Lenhardt et al., 1983). However, they may rely more on other senses, such as vision and magnetic orientation, to interact with their environment (Avens, 2003; Narazaki et al., 2013).

Some sounds have been recorded during nesting activities ashore, including belch-like sounds and sighs (Mrosovsky, 1972), exhale/inhales, gular pumps, and grunts (Cook & Forrest, 2005) by female leatherback turtles, and low-frequency pulsed and harmonic sounds by embryos in eggs and hatchlings (Ferrara et al., 2014; Ferrara et al., 2019; McKenna et al., 2019).



Source: U.S. Department of the Navy (2017a)

Notes: dB re 1 μPa = decibels referenced to 1 micropascal, kHz = kilohertz

Figure 3.7-3: Composite Audiogram for Sea Turtles

3.7.2.2 General Threats

Since the release of the Navy's 2016 GOA Final SEIS/OEIS, the Navy has found additional information relating to general threats to sea turtles, with species-specific updates for Pacific leatherback sea turtles where that appears in the literature.

Climate Change

Since the publication of the 2016 GOA Final SEIS/OEIS, the Navy has obtained and consolidated additional information to conceptualize the potential impacts of climate change on leatherback sea turtles in northern Pacific latitudes. Although recent research is available on potential impacts on nesting habitat loss, decreased productivity, and sex ratio skewing of hatchlings, this information is not relevant to leatherback sea turtles within the TMAA as it does not include nesting habitat. For a discussion of potential impacts associated with climate change, see Jensen et al. (2018); Laloë et al. (2016); Patino-Martinez et al. (2014); Reneker and Kamel (2016); Roden et al. (2017). Especially relevant for leatherback sea turtles is an improved understanding of how sea surface temperature increases may impact jellyfish distributions. New information is regularly being published on the effects of global climate change and ocean acidification on various aspects of invertebrate life development such as larval development and region-specific information for the Northern Pacific (Goyert et al., 2017; Goyert et al., 2018; Smith et al., 2019; Thompson et al., 2019). Although this SEIS/OEIS includes updated information related to potential impacts of climate change, the new research is generally in agreement with the information provided in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS.

Marine Debris

Ingestion of marine debris can cause mortality or injury to leatherback sea turtles. The United Nations Environment Programme estimates that approximately 6.4 million tons of anthropogenic debris enters the marine environment every year (Jeftic et al., 2009; Richardson et al., 2016; Schuyler et al., 2016). This estimate, however, does not account for cataclysmic events, such as the 2011 Japanese tsunami, which is estimated to have generated 1.5 million tons of floating debris (Murray et al., 2015). Plastic is the primary type of debris found in marine and coastal environments, and plastics are the most common type of marine debris ingested by sea turtles (Schuyler et al., 2014). Sea turtles can mistake debris for prey; one study found 37 percent of dead leatherback sea turtles to have ingested various types of plastic (Mrosovsky et al., 2009), and Narazaki et al. (2013) noted an observation of a loggerhead exhibiting hunting behavior on approach to a plastic bag, possibly mistaking the bag for a jellyfish. Even small amounts of plastic ingestion can cause an obstruction in a sea turtle's digestive tract and mortality (Bjorndal, 1997; Bjorndal et al., 1994), and hatchlings are at risk for ingesting small plastic fragments. Ingested plastics can also release toxins, such as bisphenol-A (commonly known as "BPA") and phthalates, or absorb heavy metals from the ocean and release those into tissues (Fukuoka et al., 2016; Teuten et al., 2007). Life stage and feeding preference affect the likelihood of ingestion. Sea turtles living in oceanic or coastal environments and feeding in the open ocean or on the seafloor may encounter different types and densities of debris, and may therefore have different probabilities of ingesting debris. Although this SEIS/OEIS includes updated information related to potential impacts of marine debris, the new research is generally in agreement with the information provided in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. As such, the information presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS regarding marine debris remains valid.

3.7.3 Environmental Consequences

As described in Chapter 2 (Description of Proposed Action and Alternatives), the Proposed Action includes the No Action Alternative and Alternative 1 (the Proposed Action), which are discussed in the sections below.

3.7.3.1 No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.7.3.2 Alternative 1

Alternative 1 for this SEIS/OEIS remains consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Though the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities.

For this SEIS/OEIS, the Navy Acoustic Effects Model was utilized to estimate impacts to leatherback sea turtles. The Gulf of Alaska Large Marine Ecosystem was used as the potential area of species occurrence to generate the leatherback sea turtle density estimate. Overall, due to a low density estimate, zero leatherback sea turtle impacts were estimated to occur from the use of acoustic and explosive sources under Alternative 1 of the Proposed Action. Because the existing baseline conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, a detailed re-analysis of this alternative with respect to sea turtles is not warranted. As described in Chapter 5 (Mitigation), the Navy will continue to implement mitigation to avoid or reduce potential impacts on sea turtles under Alternative 1 of the Proposed Action, although leatherback sea turtles are not expected to co-occur with Navy training activities in the TMAA due to low expected occurrence in the TMAA and the limited duration of the Proposed Action each year (National Marine Fisheries Service, 2017).

Prior analyses include the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011a), the 2011 Record of Decision (U.S. Department of the Navy, 2011b), the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016), the 2017 Record of Decision (U.S. Department of the Navy, 2017b), and Navy activities analyzed pursuant to the Endangered Species Act (ESA) are in the current National Marine Fisheries Service (NMFS) Biological Opinion (National Marine Fisheries Service, 2017). The National Marine Fisheries Service concluded in its Record of Decision and Final Rule (82 Federal Register 19530) that the Navy's training activities would have a negligible impact on the sea turtles present in the TMAA. In its Final Biological Opinion under the ESA, NMFS concluded that the Navy's training activities were not likely to jeopardize the continued existence of any ESA-listed sea turtle species and would not adversely modify any critical habitat.

3.7.4 Conclusion

As described above, there is new information on existing environmental conditions since the analysis in the 2016 GOA Final SEIS/OEIS, including updated information on sea turtle hearing. However, this new information does not significantly change the affected environment, which forms the environmental baseline of the analysis in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Additionally, no new activities are being proposed in this SEIS/OEIS that would affect sea turtles in the TMAA. Therefore, conclusions for sea turtles made for Alternative 1 in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remain unchanged in this SEIS/OEIS. For a summary of effects of the action alternative on sea turtles under both the National Environmental Policy Act and Executive Order 12114, please refer to Table 3.7-2 in the 2011 GOA Final EIS/OEIS.

As part of this SEIS/OEIS, the Navy is consulting under Section 7 of the ESA with NMFS for the ESA-listed leatherback sea turtle, but will continue to rely on the prior analysis from the 2011 GOA Final EIS/OEIS and Biological Evaluation, and the 2016 GOA Final SEIS/OEIS and Biological Evaluation, as it remains valid. Specifically, there has not been an exceedance of incidental take for the leatherback sea turtle under the current Biological Opinion; there is no new information that reveals new effects to leatherback sea turtles or critical habitat associated with leatherback sea turtles that were not previously considered; Navy training activities in the TMAA are not being substantially modified in a manner that would cause effects to listed leatherback sea turtles or their critical habitat that was not previously considered; and there has not been a new species of sea turtle listed or critical habitat for other sea turtles created within the TMAA. Based on the current Biological Opinion, the likelihood of Navy training activities in the TMAA impacting leatherback sea turtles is discountable due to their low abundance in the TMAA and low likelihood that any leatherback sea turtles would occur in the TMAA during training activities. Therefore, sea turtles are not likely to be adversely affected by the Proposed Action (National Marine Fisheries Service, 2017).

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3.8 Marine Mammals

3.8.1 Introduction

As presented in Chapter 1 (Purpose and Need), the United States (U.S.) Department of the Navy (Navy) analysis presented in this document supplements both the 2011 Gulf of Alaska (GOA) Final Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (U.S. Department of the Navy, 2011a) and the 2016 GOA Final Supplemental EIS (SEIS)/OEIS (U.S. Department of the Navy, 2016a). The Proposed Action would occur over a maximum time period of up to 21 consecutive days during the months of April–October. Though the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. Consistent with the previous analysis for Alternative 1, the sinking exercise (SINKEX) activity will not be part of the Proposed Action for this SEIS/OEIS. As was also the case for the previous analysis, the National Marine Fisheries Service (NMFS) is a cooperating agency with the Navy for this supplemental analysis, specifically where it relates to marine mammals and other marine resources under that agency's regulatory purview.

The purpose of the marine mammals section in this SEIS/OEIS is to provide any new or changed information since the 2016 GOA Final SEIS/OEIS that are relevant to an analysis of potential impacts on marine mammals associated with the continuation of Navy training activities in the Temporary Maritime Activities Area (TMAA) beyond May 2022 as a result of the Proposed Action. The TMAA is beyond 12 nautical miles (NM) from shore, outside of the U.S. Territorial Sea. The current regulations pursuant to the Marine Mammal Protection Act (MMPA) authorization from NMFS for Navy training in the TMAA (82 Federal Register [FR] 24679 issued on May 30, 2017) are effective from April 26, 2017, through April 26, 2022.

The marine mammal species order of presentation is the same as presented in the 2016 GOA Final SEIS/OEIS. Background information in the 2016 GOA Final SEIS/OEIS for the marine mammal species that occur in the TMAA will not be repeated in this section unless necessary for context in support of new information and emergent relevant best available science. In addition to the annually updated marine mammal stock abundance estimates from NMFS in the applicable Stock Assessment Reports (SARs), there have been changes to the status for some species and stocks, new Distinct Population Segments (DPSs) designated, and newly proposed critical habitat since the 2016 GOA Final SEIS/OEIS. These data points and any other similarly changed information are presented in the subsections that follow.

3.8.2 Affected Environment

There have been three rounds of analysis for Navy training and testing activities at-sea in various Navy range complexes in the Pacific by the Navy and NMFS (see for example 83 FR 66846, December 27, 2018). In addition, and since 2006, the Navy, non-Navy marine mammal scientists, and research groups and institutions have conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where the Navy has been and proposes to continue training and testing. Data collected from Navy monitoring, scientific research findings, and annual reports have been provided to NMFS, and this public[1] record is an important contribution to the analysis of potential impacts on

[1] Navy monitoring reports are available at the Navy website (www.navymarinespeciesmonitoring.us/) and also at the NMFS website (www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities).

marine mammals. For example, these data provide information relevant to species distribution, habitat use, and evaluation of potential responses to Navy activities. New findings regarding marine mammal habitat use have been made available since the 2016 GOA Final SEIS/OEIS, but this research involves locations outside of the TMAA (Abrahms et al., 2019b; Becker et al., 2016; Becker et al., 2018; Becker et al., 2017; Mannocci et al., 2017; National Oceanic and Atmospheric Administration, 2019b; Pirotta et al., 2018b; Rockwood et al., 2017; Santora et al., 2017).

Monitoring projects are performed using a variety of methods, including visual surveys from surface vessels and aircraft, as well as passive acoustics before, during, and after Navy activities have been conducted. The Navy also has continued to contribute to funding of basic research, including behavioral response studies specifically designed to determine the effects to marine mammals from the Navy's main mid-frequency surface ship anti-submarine warfare sonar and other acoustic sources and explosives.

Training events that have occurred in the TMAA are much less frequent and generally smaller in scope, in comparison to training occurring in Navy range complexes in the waters off Washington, Oregon, California, and Hawaii. As a result, the majority of the Navy's marine mammal monitoring and research efforts have been focused on those other locations where Navy activities are more numerous and generally more intense. For more than a decade, the Navy has been submitting exercise reports and monitoring reports to NMFS for the Navy's range complexes in the Pacific and the Atlantic. These publicly available exercise reports, monitoring reports, and the associated research findings have been integrated into adaptive management decisions regarding the focus for subsequent research and monitoring as determined in collaborations between Navy, NMFS, Marine Mammal Commission, and other marine resource subject matter experts using an adaptive management approach. For example, see the 2017 U.S. Navy Annual Marine Species Monitoring Report for the Pacific that was made available to the public in April 2018 (U.S. Department of the Navy, 2018a).

The reporting, monitoring, and research efforts in the Pacific are relevant to the TMAA, since in many cases the marine mammals occurring in the GOA are part of the same trans-boundary populations (for example, Hawaii DPS humpback whales, gray whales, elephant seals) occurring in those other range complexes, and the Navy activities that have been monitored are fundamentally the same. This research and monitoring has continued to broaden the sample of observations regarding the general health of marine mammal populations in locations where the Navy has been conducting training and testing activities for decades, which has been considered in the analysis of marine mammal impacts presented in this SEIS/OEIS. This public record of training and testing activities, monitoring, and research from across the Navy range complexes in the Pacific and Atlantic since 2006 now spans more than 14 years.

Based on the monitoring to date, it has been the Navy's assessment and that of NMFS that it is unlikely there would be impacts on populations of marine mammals (such as whales, dolphins, and pinnipeds) having any long-term consequences as a result of the proposed continuation of training in the TMAA. This assessment of likelihood is based on four indicators from areas in the Pacific where Navy training and testing has been ongoing for decades: (1) evidence suggesting or documenting increases in the numbers of marine mammals present, (2) examples of documented presence and site fidelity of species and long-term residence by individual animals of some species, (3) use of training and testing areas for breeding and nursing activities, and (4) 14 years of comprehensive monitoring data indicating a lack of any observable effects to marine mammal populations such as direct mortalities or strandings occurring as a result of Navy training. The evidence to date suggests the continuing viability of marine mammal populations where Navy trains and tests, and an absence of any direct evidence suggesting Navy training and testing has had or may have any long-term consequences to marine mammal populations. Barring any evidence to the contrary, therefore, what limited evidence there is from the monitoring reports and additional other focused scientific investigations should be considered in the analysis of impacts on marine mammals. Examples include information suggesting that

- the Endangered Species Act (ESA)-listed blue whale population in the Pacific, which includes the TMAA as part of their habitat, may have recovered and been at a stable level based on recent surveys and scientific findings (Barlow, 2016; Campbell et al., 2015; Carretta et al., 2017b; Monnahan et al., 2015; Rockwood et al., 2017; Širović et al., 2015b);
- gray whales in the Eastern North Pacific have recovered and are no longer listed under the ESA (International Whaling Commission, 2014);
- fin whale densities in the California Current Ecosystem have reached “current ecosystem limits” (Moore & Barlow, 2011);
- Cuvier’s beaked whales have been documented showing long-term residency and a population with higher densities than expected based on other nearby regions around the Southern California (SOCAL) Range Complex where the Navy has been intensively training and testing for decades, (Falcone & Schorr, 2012; Falcone et al., 2009; Hildebrand & McDonald, 2009; Schorr et al., 2014; Schorr et al., 2018); and
- the sea otter population at San Nicolas Island has increased about 10.5 percent per year, which is higher than the trend for the remainder of the population along the California coast (Hatfield et al., 2018; Hatfield et al., 2019).

In general, the evidence from reporting, monitoring, and research over more than a decade indicates that while the Proposed Action may result in the incidental harassment of marine mammals and may include auditory injury to some individuals, these impacts are expected to be inconsequential at the level of the marine mammal populations. There is no direct evidence that routine Navy training spanning decades has negatively impacted marine mammal populations at any Navy Range Complex or in the TMAA. In fact, for some of the most intensively used Navy training and testing areas, the continued multi-year presence of long-term resident individual animals and small populations (Baird, 2018; Baird et al., 2015; Baird et al., 2017; Baird et al., 2018; Baird et al., 2016; Lammers et al., 2017; Schorr et al., 2014; Schorr et al., 2018; Tinker & Hatfield, 2016; U.S. Department of the Navy, 2017b), resident females documented with and without calves from year to year, and high abundances on the Navy ranges for some species in comparison to other off-range locations (Moore & Barlow, 2017; Schorr et al., 2018; U.S. Department of the Navy, 2017b) provide no indications of significant impact and do provide evidence of generally increasing and healthy marine mammal populations. This background information forms part of the basis for the analysis of environmental consequences resulting from the Proposed Action consisting of the continuation of Navy training in the TMAA. Since the 2016 GOA Final SEIS/OEIS, there has been an approximate four-year period of additional monitoring with reports presented to NMFS regarding observations in and around Navy training and testing activities in the Pacific (see for example, U.S. Department of the Navy (2018a)), which provide further information for the assessment of significance of likely impacts resulting from the Navy’s Proposed Action in the TMAA.

As part of the baseline for analysis in this SEIS/OEIS, it is important to recognize that Navy training events in around the TMAA have been occurring there since the mid-1990s, without any indications of significant impact on the environment in general or marine mammals in particular. The most recent Navy activities in the TMAA as covered under the 2011 GOA EIS/OEIS and the 2016 GOA Final SEIS/OEIS, and as authorized by NMFS have been the exercises "Northern Edge 17," which was conducted in May 2017, and "Northern Edge 19," which was conducted in May 2019.

The approach to analysis of potential impacts on marine mammals due to the Proposed Action was also based on the review of scientific publications cited in this section, from recent Navy documents that analyzed potential impacts from the same or similar activities on marine mammals (U.S. Department of the Navy, 2018b, 2018c), and from conclusions in this regard provided by NMFS pursuant to the MMPA (82 FR 19530) and as analyzed pursuant to the ESA in the current NMFS Biological Opinion (National Marine Fisheries Service, 2017b).

3.8.2.1 General Background

The ESA provides for listing species, subspecies, or DPSs, all of which are referred to as "species" under the ESA. The Interagency Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the ESA provides that, "… any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature" (61 FR 4722, February 7, 1996; 81 FR 62660, September 8, 2016). In short, a DPS is a portion of a species' or subspecies' population that is both discrete from the remainder of the population and significant in relation to the entire species, with the DPS then defined geographically instead of biologically.

As consistent with 2016 GOA Final SEIS/OEIS, the Navy follows the naming conventions presented by NMFS in the applicable annual SARs for the Pacific and Alaska covering the marine mammals present in the TMAA (Carretta et al., 2020b; Muto et al., 2020). These species and stocks present in the TMAA are provided in Table 3.8-1 along with an abundance estimate and associated coefficient of variation value as provided by the SARs (Carretta et al., 2020b; Muto et al., 2020; U.S. Fish and Wildlife Service, 2017).

Table 3.8-1: Marine Mammals with Possible or Confirmed Presence Within the TMAA

Common Name	***Scientific Name[1]***	***Stock[2]***	***Stock Abundance[3] (CV)***	***Occurrence in TMAA[4]***	***ESA/MMPA Status***
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Family Balaenidae (right whales)					
North Pacific right whale	*Eubalaena japonica*	Eastern North Pacific	31 (0.226)	Rare	Endangered/ Depleted
Family Balaenopteridae (rorquals)					
Humpback whale	*Megaptera novaeangliae*	Central North Pacific	10,103 (0.300)	Seasonal; highest likelihood June to September	-
		California, Oregon, and Washington[5]	4,973 (0.05)	Seasonal; highest likelihood June to September	Threatened/ Endangered /Depleted
		Western North Pacific	1,107 (0.300)	Seasonal; highest likelihood June to September	Endangered/ Depleted

Table 3.8-1: Marine Mammals with Possible or Confirmed Presence Within the TMAA (continued)

Common Name	***Scientific Name[1]***	***Stock[2]***	***Stock Abundance[3] (CV)***	***Occurrence in TMAA[4]***	***ESA/MMPA Status***
Order Cetacea (continued)					
Suborder Mysticeti (baleen whales) (continued)					
Family Balaenopteridae (rorquals) (continued)					
Blue whale	*Balaenoptera musculus*	Eastern North Pacific	1,898 (0.08)	Seasonal; highest likelihood June to December	Endangered/ Depleted
		Central North Pacific	133 (1.09)	Seasonal; highest likelihood June to December	Endangered/ Depleted
Fin whale	*Balaenoptera physalus*	Northeast Pacific	Not available	Likely	Endangered/ Depleted
Sei whale	*Balaenoptera borealis*	Eastern North Pacific[6]	519 (0.4)	Rare	Endangered/ Depleted
Minke whale	*Balaenoptera acutorostrata*	Alaska	Not available	Likely	-
Family Eschrichtiidae (gray whale)					
Gray whale	*Eschrichtius robustus*	Eastern North Pacific	26,960 (0.05)	Likely: Highest numbers during seasonal migrations (June through August)	-
		Western North Pacific	290 (N/A)	Rare: Individuals migrate through GOA	Endangered/ Depleted
Suborder Odontoceti (toothed whales)					
Family Physeteridae (sperm whale)					
Sperm whale	*Physeter macrocephalus*	North Pacific	Not available	Likely; More likely in waters > 1,000 m depth, most often > 2,000 m	Endangered/ Depleted
Family Delphinidae (dolphins)					
Killer whale	*Orcinus orca*	Eastern North Pacific Alaska Resident[7]	2,347 (N/A)	Likely	-
		Eastern North Pacific Northern Resident[7]	302 (N/A)	Extralimital	-

Table 3.8-1: Marine Mammals with Possible or Confirmed Presence Within the TMAA (continued)

Common Name	*Scientific Name*[1]	*Stock*[2]	*Stock Abundance*[3] *(CV)*	*Occurrence in TMAA*[4]	*ESA/MMPA Status*
Order Cetacea (continued)					
Suborder Odontoceti (toothed whales) (continued)					
Family Delphinidae (dolphins) (continued)					
Killer whale	*Orcinus orca*	West Coast Transient[7]	243 (N/A)	Infrequent: few sightings	-
		AT1 Transient[7]	7 (N/A)	Rare; more likely inside Prince William Sound and Kenai Fjords	-
		Eastern North Pacific GOA, Aleutian Island, and Bering Sea Transient[7]	587 (N/A)	Likely	-
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	North Pacific	26,880 (N/A)	Likely	-
Family Phocoenidae (porpoises)					
Harbor porpoise	*Phocoena phocoena*	GOA	31,046 (0.21)	Rare; more likely nearshore but some inshore to the slope	-
		Southeast Alaska	Not available	Rare; more likely nearshore but some inshore to the slope	-
Dall's porpoise	*Phocoenoides dalli*	Alaska	83,400 (0.097)	Likely	-
Family Ziphiidae (beaked whales)					
Cuvier's beaked whale	*Ziphius cavirostris*	Alaska	Not available	Likely	-
Baird's beaked whale	*Berardius bairdii*	Alaska	Not available	Likely	-
Stejneger's beaked whale	*Mesoplodon stejnegeri*	Alaska	Not available	Likely	-

Table 3.8-1: Marine Mammals with Possible or Confirmed Presence Within the TMAA (continued)

Common Name	*Scientific Name[1]*	*Stock[2]*	*Stock Abundance[3] (CV)*	*Occurrence in TMAA[4]*	*ESA/MMPA Status*
Order Carnivora					
Suborder Pinnipedia[8]					
Family Otarieidae (fur seals and sea lions)					
Steller sea lion	*Eumetopias jubatus*	Eastern U.S.	41,201 (N/A)	Rare (Nearshore and over the shelf east of the TMAA)	-
		Western U.S.	54,624 (N/A)	Likely in the inshore portion of the TMAA	Endangered/ Depleted
California sea lion	*Zalophus californianus*	U.S.	257,606 (N/A)	Rare (April and May)	-
Northern fur seal	*Callorhinus ursinus*	Eastern Pacific	620,660 (0.2)	Likely	Depleted
		California	14,050 (N/A)	Rare	-
Family Phocidae (true seals)					
Northern elephant seal	*Mirounga angustirostris*	California Breeding	179,000 (N/A)	Seasonal (highest likelihood July-September)	-
Harbor seal	*Phoca vitulina*	N. Kodiak	8,677 (N/A)	Likely in the inshore portion of the TMAA	-
		S. Kodiak	26,448 (N/A)	Likely in the inshore portion of the TMAA	-
		Prince William Sound	44,756 (N/A)	Likely in the inshore portion of the TMAA	-
		Cook Inlet/Shelikof	28,411 (N/A)	Likely in the inshore portion of the TMAA	-
Ribbon seal	*Histriophoca fasciata*	Alaska	184,697 (N/A)	Rare	

Table 3.8-1: Marine Mammals with Possible or Confirmed Presence Within the TMAA (continued)

Common Name	*Scientific Name[1]*	*Stock[2]*	*Stock Abundance[3] (CV)*	*Occurrence in TMAA[4]*	*ESA/MMPA Status*
Family Mustelidae					
Northern sea otter	*Enhydra lutris kenyoni*	Southeast Alaska	25,712 (N/A)	Extralimital	-
		Southcentral Alaska	18,297 (N/A)	Rare	-
		Southwest Alaska	54,771 (N/A)	Rare	Threatened

[1]Taxonomy follows the naming conventions of the Society for Marine Mammalogy Committee on Taxonomy (2017); (Committee on Taxonomy, 2018) and the NMFS Stock Assessment Reports (Carretta et al., 2020b; Muto et al., 2020; U.S. Fish and Wildlife Service, 2018).

[2]Stock names and designations for the U.S. Exclusive Economic Zones are from the Pacific Stock Assessment Report (Carretta et al., 2020b; U.S. Fish and Wildlife Service, 2018), Alaska Stock Assessment Report (Muto et al., 2020) and USFWS (U.S. Fish and Wildlife Service, 2018).

[3]The stated coefficient of variation (CV) from the NMFS Stock Assessment Reports is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the population mean. It is expressed as a fraction or sometimes a percentage and can range upward from zero, indicating no uncertainty, to high values. For example, a CV of 0.85 would indicate high uncertainty in the population estimate. When the CV exceeds 1.0, the estimate is very uncertain. The uncertainty associated with movements of animals into or out of an area (due to factors such as availability of prey or changing oceanographic conditions) is much larger than is indicated by the CVs that are given.

[4]EXTRALIMITAL: There may be sightings, acoustic detections, or stranding records, but the TMAA and GOA are outside the species range of normal occurrence. RARE: The distribution of the species is near enough to the TMAA that the species could occur there, or there are a few confirmed sightings. INFREQUENT: Confirmed, but irregular sightings or acoustic detections. LIKELY: Year-round sightings or acoustic detections of the species in the TMAA, although there may be variation in local abundance over the year. SEASONAL: Species absence and presence as documented by surveys or acoustic monitoring. Names for the four areas within the TMAA follow the survey strata terminology as presented in Rone et al. (2017).

[5]Humpback whales in the Central North Pacific stock and the California, Oregon, and Washington stock are from three Distinct Population Segments based on animals identified in breeding areas in Hawaii, Mexico, and Central America (Carretta et al., 2020b; Muto et al., 2020; National Marine Fisheries Service, 2016a, 2016d, 2016e; Titova et al., 2017; Wade et al., 2016). All three stocks and all three DPSs co-occur in the TMAA (National Marine Fisheries Service, 2016d, 2016i).

[6]This analysis assumes that these individuals are from the Eastern North Pacific stock; however, they are not discussed in the West Coast or the Alaska Stock Assessment Reports (Carretta et al., 2020b; Muto et al., 2020).

[7]The abundance is based on counts of individual animals identified from photo-identification catalogues. Surveys for abundance estimates for these stocks are conducted infrequently (Muto et al., 2020).

[8]There are no data regarding the CV for some of the pinniped species given that abundance is determined by different methods than those used for cetaceans.

Table 3.8-1: Marine Mammals with Possible or Confirmed Presence Within the TMAA (continued)

Common Name	*Scientific Name*[1]	*Stock*[2]	*Stock Abundance*[3] *(CV)*	*Occurrence in TMAA*[4]	*ESA/MMPA Status*

[9]The Pribilof Islands stock abundance estimate is simply the count of seals ashore during the survey and does not include a correction for seals in the water.

[10]There are no data regarding the CV for sea otter given that abundance is determined by different methods than those used for cetaceans.

Notes: The stocks and stock abundance number are as provided in Carretta et al. (2020b); Muto et al. (2020) with exceptions for blue whales and the California, Oregon, Washington stock of humpback whales which reflect more recent data Calambokidis and Barlow (2020) than what is presented in the 2019 SARs.
CV = coefficient of variation, ESA = Endangered Species Act, GOA = Gulf of Alaska, m = meter(s), MMPA = Marine Mammal Protection Act, N/A = not available, U.S. = United States.

The abundance provided is the number of animals in a stock that NMFS has estimated are present in the specific portion of U.S. waters covered by that SAR (National Marine Fisheries Service, 2016c). For example, 2018 abundance for the North Pacific stock of Pacific white-sided dolphins (26,880) is only the number of those animals present within 200 NM of the Alaska coast (the Economic Exclusion Zone [EEZ]), even though the total population that must be used by NMFS to determine what constitutes a negligible impact numbered an estimated 931,000 individuals when last counted (Muto et al., 2020). Most marine mammal species are transboundary animals, and given that most counts are based on surveying only within the EEZ, the stock abundance estimates are not always inclusive of the total population number for a stock or species. The coefficient of variation provided for each of the abundances is a statistical term that describes the variation possible in the estimate of the stock abundance. The minimum population estimate is either a direct count (e.g., pinnipeds on land) or the lower 20th percentile of a statistical abundance estimate for a stock.

3.8.2.1.1 Species Unlikely to be Present in the Temporary Maritime Activities Area

There has been no change in the species unlikely to be present in the TMAA since the 2016 GOA Final SEIS/OEIS. The species carried forward for analysis are those likely to be found in the TMAA based on the most recent data available and do not include species that may have once inhabited or transited the area but have not been sighted in recent years (e.g., species which were extirpated from factors such as nineteenth and twentieth century commercial exploitation). Several species that may be present in the northeast Pacific Ocean have an extremely low probability of presence in the TMAA. These species are considered extralimital, meaning there may be a small number of sighting or stranding records within the TMAA, but the area of concern is outside the species range of normal occurrence. These species include beluga whale (*Delphinapterus leucas*), false killer whale (*Pseudorca crassidens*), short-finned pilot whale (*Globicephala macrorhynchus*), northern right whale dolphin (*Lissodelphis borealis*), and Risso's dolphin (*Grampus griseus*), and have been excluded from subsequent analysis for the same reasons as described in the 2016 GOA Final SEIS/OEIS.

3.8.2.1.2 Group Size

Group size characteristics are again incorporated into acoustic effects modeling for the given marine mammal density, but this is now based on information that has been updated (U.S. Department of the Navy, 2020b) since the 2016 GOA Final SEIS/OEIS.

3.8.2.1.3 Diving Behavior

Diving behavior has again been incorporated into acoustic effects modeling for the various marine mammal species, but this is now based on information that has been updated (U.S. Department of the Navy, 2020b) since the 2016 GOA Final SEIS/OEIS.

3.8.2.1.4 Hearing and Vocalization

The typical terrestrial mammalian ear (which is ancestral to that of marine mammals) consists of an outer ear that collects and transfers sound to the tympanic membrane and then to the middle ear (Fay & Popper, 1994; Rosowski, 1994). The middle ear contains ossicles that amplify and transfer acoustic energy to the sensory cells (called hair cells) in the cochlea, which transforms acoustic energy into electrical neural impulses that are transferred by the auditory nerve to high levels in the brain (Møller, 2013). All marine mammals display some degree of modification to the terrestrial ear; however, there are differences in the hearing mechanisms of marine mammals with an amphibious ear versus those with a fully aquatic ear (Wartzok & Ketten, 1999). Marine mammals with an amphibious ear include the marine carnivores: pinnipeds, sea otters, and polar bears (Ghoul & Reichmuth, 2014b; Owen & Bowles, 2011; Reichmuth et al., 2013). Outer ear adaptations in this group include external pinnae (ears) that are reduced or absent, and in the pinnipeds, cavernous tissue, muscle, and cartilaginous valves seal off water from entering the auditory canal when submerged (Wartzok & Ketten, 1999). Marine mammals with the fully aquatic ear (cetaceans and sirenians) use bone and fat channels in the head to conduct sound to the ear; while the auditory canal still exists, it is narrow and sealed with wax and debris, and external pinnae are absent (Castellini et al., 2016; Ketten, 1998).

The most accurate means of determining the hearing capabilities of marine mammal species are direct measurements of auditory system sensitivity (Nachtigall et al., 2000; Supin et al., 2001). Studies using these methods produce audiograms—plots describing hearing threshold (the quietest sound a listener can hear) as a function of frequency. Marine mammal audiograms, like those of terrestrial mammals, typically have a "U-shape," with a frequency region of best hearing sensitivity at the bottom of the "U" and a progressive decrease in sensitivity outside of the range of best hearing (Fay, 1988; Mooney et al., 2012; Nedwell et al., 2004; Reichmuth et al., 2013). The "gold standard" for producing audiograms is the use of behavioral (psychophysical) methods, where marine mammals are trained to respond to acoustic stimuli (Nachtigall et al., 2000). For species that are untrained for behavioral psychophysical procedures, those that are difficult to house under human care, or in stranding rehabilitation and temporary capture contexts, auditory evoked potential (AEP) methods are used to measure hearing sensitivity (e.g., Castellote et al., 2014; Finneran et al., 2009; Montie et al., 2011; Mulsow et al., 2011; Nachtigall et al., 2008; Nachtigall et al., 2007; Supin et al., 2001). For odontocetes, the procedure for determining audiograms through auditory evoked potential methods has recently been standardized (American National Standards Institute & Acoustical Society of America, 2018).

These AEP methods, which measure electrical potentials generated by the auditory system in response to sound and do not require the extensive training needed for psychophysical methods, can provide an efficient estimate of hearing sensitivity (Finneran & Houser, 2006; Schlundt et al., 2007; Yuen et al., 2005). The thresholds provided by AEP methods are, however, typically elevated above behaviorally measured thresholds, and AEP methods are not appropriate for estimating hearing sensitivity at frequencies much lower than the region of best hearing sensitivity (Finneran, 2015; Finneran et al., 2016). For marine mammal species for which access is limited and therefore psychophysical or AEP testing is impractical (e.g., mysticete whales and rare species), some aspects of hearing can be estimated from anatomical structures, frequency content of vocalizations, and extrapolations from related species.

Direct measurements of hearing sensitivity exist for approximately 25 of the nearly 130 species of marine mammals. Table 3.8-2 summarizes hearing capabilities for marine mammal species in the study area. For this analysis, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities: high-frequency cetaceans (HF group: porpoises, Kogia spp.), mid-frequency cetaceans (MF group: delphinids, beaked whales, sperm whales), low-frequency cetaceans (LF group: mysticetes), otariids and other non-phocid marine carnivores in water and air (OW and OA groups: sea lions, otters), and phocids in water and air (PW and PA groups: true seals). Note that the designations of high-, mid-, and low-frequency cetaceans are based on relative differences of sensitivity between groups, as opposed to conventions used to describe active sonar systems.

For Phase III analyses, a single representative composite audiogram (Figure 3.8-1) was created for each functional hearing group using audiograms from published literature. For discussion of all marine mammal functional hearing groups and their derivation see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects (Phase III)* (U.S. Department of the Navy, 2017a). These auditory composite audiograms were recently published by Southall et al. (2019c). The mid-frequency cetacean composite audiogram is consistent with behavioral audiograms of killer whales (Branstetter et al., 2017a) and audiograms of healthy wild belugas obtained via auditory evoked potential methods (Mooney et al., 2018) that were published following development of the technical report. The high-frequency cetacean composite audiogram is consistent with behavioral audiograms of harbor porpoises (Kastelein et al., 2017b) published after the technical report.

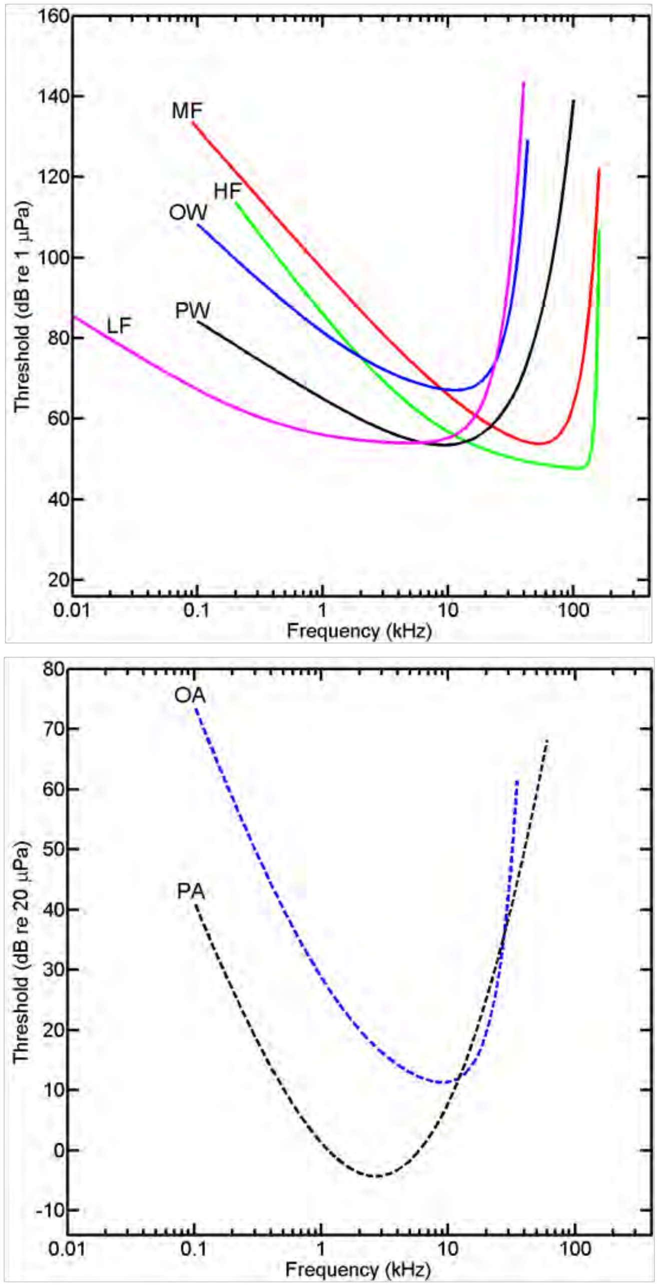
Few field studies aim to determine the hearing range of low-frequency cetaceans. However, Frankel and Stein (2020) exposed migrating gray whales to moored-source IMAPS sonar transmissions in the 21–25 kilohertz (kHz) frequency band (estimated RL = 148 decibels referenced to 1 micropascal squared [dB re 1 μPa^2]), demonstrating that whales moved closer inshore when the vessel range was 1–2 kilometers (km) during sonar transmissions. The authors concluded that gray whales can hear up to 21 kHz. This evidence supports the mysticete hearing range extending up to 30 kHz, as reflected in the LF cetacean composite audiogram estimated by Southall et al. (2019c) and the Navy (U.S. Department of the Navy, 2017a).

Lastly, the otariid and phocid composite audiograms are consistent with recently published behavioral audiograms (Cunningham & Reichmuth, 2015; Kastelein et al., 2019b). This recent work shows that phocid detection thresholds are around 4 decibels (dB) lower for longer-duration sounds with harmonics than shorter-duration tonal sounds without harmonics (Kastelein et al., 2019b), and pinniped hearing sensitivity at frequencies and thresholds far above the range of best hearing may drop off at a slower rate than previously predicted (Cunningham & Reichmuth, 2015).

Research has shown that hearing in bottlenose dolphins is directional, i.e., the relative angle between the sound source location and the dolphin affects the hearing threshold (Accomando et al., 2020; Au & Moore, 1984). Hearing sensitivity becomes more directional as the sound frequency increases, with the greatest sensitivity to sounds presented in front and below the dolphin. Other odontocete species with less elongated skull anatomy than the bottlenose dolphin also exhibit direction-dependent hearing, but to a lesser degree (Kastelein et al., 2019b; Kastelein et al., 2005a; Popov & Supin, 2009). Byl et al. (2019) showed that harbor seals likely have well-developed directional hearing for biologically relevant sounds (Section 3.8.3.1.1.4, Masking).

Table 3.8-2: Species Within Marine Mammal Hearing Groups Likely Found in the TMAA

Hearing Group	***Species within the Study Area***
High-frequency cetaceans	Dall's porpoise
	Harbor porpoise
Mid-frequency cetaceans	Baird's beaked whale
	Cuvier's beaked whale
	Killer whale
	Pacific white-sided dolphin
	Sperm whale
	Stejneger's beaked whale
Low-frequency cetaceans	Blue whale
	Fin whale
	Gray whale
	Humpback whale
	Minke whale
	North Pacific right whale
	Sei whale
Otariids and other non-phocid marine carnivores	California sea lion
	Northern fur seal
	Northern sea otter
	Steller sea lion
Phocids	Harbor seal
	Northern elephant seal
	Ribbon Seal



Source: *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017).

Notes: For hearing in water (top) and in air (bottom, phocids and otariids only). LF = low-frequency, MF = mid-frequency, HF = high-frequency, OW = otariids and other non-phocid marine carnivores in water, PW = phocids in water, OA = otariids and other non-phocid marine carnivores in air, PA = phocids in air.

Figure 3.8-1: Composite Audiograms for Hearing Groups Likely Found in the TMAA

Similar to the diversity of hearing capabilities among species, the wide variety of acoustic signals used in marine mammal communication (including biosonar or echolocation) is reflective of the diverse ecological characteristics of cetacean, sirenian, and carnivore species (see Avens, 2003; Richardson et al., 1995b). This makes a succinct summary difficult (see Richardson et al., 1995b; Wartzok & Ketten, 1999 for thorough reviews); however, a division can be drawn between lower frequency communication signals that are used by marine mammals in general, and the specific, high-frequency biosonar signals that are used by odontocetes to sense their environment.

Non-biosonar communication signals span a wide frequency range, primarily having energy up into the tens of kilohertz range. Of particular note are the very low-frequency calls of mysticete whales that range from tens of hertz (Hz) to several kilohertz, and have source levels of 150–200 decibels referenced to 1 micropascal (dB re 1 µPa) (Cummings & Thompson, 1971; Edds-Walton, 1997; Širović et al., 2007; Stimpert et al., 2007; Wartzok & Ketten, 1999). These calls most likely serve social functions such as mate attraction, but may serve an orientation function as well (Green, 1994; Green et al., 1994; Richardson et al., 1995b). Humpback whales are a notable exception within the mysticetes, with some calls exceeding 10 kHz (Zoidis et al., 2008).

Odontocete cetaceans and marine carnivores use underwater communicative signals that, while not as low in frequency as those of many mysticetes, likely serve similar functions. These include tonal whistles in some odontocetes and the wide variety of barks, grunts, clicks, sweeps, and pulses of pinnipeds. Of additional note are the aerial vocalizations that are produced by pinnipeds, otters, and polar bears. Again, the acoustic characteristics of these signals are quite diverse among species, but can be generally classified as having dominant energy at frequencies below 20 kHz (Richardson et al., 1995b; Wartzok & Ketten, 1999).

Odontocete cetaceans generate short-duration (50–200 microseconds), specialized clicks used in biosonar with peak frequencies between 10 and 200 kHz to detect, localize, and characterize underwater objects such as prey (Au, 1993; Wartzok & Ketten, 1999). These clicks are often more intense than other communicative signals, with reported source levels as high as 229 dB re 1 µPa peak-to-peak (Au et al., 1974). The echolocation clicks of high-frequency cetaceans (e.g., porpoises) are narrower in bandwidth (i.e., the difference between the upper and lower frequencies in a sound) and higher in frequency than those of mid-frequency cetaceans (Madsen et al., 2005; Villadsgaard et al., 2007).

In general, frequency ranges of vocalization lie within the audible frequency range for an animal (i.e., animals vocalize within their audible frequency range); however, auditory frequency range and vocalization frequencies do not perfectly align. For example, odontocete echolocation clicks contain a broad range of frequencies, and not all of the frequency content is necessarily heard by the individual that emitted the click. The frequency range of vocalization in a species can therefore be used to infer some characteristics of their auditory system; however, caution must be taken when considering vocalization frequencies alone in predicting the hearing capabilities of species for which no data exist (i.e., mysticetes). It is important to note that aspects of vocalization and hearing sensitivity are subject to evolutionary pressures that are not solely related to detecting communication signals. For example, hearing plays an important role in detecting threats (e.g., Deecke et al., 2002), and high-frequency hearing is advantageous to animals with small heads in that it facilitates sound localization based on differences in sound levels at each ear (Heffner & Heffner, 1982). This may be partially responsible for the difference in best hearing thresholds and dominant vocalization frequencies in some species of marine mammals (e.g., Steller sea lions, Mulsow & Reichmuth, 2010).

3.8.2.1.5 General Threats

As noted in the 2016 GOA Final SEIS/OEIS and subsequently provided in various publications (Barcenas De La Cruz et al., 2017; Bradford & Lyman, 2015; Carretta et al., 2019a; Carretta et al., 2019b; Carretta et al., 2020a; Delean et al., 2020; Esquible & Atkinson, 2019; Helker et al., 2019), investigations of stranded marine mammals are undertaken to monitor threats to marine mammals and out of concerns for animal welfare and ocean stewardship. For the marine mammal populations present in Alaska waters, data regarding human-caused mortality and injury to NMFS-managed stocks are available in a NMFS Technical Memorandum for marine mammal stocks in Alaska (Delean et al., 2020; Helker et al., 2019) and for stocks present on the U.S. West Coast (Carretta et al., 2019a; Carretta et al., 2020a). The known serious injury and mortalities resulting from non-Navy human activities that these reports summarize give important context in reviewing the analysis of potential impacts that may result from the continuation of Navy training in the TMAA.

Causes for strandings also include natural causes such as infectious disease, parasite infestation, climate change, harmful algal blooms and associated biotoxins, and tectonic events such as underwater earthquakes (for more information see NMFS Marine Mammal Stranding Response Fact Sheet; National Marine Fisheries Service (2016b) and National Marine Fisheries Service (2020a)). For a general discussion of strandings and their causes as well as strandings in association with U.S. Navy activity, see the technical report titled *Marine Mammal Strandings Associated with U.S. Navy Sonar* (U.S. Department of the Navy, 2017c).

Climate Change

The global climate is warming and is having impacts on some populations of marine mammals (Garcia-Aguilar et al., 2018; Jefferson & Schulman-Janiger, 2018; National Marine Fisheries Service, 2020c; National Oceanic and Atmospheric Administration, 2015b, 2018b; Peterson et al., 2006; Salvadeo et al., 2010; Sanderson & Alexander, 2020; Shirasago-Germán et al., 2015; Silber et al., 2017; Simmonds & Eliott, 2009; Straley et al., 2017; Szpak et al., 2018; von Biela et al., 2019). Climate change can affect marine mammal species directly by causing shifts in distribution to match physiological tolerance under changing environmental conditions (Doney et al., 2012; National Marine Fisheries Service, 2018d; Peterson et al., 2006; Silber et al., 2017), which may or may not result in net habitat loss (some can experience habitat gains). Climate change can also affect marine mammals indirectly via impacts on prey, changing prey distributions and locations, and changes in water temperature (Cheung & Frolicher, 2020; Giorli & Au, 2017; Peterson et al., 2006; Straley et al., 2017; von Biela et al., 2019). In Prince William Sound between 2012 and 2016, researchers suggested the quality of sand lance (the prey of humpbacks whale and other species) may have been reduced by increased water temperatures in North Pacific in 2015–2016, which probably contributed to population declines and/or breeding failures observed among several predators in the Gulf of Alaska (von Biela et al., 2019); see also National Marine Fisheries Service (2018e); Savage (2017); Savage (2020). Also note that because many marine mammals to the TMAA through waters off California, it is relevant that Sanford et al. (2019) have noted that severe marine heatwaves occurring off California in 2014–2016 triggered marine mammal mortality events, harmful algal blooms, and declines in subtidal kelp beds.

Changes in prey can impact marine mammal foraging success, which in turn affects reproduction success and survival. Starting in January 2013, an elevated number of strandings of California sea lion pups were observed in Southern California counties, such as Santa Barbara County, Ventura County, Los Angeles County, and Orange County. This unusual number of strandings, continuing into 2016, were declared an Unusual Mortality Event (UME) by NMFS (National Oceanic and Atmospheric Administration, 2018a, 2018b). Although this UME was still considered as "ongoing" through 2017, the number of strandings recorded in 2017 were at or below average (National Oceanic and Atmospheric Administration, 2018a). This is the sixth UME involving California sea lions that has occurred in California since 1991. For this

2013–2015 event, NMFS biologists indicated that warmer ocean temperatures have shifted the location of prey species that are no longer adjacent to the rookeries, which thereby impacted the female sea lions' ability to find food and supply milk to their pups (National Oceanic and Atmospheric Administration, 2018a). As a result, this confluence of natural events causes the pups to be undernourished, and many are subsequently found stranded dead or emaciated due to starvation. In a similar occurrence for gray whales and since January 2019, an elevated number of gray whale strandings has occurred along the west coast of North America from Mexico through Alaska, resulting in NMFS declaring a UME for this species (National Marine Fisheries Service, 2019a). This is similar to a previous UME for gray whales that occurred in 1999–2000. Using photogrammetry to assess the condition of gray whales while foraging along the Oregon coast over the three-year period between 2016 and 2018, researchers determined that the body condition of whales correlated with environmental changes and hypothesized that low prey availability between 2016 and 2018 carried over to result in the UME starting in 2019 (Lemos et al., 2020).

Likely also due to changing prey distributions, data tagging efforts in July 2016 focusing on blue and fin whales had to be shifted north to central California waters when the majority of blue, fin, and humpback whales encountered in Southern California waters were found to be too thin or otherwise in poor body condition to allow for them to be tagged (Oregon State University, 2017). In central California waters, the researchers identified good numbers of blue, fin, and humpback whales in better condition and indicative of a good feeding area that was likely to be sustained that season (Oregon State University, 2017).

Harmful algal blooms may become more prevalent in warmer ocean temperatures with increased salinity levels such that blooms will begin earlier, last longer, and cover a larger geographical range (Edwards, 2013; Moore et al., 2008). Warming ocean waters have been linked to the spread of harmful algal blooms into the North Pacific where waters had previously been too cold for most of these algae to thrive. The spread of the algae and associated blooms has led to mortality in marine mammals in locations where algae-caused biotoxicity had not been previously known (Lefebvre et al., 2016).

Climate change may indirectly influence marine mammals through changes in human behavior, such as increased shipping and oil and gas extraction, which benefit from sea ice loss (Alter et al., 2010). Ultimately impacts from global climate change may result in an intensification of current and on-going threats to marine mammals (Edwards, 2013). In addition, the ability of marine mammals to alter behaviors may serve as a buffer against measurable climate change-induced impacts and could delay or mask any adverse effects until critical thresholds are reached (Baker et al., 2016).

Marine mammals are influenced by climate-related phenomena, including storms and other extreme weather patterns, such as the 2015–2016 El Niño in the ocean off the U.S. West Coast. Generally, not much is known about how large storms and other weather patterns affect marine mammals, other than that mass strandings (when two or more marine mammals become beached or stuck in shallow water) sometimes coincide with hurricanes, typhoons, and other tropical storms (Bradshaw et al., 2006; Marsh, 1989; Rosel & Watts, 2008) or other oceanographic conditions.

Concerns over climate change modifying the U.S. West Coast upwelling patterns, increasing levels of hypoxia, and ocean acidification have generated targeted research and monitoring efforts at selected "Sentinel Sites" (Lott et al., 2011). There remains scientific uncertainty about how or if such changes will affect marine mammals and their prey, but acidification of the ocean could potentially impact the mobility, growth, and reproduction of calcium carbonate-forming organisms such as crustaceans and plankton, which are the direct prey of some marine mammals, as well as an important part of the overall food chain in the ocean; as well as slightly altering the propagation of sound underwater (Lynch et al., 2018; Meyers et al., 2019; Rossi et al., 2016).

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals, with effects ranging from depleting a habitat's prey base to the complete loss of habitat (Ayres et al., 2012; Kemp, 1996; Pine et al., 2016; Rolland et al., 2012; Smith et al., 2009; Veirs et al., 2015; Williams et al., 2014a). Many researchers predict that if oceanic temperatures continue to rise with an associated effect on marine habitat and prey availability, then either changes in foraging or life history strategies, including poleward shifts in many marine mammal species distributions, should be anticipated (Alter et al., 2010; Fleming et al., 2016; Ramp et al., 2015; Salvadeo et al., 2015; Silber et al., 2017; Sydeman & Allen, 1999). Poloczanska et al. (2016) analyzed climate change impact data that integrate multiple climate influenced changes in ocean conditions (e.g., temperature, acidification, dissolved oxygen, and rainfall) to assess anticipated changes to a number of key ocean fauna across representative areas. Poloczanska et al. (2016) predict a northward expansion in the distribution of zooplankton, fish, and squid, all of which are prey for many marine mammal species. Sanford et al. (2019) have noted that severe marine heatwaves in the northeast Pacific in 2014–2016 triggered marine mammal mortality events, harmful algal blooms, and declines in subtidal kelp beds.

Commercial Industries

Human impacts on marine mammals have received much attention in recent decades and include: fisheries interactions, including bycatch (accidental or incidental catch), gear entanglement, and indirect effects from takes of prey species; noise pollution; marine debris (ingestion and entanglement); hunting (both commercial and native practices); vessel strikes; entrainment in power plant water intakes; increased ocean acidification; and general habitat deterioration or destruction.

Fishery Bycatch

Fishery bycatch is likely the most impactful threat to marine mammal individuals and populations and may account for the deaths of more marine mammals than any other cause (Geijer & Read, 2013; Hamer et al., 2010; Northridge, 2009; Read, 2008). In 1994, the MMPA was amended to formally address bycatch. The amendment requires the development of a take reduction plan when bycatch exceeds a level considered unsustainable and will lead to marine mammal population decline. In addition, NMFS develops and implements take reduction plans that help recover and prevent the depletion of strategic stocks of marine mammals that interact with certain fisheries (National Marine Fisheries Service, 2016c). For example, fishing-related injuries occurring in 2013–2017 involving the stocks of marine mammals present in the TMAA totaled 448 marine mammals in that five-year period (Delean et al., 2020; Helker et al., 2019).

Hunting

Commercial hunting, as in whaling and sealing operations, provided the original impetus for marine mammal management efforts and has driven much of the early research on cetaceans and pinnipeds (Twiss & Reeves, 1999). With the enactment of the MMPA and the 1946 International Convention for the Regulation of Whaling, commercial hunting-related mortality has decreased over the last 40 years. Unregulated harvests are still considered to be direct threats; however, since passage of the MMPA, there have been relatively few serious calls for culls of marine mammals in the United States compared to other countries, including Canada (Roman et al., 2013). Review of uncovered Union of Soviet Socialist Republics catch records in the North Pacific Ocean indicate extensive illegal whaling activity between

1948 and 1979, with a harvest totaling 195,783 whales. Of these, 169,638 were reported (over 26,000 takes unreported) by the Union of Soviet Socialist Republics to the International Whaling Commission (Ilyashenko et al., 2014; Ilyashenko & Chapham, 2014; Ilyashenko et al., 2013, 2015). On July 1, 2019, Japan resumed commercial whaling within its EEZ (BBC News, 2019; Nishimura, 2019; Victor, 2018). Japan had set an annual quota of 227 whales until the end of the 2019, which included 52 minke whales, 150 Bryde's whales, and 25 sei whales (Nishimura, 2019); the annual quota set for 2020 was 383 whales total (Hurst, 2020). Although the resumed commercial whaling will only take place within the Japanese Exclusive Economic Zone waters, it is possible that some of the whales found in those waters may be part of the same North Pacific populations that are also present seasonally in the TMAA.

For U.S. waters, there is a provision in the MMPA that allows for subsistence harvest of marine mammals, primarily by Alaska Natives. Subsistence hunting by Russia and Alaska Natives also occurs in the North Pacific, Chukchi Sea, and Bering Sea, involving marine mammal stocks that may be present in the TMAA. For whales, the quotas for "aboriginal subsistence whaling" are established by the International Whaling Commission (International Whaling Commission, 2020). For example, the International Whaling Commission quotas for 2019–2025 are for a total of 980 gray whales with not more than 140 landed in any one year by native people in Chukotka (Russia) and Washington State (International Whaling Commission, 2020). For example, in Russian waters in 2013, there were a total of 127 gray whales "struck" during subsistence whaling by the inhabitants of the Chukchi Peninsula between the Bering and Chukchi Sea (Ilyashenko & Zharikov, 2014). These gray whales harvested in Russian waters may be individuals from either the endangered Western North Pacific stock or the non-ESA-listed Eastern North Pacific stock that may migrate through the TMAA. In 2017 at the Kuskowim River in Alaska, a gray whale was killed and harvested in what NMFS described as being an "illegal hunt" (Carretta et al., 2019a). In 2018, a total of 106 gray whales were harvested for subsistence use (International Whaling Commission, 2019b). Subsistence hunting of certain pinnipeds are also permitted by NMFS such as in 84 FR 52372 (dated Wednesday, October 2, 2019) which authorized, "… Pribilovians who reside on St. Paul Island, Alaska, to kill for subsistence uses each year up to 2,000 male fur seals less than seven years old ...." Subsistence hunting in nearshore waters also occurs in communities on Kodiak Island and the Kenai Peninsula. For example, the most recent report[2] from the Kodiak Island communities indicated that in 2011 there were a reported 163 harbor seals and 20 Western DPS Steller sea lions taken in that year (Wolfe et al., 2012). This was the third-lowest recorded number of harbor seals taken since reporting began in 1992 (Wolfe et al., 2012). The U.S. Fish and Wildlife Service (USFWS) records show that in 2012 there were 1,281 sea otters reported taken in Alaska as part of that year's subsistence harvest (Lichtenstein, 2013).

Vessel Strike

Ship strikes are also a growing issue for most marine mammals, although mortality may be a more significant concern for species that occupy areas with high levels of vessel traffic, because the likelihood of encounter would be greater (Aleutian Islands Waterways Safety Committee, 2019; Currie et al., 2017a; Keen et al., 2019; Moore et al., 2018; Redfern et al., 2013; Redfern et al., 2019; Rockwood et al., 2017; Ryan, 2019; Van der Hoop et al., 2013; Van der Hoop et al., 2015; Wright et al., 2018). Most

[2] The Alaska Department of Fish and Game no longer collects data related to the subsistence harvest assessment program, and the most recent report for the Kodiak Island communities in 2011 and for sea otters in the State of Alaska was 2012.

reported marine mammal vessel strikes involve commercial vessels transiting over or near the continental shelf hitting whales (Laist et al., 2001; National Marine Fisheries Service, 2008, 2019d; Nichol et al., 2017; Scordino et al., 2020; Silber et al., 2008), but strikes also occur in coastal areas frequented by smaller vessels and involve smaller marine mammals and other species (Schoeman et al., 2020).

Available data from NMFS indicate that in Alaska in the five-year period between 2013 and 2017, mortalities or serious injuries occurred to a minimum of 29 humpbacks as a result of vessel strike (Delean et al., 2020), and along the U.S. Pacific coast between 2013 and 2017, there were an additional 14 known strikes involving humpback whales (Carretta et al., 2019a); these animals struck off California may be part of the same populations inhabiting the TMAA.

Since 1995, the U.S. Navy and U.S. Coast Guard have reported all known or suspected vessel collisions with whales to NMFS. The assumed under-reporting of whale collisions by vessels other than U.S. Navy or U.S. Coast Guard makes any comparison of data involving vessel strikes between Navy vessels and other vessels heavily biased. This under-reporting of civilian vessel collisions with whales is recognized by NMFS (Bradford & Lyman, 2015). Within Alaska waters, there were 28 reported marine mammal vessel strikes between 2013 and 2017 (none of which were from U.S. Navy vessels) (Delean et al., 2020), and for the U.S. West Coast in the same period there were 65 reported vessel strikes to marine mammals (Carretta et al., 2020b), which is an approximate average consistent with previous reporting periods (Carretta et al., 2019a; Carretta et al., 2018b; Helker et al., 2019; Helker et al., 2017).

Noise

In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise can be a potential habitat-level stressor (Castellote et al., 2019; Dunlop, 2016; Dyndo et al., 2015; Erbe et al., 2018; Erbe et al., 2014; Frisk, 2012; Gabriele et al., 2017; Gedamke et al., 2016; Haver et al., 2018; Hermannsen et al., 2014; Li et al., 2015; McKenna et al., 2012; Melcón et al., 2012; Merchant et al., 2014; Merchant et al., 2012; Mikkelsen et al., 2019; Miksis-Olds & Nichols, 2016; Nowacek et al., 2015; Pine et al., 2016; Rice et al., 2018a; Williams et al., 2014c). Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. Noise associated with tourism (whale watch vessels and cruise ships) is also a concern in some areas of Alaska (Cates et al., 2020; Frankel & Gabriele, 2017; Schuler et al., 2019; Sprogis et al., 2020). Noise may cause marine mammals to leave a habitat, impair their ability to communicate, or cause physiological stress (Burnham & Duffus, 2019; Cholewiak et al., 2018; Courbis & Timmel, 2008; Erbe, 2002; Erbe et al., 2019; Erbe et al., 2016; Gabriele et al., 2018; Hildebrand, 2009; Holt et al., 2017; Putland et al., 2018; Rolland et al., 2012; Southall et al., 2018; Tyack et al., 2011; Tyne et al., 2017; Wieland et al., 2010; Williams et al., 2014b; Williams et al., 2019; Wisniewska et al., 2018). Noise can cause behavioral disturbances, mask other sounds including their own vocalizations, may result in injury, and in some cases may result in behaviors that ultimately lead to death (Erbe et al., 2019; Erbe et al., 2016; Erbe et al., 2014; National Research Council, 2003, 2005; Nowacek et al., 2007; Southall et al., 2009; Tsujii et al., 2018; Tyack, 2009; Würsig & Richardson, 2009). As noted in Section 3.0 (Introduction), anthropogenic noise in the TMAA is generated from a variety of sources, including commercial shipping, oil and gas exploration activities, commercial and recreational fishing (including fish finding sonar, fathometers, and acoustic deterrent and harassment devices), recreational boating, research (including sound from air guns, sonar, and telemetry).

Ships leaving ports in Japan and Korea travel in a direct line following the North Pacific Great Circle Route to ports in Canada and Washington via the Unimak Pass in the Aleutian Islands (Aleutian Islands

Waterways Safety Committee, 2019; Nuka Research and Planning Group LLC, 2015). For example, there were a total of 28,302 vessel transits in the Bering Sea in 2015 (Adams & Silber, 2017). In addition, vessels calling at ports in Alaska including Anchorage and Prince William Sound may travel directly through the TMAA. As a result, commercial vessel noise is the main source of underwater anthropogenic noise in the area (Klinck et al., 2016; Rice et al., 2018b; Wiggins et al., 2017; Wiggins & Hildebrand, 2018). Redfern et al. (2017a) found that commercial vessel noise in some locations may have degraded the habitat for right whales, blue whales, fin whales, and humpback whales due to the loss of communication space where important habitat for these species overlaps with commercial vessel traffic (Redfern et al., 2017a; Rolland et al., 2016). Commercial vessel traffic running adjacent to the coast in the TMAA may be adjacent to or run through portions of the designated critical habitat for North Pacific right whales and biologically important areas for fin, gray, Cook Inlet beluga whales, and humpback whales (Castellote et al., 2019; Ferguson et al., 2015; Wiggins et al., 2017).

In many areas of the world, oil and gas seismic exploration in the ocean is undertaken using a group of air guns towed behind large research vessels. The airguns convert high-pressure air into very strong shock wave impulses that are designed to return information off the various buried layers of sediment under the seafloor. Seismic exploration surveys last many days and cover vast overlapping swaths of the ocean area being explored. Most of the impulse energy (analogous to underwater explosions) produced by these airguns is heard as low-frequency sound, which can travel long distances and has the potential to impact marine mammals. The National Marine Fisheries Service routinely issues permits for the taking of marine mammals associated with these commercial activities (see for example, 84 FR 27246, Wednesday, June 12, 2019).

Marine Debris and Pollution

Approximately 80 percent of marine debris in the ocean come from land-based sources (California Ocean Protection Council & National Oceanic and Atmospheric Administration Marine Degree Program, 2018; Thiel et al., 2018). In a seafloor survey off Southern California where the Navy has routinely trained and tested for decades, urban refuse (beverage cans, bottles, household items, and construction materials) constituted approximately 88 percent of the identified debris observed (Watters et al., 2010). Without improved waste management and infrastructure in underdeveloped coastal countries worldwide, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025 (Jambeck et al., 2015). Marine debris is a global threat to marine mammals (National Oceanic and Atmospheric Administration Marine Debris Program, 2014a). For example, entanglement of California sea lions documented along the north coast of Washington from 2010 to 2018 were mostly from packing bands (Allyn & Scordino, 2020). A literature review by Baulch and Perry (2014), found that 56 percent of cetacean species are documented as having ingested marine debris. Interactions between marine mammals and marine debris, including derelict fishing gear and plastics, are significant sources of injury and mortality (Baulch & Perry, 2014). Comparing the Baulch and Perry review with that conducted by an earlier investigation (Laist, 1997), the percentage of marine mammal species with documented records of entanglement in or ingestion of marine debris has increased from 43 to 66 percent over the past 18 years (Bergmann et al., 2015). Ingestion of marine debris by marine mammals is a less well-documented cause of mortality than entanglement, but it is a growing concern (Bergmann et al., 2015; Jacobsen et al., 2010; Paul, 2019; Puig-Lozano et al., 2018). Baulch and Perry (2014) found that ingestion of debris has been documented in 48 cetacean species, with rates of ingestion as high as 31 percent in some populations. Attributing cause of death to marine debris ingestion is difficult (Laist, 1997), but ingestion of plastic bags and Styrofoam has been identified as the cause of injury or death of minke whales (De Pierrepont et al., 2005) and deep-diving odontocetes, including beaked whales (Baulch & Perry, 2014; Paul, 2019; Puig-Lozano et al., 2018), pygmy sperm whales (Sadove & Morreale, 1989; Stamper et al., 2006; Tarpley & Marwitz, 1993), and sperm whales (Jacobsen et al., 2010; Sadove & Morreale, 1989). As noted elsewhere, without improved waste management and infrastructure in undeveloped coastal countries worldwide, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025 (Jambeck et al., 2015).

Marine mammals migrating to Alaska also encounter threats outside the TMAA (Díaz-Torres et al., 2016; Lian et al., 2018; Thiel et al., 2018). In Alaska from 2011 through 2015, records of approximately 3,700 human-marine mammal interactions were reviewed by NMFS and determined to have resulted in 440 entanglement/entrapment-related marine mammal serious injury or mortality to various species (Helker et al., 2017). For example, between 2011 and 2015 the most common cause of serious injuries for the Eastern U.S. stock of Steller sea lions was entanglement in marine debris or fishery gear (totaling 146 sea lions) (Helker et al., 2017); for the period from 2012 to 2016 this total was 117 seriously injured Steller sea lions (Helker et al., 2019). Entanglement of California sea lions and Steller sea lions documented along the north coast of Washington from 2010 to 2018 were mostly from shipping packing bands, followed by salmon flashers during the local ocean salmon troll season (Allyn & Scordino, 2020). Likely reflecting fishery practices across the North Pacific, in the Northwest Hawaiian Islands, where there have been active efforts at marine debris removal since 1996, the National Oceanic and Atmospheric Administration marine debris team has removed 848 metric tons of derelict fishing nets and debris and estimates an additional 52 metric tons of derelict fishing gear collects on the shallow coral reefs and shores there every year (National Oceanic and Atmospheric Administration, 2018e).

On the U.S. West Coast for the marine mammal stocks that are present in the TMAA, marine debris resulted in mortalities to 129 marine mammals in the five-year period from 2013 to 2017 (the majority California sea lions), two gray whales, and one each of the following species: humpback whale, minke whale, and harbor porpoise (Barcenas De La Cruz et al., 2017; Carretta et al., 2019a). From 2013 through 2017, there were 10 blue whales, 54 humpback whales, and six sperm whales entanglements documented for those ESA-listed species (Carretta et al., 2019a). Marine debris documented off the Mexican Central Pacific coast (Díaz-Torres et al., 2016) and waters farther south (Thiel et al., 2018) also have the potential to impact marine mammals that migrate to Alaska, such as the ESA-listed humpback whale DPSs from Mexico and the stock of blue whales along the U.S. West Coast that move at least as far south as the Costa Rica Dome[3] located off the west coast of Central America.

An estimated 75 percent or more of marine debris consists of plastic (California Coastal Commission, 2018; Derraik, 2002; Hardesty & Wilcox, 2017). High concentrations of floating plastic have been reported in the central areas of the North Atlantic and Pacific Oceans (Cozar et al., 2014). Plastic pollution found in the oceans is primarily dominated by particles smaller than 1 centimeter, commonly referred to as microplastics (Hidalgo-Ruz et al., 2012). Other researchers have defined microplastics as particles with a diameter ranging from a few micrometers up to 5 millimeters and not readily visible to the naked eye (Andrady, 2015). Most microplastic fragments and fibers found throughout the oceans

[3] The Costa Rica Dome is an area of deep ocean upwelling in the Eastern Tropical Pacific, centered approximately 500 km off the west coast of Costa Rica and Nicaragua. The size of the roughly elliptical area varies from approximately 300 to 1,000 km in an east-west direction and is an area of high productivity and known wintering location for blue whales.

result from the breakdown of larger items, such as clothing, packaging, and rope and have accumulated in the pelagic zone and sedimentary habitats (Thompson et al., 2004). Results from the investigation by Browne et al. (2011) have also suggested that microplastic fibers are discharged in sewage effluent resulting from the washing of synthetic fiber clothes. DeForges et al. (2014) sampled the Northeast Pacific Ocean in areas in and near the coastal waters of British Columbia, Canada, and found microplastics (those 62–5,000 micrometers in size) were abundant in all samples with elevated concentrations near urban centers; a finding that should be applicable to all urban centers such as those in the TMAA. Besseling et al. (2015) documented the first occurrence of microplastics in the intestines of a humpback whale; while the primary cause of the stranding was not determined, the researchers found multiple types of microplastics ranging in sizes from 1 millimeter to 17 centimeters. There is still a large knowledge gap about the negative effects of microplastics, but it remains a concern (Besseling et al., 2015). Specifically, the propensity of plastics to absorb and concentrate dissolved pollutant chemicals, such as persistent organic pollutants, is a concern because microfauna may be able to digest plastic nanoparticles, facilitating the delivery of dissolved pollutant chemicals across trophic levels and making them bioavailable to larger marine organisms, such as marine mammals (Andrady, 2015; Carlos de Sá et al., 2018; Gallo et al., 2018; Nelms et al., 2018).

Other Interactions (Including Derelict Fishing Gear)

Fishery interactions other than bycatch include entanglement from abandoned or partial nets, fishing line, hooks, and the ropes and lines connected to fishing gear (Barcenas De La Cruz et al., 2017; California Coastal Commission, 2018; California Ocean Protection Council & National Oceanic and Atmospheric Administration Marine Degree Program, 2018; Carretta et al., 2019a; Carretta et al., 2019b; Carretta et al., 2020a; Currie et al., 2017b; Delean et al., 2020; Díaz-Torres et al., 2016; Esquible & Atkinson, 2019; Helker et al., 2019; Lowry et al., 2018; National Marine Fisheries Service, 2018c; National Oceanic and Atmospheric Administration, 2016a, 2018e; National Oceanic and Atmospheric Administration Marine Debris Program, 2014a; Polasek et al., 2017; Saez, 2018). The National Oceanic and Atmospheric Administration Marine Debris Program (2014b) reports that abandoned, lost, or otherwise discarded fishing gear constitutes the vast majority of mysticete and pinniped entanglements. For the five-year period between 2012 and 2016 there were 52 known cases of humpback whale entanglement in Alaska (Helker et al., 2019) and between 2013 and 2017 there were an additional 117 cases of reported interactions with fishing gear resulting in serious injuries or mortality off the U.S. West Coast (Carretta et al., 2019a; Carretta et al., 2019b). In the two-year period of 2018–2019, there were 51 confirmed entangled humpback whales along the U.S. West Coast (National Oceanic and Atmospheric Administration, 2020c). Humpback whales from Mexico and Central America have been identified feeding in Alaska (Bettridge et al., 2015; Calambokidis et al., 2008), so some proportion of the entanglements in Alaska could be to whales from the Mexico DPS and Central America DPS individuals. Humpback whales from Mexico and Central America have been identified feeding in Alaska (Bettridge et al., 2015; Calambokidis et al., 2008), so some proportion of the entanglements in Alaska could be to whales from the Mexico DPS and Central America DPS individuals. In total for Alaska between 2012 and 2016, there were 334 fishery-related serious injuries or mortalities (Helker et al., 2019), and for the U.S. West Coast between 2013 and 2017 there were 1,043 cases of fishery-related entanglements (Carretta et al., 2019a). In May 2017, a gray whale calf was discovered dead onshore near the mouth of the Columbia River after becoming entangled in crab pot fishing gear (Cascadia Research, 2017). Outside of U.S. waters, NMFS has identified incidental catches in coastal net fisheries off Japan, Korea, and northeastern Sakhalin Island as a significant threat to endangered Western North Pacific gray whales (Carretta et al., 2020b; Lowry et al., 2018); this species may be seasonally present in the TMAA. Species of large whales found entangled in 2015 and 2016 included stocks that are present in the TMAA such as ESA-listed humpback, blue, and fin whales and also included gray whale and killer whales, with a total of 133 entanglements to those species in the two-year period (National Marine Fisheries Service, 2018c; National Oceanic and Atmospheric Administration, 2017). In the most recent five-year reporting period for Alaska and the U.S. West Coast, most humpback whale injuries and mortality were from entanglements in fishing gear totaling 169 known occurrences (Carretta et al., 2019a; Helker et al., 2019; National Oceanic and Atmospheric Administration, 2019a). For the identified sources of entanglement in these NMFS reports, none included Navy expended materials.

Along the U.S. West Coast, hook and line fishery and gunshot wounds are two of the primary causes of pinniped serious injuries or mortalities injuries found in strandings (Barcenas De La Cruz et al., 2017; Carretta et al., 2020a; Warlick et al., 2018). Between 2013 and 2017, there were 199 known cases of marine mammals being shot (Carretta et al., 2019a). In December 2018, due to the prevalence of known pinniped shootings, National Oceanic and Atmospheric Administration Fisheries was working on publishing guidelines for fishermen who take actions to deter pinnipeds and other marine mammals from their catch (Esquible & Atkinson, 2019; National Oceanic and Atmospheric Administration, 2018d, 2019c).

In waters off Alaska, Washington, and Southern California, Navy research involving the use of passive acoustic recording devices since 2009 have documented the routine use of non-military explosives at sea (Baumann-Pickering et al., 2013; Bland, 2017; Debich et al., 2014b; Kerosky et al., 2013; Rice et al., 2015; Rice et al., 2018b; Trickey et al., 2015; U.S. Department of the Navy, 2016b; Wiggins et al., 2019; Wiggins et al., 2017). Based on the spectral properties of the recorded sounds and their correspondence with known fishing seasons or activity, the source of these explosions has been linked to the use of explosive marine mammal deterrents, which as a group are commonly known as “seal bombs” (Baumann-Pickering et al., 2013; Wiggins et al., 2019). Seal bombs are intended to be used by commercial fishers to deter marine mammals, particularly pinnipeds, from preying upon their catch and to prevent marine mammals from interacting and potentially becoming entangled with fishing gear (Klint, 2016; National Marine Fisheries Service, 2015; U.S. Department of the Navy, 2016b).

Based on the number of explosions recorded over the past several years in the monitoring within the TMAA, the use of seal bombs is much more prevalent than might be expected by the general public (Rice et al., 2018b; Wiggins et al., 2017). Simonis et al. (2020b) have suggested that the noise from seal bomb use associated with purse seine fishing may be a potential threat to harbor porpoise in the region around the Monterey Bay National Marine Sanctuary. Seal bombs have resulted in at least three known marine mammal injuries in the past (Carretta et al., 2019a), but the seemingly routine use of seal bombs has likely had no significant effect on populations of marine mammals given that it is likely at least some individuals, if not larger groups of marine mammals, have been repeatedly exposed to this explosive stressor.

Since 2010, the Oregon Department of Fish & Wildlife and Washington Department of Fish & Wildlife have conducted a removal program for California sea lions that prey on ESA-listed Chinook salmon and steelhead stocks at Bonneville Dam (Schakner et al., 2016). This is the same population of California sea lions that seasonally inhabit the TMAA, Washington, Oregon, and California waters. Although non-lethal pyrotechnic and rubber buckshot are used as short-term deterrents, in 2016 (for example), these state Fish & Wildlife activities lethally removed (i.e., euthanized) 59 California sea lions (Madson et al., 2017). In December 2018, Congress signed into law the Endangered Salmon Predation Prevention Act, which allows NMFS to authorize the intentional lethal taking of California sea lions on the waters of the

Columbia River and its tributaries for the protection of endangered salmon. In the five-year period from 2013 to 2017, there were 124 pinniped "removals" for that purpose (Carretta et al., 2019a).

Water Quality

For a general discussion regarding potential impacts on the ocean's water quality from Military Expended Material (MEM), see Section 3.2 (Expended Materials) of the 2016 GOA Final SEIS/OEIS. Chemical pollution and impacts on ocean water quality are of great concern, although their effects on marine mammals are just starting to be understood (Bachman et al., 2015; Bachman et al., 2014; Cossaboon et al., 2019; Desforges et al., 2016; Foltz et al., 2014; Godard-Codding et al., 2011; Hansen et al., 2015; Jepson & Law, 2016; Law, 2014; Lian et al., 2018; Peterson et al., 2015; Peterson et al., 2014; Ylitalo et al., 2009; Ylitalo et al., 2005). Oil and other chemical spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species directly through exposure to oil or chemicals and indirectly due to pollutants' impacts on prey and habitat quality (Engelhardt, 1983; Marine Mammal Commission, 2010; Matkin et al., 2008). For example, in the five-year period from 2013 to 2017 along the Pacific coast, there were 127 pinnipeds found stranded with a serious injury or mortality caused by oil or tar coating their body (Carretta et al., 2019a); some of the pinnipeds found seasonally in the TMAA spend part of the year in areas to the south along the Pacific Coast or in islands off that coast.

On a broader scale ocean contamination resulting from chemical pollutants inadvertently introduced into the environment by industrial, urban, and agricultural use is also a concern for marine mammal conservation and has been the subject of numerous studies (Cossaboon et al., 2019; Desforges et al., 2016; Fair et al., 2010; Krahn et al., 2007; Krahn et al., 2009; Moon et al., 2010; Ocean Alliance, 2010). For example, the chemical components of pesticides used on land flow as runoff into the marine environment and can accumulate in the bodies of marine mammals and be transferred to their young through mother's milk (Fair et al., 2010). The presence of these chemicals in marine mammals has been assumed to put those animals at greater risk for adverse health effects and potential impact on their reproductive success given toxicology studies and results from laboratory animals (Fair et al., 2010; Godard-Codding et al., 2011; Krahn et al., 2007; Krahn et al., 2009; Peterson et al., 2015; Peterson et al., 2014). Desforges et al. (2016) have suggested that exposure to chemical pollutants may act in an additive or synergistic manner with other stressors, resulting in significant population-level consequences. Although the general trend has been a decrease in chemical pollutants in the environment following their regulation, chemical pollutants remain important given their potential to impact marine mammals (Bonito et al., 2016; Jepson & Law, 2016; Law, 2014).

Disease and Parasites

Just as in humans, disease affects marine mammal health and especially older animals. (Pascual, 2015). Occasionally disease epidemics can also injure or kill a large percentage of a marine mammal population (Keck et al., 2010; Paniz-Mondolfi & Sander-Hoffmann, 2009; Simeone et al., 2015). Mass die-offs of some marine mammal species have been linked to toxic algal blooms, which occurs as larger organisms consume multiple prey containing those toxins, thereby accumulating fatal doses (McCabe et al., 2016; National Oceanic and Atmospheric Administration, 2016b). An example is domoic acid poisoning in California sea lions and northern fur seals from the diatom *Pseudo-nitzschia* spp. (Doucette et al., 2006; Fire et al., 2008; Lefebvre et al., 2016; Lefebvre et al., 2010; Torres de la Riva et al., 2009). A comprehensive study in Alaska that sampled over 900 marine mammals across 13 species, including several mysticetes, odontocetes, pinnipeds, and mustelids, found detectable concentrations of domoic acid in all 13 species and saxitoxin, a toxin absorbed from ingesting dinoflagellates, in 10 of the 13 species (Lefebvre et al., 2016). Algal toxins may have contributed to the stranding and mortality of 34 whales found around the islands in the western GOA and the southern shoreline of the Alaska Peninsula and another 16 stranded whales in British Columbia starting in May 2015–2016 (National Oceanic and Atmospheric Administration, 2016b; Rosen, 2015; Savage et al., 2017; Summers, 2017).

Additionally, all marine mammals have parasites that, under normal circumstances, probably do little overall harm, but under certain conditions can cause serious health problems or even death (Barbieri et al., 2017; Bull et al., 2006; Fauquier et al., 2009; Hawaiian Monk Seal Research Program, 2015; Jepson et al., 2005; Rogers, 2016; Ten Doeschate et al., 2017). The most commonly reported parasitic infections are protozoans in sea otters (Burgess et al., 2018); other parasites known to cause disease in pinnipeds and sea otters include hookworms, lungworms, and thorny-headed worms (Simeone et al., 2015).

3.8.2.2 North Pacific Right Whale (*Eubalaena japonica*)

3.8.2.2.1 Status and Management

There has been no change in the status or the management of North Pacific right whales since the 2016 GOA Final SEIS/OEIS (Clapham, 2016; Muto et al., 2020; National Marine Fisheries Service, 2013, 2017d; Wade et al., 2010). North Pacific right whales are listed as depleted under the MMPA and endangered under the ESA.

3.8.2.2.2 Abundance

The most recent estimated population for the North Pacific right whale as presented in the Alaska SAR is between 28 and 31 individuals (Muto et al., 2020). The current abundance in the SAR is an estimated 31 individuals (International Whaling Commission, 2019a). For purposes of the current analysis presented in this SEIS/OEIS, a new estimated North Pacific right whale density was derived in coordination with scientists from the NMFS Southwest Fisheries Science Center and the Alaska Fisheries Science Center. Based on the discussions with these subject matter experts, the Navy has assumed for purposes of acoustic effects modeling that five North Pacific right whales may be present within the TMAA during the 21-day period for the proposed Navy activities. This is a substantial increase in the assumed number of right whales present in comparison to the analysis done for the 2016 GOA Final SEIS/OEIS, but it will provide for a more conservative analysis erring on the side of overestimating potential effects to the species.

3.8.2.2.3 Distribution

The Navy has determined the North Pacific right whale's occurrence in the TMAA would be year round but rare with a potentially higher density between June and September. Since the 2016 GOA Final SEIS/OEIS there have been a few new sightings or acoustic detections of North Pacific right whales in the Arctic and locations farther south off the U.S. West Coast; off Hokkaido, Japan; and in the North Pacific Ocean to the southeast of Kamchatka Peninsula (Filatova et al., 2019; Hakamada & Matsuoka, 2016; Matsuoka et al., 2018a; Matsuoka et al., 2018b; Rice et al., 2018b; Širović et al., 2015a; U.S. Department of the Navy, 2017d; WorldNow, 2017; Wright et al., 2019; Wright et al., 2018). Right whales were acoustically detected in Barnabus Trough outside the TMAA in 2013, but were not visually observed during the Gulf of Alaska Line-Transect Survey for marine mammals within the TMAA; six of the possible detections shown in Figure 33 of Rone et al. (2014) occurred within the TMAA (Rone et al., 2014). Right whales were again acoustically detected in the same Barnabus Trough area in August of 2015 (Rone et al., 2015). A line transect survey was conducted in 2015 that had a primary focus and design to locate North Pacific right whales in the nearshore waters of the Gulf of Alaska, including the designated critical habitat located off Kodiak Island, the Biologically Important Area for feeding, right whale habitat based on historical whale catch data, and the nearshore margins of the TMAA (Rone et al., 2017). This survey, which occurred from August 10 to September 8, 2015, had no right whales sighted (Rone et al., 2017). As noted in the 2016 GOA Final SEIS/OEIS, this species has generally been described as routinely observed or acoustically detected in the Bering Sea/Bristol Bay Alaska area (Matsuoka et al., 2018a; Muto et al., 2020). Acoustic monitoring occurring at five sites in the TMAA between July 2011 and September 2017 did not detect any North Pacific right whale calls (Rice et al., 2018b; Wiggins et al., 2017). For additional information about important North Pacific right whale feeding areas in the TMAA, see Section 5.4.1.1 (North Pacific Right Whales) of this SEIS/OEIS.

For additional information about North Pacific right whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.3 Humpback Whale (*Megaptera novaeangliae*)

3.8.2.3.1 Status and Management

The status and management of humpback whales that are seasonally present in the TMAA has changed since the 2016 GOA Final SEIS/OEIS as a result of the 14 DPSs established under the ESA in September 2016 (81 FR 62259). Humpback whales in the TMAA are now managed as being from three stocks and three DPSs that are, "… both discrete from other conspecific populations and significant to the species of humpback whales to which they belong" (National Marine Fisheries Service, 2016a). The stock structure of humpback whales is defined by NMFS based on the stock's fidelity to feeding grounds (Gabriele et al., 2017), while the DPSs are based on humpback whales present at known breeding grounds (Bettridge et al., 2015; Carretta et al., 2020b; Darling et al., 2019b; Muto et al., 2020; National Marine Fisheries Service, 2016a). As noted in the 2018 Alaska SAR (Muto et al., 2020), NMFS is in the process of reviewing humpback whale stock structure in light of the 14 DPSs established under the ESA in September 2016 (81 FR 62259). Within the GOA, humpback whales of the Western North Pacific DPS and the Mexico DPS are listed as threatened under the ESA (National Marine Fisheries Service, 2016a). The Hawaii DPS humpback whales, which are the majority of the humpback whale in the TMAA, are no longer listed under ESA.

Humpback whales of the Western North Pacific Stock and DPS are humpback whales that mainly feed in Russian waters but that may also feed in the GOA (Muto et al., 2020; National Marine Fisheries Service, 2016d). This population winters in waters described as Okinawa/Osagawara/Philippines or Western North Pacific (Bettridge et al., 2015), which now also includes the Mariana Islands (Hill et al., 2017; Hill et al., 2016; National Marine Fisheries Service, 2016d; National Oceanic and Atmospheric Administration, 2015a, 2018c; Titova et al., 2017).

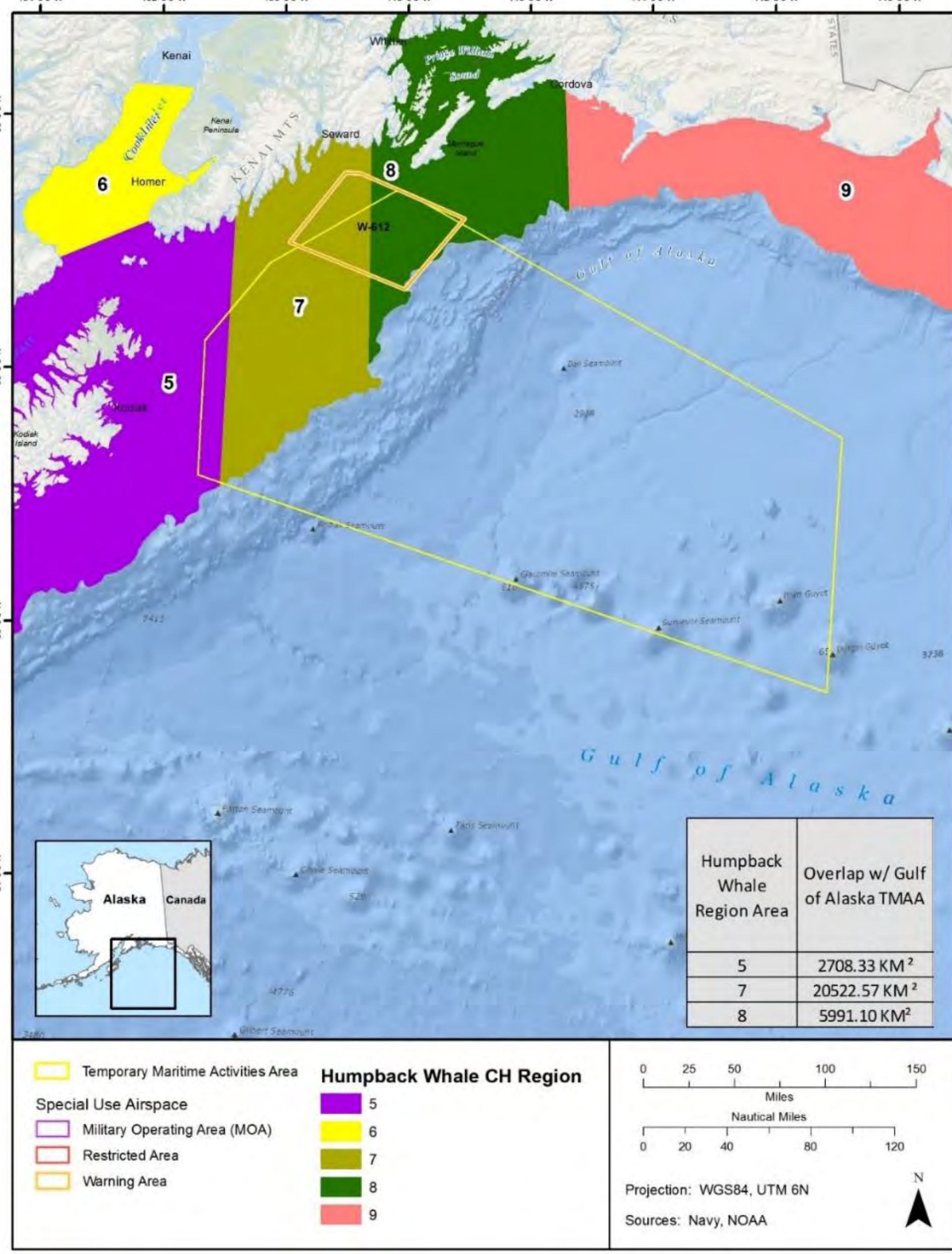
The Central North Pacific Stock and Hawaii DPS humpback whales are present in feeding areas off the coast of Alaska (including the nearshore waters of the TMAA), British Columbia, Washington, and Oregon in the summer and then migrate to winter in the Hawaiian Islands (Muto et al., 2020).

A portion of the California, Oregon, Washington stock consisting of the Mexico DPS individuals and the Central North Pacific Stock (the Hawaii DPS) are present in feeding areas off the coast of Alaska (including the nearshore waters of the TMAA), British Columbia, Washington, Oregon, and California in the summer and then return to waters off Mexico and Hawaii in the winter (Bettridge et al., 2015; Calambokidis et al., 2017a; Carretta et al., 2020b; Muto et al., 2020; National Marine Fisheries Service, 2016d, 2016e; Wade et al., 2016).

On October 9, 2019, NMFS proposed to designate critical habitat for the endangered Western North Pacific DPS, the threatened Mexico DPS, and the endangered Central America DPS of humpback whales along the coasts of California, Oregon, Washington, and Alaska (84 FR 54354; note that whales belonging to the Central America DPS should not be present in the GOA or the TMAA according to NMFS (Mate et al., 2018; National Marine Fisheries Service, 2016d, 2019b, 2019c). As shown on Figure 3.8-2 the northwestern portion of the TMAA over the continental shelf overlaps with approximately 29,222 square kilometers of the proposed areas in the NMFS designated Region/Units 5, 7, and 8.

Region/Unit 5 is "occupied critical habitat" for the Western North Pacific DPS and characterized as having a high conservation value (National Marine Fisheries Service, 2019b, 2019c). The National Marine Fisheries Service has determined that Region/Unit 7 (named the "Kenai Peninsula Area" by NMFS) has low conservation value and concluded that exclusion of that and other similar areas from the designations will not result in extinction of any humpback whale DPSs (84 FR 54378), given the whales are not expected to rely on the area for feeding (National Marine Fisheries Service, 2019b, 2019c). Region/Unit 8 (the "Prince William Sound Area") was also determined to have a low conservation value and "limited conservation benefit" for the Western North Pacific DPS, and the area was excluded because "… whales from the WNP DPS have not been directly observed …" in Region/Unit 8 (National Marine Fisheries Service, 2019b, 2019c). Region/Unit 8 was determined to have a high conservation value as critical habitat for the threatened Mexico DPS humpback whales (84 FR 54378). Sighting data from three line transect surveys (in the summers of 2009, 2013, and 2015) that included Region/Unit 8 of the Critical Habitat had no sightings of humpback whales in any of the survey years in that portion of the Critical Habitat overlapping with the TMAA (see Rone et al. (2017)).

In the proposed rule to designate humpback whale Critical Habitat (84 FR 54354) (shown in Figure 3.8-2), NMFS has identified one essential feature of that habitat, but that essential feature is a composite of three factors defined as (1) sufficient quality, (2) abundance, and (3) accessibility of prey species within humpback whale feeding areas to support population growth of the ESA-listed humpback whale DPSs. Prey species identified by NMFS are primarily zooplankton/krill (euphausiids) and small pelagic schooling fishes of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth (84 FR 54354). In Alaska waters, humpback whales feed in association with high densities of zooplankton and fish near the Kodiak Archipelago (Witteveen et al., 2014; Witteveen & Wynne, 2017) and in associated with seasonal runs of herring in Prince William Sound (Moran et al., 2015).



Humpback Whale Region Area	Overlap w/ Gulf of Alaska TMAA
5	2708.33 KM ^{2}
7	20522.57 KM ^{2}
8	5991.10 KM^2

Figure 3.8-2: Proposed Humpback Whale Critical Habitat Overlapping the TMAA

3.8.2.3.2 Abundance

For the Western North Pacific stock and DPS, photographic identifications off Okinawa and Ogasawara were used to estimate that the abundance of humpback whales in the Western North Pacific population was approximately 1,000 individuals (Bettridge et al., 2015; Calambokidis, 2009; Muto et al., 2017). The inclusion of more recent data from photographic identifications off Okinawa have documented the presence of at least 1,402 unique individuals in the Western North Pacific DPS (Kobayashi et al., 2016). The 2018 Alaska SAR provides that it is reasonable to assume that that the growth rate for this stock would be at least 7 percent annual rate of increase based on the other observations from the North Pacific (Muto et al., 2020); the most recent Alaska SAR provides that the rate of increase is unknown given the age of the data used in the previous assessment (Muto et al., 2020).

For the Central North Pacific stock and the Hawaii DPS portion of the humpback whale population in the TMAA, the Hawaii DPS was delisted under the ESA given that this population segment is believed to have fully recovered and now has an abundance greater than the pre-whaling estimate (Barlow et al., 2011; Bettridge et al., 2015; Muto et al., 2017; Muto et al., 2018b; Muto et al., 2020; National Marine Fisheries Service, 2016a; Wade et al., 2016).

For the California, Oregon, and Washington stock, data from the most recently published NMFS survey (in 2014) (Barlow, 2016) and other corresponding investigations (Calambokidis & Barlow, 2020; Calambokidis et al., 2017a; Henry et al., 2020; Smultea, 2014) appear consistent with the highest-yet abundance estimates of humpback whales along the along the U.S. West Coast (Carretta et al., 2020b). The new best overall estimate of abundance of humpback whales along the U.S. West Coast has been provided by photo identification data gathered between 2015 and 2018 along the U.S. West Coast (Calambokidis & Barlow, 2020). This estimate, which includes the Mexico DPS and the Central America DPS (n=4,973; CV=0.05), is significantly higher than the abundance (n=2,900) presented in the 2019 Pacific SAR (Carretta et al., 2020b). This increase in the California, Oregon, Washington stock is estimated to have been between 7.5 and 8.2 percent, since the late 1980s, to have reached that new reported higher abundance (Calambokidis & Barlow, 2020).

The humpback whales in Glacier Bay and Icy Strait are potentially from all three stocks, and data collected from 1985 to 2014 found an increase in the number of individual whales counted averaging 5.1 percent per year with an accelerated rate of growth from 2002 to 2011 of 11.1 percent per year (Gabriele et al., 2017).

3.8.2.3.3 Distribution

There have been no changes to the general known distribution of humpback whales in the TMAA since the 2016 GOA Final SEIS/OEIS, however there has been new research relevant to the presence of humpbacks in the TMAA and GOA region. Consistent with the information presented in the 2016 GOA Final SEIS/OEIS, humpback whale typically are present in higher numbers during the summer in high-latitude nearshore feeding grounds (Barlow et al., 2011; Becker et al., 2016; Becker et al., 2017; Bettridge et al., 2015; Calambokidis et al., 2017a; Calambokidis et al., 2010; Keen et al., 2018; Pack et al., 2017; Wade et al., 2016). Migrations are variable and dynamic seasonally and timing of migration may change from year to year based on nutritional needs, oceanic conditions impacting the prey base, and competition for food between species of whales (Burrows et al., 2016; Gabriele et al., 2017; Moran et al., 2018). These factors can result in humpback whales lengthening their feeding time in northern latitudes, skipping the annual migration, and potentially increasing their predation on herring in the GOA (Straley et al., 2017). Passive acoustic monitoring (Debich et al., 2013; Debich et al., 2014a; Rice et al., 2015; Rice et al., 2018b) have documented the presence of humpback whales year round in the TMAA, although they have been fewer in number based on three line transect surveys of the TMAA and surrounding waters (Rone et al., 2009; Rone et al., 2014; Rone et al., 2017) and the locations and destinations of satellite tagged humpback whales, as reported in Mate et al. (2018) and Palacios et al. (2020). This corresponds to the distribution of their prey, which is primarily concentrated on the shelf over shallow banks less than 100 meters (m) in depth (Burrows et al., 2016; Matta & Baker, 2020; McGowan et al., 2019; Moran et al., 2015; Straley et al., 2017).

Specific to the Western North Pacific humpback whale DPS designated since the 2016 GOA Final SEIS/OEIS, individuals in the Western North Pacific DPS mainly feed in Russian waters, but may also feed in the GOA, including the TMAA (Muto et al., 2020; National Marine Fisheries Service, 2016d). This population winters in waters described as Okinawa/Osagawara/Philippines or Western North Pacific (Bettridge et al., 2015), which now also includes the Mariana Islands (Hill et al., 2017; Hill et al., 2016; National Marine Fisheries Service, 2016d; National Oceanic and Atmospheric Administration, 2015a, 2018c; Titova et al., 2017). Completed analyses of genetic samples to date have found humpback whales in the Mariana Islands share four haplotypes common in humpback whales throughout the North Pacific and two haplotypes that are more common in Western North Pacific DPS whales, but which are also present in humpback whales throughout the North Pacific (Hill et al., 2018). This genetic data as well as early photo-identification data from Darling et al. (1996) and more recent data regarding the analysis of humpback vocalizations suggest mixing of the humpback whale populations throughout the Pacific (Darling et al., 2019a).

The Hawaii DPS humpback whales are present in feeding areas off the coast of Alaska (including the nearshore waters of the TMAA), British Columbia, Washington, and Oregon in the summer and then migrate to winter in the Hawaiian Islands (Muto et al., 2020; National Marine Fisheries Service, 2016d, 2016e).

The Mexico DPS individuals are also present in feeding areas off the coast of Alaska (including the nearshore waters of the TMAA), British Columbia, Washington, Oregon, and California in the summer and then return to waters off Mexico in the winter (Bettridge et al., 2015; Calambokidis et al., 2017a; Carretta et al., 2020b; Muto et al., 2020; National Marine Fisheries Service, 2016d, 2016e; Wade et al., 2016). For additional information about important humpback whale feeding areas in the TMAA, see Section 5.4.1.2 (Humpback Whales) of this SEIS/OEIS.

For additional information about humpback whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.4 Blue Whale (*Balaenoptera musculus*)

3.8.2.4.1 Status and Management

There has been no change in the status or the management of the two blue whale stocks as designated by NMFS for the TMAA since the 2016 GOA Final SEIS/OEIS. The blue whale is listed as endangered under the ESA and as depleted under the MMPA throughout its range, but there is no designated critical habitat for this species (Carretta et al., 2020b; Muto et al., 2020; National Marine Fisheries Service, 2018b). The National Marine Fisheries Service has determined that for blue whales with regards to critical habitat, more research is needed to rigorously and specifically define the environmental features that make an area biologically important to blue whales (National Marine Fisheries Service, 2018b). Blue whale subspecific taxonomy and population structure has not been fully resolved and is an area of active research (International Whaling Commission, 2019b; National Marine Fisheries Service, 2018b). The number of blue whales in the population that inhabits the TMAA is complicated by there being uncertainty regarding the number of populations of blue whale in the Pacific, one to possibly three populations (Carretta et al., 2020b; International Whaling Commission, 2019b; Monnahan et al., 2015; National Marine Fisheries Service, 2018b). NMFS currently has designated two stock management units in the North Pacific, one for waters around Hawaii (the Central North Pacific stock) and one for the "U.S. West Coast" (the Eastern North Pacific stock), but with a description for the range for both stocks that includes Alaska waters (Carretta et al., 2020b; National Marine Fisheries Service, 2018b); blue whales in Alaska waters are not addressed in the Alaska SAR (Muto et al., 2020).

3.8.2.4.2 Abundance

Since the 2016 GOA Final SEIS/OEIS, multiple lines of evidence suggest that blue whales in the Pacific may have recovered and been at a stable level based on surveys and scientific findings (Barlow, 2016; Campbell et al., 2015; Carretta et al., 2020b; Carretta et al., 2015; International Whaling Commission, 2016, 2019b; Monnahan, 2013; Monnahan & Branch, 2015; Monnahan et al., 2015; Monnahan et al., 2014; National Marine Fisheries Service, 2018b; Rockwood et al., 2017; Širović et al., 2015b; Valdivia et al., 2019). The new best overall estimate of abundance of blue whales along the U.S. West Coast (n=1,898; CV=0.08) has been provided by photo identification data gathered between 2015 and 2018 (Calambokidis & Barlow, 2020). This estimate is higher than the abundance (n=1,496) in the 2019 Pacific SAR (Carretta et al., 2020b) and suggests an increase in the abundance since the 1990s (Calambokidis & Barlow, 2020).

3.8.2.4.3 Distribution

There have been no changes to the known distribution of blue whales in the TMAA since the 2016 GOA Final SEIS/OEIS. There have not been a sufficient number of surveys in Alaska waters to support the type of habitat models that have been used to predict the species distribution elsewhere (Abrahms et al., 2019a; Becker et al., 2018; Becker et al., 2017; Carretta et al., 2020b; Forney et al., 2015; Redfern et al., 2017b). The Eastern North Pacific stock of blue whales range from the GOA to as far south as the waters off Costa Rica (Carretta et al., 2020b). Blue whales in the Central North Pacific Stock have been observed in the limited surveys of the U.S. EEZ around Hawaii (Carretta et al., 2020b; National Marine Fisheries Service, 2018b) and acoustically detected at Saipan and Tinian in the Mariana Islands (Oleson et al., 2015), but this reflects very limited survey coverage of the Central Pacific. There are no data suggesting or reason to believe that the two stocks do not overlap in their distribution when in Alaska waters.

Based on passive acoustic data, the Navy has determined the blue whale's occurrence in the TMAA is year round with the highest numbers present in June to December (Debich et al., 2013; Debich et al., 2014a; Rice et al., 2015; Rice et al., 2018b). This is consistent with the conservative approach to the analysis provided in the 2016 GOA Final SEIS/OEIS and the analysis in this document, in which Navy assumed the species would be present during the Proposed Action.

For additional information about blue whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.5 Fin Whale (*Balaenoptera physalus*)

3.8.2.5.1 Status and Management

There has been no change in the status or the management of fin whales since the 2016 GOA Final SEIS/OEIS. The fin whale is listed as depleted under the MMPA and endangered under the ESA throughout its range, but there is no designated critical habitat for this species in the Pacific (Carretta et al., 2020b; Muto et al., 2020; National Marine Fisheries Service, 2010).

3.8.2.5.2 Abundance

The National Marine Fisheries Service has determined there are no reliable estimates of current and historical abundances for the entire Northeast Pacific fin whale stock (Muto et al., 2020). In areas of the Pacific where research has occurred, various efforts and methodologies have indicated increases in the number of fin whales (Barlow, 2016; Širović et al., 2015b; Towers et al., 2018; Valdivia et al., 2019). These findings and the trend for an increase in population appear consistent with the highest-yet abundances of fin whales in the 2014 NMFS survey of the U.S. West Coast (Barlow, 2016).

3.8.2.5.3 Distribution

The Navy has determined the fin whale's occurrence in the TMAA would be likely year round with a potential for higher numbers between June and August. There have been no changes to the known distribution of fin whales in the TMAA since the 2016 GOA Final SEIS/OEIS, although there is evidence suggesting general connectivity among fin whales in the Pacific (Archer et al., 2019). Fin whales were found to feed in association with high density of zooplankton near the Kodiak Archipelago (Witteveen et al., 2014).

Passive acoustic monitoring between May and September in 2015 and 2017 detected only low numbers of fin whale vocalizations in the TMAA (Rice et al., 2018b; Wiggins & Hildebrand, 2018) or in the western GOA in the spring and fall (Archer et al., 2019). These acoustic data are not reflective of the survey data indicative of greater numbers (Rone et al., 2017), which was factored into the derivation of fin whale densities in the TMAA and consistent with the analysis provided in the 2016 GOA Final SEIS/OEIS and the analysis in this document.

For additional information about fin whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.6 Sei Whale (*Balaenoptera borealis*)

3.8.2.6.1 Status and Management

There has been no change in the status or the management of sei whales since the 2016 GOA Final SEIS/OEIS. The Eastern North Pacific stock includes animals found within the U.S. West Coast EEZ and in adjacent high seas waters (Carretta et al., 2020b). The sei whale is listed as endangered under the ESA and as depleted under the MMPA throughout its range (National Marine Fisheries Service, 2011). Analysis of samples from sei whales in the Pacific by Huijser et al. (2018) did not identify significant levels of genetic structure or find support for the current stock management designations in the Pacific; there have been arguments made for a single stock of sei whales in the Pacific (International Whaling Commission, 2019b).

3.8.2.6.2 Abundance

Since the 2016 GOA Final SEIS/OEIS, there has been an estimate published that provides an abundance for sei whales in the North Pacific (Hakamada et al., 2017). Line transect surveys were conducted between 2010 and 2012 in the Pacific from 40° north latitude northward to the Aleutian Islands and eastward into the GOA provided the data used in that abundance estimate (n=29,632; Coefficient of Variation=0.242) (Hakamada et al., 2017). Based on that estimate, a revised density for sei whales in the TMAA has been incorporated into the new analysis presented in this document. This is consistent with survey results indicating that sei whales have increased in number off the U.S. West Coast (Barlow, 2016) and in the Pacific (Valdivia et al., 2019).

3.8.2.6.3 Distribution

The Navy has determined the sei whale's occurrence in the TMAA would be year round but rare. There have been no changes to the known distribution of sei whales in the TMAA since the 2016 GOA Final SEIS/OEIS. As was noted in the 2016 GOA Final SEIS/OEIS, whaling records documented high densities of sei whales in the northwestern and northeastern portions of the GOA (i.e., near Portlock Bank). The only confirmed sightings of sei whales in the GOA (and outside the TMAA) in modern times were in 2011 to the west of Kodiak Island (Davis et al., 2011), and two sightings in 2015; a sei whale within the aggregation of fin and humpback whales at Albatross Bank off Kodiak Island and a second observed approximately 300 km south of Kodiak Island (Rone et al., 2017). Although recent surveys (2009, 2013, 2015) have not produced confirmed sei whale sightings in the TMAA and passive acoustic monitoring at fixed sites has not detected their vocalizations (Rice et al., 2020), sei whale calls were acoustically detected in the TMAA during the 2013 survey (Rone et al., 2014). Based on the above considerations, sei whale occurrence in the TMAA during the summer time period is considered rare.

For additional information about sei whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.7 Minke Whale (*Balaenoptera acutorostrata*)

3.8.2.7.1 Status and Management

There has been no change in the status or the management of minke whales since the 2016 GOA Final SEIS/OEIS. The minke whale is not listed under the ESA. The stock structure for minke whales remains uncertain in the Pacific, and minke whales in the TMAA are considered the Alaska stock in the current SAR (Muto et al., 2020).

3.8.2.7.2 Abundance

There are no data on population trends for minke whales in the GOA, given that so few minke whales have been seen during surveys in the area (Muto et al., 2020; Rone et al., 2017).

3.8.2.7.3 Distribution

The Navy has determined the minke whale's occurrence in the TMAA would be likely year round. There have been no changes to the known distribution of minke whales in the TMAA since the 2016 GOA Final SEIS/OEIS.

For additional information about minke whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.8 Gray Whale (*Eschrichtius robustus*)

3.8.2.8.1 Status and Management

There has been no change in the status or the management of gray whales since the 2016 GOA Final SEIS/OEIS. There are two North Pacific populations of gray whales present in the TMAA: the Western subpopulation and the Eastern subpopulation (Carretta et al., 2020b; Cooke, 2019a; Cooke, 2019b). The current stock structure for gray whales in the Pacific has been in the process of being re-examined for a number of years (see for example, Brüniche-Olsen et al. (2018)) and remains uncertain as of the most recent (2020) Pacific SAR (Carretta et al., 2020b); gray whales are not addressed in the Alaska SAR (Muto et al., 2020).

The Western North Pacific gray whale DPS is listed as endangered, and there has been no designated critical habitat for this species; the Eastern North Pacific DPS recovered from whaling exploitation, was delisted under the ESA in 1994, and is not considered depleted (Carretta et al., 2020b).

There are also a few hundred gray whales that feed along the Pacific coast as far north as Kodiak Island (Gosho et al., 2011) and as far south as Northern California throughout the summer and fall that are known as the Pacific Coast Feeding Group (Calambokidis et al., 2002; Calambokidis et al., 2017b; Carretta et al., 2017b; Mate et al., 2013; Weller et al., 2013). Photo-identification, telemetry, and genetic studies suggest that the Pacific Coast Feeding Group is demographically distinct from the Eastern North Pacific population (Calambokidis et al., 2017b; Calambokidis et al., 2010; Frasier et al., 2011; Lagerquist et al., 2018; Mate et al., 2010), but the Pacific Coast Feeding Group is not currently managed as a distinct stock in NMFS SARs (Carretta et al., 2020b).

3.8.2.8.2 Abundance

Recent analysis of the data available for 2005 through 2016 estimate the combined Sakhalin Island and Kamchatka populations that are part of the Western North Pacific stock are increasing in number (Bröker et al., 2020; Carretta et al., 2020b; Cooke, 2019a; Cooke, 2019b; Moore & Weller, 2018; Nakamura et al., 2017a; Nakamura et al., 2017b). Findings from Valdivia et al. (2019) indicate an average growth rate of 6.22 percent for the DPS overall. The combined Sakhalin Island and Kamchatka populations are estimated to be increasing from 2005 through 2016 at an average rate between 2 and 5 percent annually (Cooke, 2019a; Cooke, 2019b; Cooke et al., 2015). A recent increase in the occurrence of gray whales off Japan (Nakamura et al., 2017a), is also consistent with a positive population growth for Western North Pacific gray whales.

The eastern population has increased over several decades despite the 1999 and 2000 UMEs in which an unusually large number of gray whales stranded along the coast, from Mexico to Alaska (Gulland et al., 2005), when many scientists thought the population had reached “carrying capacity” (Carretta et al., 2018a; Carretta et al., 2017b; Durban et al., 2016). Starting in January of 2019, an elevated number of gray whale strandings occurred along the west coast of North America from Mexico through Alaska, which prompted NMFS to declare those strandings a UME (National Marine Fisheries Service, 2019a; National Oceanic and Atmospheric Administration, 2020b). As of February 2020, the strandings totaled 236 known individuals along their migratory corridor (National Oceanic and Atmospheric Administration, 2020b). Preliminary findings for several of the whales indicated signs of emaciation, although the findings were not consistent across the subset of the whales examined, and additional future research will be required to better identify factors resulting in the UME (National Oceanic and Atmospheric Administration, 2020b). Although the future trend for this population may be affected by the previously mentioned 2019 UME, as of August 4, 2020, there have been 32 strandings in Alaska, and 63 total on the U.S. West Coast (National Oceanic and Atmospheric Administration, 2020a).

3.8.2.8.3 Distribution

The Navy has determined the gray whale's occurrence in the TMAA would be seasonal with their highest likelihood of occurring being between June and August. There have been no changes to the known distribution of gray whales in the TMAA since the 2016 GOA Final SEIS/OEIS. Consistent with results from their expected distribution, gray whale call detections are most common on the continental shelf (Rice et al., 2015; Rice et al., 2018b; Wiggins et al., 2017). For additional information about important gray whale migration areas in the TMAA, see Section 5.4.1.3 (Gray Whales) of this SEIS/OEIS. Both the Western subpopulation and the Eastern subpopulation are expected to migrate through the Gulf of Alaska, for example, as of 2013 there were 23 known cases of Western North Pacific DPS gray whales being identified along the coasts of Canada and the U.S., including 14 as far south as off Mexico (Mate et al., 2015; Moore & Weller, 2018; Weller et al., 2013; Weller et al., 2012).

For additional information about gray whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.9 Sperm Whale (*Physeter macrocephalus*)

3.8.2.9.1 Status and Management

There has been no change in the status or the management of sperm whales since the 2016 GOA Final SEIS/OEIS. The sperm whale has been listed as endangered since 1970 under the precursor to the ESA (National Marine Fisheries Service, 2009), and is depleted under the MMPA throughout its range, but there is no designated critical habitat for this species in the North Pacific.

3.8.2.9.2 Abundance

Sperm whale population abundance and trends based on line-transect surveys conducted off the U.S. West Coast from 1991 to 2014 include a high level of uncertainty but indicate that sperm whale abundance has appeared stable (Carretta et al., 2020b; Moore & Barlow, 2017; Moore & Barlow, 2014).

3.8.2.9.3 Distribution

The Navy has determined the sperm whale's occurrence in the TMAA would be likely year round in waters greater than 1,000 m and most often in waters greater than 2,000 m. A study found that although they are present year round in the GOA, they are potentially present in greater numbers between June and September due to higher numbers of acoustic detections (Diogou et al., 2019). There have been no changes to the known distribution of sperm whales in the TMAA since the 2016 GOA Final SEIS/OEIS. Sperm whale are somewhat migratory, and passive acoustic monitoring at five sites in the TMAA recorded sperm whale clicks throughout each summer between May and September in 2015 and 2017 at all sites, but were most common at the shelf break and offshore (Rice et al., 2018b).

For additional information about sperm whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.10 Killer Whale (*Orcinus orca*)

3.8.2.10.1 Status and Management

There has been no change in the status or the management of killer whales since the 2016 GOA Final SEIS/OEIS. Killer whales likely present in the TMAA are not species listed under the ESA.

Four killer whale stocks are likely to be present in the TMAA. These stocks include (1) the Eastern North Pacific Alaska Resident stock; (2) the West Coast Transient stock; (3) the Eastern North Pacific GOA, Aleutian Islands, and Bering Sea Transient stock; and (4) the Eastern North Pacific Offshore stock (Carretta et al., 2020b; Muto et al., 2020). Preliminary genetic data for killer whales Alaska indicate that the current stock structure of killer whales in Alaska needs revision, but this revision is awaiting completion of a stock structure evaluation before any new stocks are identified (Muto et al., 2020).

3.8.2.10.2 Abundance

The Eastern North Pacific Alaska Resident stock of killer whales continues to increase in abundance by about 3 percent per year (GulfWatch Alaska, 2019; Matkin et al., 2018). No data are available on current population trends for the West Coast Transient stock or the Eastern North Pacific GOA, Aleutian Islands, and Bering Sea Transient stocks of killer whales (Carretta et al., 2020b; Muto et al., 2020). The National Marine Fisheries Service considers the population trajectory for Eastern North Pacific Offshore killer whales to be stable (Carretta et al., 2020b).

3.8.2.10.3 Distribution

The Navy has determined that the killer whale's occurrence in the TMAA would be likely year round. Based on data from Olsen et al. (2018), the Alaska Resident killer whales seasonally follow herring and salmon inshore during the summer runs of those species (Matkin et al., 2018). Transient killer whales have been sighted off of Alaska, British Columbia, and Washington State (Towers et al., 2012). As a clarification from the 2016 GOA Final SEIS/OEIS, all killer whale ecotypes may be present but the one offshore population and the two transient types are more likely in the majority of the TMAA given the Navy training area mostly consists of deep ocean far offshore.

For additional information about killer whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.11 Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*)

3.8.2.11.1 Status and Management

There has been no change in the status or the management of Pacific white-sided dolphins since the 2016 GOA Final SEIS/OEIS. This species is not listed under the ESA. The National Marine Fisheries Service recognizes a single stock for the U.S. West Coast—the California, Oregon, and Washington stock (Carretta et al., 2020b).

3.8.2.11.2 Abundance

No data are available on current population trends for Pacific white-sided dolphins present in the TMAA (Muto et al., 2020). As a clarification from the 2016 GOA Final SEIS/OEIS and as noted in the 2018 Alaska SAR, the population of Pacific white-sided dolphins in the North Pacific Ocean was last estimated (in 1993) to number approximately 931,000 dolphins, but the subset number of those dolphins in North Pacific stock as managed by NMFS has been given as 26,880 dolphins (Muto et al., 2020).

3.8.2.11.3 Distribution

The Navy has determined the Pacific white-sided dolphins' occurrence in the TMAA would be likely year round. There have been no changes to the known distribution of Pacific white-sided dolphins in the TMAA since the 2016 GOA Final SEIS/OEIS.

For additional information about Pacific white-sided dolphins occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.12 Harbor Porpoise (*Phocoena phocoena*)

3.8.2.12.1 Status and Management

There has been no change in the status or the management of harbor porpoise since the 2016 GOA Final SEIS/OEIS. This species is not listed under the ESA. The stocks of harbor porpoise present in Alaska waters near the TMAA are not considered depleted under the MMPA.

3.8.2.12.2 Abundance

No data are available regarding population trends for the stock of harbor porpoises in the area given the last comprehensive survey of their habitat in and adjacent to the GOA occurred in 1998 (Muto et al., 2020).

3.8.2.12.3 Distribution

The Navy has determined the harbor porpoise's occurrence in the TMAA would be likely year round in the nearshore locations to the shelf break. There have been no changes to the known distribution of harbor porpoise in the TMAA since the 2016 GOA Final SEIS/OEIS.

For additional information about harbor porpoise occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.13 Dall's Porpoise (*Phocoenoides dalli*)

3.8.2.13.1 Status and Management

There has been no change in the status or the management of Dall's porpoise since the 2016 GOA Final SEIS/OEIS. This species is not listed under the ESA (Muto et al., 2020).

3.8.2.13.2 Abundance

No data are available regarding population trends for the Alaska stock of Dall's porpoises, given the last comprehensive survey of their habitat in and adjacent to the GOA occurred in 1991 (Muto et al., 2020). Density estimates derived from line-transect survey data collected in and near the TMAA (Rone et al., 2017) were used in the analyses.

3.8.2.13.3 Distribution

The Navy has determined the Dall's porpoise's occurrence in the TMAA would be likely year round. There have been no changes to the known distribution of Dall's porpoise in the TMAA since the 2016 GOA Final SEIS/OEIS.

For additional information about Dall's porpoise occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.14 Cuvier's Beaked Whale (*Ziphius cavirostris*)

3.8.2.14.1 Status and Management

There has been no change in the status or the management of the Alaska stock of Cuvier's beaked whales since the 2016 GOA Final SEIS/OEIS (Muto et al., 2020).

3.8.2.14.2 Abundance

No data are available regarding population trends for the stock of Cuvier's beaked whales in the TMAA (Muto et al., 2020).

3.8.2.14.3 Distribution

The Navy has determined the Cuvier's beaked whale's occurrence in the TMAA would be likely year round. Passive acoustic monitoring at five sites in the TMAA occurred between May and September in 2015 and April and September in 2017 (Rice et al., 2018b). That monitoring detected Cuvier's beaked whales most commonly in spring at the monitoring site located in the approximate middle of the TMAA (Site "AB"), while no detections occurred in the summer time period between July and September (Rice et al., 2018b). Cuvier's beaked whales were detected only once in 2015 at seamounts site (Site "QN") and were never detected at the monitoring site located at the shelf break (Site "CB") (Rice et al., 2018b). Although there are no data from the GOA, acoustic sampling of bathymetrically featureless areas off Southern California detected many beaked whales over an abyssal plain, which counters a common misperception that beaked whales are primarily found over slope waters, in deep basins, or over seamounts (Griffiths & Barlow, 2016); this is consistent with the 2015 and 2017 acoustic monitoring (Rice et al., 2018b). Research involving tagged Cuvier's beaked whales In Southern California has documented movements in excess of hundreds of kilometers. Schorr et al. (2014) reported that five out of eight tagged whales journeyed approximately 250 km from their tag deployment location, and one of these five made an extra-regional excursion over 450 km to the south to Mexico and back (Falcone & Schorr, 2011, 2012, 2013, 2014; Falcone et al., 2009).

For additional information about Cuvier's beaked whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.15 Baird's Beaked Whale (*Berardius bairdii*)

3.8.2.15.1 Status and Management

There has been no change in the status or the management of Baird's beaked whale since the 2016 GOA Final SEIS/OEIS (Muto et al., 2020). The Alaska stock of Baird's beaked whales is not listed under the ESA (Muto et al., 2020).

3.8.2.15.2 Abundance

As was the case in for 2016 GOA Final SEIS/OEIS, there are no abundance or population trend data for the Alaska stock of Baird's beaked whale (Muto et al., 2020).

3.8.2.15.3 Distribution

The Navy has determined the Baird's beaked whale's occurrence in the TMAA would be likely year round. There have been no changes to the known distribution of Baird's beaked whales in the TMAA since the 2016 GOA Final SEIS/OEIS. Data from a satellite-tagged Baird's beaked whale off Southern California recently documented movement north along the shelf-edge for more than 400 NM over a six-and-a-half day period (Schorr et. al., Unpublished). If that one sample involving a 400 NM excursion is reflective of more general behavior, Baird's beaked whales present in the TMAA may have much larger home ranges than the waters bounded by the TMAA.

For additional information about Baird's beaked whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.16 Stejneger's Beaked Whale (*Mesoplodon stejnergi*)

3.8.2.16.1 Status and Management

There has been no change in the status or the management of Stejneger's beaked whales since the 2016 GOA Final SEIS/OEIS. Stejneger's beaked whale is not listed under the ESA, and the Alaska stock is not a depleted stock (Muto et al., 2020).

3.8.2.16.2 Abundance

There have been no new data regarding the number of Stejneger's beaked whales present in the TMAA since the 2016 GOA Final SEIS/OEIS. As was the case in for 2016 GOA Final SEIS/OEIS, reliable estimates of abundance for this stock are currently unavailable (Muto et al., 2020).

3.8.2.16.3 Distribution

The Navy has determined the Stejneger's beaked whale's occurrence in the TMAA would be likely year round. There have been no changes to the known distribution of Stejneger's beaked whales in the TMAA since the 2016 GOA Final SEIS/OEIS. Stejneger's beaked whale vocalizations have been detected by passive acoustic monitoring sites at the shelfbreak and offshore in the TMAA (Rice et al., 2018b).

For additional information about Stejneger's beaked whale occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.17 Steller sea lion (*Eumetopias jubatus*)

3.8.2.17.1 Status and Management

There has been no change in the status or the management of Steller sea lion stocks since the 2016 GOA Final SEIS/OEIS. The National Marine Fisheries Service has designated two Steller sea lion stocks in the North Pacific corresponding to two DPSs with the same names (Muto et al., 2020); both populations are potentially present within the TMAA. The Western U.S. stock (or DPS) consists of sea lions occurring west of 144°W longitude, and the Eastern U.S. stock (or DPS) is defined as the population occurring east of 144°W longitude (Muto et al., 2020). The Western U.S. stock is listed as depleted under the MMPA and endangered under the ESA. Critical habitat for the Western DPS was designated by NMFS in 1993 (58 FR 45269) and includes a 20 NM buffer around all major haulouts and rookeries, as well as associated terrestrial, air, and aquatic zones, and three large offshore foraging areas that are all in Alaska waters. As described in Section 5.4.1.4 (Steller Sea Lions) and Section 5.4 (Geographic Mitigation to be Implemented), the TMAA boundaries will continue to be located outside of the Steller sea lion critical habitat designated by NMFS in 1993 (58 FR 45269).

The Eastern U.S. stock (or DPS) of Steller sea lions is currently listed as depleted under the MMPA and in recognition of their recovery, Steller sea lions in the Eastern U.S. stock were removed from the List of Endangered and Threatened Wildlife in October 2013 (Muto et al., 2020; National Marine Fisheries Service, 2016f).

3.8.2.17.2 Abundance

Using data collected from 1978 through 2017, there are strong evidence for positive trends in pup and non-pup counts of western stock Steller sea lions in the GOA (Fritz et al., 2015; Muto et al., 2020; Sweeney et al., 2018). In the central and eastern GOA, pup counts declined sharply between 2015 and 2017, which may have been due to changes in availability of prey associated with warm ocean temperatures that occurred in the northern GOA from 2014 to 2016. No new data were collected for the GOA region in the 2018 survey, but the 2019 survey focused on the GOA and should contain more precise and accurate estimates of counts and trends for this species in the GOA (Muto et al., 2020).

3.8.2.17.3 Distribution

Steller sea lions from the Western DPS are likely to occur year round in the inshore portion of the TMAA. Unpublished data from the Alaska Department of Fish and Game show tagged female Steller sea lions repeatedly traveling from haulout sites to the shelf break (approximated as the 500 m isobath) to forage but not venturing off the shelf. Very little data exist on the offshore movements of male Steller sea lions.

Steller sea lions within the Western DPS are divided into three sub-groups: the Western Gulf of Alaska, Central Gulf of Alaska, and Eastern Gulf of Alaska (Sweeney et al., 2017). Of these three groups, only Steller sea lions from the Eastern Gulf of Alaska and Central Gulf of Alaska are expected to occur within the TMAA, based on proximity of haulout and breeding sites located along the coastline.

While the distribution of sea lions from the two DPSs overlap outside of the breeding season, only a few individuals from the Eastern DPS are expected to occur west of 144° W longitude for a portion of the non-breeding season (Fritz et al., 2016; Jemison et al., 2018). Steller sea lions from the Eastern DPS are expected to remain primarily over the continental shelf, consistent with tagging data, and are not expected to occur in the deeper waters far offshore in the portion of the TMAA east of 144° W longitude (Bishop et al., 2018; Jemison et al., 2018). Reports published since the 2016 GOA Final SEIS/OEIS have provided additional evidence of mixing of the stocks and suggest that it may be inappropriate to treat the eastern and central GOA as “closed” populations (Jemison et al., 2018). During the breeding season, sea lions, especially adult females, typically return to their natal rookery or a nearby breeding rookery to breed and pup (Hastings et al., 2017). The pooled-juvenile home range of Steller sea lions tagged between 2000 and 2014 in Prince William Sound extended from Kayak Island in the east to Kodiak Island in the west, and was generally coastal, with some evidence of excursions offshore onto the shelf, or to adjacent coastal and shelf regions, as well as movement between the two DPSs (Bishop et al., 2018; Jemison et al., 2018; Kuhn et al., 2017).

For additional information about Steller sea lion occurrence and distribution as well as important areas in the TMAA, see Section 5.4.1.4 (Steller Sea Lions) of this SEIS/OEIS and the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.18 California Sea Lion (*Zalophus californianus*)

3.8.2.18.1 Status and Management

There has been no change in the status or the management of California sea lion since the 2016 GOA Final SEIS/OEIS. The California sea lion is not listed under the ESA. The California sea lion is managed by NMFS as the U.S. stock in all areas where they occur along the U.S. West Coast and in Alaska (Carretta et al., 2020b).

3.8.2.18.2 Abundance

The current population estimate of California sea lions in the U.S. stock is 257,606 (Carretta et al., 2020b). The total population in U.S. waters cannot be directly counted because all age and sex classes are not on shore at the same time during field surveys (i.e., a segment of the population is always in the water). In lieu of counting all sea lions, pups are counted during the breeding season, because this is the only age class that is ashore in its entirety. The size of the U.S. stock is then estimated from the number of births and the proportion of pups observed at the surveyed rookeries (Carretta et al., 2020b; Laake et al., 2018). The abundance of California sea lions in the TMAA is not likely to have changed since the 2016 GOA Final SEIS/OEIS; however, warmer water temperatures and changes in the ocean environment may be factors that have favored California sea lions over Steller sea lions in the southern part of the Steller sea lion range in Alaska (Muto et al., 2020). California sea lions are often observed hauled out with Steller sea lions, including on Middleton Island. Counts in the hundreds of California sea lions have been reported at Dry Bay, Alaska, located north of Glacier Bay National Park on the eastern shore of the Gulf of Alaska (based on unpublished data collected by the Alaska Department of Fish and Game).

3.8.2.18.3 Distribution

The Navy has determined the California sea lion's occurrence in the TMAA would be seasonal with their highest likelihood of occurring being between April and May. There have been no changes to the known distribution of California sea lions since the 2016 GOA Final SEIS/OEIS. The California sea lion occurs in the eastern North Pacific from Puerto Vallarta, Mexico, through the Gulf of California and north along the west coast of North America to the GOA (Barlow et al., 2008; DeLong et al., 2017; Jefferson et al., 2008; Maniscalco et al., 2004). Typically, during the summer, California sea lions congregate near rookery islands and specific open-water areas. The primary rookeries off the coast of the United States are on San Nicolas, San Miguel, Santa Barbara, and San Clemente Islands (Carretta et al., 2000; Le Boeuf & Bonnell, 1980; Lowry et al., 1992; Lowry & Forney, 2005; Lowry et al., 2017).

This species is prone to invade human-modified coastal sites that provide good haulout substrate, such as marinas, buoys, bait barges, and rip-rap tidal control structures. During the nonbreeding season, they occur most often over the slope or offshore; during the breeding season, they occur most often over the continental shelf (Melin & DeLong, 2000; Melin et al., 2008). Lowry and Forney (2005) estimated that 47 percent of sea lions would potentially be at sea during the cold seasons. Dive durations range from 1.4 to 5.0 minutes, with longer dives during El Niño events; surface intervals range from 0.7 to 17.0 minutes, with sea lions diving about 32–47 percent of the time at sea (Feldkamp et al., 1989; Kuhn & Costa, 2014; Melin et al., 2008; Melin et al., 2012). Adult females alternate between nursing their pup on shore and foraging at sea, spending approximately 67–77 percent of time at sea (Kuhn & Costa, 2014; Melin & DeLong, 2000). Data from satellite tags and time-depth recorders on 15 California sea lions indicated different foraging strategies, with some individuals spending energy at almost twice the rate of other individuals (McHuron et al., 2017). California sea lions would begin migrating out of the Gulf of Alaska to summer breeding sites in California by May, and their occurrence in the Gulf of Alaska is only likely in May or conservatively June. The offshore waters of the Gulf of Alaska are not considered part of the typical habitat for California sea lions, and their occurrence in the TMAA should be considered rare.

For additional information about California sea lion occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.19 Northern Fur Seal (*Callorhinus ursinus*)

3.8.2.19.1 Status and Management

There has been no change in the status or the management of northern fur seals since the 2016 GOA Final SEIS/OEIS. Two stocks of northern fur seals are recognized in U.S. waters: an Eastern Pacific stock that breeds in southern Bering Sea and a California stock that breeds in the Farallon Islands and on San Miguel Island (Carretta et al., 2020b; Muto et al., 2020). The Eastern Pacific stock occurs year round in the TMAA, and pups from the California stock may also occur in the Gulf of Alaska year round. Northern fur seals are considered depleted under the MMPA but are not listed under the ESA (Carretta et al., 2020b).

3.8.2.19.2 Abundance

The abundance of the northern fur seal in the TMAA has not changed substantially since the 2016 GOA Final SEIS/OEIS. The abundance of the Eastern Pacific stock is currently estimated to be 620,660 animals (Muto et al., 2017; Muto et al., 2018b; Muto et al., 2020), and the abundance of the California Stock is estimate to be 14,050 (Carretta et al., 2020b); however, only a small portion of the California (mainly pups) would be expected to occur in the Gulf of Alaska. Nevertheless, the vast majority of fur seals in the Gulf of Alaska would be from the Eastern Pacific stock.

3.8.2.19.3 Distribution

Northern fur seals' occurrence in the TMAA would be seasonal with their highest likelihood of occurring being between December and July; however, yearlings are potentially present year round, with adults either migrating to or at breeding sites in the Pribilof Islands and Aleutian Islands between June and October (males) or August and November (females). There have been no changes to the known distribution of northern fur seals since the 2016 GOA Final SEIS/OEIS. Northern fur seals range throughout the North Pacific along the west coast of North America, from California (32° N) to the Bering Sea, and west to the Sea of Okhotsk and Honshu Island, Japan (36° N) (Baird & Hanson, 1997; Carretta et al., 2010; Gelatt & Gentry, 2018; Gentry, 2009; Jefferson et al., 2008; Kuhn et al., 2020; Lee et al., 2018; Orr et al., 2018; Ream et al., 2005; Zeppelin et al., 2019). Olesiuk (2012) characterized northern fur seals as ubiquitous in the North Pacific between 60° N and 40° N latitude, with their distribution at sea driven by prey concentrations associated with oceanographic features such as the boundary of the sub-arctic–sub-tropical transition zone near 42° N latitude (Polovina et al., 2001).

In general, the northern fur seals present in the TMAA are those that annually migrate from breeding sites in the Pribilof Islands and Aleutian Islands into the North Pacific each fall, returning in the late spring to give birth (Gelatt & Gentry, 2018). There are no rookeries or breeding sites for the species in or around the TMAA. Migrating fur seals and those along the U.S. West Coast are typically found beyond the continental shelf break and over the slope (Adams et al., 2014; Gentry, 2009; Kenyon & Wilke, 1953; Sterling & Ream, 2004), although two fur seals were tracked over 2,000 km offshore into the central North Pacific Ocean (Ream et al., 2005). Their offshore distribution has been correlated with oceanographic features (e.g., eddies and fronts) where prey may be concentrated (Ream et al., 2005; Sterling et al., 2014). Northern fur seals are found throughout their Pacific offshore range throughout the year, although seasonal fluctuations in distribution occur. Females and pups spend time ashore in the Pribilof Islands and Aleutian Islands of Alaska, then move south to the waters offshore of Oregon and California, while adult males generally move only as far south as the GOA and therefore would be more likely to be present than females or pups in the TMAA (Muto et al., 2020).

Most northern fur seals migrate along continental margins from low-latitude winter foraging areas to northern breeding islands (Gentry, 2009; Lee et al., 2018; Ragen et al., 1995). They leave the breeding islands in November and concentrate around the continental margins of the North Pacific in January and February, where they have access to vast, predictable food supplies and where the Eastern Pacific and the California stocks overlap (Gentry, 2009; Lee et al., 2018; Loughlin et al., 1994; Newsome et al., 2007; Ream et al., 2005). Juveniles have been known to conduct trips between 8 and 29 days in duration, ranging from 171 to 680 km (Sterling & Ream, 2004). Adult female fur seals equipped with radio transmitters have been recorded conducting roundtrip foraging trips of up to 740 km (National Marine Fisheries Service, 2007b; Robson et al., 2004).

For additional information about northern fur seal occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.20 Northern Elephant Seal (*Mirounga angustirostris*)

3.8.2.20.1 Status and Management

There has been no change in the status or the management of northern elephant seal since the 2016 GOA Final SEIS/OEIS. The northern elephant seal is not listed under the ESA. The northern elephant seal population has recovered dramatically after being reduced to perhaps no more than 10–100 animals surviving in Mexico in the 1890s (Carretta et al., 2010; Hoelzel, 1999; Stewart et al., 1994). Movement and some genetic interchange occur between rookeries, but most elephant seals return to the rookeries where they were born to breed and thus may have limited genetic differentiation (Carretta et al., 2020b). There are two distinct populations of northern elephant seals: one that breeds in Baja, Mexico; and a population that breeds in California (Garcia-Aguilar et al., 2018). The National Marine Fisheries Service considers northern elephant seals in the TMAA to be from the California Breeding Stock. Although elephant seals from Baja California, Mexico, may migrate north as far as the TMAA, females breeding in Mexico are known to forage approximately 8° farther south than females from the California Breeding stock (Aurioles et al., 2006; Carretta et al., 2020b).

3.8.2.20.2 Abundance

Lowry et al. (2014) reported that 40,684 pups were born on U.S. rookeries in 2010. Based on the pup count, the population estimate in the California Breeding stock is approximately 179,000 elephant seals (Carretta et al., 2020b).

3.8.2.20.3 Distribution

Northern elephant seals occurrence in the TMAA would be seasonal with their highest likelihood of occurrence between March and September. Little to no occurrence is expected in January, February, and November. There have been no changes to the known distribution of northern elephant seals since the 2016 GOA Final SEIS/OEIS. Northern elephant seals are found in both coastal and deep waters of the eastern and central North Pacific. Northern elephant seals spend nearly 90 percent of their time at sea underwater, making long migrations to offshore foraging areas and feeding intensively to build up the blubber stores required to support them during breeding and molting seasons when they are hauled out (Hindell & Perrin, 2009; Le Boeuf & Laws, 1994; Worthy et al., 1992). Breeding and pupping take place on offshore islands and mainland rookeries in California (Carretta et al., 2010; Le Boeuf & Laws, 1994; Lowry et al., 2014; Lowry et al., 2017). Small colonies of northern elephant seals breed and haul out on Santa Barbara Island and San Clemente Island, while large colonies are found on Año Nuevo, San Nicolas, Santa, Rosa, and San Miguel islands. Elephant seals use these islands as rookeries from late

December to February, and to molt from April to July. Northern elephant seals spend little time nearshore and migrate through offshore waters four times a year as they travel to and from breeding and molting sites on islands and mainland sites along the Mexico and California coasts.

With most of their prey found in open oceans, northern elephant seal juveniles and females are often found in deepwater, while males tend to forage on the seafloor closer to shore and travel as far north as seamounts in the GOA (Le Boeuf et al., 2000; Le Boeuf et al., 1996; Robinson et al., 2012; Simmons et al., 2010; Simmons et al., 2007; Stewart & DeLong, 1995). The foraging range and distribution of northern elephant seals extends thousands of kilometers offshore into the central North Pacific Transition Zone Chlorophyll Front (Robinson et al., 2012); however, their range is not continuous across the North Pacific (Robinson et al., 2012; Simmons et al., 2010; Stewart & Huber, 1993). Adult males and females segregate while foraging and migrating (Simmons et al., 2010; Stewart, 1997; Stewart & DeLong, 1995). Adult females mostly range west to about 173° W, between the latitudes of 40° N and 45° N, whereas adult males range farther north into the GOA and along the Aleutian Islands to between 47° N and 58° N (Le Boeuf et al., 2000; Robinson et al., 2012; Stewart & DeLong, 1995; Stewart et al., 1993). Robinson et al. (2012) tracked 297 adult female northern elephant seals during post-breeding and post-molting migrations from a central California and a Baja California, Mexico, rookery to foraging areas in the eastern North Pacific. The data showed that female elephant seal foraging areas strongly correlated with the location of the stable boundary separating the sub-arctic and sub-tropical gyres. The boundary fluctuates seasonally but remains between 40° and 50° N latitude and is typically at or slightly north of 45° N latitude, well south of the Gulf of Alaska.

Adults mainly stay offshore during migration, while juveniles are often seen along the coasts of Oregon, Washington, and British Columbia (Le Boeuf et al., 1996; Stewart & Huber, 1993). The most far-ranging individual appeared on Nijima Island off the Pacific coast of Japan in 1989 (Kiyota et al., 1992). This demonstrates the great distances that these animals are capable of covering.

For additional information about northern elephant seal occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.21 Harbor Seal (*Phoca vitulina*)

3.8.2.21.1 Status and Management

There has been no change in the status or the management of harbor seals since the 2016 GOA Final SEIS/OEIS. The harbor seal is not listed under the ESA. The Society of Marine Mammalogy's Committee on Taxonomy (2016) has determined that all harbor seals in the North Pacific should be recognized as a single subspecies (*Phoca vitulina richardii*) until the subspecies limits of various populations are better known. There are 17 stocks of harbor seal along the U.S. West Coast, including in Alaska, four of which have the greatest likelihood of occurring in the TMAA: the North Kodiak, South Kodiak, Prince William Sound, and Cook Inlet/Shelikof Strait stocks (Carretta et al., 2020b; Muto et al., 2020). While it is possible that harbor seals may travel farther offshore into the deeper waters of the central TMAA, the vast majority of harbor seals would remain closer to shore, over the continental shelf out to the shelf break, which is estimated as the 500 m isobath.

3.8.2.21.2 Abundance

The current statewide abundance estimate for Alaska harbor seals is 243,938 (Muto et al., 2020). Abundance estimates for the four stocks considered in this SEIS/OEIS are shown in Table 3.8-1. The eight-year population trend estimates for the Prince William Sound and Cook Inlet/Shelikof Strait stocks have been decreasing while the North Kodiak and South Kodiak stocks have been increasing (Muto et al., 2020).

3.8.2.21.3 Distribution

Harbor seal occurrence in the TMAA would be rare year round, except for the nearshore portions of the TMAA that overlap with the continental shelf. Since the 2016 GOA Final SEIS/OEIS, abundance estimates have been updated and harbor seal distribution is expected to occur out to the shelf break. The harbor seal is one of the most widely distributed seals, found in nearly all temperate coastal waters of the northern hemisphere (Jefferson et al., 2008). Harbor seals are generally not present in the deep waters of the open ocean, which includes the majority of the TMAA. Harbor seals prefer coastal habitat, rarely found more than 20 km from shore, and spend much of their time hauled-out along rocky shorelines, and frequently occupying bays, estuaries, and inlets (Baird, 2001; Harvey & Goley, 2011; Huber et al., 2001; Jefferson et al., 2014). Individual seals have been observed several kilometers upstream in coastal rivers (Baird, 2001). Harbor seals are not considered migratory (Burns, 2009; Harvey & Goley, 2011; Jefferson et al., 2008), and data from 180 radio-tagged harbor seals in California indicated most remained within 10 km of the location where they were captured and tagged (Harvey & Goley, 2011). Ideal harbor seal habitat includes suitable haulout sites, shelter from high surf during the breeding periods, and sufficient food near haulout sites to sustain the population throughout the year (Bjorge, 2002). Haulout sites vary but include intertidal and subtidal rock outcrops, sandbars, sandy beaches, estuaries, and even peat banks in salt marshes (Burns, 2009; Gilbert & Guldager, 1998; Prescott, 1982; Schneider & Payne, 1983; Wilson, 1978).

For additional information about harbor seal occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.22 Ribbon Seal (*Histriophoca fasciata*)

3.8.2.22.1 Status and Management

There has been no change in the status or the management of ribbon seals since the 2016 GOA Final SEIS/OEIS. The Alaska stock of ribbon seals is not considered a strategic stock (Muto et al., 2020). Ribbon seals are not listed under the ESA.

3.8.2.22.2 Abundance

A reliable population estimate for the entire stock is not available; however, based on limited survey data, the abundance estimate of 184,697 is a reasonable estimate for the entire U.S. population, because relatively few ribbon seals are expected north of the Bering Strait (Muto et al., 2020).

3.8.2.22.3 Distribution

Ribbon seal occurrence in the TMAA would be rare year round; however, the highest likelihood of occurrence would be July to September. There is no known range for ribbon seals in Alaska (Muto et al., 2018a); however, ribbon seals inhabit the North Pacific and adjacent parts of the Arctic Ocean. In Alaska waters, ribbon seals occur in the western Beaufort sea, Chukchi sea, Bering Sea, and the North Pacific (Muto et al., 2018a). They are rarely found on shorefast ice or land and are more frequently seen on sea ice and are abundant in the northern part of the ice front in the central and western parts of the Bering Sea. When the ice recedes, they are known to move farther north in the Bering Sea, hauling out on receding ice edges and remnant ice from May through mid-July (Muto et al., 2018a). In 2009, a tagged ribbon seal traveled from the northern Bering Sea into the Gulf of Alaska, indicating that their summer distribution includes the Gulf of Alaska; however, the number of ribbon seals that could occur in the Gulf of Alaska and the TMAA is unknown.

For additional information about ribbon seal occurrence and distribution in the TMAA, refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* (U.S. Department of the Navy, 2020b).

3.8.2.23 Northern Sea Otter (*Enhydra lutris neris*)

3.8.2.23.1 Status and Management

There has been no change in the status or the management of sea otters since the 2016 GOA Final SEIS/OEIS. Unlike all other marine mammals in the TMAA, the Northern sea otter is a species under the federal jurisdiction of USFWS within the Department of the Interior. The range and habitat of sea otters in Alaska as provided in the literature (limited to waters less than 100 m in depth) is well inland of the TMAA boundaries (Coletti et al., 2011; Garlich-Miller et al., 2018; Muto et al., 2020; Tinker et al., 2019; U.S. Fish and Wildlife Service, 2009, 2013; Wolt et al., 2012). The Southwest Alaska Northern sea otter stock is listed as threatened under the ESA (70 FR 46366–46386) and, by definition, is considered a depleted stock under the MMPA (Carretta et al., 2017b). The recovery plan for the Southwest Alaska DPS sea otters includes five management units: (1) Western Aleutian Islands; (2) Eastern Aleutian Islands; (3) South Alaska Peninsula; (4) Bristol Bay; and (5) Kodiak, Kamishak, Alaska Peninsula (Lance et al., 2015; U.S. Fish and Wildlife Service, 2013). Critical habitat has been designated for the Southwest Alaska population of northern sea otters, and it encompasses approximately 15,000 square kilometers of nearshore habitat, none of which is within or near the TMAA. The Southcentral Alaska stock and the Southeast Alaska are also found along the Gulf of Alaska coast, but those populations are not ESA-listed. All sea otter stocks in Alaska are protected under the MMPA, although that same law also allows for sea otters to be hunted and harvested by Alaska Natives for subsistence use. For example, USFWS records for 2013 (not counting fall) indicated Alaska Natives had reported a harvest of 1,380 sea otters for that year (Lichtenstein, 2013).

3.8.2.23.2 Abundance

The abundance estimates for sea otter stocks in Alaska, as presented in the 2019 Stock Assessment Report, are based on disparate surveys covering parts of each stock’s range in separate years; the reported Southeast Alaska stock surveys occurred between 2000 and 2008, the Southcentral Alaska stock surveys occurred between 2000-2010, and the Southwest Alaska stock between 2000 and 2014 (Lance et al., 2015; Muto et al., 2020). The threatened Southwest Alaska stock are stable and may be increasing in number (Muto et al., 2020). The Southcentral Alaska stock and Southeast Alaska stock also appear to be increasing in overall abundance (Muto et al., 2020).

3.8.2.23.3 Distribution

There have been no changes to the known distribution of sea otters since the 2016 GOA Final SEIS/OEIS. The Southeast Alaska stock extends from Dixon Entrance to Cape Yakataga; the Southcentral Alaska stock extends from Cape Yakataga to Cook Inlet including Prince William Sound, the Kenai Peninsula coast, and Kachemak Bay; and the Southwest Alaska stock includes Kodiak Island, Barren Island, the Alaska Peninsula and Bristol Bay coasts, the Pribilof Islands, and the Aleutian Islands.

Sea otters forage in shallow water, nearshore coastal habitats and are most commonly found in less than 40 m (131 feet [ft.]) of water or within 400 m of the shore (Bodkin, 2015; Bodkin et al., 2004; Coletti et al., 2011; Coletti et al., 2016; Fisheries and Oceans Canada, 2015; Garlich-Miller et al., 2018;

Schneider, 1977; Tinker et al., 2019). In general, sea otters are constrained by their ability to forage at depth deeper than 100 m (Bodkin, 2015; Bodkin et al., 2004; Coletti et al., 2011; Thometz et al., 2014; Tinker et al., 2019). Bodkin (2015) notes that sea otters can be found many kilometers from shore in locations where there are shoals far from land, however, there are no known offshore populations near the TMAA. It is possible that vagrant individuals from the Southcentral Alaska stock or the Southeast Alaska stock of sea otters could potentially occur in the nearshore margins of the TMAA. U.S. Fish and Wildlife Service (2011a) previously determined that the incidence of sea otters occurring offshore was rare and therefore discountable.

3.8.3 Environmental Consequences

The Proposed Action, presented as Alternative 1 in this supplemental analysis, consists of activities that have been occurring in the TMAA, that have all been analyzed in the past with regard to potential impacts on marine mammals. These prior analyses include the 2011 GOA EIS/OEIS (U.S. Department of the Navy, 2011d), 2011 Record of Decision (U.S. Department of the Navy, 2011d), the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a), the 2017 Record of Decision (U.S. Department of the Navy, 2017e), regulations pursuant to the MMPA (see 82 FR 19530 dated Thursday April 27, 2017), and Navy activities analyzed pursuant to the ESA in the current NMFS Biological Opinion (National Marine Fisheries Service, 2017b). The National Marine Fisheries Service concluded in its Record of Decision and Final Rule (82 FR 19530) that the Navy's training activities would have a negligible impact on the marine mammal species and stocks present in the TMAA. In its Final Biological Opinion under the ESA, NMFS concluded that the Navy's training activities were not likely to jeopardize the continued existence of any ESA-listed marine mammal species and would not adversely modify any critical habitat. Additionally, the USFWS concurred in 2011 that the Navy's training activities were not likely to adversely affect the threatened Southwest Alaska stock of Northern sea otters under the ESA (U.S. Fish and Wildlife Service, 2011b).

As presented in Section 1.3 (Proposed Action), Alternative 1 (the Proposed Action) for this SEIS/OEIS remains consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS GOA Final (U.S. Department of the Navy, 2016a), the 2017 Record of Decision (U.S. Department of the Navy, 2017e), or the activities analyzed previously by NMFS (82 FR 19530; National Marine Fisheries Service (2017b)). This SEIS/OEIS analyzes the impacts on marine mammals under two alternatives, the No Action Alternative and Alternative 1.

This section presents changes since the 2016 GOA Final SEIS/OEIS and evaluates how and to what degree the activities described in Proposed Action could impact marine mammals in the TMAA (see Section 3.0.3, Resources and Issues Considered for Re-Evaluation in this Document, to set framework for why the Alternative 1 required reanalysis). The stressors analyzed for impacts on marine mammals in the TMAA in the 2011 GOA Final EIS/OEIS (see Section 3.8.7, Environmental Consequences, in the 2011 GOA Final EIS/OEIS) included the following:

- Vessel movements
- Aircraft overflights
- Non-explosive practice ordnance
- High explosive ordnance (at-sea explosions)
- Active sonar
- Expended materials ((ordnance-related materials, targets, flares, chaff, sonobuoys, and marine dye markers)

The stressors analyzed for impacts on marine mammals in the TMAA in the 2016 GOA Final SEIS/OEIS (see Section 3.8.3, Environmental Consequences, in the 2016 GOA Final SEIS/OEIS) included the following:

- sonar and other active acoustic sources
- explosives

The Navy has reduced the number and types of explosives used in the TMAA because unlike the analyses in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, future proposed training in the TMAA does not include a SINKEX event and its associated munitions. As a result of there being no SINKEX in the current Proposed Action, there are no explosives detonated underwater. The Proposed Action retains activities involving the use of explosives detonating at or near the surface,[4] which have been conservatively modeled as occurring underwater for purposes of estimating potential effects to marine mammals (see U.S. Department of the Navy (2018d)).

The assessment of which stressors are likely to have potential impact on marine mammals presented in the following sections in this SEIS/OEIS have been based on five main categories of information: (1) multiple previous analyses undertaken and conclusions reached by the Navy since 2001 for the same type of training and testing activities as are presented in the Proposed Action, (2) the best available science (see "References" at the end of this section), (3) analysis of strike stressor probabilities for in-water devices and MEM used in the TMAA, (4) regulations and authorizations pursuant to the MMPA reached by NMFS for all other Navy areas analyzed in the Pacific and Atlantic, and (5) Biological Opinions from NMFS and findings from USFWS analyzing the effects of the Navy's activities on ESA-listed marine mammals for all other Navy areas analyzed in the Pacific and Atlantic. Based on that assessment, each of the potential stressors was evaluated to determine if that stressor should be carried forward for additional analysis of possible impacts on marine mammals resulting from Navy's training activities in the TMAA.

Since 1995, the U.S. Navy has reported all known or suspected vessel collisions with whales to NMFS, and there have been no known collisions between Navy vessels and whales in the TMAA associated with any of the activities from the Proposed Action. The Navy has several standard operating procedures and mitigation measures for vessel safety that benefit marine mammals through a reduction in the potential for vessel strike, as discussed in Section 2.3.2 (Standard Operating Procedures) and Chapter 5 (Mitigation). Based on the absence of any Navy vessel strikes associated with the Proposed Action in the TMAA and the general reduction in strike incidents Navy-wide since introduction of the Marine Species Awareness Training in 2006, the Navy does not anticipate the occurrence of future vessel strikes to marine mammals within the TMAA during the Proposed Action. For these reasons, the Navy is not requesting authorization of a take by vessel strike during the Proposed Action in the TMAA.

Most in-water devices, such as unmanned underwater vehicles and towed devices, will move slowly through the water and are highly unlikely to strike marine mammals because the mammal could easily avoid the device. In-water devices towed by manned platforms are unlikely to strike a marine mammal

[4] Throughout this document and in the context of the detonation of explosives, the words "…near the surface…" refer to a detonation occurring in air within 10 m of the ocean surface. These detonations are modeled as if the detonation occurs underwater with all peak pressure and acoustic energy contained with the water and not released at the surface. Unlike the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, there are no training events involving underwater explosions in the current Proposed Action.

because of the observers on the towing platform and other standard safety measures employed when towing in-water devices. In-water devices that could pose a higher risk to marine mammals are those operated at high speeds and unmanned, but there have been no previous occurrences of a strike by a high speed unmanned in-water device over thousands of deployments across the Navy. As part of military expended materials, small-caliber munitions are inert, are meant to be aimed at targets, and are not long-range weapons. As a result, marine mammals are extremely unlikely to be disturbed or struck by expended small-caliber munitions. There have been no known instances of a seafloor device (such as an anchor) striking a marine mammal as it was being deployed or recovered.

In short, there have been no known instances of physical disturbance or strike to any marine mammals as a result of proposed activities prior to or since the 2016 GOA Final SEIS/OEIS. The Navy will continue to implement mitigation measures for applicable vessel movements, towed in-water devices, and military expended materials during non-explosive activities. The mitigation measures will further avoid or reduce the already low potential for impacts on marine mammals during activities involving physical disturbance or strike stressors. Therefore, the Navy did not carry physical disturbance or strike forward for further stressor re-analysis. The Navy determined (U.S. Department of the Navy, 2016a, 2017e) and NMFS agreed (82 FR 19530; 82 FR 24679; National Marine Fisheries Service (2017b)) that for Navy activities in the TMAA, only acoustics and explosives could potentially result in the incidental taking of marine mammals. An explanation of why the other stressors (such as non-explosive ordnance use [ingestion, and strikes], electronic combat [electromagnetic energy stressors], and discharges of expended materials [physical disturbance, strikes, entanglement, ingestion, sediments and water quality]) listed above are unlikely to result in the incidental taking of marine mammals is provided in the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a) and the NMFS final rule for authorizing those activities under the MMPA (82 FR 19530, Thursday, April 27, 2017). There has been no emergent science since those prior determinations that would change or otherwise call into question those findings, as has been recently reaffirmed by NMFS for other Navy actions (see National Marine Fisheries Service (2020b); 85 FR 46302, Friday, July 31, 2020; and 85 FR 72312, Thursday, 12 November 2020). For these reasons, the stressors analyzed for impacts on marine mammals in the TMAA in this SEIS/OEIS include the following:

- Acoustic (sonar and other transducers, vessel noise, aircraft noise, weapon noise).
- Explosives (at or near the surface).

The majority of the changes in the results of the impact analyses presented in this SEIS/OEIS pursuant to requirements of the MMPA and ESA arise from changes in the model input; specifically, more accurate marine mammal density data, revised acoustic impact criteria, and revised computer modeling of predicted effects on marine mammals. These improvements are described in Section 3.0.1.2 (Navy's Quantitative Analysis to Determine Impacts to Sea Turtles and Marine Mammals). Assessment of likely long-term consequences to populations of marine mammals are provided by empirical data gathered from areas where the Navy routinely trains and tests. Substantial Navy-funded marine mammal survey data, monitoring data, and scientific research have been completed since 2006. These empirical data are beginning to provide insight on the qualitative analysis of the actual (as opposed to model-predicted numerical) impact on marine mammals resulting from Navy training and testing activities based on observations of marine mammals generally in and around Navy Range Complexes.

The following subsections of this SEIS/OEIS (Section 3.8.3.1, Acoustic Stressors; and Section 3.8.3.2, Explosive Stressors) present the potential environmental consequences based on modeling and the scientific observations and investigations made over 12 years of monitoring of Navy training and testing activities in the Pacific and elsewhere that are representative of the type of activities proposed in this SEIS/OEIS.

3.8.3.1 Acoustic Stressors

Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sources, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council, 2003, 2005), there are many unknowns in assessing impacts such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al., 2007; Southall et al., 2007). Many other factors besides just the received level of sound may affect an animal's reaction such as the duration of the sound-producing activity, the animal's physical condition, prior experience with the sound, activity at the time of exposure (e.g., feeding, traveling, resting), the context of the exposure (e.g., in a semi-enclosed bay vs. open ocean), and proximity to the source of the sound.

The ways in which an acoustic exposure could result in immediate effects or long-term consequences for an animal are explained in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). The following Background section discusses what is currently known about acoustic effects to marine mammals. These effects could hypothetically extend from physical injury or trauma to a behavioral or stress response that may or may not be detectable. Injury (physical trauma) can occur to organs or tissues of an animal (Section 3.8.3.1.1.1, Injury). Hearing Loss (Section 3.8.3.1.1.2, Hearing Loss) is a noise-induced decrease in hearing sensitivity, which can be either temporary or permanent. Physiological stress (Section 3.8.3.1.1.3, Physiological Stress) is an adaptive process that helps an animal cope with changing conditions; however, too much stress can result in physiological effects. Masking (Section 3.8.3.1.1.4, Masking) can occur when the perception of a biologically important sound (i.e., signal) is interfered with by a second sound (i.e., noise). Behavioral response (Section 3.8.3.1.1.5, Behavioral Reactions) ranges from brief distractions to avoidance of a sound source to prolonged flight. Extreme behavioral or physiological responses can lead to stranding (Section 3.8.3.1.1.6, Stranding). Long-term consequences (Section 3.8.3.1.1.7, Long-Term Consequences) are those impacts, or accumulation of impacts, that can result in decreases in individual fitness or population changes. To avoid or reduce potential impacts to the maximum extent practicable, the Navy will implement marine mammal mitigation measures during applicable training activities that generate acoustic stressors (see Chapter 5, Mitigation).

The Navy will rely on the previous 2016 GOA Final SEIS/OEIS for the analysis of vessel noise, aircraft noise, and weapon noise, and new applicable and emergent science in regard to these sub-stressors is presented in the sections which follow. Due to new acoustic impact criteria, marine mammal densities, and revisions to the Navy Acoustic Effects Model, the analysis provided in Section 3.8.3.1.2 (Impacts from Sonar and Other Transducers) of this SEIS/OEIS supplants the 2016 GOA Final SEIS/OEIS for marine mammals and changes estimated impacts for some species since the 2016 GOA Final SEIS/OEIS.

3.8.3.1.1 Background

3.8.3.1.1.1 Injury

Injury (i.e., physical trauma) refers to the effects on the tissues or organs of an animal due to pressure waves. Injury due to non-explosive acoustic stressors such as sonar is discussed below. Moderate- to low-level sound sources, including vessel and aircraft noise, would not cause injury. Section 3.0.4.3

(Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on injury (i.e., physical trauma) and the framework used to analyze this potential impact.

Several mechanisms of acoustically induced tissue damage (non-auditory) have been proposed and are discussed below.

Injury due to Sonar-Induced Acoustic Resonance

An object exposed to its resonant frequency will tend to amplify its vibration at that frequency, a phenomenon called acoustic resonance. Acoustic resonance has been proposed as a mechanism by which a sonar or sources with similar operating characteristics could damage tissues of marine mammals. In 2002, NMFS convened a panel of government and private scientists to investigate the potential for acoustic resonance to occur in marine mammals (National Oceanic and Atmospheric Administration, 2002). They modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding. The conclusions of the group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding in 2000. The frequency at which resonance was predicted to occur in the animals' lungs was 50 Hz, well below the frequencies used by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations, even at resonant frequencies, were not considered to be of sufficient amplitude to cause tissue damage, even under the unrealistic scenario in which air volumes would be undamped (unrestrained) by surrounding tissues and the amplitude of the resonant response would be greatest. These same conclusions would apply to other training activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance would not occur under real training conditions. The potential impact of acoustic resonance is not considered further in this analysis.

Nitrogen Decompression

Marine mammals mitigate nitrogen gas accumulation in their blood and other tissues, which is caused by gas exchange from the lungs under conditions of increased hydrostatic pressure during diving, through anatomical, behavioral, and physiological adaptations (Hooker et al., 2012).

Although not an injury caused by the interaction of sound with tissues, variations in marine mammal diving behavior or avoidance responses in response to sound exposure have been hypothesized to result in the off-gassing of nitrogen super-saturated tissues, possibly to the point of deleterious vascular and tissue bubble formation (Hooker et al., 2012; Jepson et al., 2003; Saunders et al., 2008) with resulting symptoms similar to decompression sickness (also known as "the bends").

Whether marine mammals can produce deleterious gas emboli has been under debate in the scientific community (Hooker et al., 2012; Saunders et al., 2008), although various lines of evidence have been presented in support of the phenomenon. Some of these postulations are described below.

1. Analyses of bycaught animals demonstrated that nitrogen bubble formation occurs in drowned animals when they are brought to the surface (Bernaldo de Quiros et al., 2013b; Moore et al., 2009). Since gas exchange with the lungs no longer occurs once drowned, tissues become supersaturated with nitrogen due to the reduction in hydrostatic pressure near the surface. This demonstrates that the phenomenon of bubble formation is at least physically possible.
2. The presence of osteonecrosis (bone death due to reduced blood flow) in deep-diving sperm whales has been offered as evidence of impacts due to chronic nitrogen supersaturation and a lifetime of decompression insults (Moore & Early, 2004).

3. Dennison et al. (2012) investigated dolphins stranded in 2009–2010. Using ultrasound, they identified gas bubbles in kidneys of 21 of the 22 live-stranded dolphins and in the liver of two of the 22. The authors postulated that stranded animals were unable to recompress by diving, and thus retained bubbles that would have otherwise re-absorbed in animals that continued to dive. However, the researchers concluded that the minor bubble formation observed could be tolerated since the majority of stranded dolphins released did not re-strand.
4. A fat embolic syndrome (out-of-place fat particles, typically in the bloodstream) was identified by Fernández et al. (2005) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals and was thought to possibly arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream.
5. Findings of gas and fat emboli in a few stranded Risso's dolphin, and in which sonar exposure was ruled out as a cause of stranding, suggested that other factors, in this case struggling with a prey item, might cause significant variations in dive behavior such that emboli formation could occur (Fernandez et al., 2017).

Only one study has attempted to find vascular bubbles in a freely diving marine mammal (Houser et al., 2009). In that study, no vascular bubbles were imaged by ultrasound in a bottlenose dolphin that repeatedly dove to a 100 m depth and maintained a dive profile meant to maximize nitrogen gas uptake. Thus, although lines of evidence suggest that marine mammals manage excessive nitrogen gas loads, the majority of the evidence for the formation of bubble and fat emboli come from stranded animals in which physiological compromise due to the stranding event is a potential confounding factor.

Researchers have examined how dive behavior affects tissue supersaturation conditions that could put an animal at risk of gas bubble embolism. An early hypothesis was that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Fernandez et al., 2005; Jepson et al., 2003). However, modeling suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer & Tyack, 2007). Instead, emboli observed in animals exposed to mid-frequency active sonar (Fernandez et al., 2005; Jepson et al., 2003) could stem from a behavioral response that involves repeated dives, shallower than the depth of lung collapse (Aguilar de Soto et al., 2006; Hooker et al., 2012; Tyack et al., 2006; Zimmer & Tyack, 2007). Longer times spent diving at mid-depths above lung collapse would allow gas exchange from the lungs to continue under high hydrostatic pressure conditions, increasing potential for supersaturation; below the depth of lung collapse, gas exchange from the lungs to the blood would likely not occur (Costidis & Rommel, 2016; Fahlman et al., 2014b). To estimate risk of decompression sickness, Kvadsheim et al. (2012) modeled gas exchange in the tissues of sperm, pilot, killer, and beaked whales based on actual dive behavior during exposure to sonar in the wild. Results predicted that venous supersaturation would be within the normal range for these species, which would presumably have naturally higher levels of nitrogen gas loading. Nevertheless, deep-diving whales, such as beaked whales, have also been predicted to have higher nitrogen gas loads in body tissues for certain modeled changes in dive behavior, which might make them more susceptible to decompression sickness (Fahlman et al., 2014b; Fernandez et al., 2005; Hooker et al., 2012; Jepson et al., 2003). Bernaldo de Quirós et al. (2019) summarized discussions from a 2017 workshop on potential sonar impacts on beaked whales, suggesting that the effect of mid-frequency active sonar on beaked whales varies among individuals or populations and that predisposing conditions such as previous exposure to sonar and individual health risk factors may contribute to individual outcomes (such as decompression sickness) as well.

Modeling has suggested that the long, deep dives performed regularly by beaked whales over a lifetime could result in the saturation of long-halftime tissues (i.e., tissues that take longer to give off nitrogen, e.g., fat and bone lipid) to the point that they are supersaturated when the animals are at the surface (Fahlman et al., 2014b; Hooker et al., 2009; Saunders et al., 2008). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al., 2006; Hooker et al., 2009), and because of the time it takes for tissue offloading, it is feasible that long-halftime tissues are not a concern for decompression insults under normal ventilation or dive (recompression) conditions. However, for beaked whale strandings associated with sonar use, one proposed hypothesis is that observed bubble formation may be caused by compromised blood flow due to stranding-related cardiovascular collapse. This would reduce the ability to remove nitrogen from tissues following rapid sonar-induced stranding and could preclude typical management of nitrogen in supersaturated, long-halftime tissues (Houser et al., 2009).

Predictive modeling conducted to date has been performed with many unknowns about the respiratory physiology of deep-diving breath-hold animals. For example, Denk et al. (2020) found intra-species differences in the compliance of tracheobronchial structures of post-mortem cetaceans and pinnipeds under diving hydrostatic pressures, which would affect depth of alveolar collapse. Although, as hypothesized by Garcia Parraga et al. (2018), mechanisms may exist that allow marine mammals to create a pulmonary shunt without the need for hydrostatic pressure-induced lung collapse, i.e., by varying perfusion to the lung independent of lung collapse and degree of ventilation. If such a mechanism exists, then assumptions in prior gas models require reconsideration, the degree of nitrogen gas accumulation associated with dive profiles needs to be re-evaluated, and behavioral responses potentially leading to a destabilization of the relationship between pulmonary ventilation and perfusion should be considered. Costidis and Rommel (2016) suggested that gas exchange may continue to occur across the tissues of air-filled sinuses in deep-diving odontocetes below the depth of lung collapse, if hydrostatic pressures are high enough to drive gas exchange across into non-capillary veins.

If feasible, kinetic gas models would need to consider an additional gas exchange route that might be functional at great depths within the odontocetes. Other adaptations potentially mitigating and defending against deleterious nitrogen gas emboli have been proposed (Blix et al., 2013). Researchers have also considered the accumulation of carbon dioxide produced during periods of high activity by an animal, theorizing that accumulating carbon dioxide, which cannot be removed by gas exchange below the depth of lung collapse, might also facilitate the formation of bubbles in nitrogen-saturated tissues (Bernaldo de Quiros et al., 2012; Fahlman et al., 2014b). In all of these cases, the hypotheses have received little in the way of experimentation to evaluate whether or not they are supported, thus leaving many unknowns as to the predictive accuracy of modeling efforts.

The appearance of extensive bubble and fat emboli in beaked whales was unique to a small number of strandings associated with certain high-intensity sonar events; the phenomenon has not been observed to the same degree in other stranded marine mammals, including other beaked whale strandings not associated with sonar use. It is uncertain as to whether there is some more easily-triggered mechanism for this phenomenon specific to beaked whales or whether the phenomenon occurs only following rapidly occurring stranding events (i.e., when whales are not capable of sufficiently decompressing). Nevertheless, based on the rarity of observations of bubble pathology, the potential for nitrogen decompression sickness, or "the bends," as a result of exposure to Navy sound sources is considered discountable.

Acoustically Induced Bubble Formation due to Sonars

A suggested cause of injury to marine mammals is rectified diffusion (Crum & Mao, 1996), the process of increasing the size of a microscopic gas bubble by exposing it to a sound field. The process is dependent upon a number of factors, including the sound pressure level (SPL) and duration. Under this hypothesis, microscopic bubbles assumed to exist in the tissues of marine mammals may experience one of three things: (1) bubbles grow to the extent they become emboli or cause localized tissue trauma, (2) bubbles develop to the extent that a complement immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lung without negative consequence to the animal.

Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. As discussed above, repetitive diving by marine mammals can cause the blood and some tissues to become supersaturated (Ridgway & Howard, 1979). The dive patterns of some marine mammals (e.g., beaked whales) are predicted to induce greater supersaturation (Houser et al., 2001). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness.

It is unlikely that the short duration of sonar pulses would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of supersaturated tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough time for bubbles to become a problematic size. The phenomena of bubble growth due to a destabilizing exposure was shown by Crum et al. (2005) by exposing highly supersaturated ex vivo bovine tissues to a 37 kHz source at 214 dB re 1 µPa. Although bubble growth occurred under the extreme conditions created for the study, these conditions would not exist in the wild because the levels of tissue supersaturation in the study (as high as 400–700 percent) are substantially higher than model predictions for marine mammals (Fahlman et al., 2009; Fahlman et al., 2014b; Houser et al., 2001; Saunders et al., 2008), and such high exposure levels would only occur in very close proximity to the most powerful sonars. For these reasons, it is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings.

There has been considerable disagreement among scientists as to the likelihood of this phenomenon (Evans & Miller, 2003; Piantadosi & Thalmann, 2004). Although it has been argued that traumas from beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernandez et al., 2005; Jepson et al., 2003), nitrogen bubble formation as the cause of the traumas has not been verified. The presence of bubbles postmortem, particularly after decompression, is not necessarily indicative of bubble pathology (Bernaldo de Quiros et al., 2012; Bernaldo de Quiros et al., 2013a; Bernaldo de Quiros et al., 2013b; Dennison et al., 2012; Moore et al., 2009), and other mechanisms by which bubble emboli might occur once animals are rapidly stranded (e.g., cardiovascular collapse preventing tissue off-gassing) have not been ruled out (Houser et al., 2009).

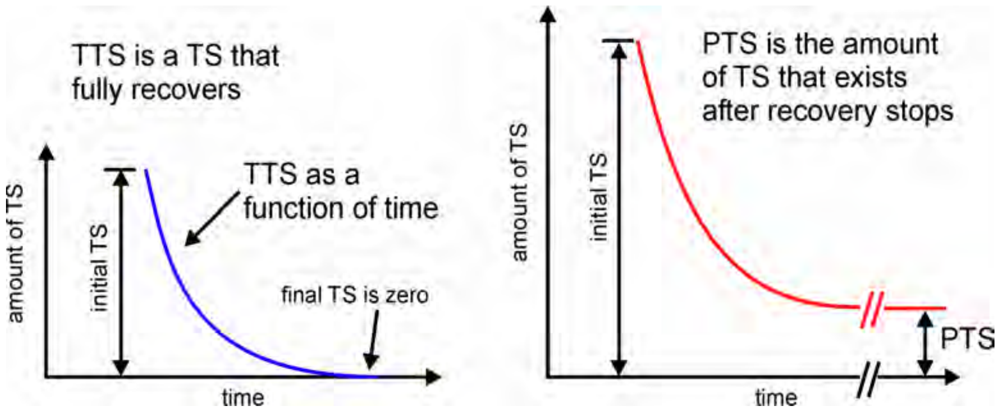
3.8.3.1.1.2 Hearing Loss

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. The specific amount of hearing loss, and whether the loss is temporary or permanent, depend on factors such as the exposure frequency, received sound pressure level, temporal pattern, and duration. The frequencies affected by hearing loss will vary depending on the frequency of the fatiguing noise, with frequencies at and above the noise frequency most strongly affected. The amount of hearing loss is highly variable and depends on the species, individual, and contextual factors.

Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on hearing loss and the framework used to analyze this potential impact. Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative.

Hearing loss is typically quantified in terms of threshold shift—the amount (in dB) that hearing thresholds at one or more specified frequencies are elevated, compared to their pre-exposure values, at some specific time after the noise exposure. The amount of threshold shift measured usually decreases with increasing recovery time—the amount of time that has elapsed since a noise exposure. If the threshold shift eventually returns to zero (i.e., the hearing threshold returns to the pre-exposure value), the threshold shift is called a temporary threshold shift (TTS). If the threshold shift does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining threshold shift is called a permanent threshold shift (PTS). Figure 3.8-3 shows two hypothetical threshold shifts: one that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. By definition, TTS is a function of the recovery time, therefore comparing the severity of noise exposures based on the amount of induced TTS can only be done if the recovery times are also taken into account. For example, a 20 dB TTS measured 24 hours post-exposure indicates a more hazardous exposure than one producing 20 dB of TTS measured only two minutes after exposure; if the TTS is 20 dB after 24 hours, the TTS measured after two minutes would have likely been much higher. Conversely, if 20 dB of TTS was measured after two minutes, the TTS measured after 24 hours would likely have been much smaller.

Studies have revealed that intense noise exposures may also cause auditory system injury that does not result in PTS (i.e., hearing thresholds return to normal after the exposure, but there is injury nonetheless). Kujawa and Liberman (2009) found that noise exposures sufficient to produce a TTS of 40 dB, measured 24 hours post-exposure using electro-physiological methods, resulted in acute loss of nerve terminals and delayed degeneration of the cochlear nerve in mice. Lin et al. (2011) found a similar result in guinea pigs, that a TTS in AEP of up to approximately 50 dB, measured 24 hours post-exposure, resulted in neural degeneration. These studies demonstrate that PTS should not be used as the sole indicator of auditory injury, since exposures producing high levels of TTS (40 to 50 dB measured 24 hours after exposure)—but no PTS—may result in auditory injury.



Notes: TTS = Temporary Threshold Shift, TS = Threshold Shift, PTS = Permanent Threshold Shift

Figure 3.8-3: Two Hypothetical Threshold Shifts

There are no simple functional relationships between TTS and the occurrence of PTS or other auditory injury (e.g., neural degeneration). However, TTS and PTS are, by definition, mutually exclusive: an exposure that produces TTS cannot also produce PTS within the same frequency band in the same individual (Reichmuth et al., 2019); conversely, if an initial threshold shift only partially recovers, resulting in some amount of PTS, the difference between the initial threshold shift and the PTS is not called TTS. As TTS increases, the likelihood that additional exposure SPL or duration will result in PTS or other injury also increases (with the exception that researchers might not be able to observe gradual growth of TTS with increased sound exposure levels (SELs) before onset of PTS (Reichmuth et al., 2019)). Exposure thresholds for the occurrence of PTS or other auditory injury can therefore be defined based on a specific amount of TTS; that is, we assume that any additional exposure may result in some PTS or other injury. The specific upper limit of TTS is based on experimental data showing amount of TTS that have not resulted in PTS or injury. In other words, we do not need to know the exact functional relationship between TTS and PTS or other injury, we only need to know the upper limit for TTS before some PTS or injury is possible.

A variety of human and terrestrial mammal data indicate that threshold shifts up to 40 dB may be induced without PTS, and that 40 dB is a reasonable upper limit for allowable threshold shift to prevent PTS (e.g., Kryter et al., 1965; Miller et al., 1963; Ward, 1960; Ward et al., 1958; Ward et al., 1959). It is reasonable to assume the same relationship would hold for marine mammals, since there are many similarities between the inner ears of marine and terrestrial mammals, and experiments with marine mammals have revealed similarities to terrestrial mammals for features such as TTS, age-related hearing loss, drug-induced hearing loss, masking, and frequency selectivity (Finneran, 2015; Finneran et al., 2005a; Ketten, 2000). Therefore, we assume that sound exposures sufficient to produce 40 dB of TTS measured approximately four minutes after exposure represent the limit of a non-injurious exposure (i.e., higher level exposures have the potential to cause auditory injury). Exposures sufficient to produce a TTS of 40 dB, measured approximately four minutes after exposure, therefore represent the threshold for auditory injury. The predicted injury could consist of either hair cell damage/loss resulting in PTS or other auditory injury, such as the delayed neural degeneration identified by Kujawa and Liberman (2009) and Lin et al. (2011) that may not result in PTS.

Numerous studies have directly examined noise-induced hearing loss in marine mammals (see Finneran, 2015). In these studies, hearing thresholds were measured in marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds was then used to determine the amount of TTS at various post-exposure times. The major findings from these studies include the following:

- The method used to test hearing may affect the resulting amount of measured TTS, with neurophysiological (i.e., AEP) measures producing larger amounts of TTS compared to psychophysical (i.e., behavioral) measures (Finneran, 2015; Finneran et al., 2007).
- The amount of TTS usually varies with the hearing test frequency. As the exposure SPL increases, the frequency at which the maximum TTS occurs also increases (Kastelein et al., 2020a; Kastelein et al., 2014a). For high level exposures, the maximum TTS typically occurs one-half to one octave above the exposure frequency (Finneran et al., 2007; Kastelein et al., 2020a; Kastelein et al., 2019d; Kastelein et al., 2019f; Mooney et al., 2009a; Nachtigall et al., 2004; Popov et al., 2013; Popov et al., 2011; Reichmuth et al., 2019; Schlundt et al., 2000). The overall spread of TTS from tonal exposures can therefore extend over a large frequency range (i.e., narrowband exposures can produce broadband [greater than one octave] TTS).
- The amount of TTS increases with exposure SPL and duration, and is correlated with SEL, especially if the range of exposure durations is relatively small (Kastak et al., 2007; Kastelein et al., 2014a; Popov et al., 2014). As the exposure duration increases, however, the relationship between TTS and SEL begins to break down. Specifically, duration has a more significant effect on TTS than would be predicted on the basis of SEL alone (Finneran et al., 2010b; Kastak et al., 2005; Mooney et al., 2009a). This means if two exposures have the same SEL but different durations, the exposure with the longer duration (thus lower SPL) will tend to produce more TTS than the exposure with the higher SPL and shorter duration. In most acoustic impact assessments, the scenarios of interest involve shorter duration exposures than the marine mammal experimental data from which impact thresholds are derived; therefore, use of SEL tends to over-estimate the amount of TTS. Despite this, SEL continues to be used in many situations because it is relatively simple, more accurate than SPL alone, and lends itself easily to scenarios involving multiple exposures with different SPL.
- Gradual increases of TTS may not be directly observable with increasing exposure levels, before the onset of PTS (Reichmuth et al., 2019). Similarly, PTS can occur without measurable behavioral modifications (Reichmuth et al., 2019).
- The amount of TTS depends on the exposure frequency. Sounds at low frequencies, well below the region of best sensitivity, are less hazardous than those at higher frequencies, near the region of best sensitivity (Finneran & Schlundt, 2013). The onset of TTS—defined as the exposure level at which a threshold shift of 6 dB is measured approximately four minutes after exposure (i.e., clearly above the typical variation in threshold measurements)—also varies with exposure frequency. At low frequencies TTS onset exposure levels are higher compared to those in the region of best sensitivity. For example, for harbor porpoises exposed to one-sixth octave noise bands at 16 kHz (Kastelein et al., 2019f), 32 kHz (Kastelein et al., 2019d), and 63 kHz (Kastelein et al., 2020a), less susceptibility to TTS was found as frequency increased, whereas exposure frequencies below ~6.5 kHz showed an increase in TTS susceptibility as frequency increased and approached the region of best sensitivity.
- TTS can accumulate across multiple exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL (Finneran et al., 2010b; Kastelein et al., 2015b; Kastelein et al., 2014a; Mooney et al., 2009b). This means that TTS predictions based on the total, cumulative SEL will overestimate the amount of TTS from intermittent exposures such as sonars and impulsive sources.

- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic (i.e., increasing exposure does not always increase TTS). The time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., approximately 40 dB) may require several days for recovery. Recovery times are consistent for similar-magnitude TTS, regardless of the type of fatiguing sound exposure (impulsive, continuous noise band, or sinusoidal wave; (Kastelein et al., 2019e)). Under many circumstances TTS recovers linearly with the logarithm of time (Finneran et al., 2010a, 2010b; Finneran & Schlundt, 2013; Kastelein et al., 2012a; Kastelein et al., 2012b; Kastelein et al., 2013a; Kastelein et al., 2014a; Kastelein et al., 2014b; Kastelein et al., 2014c; Popov et al., 2014; Popov et al., 2013; Popov et al., 2011). This means that for each doubling of recovery time, the amount of TTS will decrease by the same amount (e.g., 6 dB recovery per doubling of time).

Several recent studies have shown that certain odontocete cetaceans (toothed whales) may learn to reduce their hearing sensitivity (presumably to protect their hearing) when warned of an impending intense sound exposure (Finneran, 2018; Nachtigall & Supin, 2013, 2014, 2015; Nachtigall et al., 2015; Nachtigall et al., 2016a, 2018; Nachtigall et al., 2016b). The effect was first demonstrated in a false killer whale (*Pseudorca crassidens*) by Nachtigall and Supin (2013). Subsequent experiments, using similar methods, demonstrated similar conditioned hearing changes in a bottlenose dolphin (*Tursiops truncatus*), (Nachtigall & Supin, 2014, 2015; Nachtigall et al., 2016b), beluga (*Delphinapterus leucas*) (Nachtigall et al., 2015), and harbor porpoises (*Phocoena phocoena*) (Nachtigall et al., 2016a). Using slightly different methods, Finneran (2018) measured the time course and frequency patterns of conditioned hearing changes in two dolphins. Based on these experimental measurements with captive odontocetes, it is likely that wild odontocetes would also suppress their hearing if they could anticipate an impending, intense sound, or during a prolonged exposure (even if not anticipated). Based on the time course and duration of the conditioned hearing reduction, odontocetes participating in some previous TTS experiments could have been protecting their hearing during exposures (Finneran, 2018). A better understanding of the mechanisms responsible for the observed hearing changes is needed for proper interpretation of some existing temporary threshold shift data, particularly for considering TTS due to short duration, unpredictable exposures. No modification of analysis of auditory impacts is currently suggested, as the Phase III auditory impact thresholds are based on best available data for both impulsive and non-impulsive exposures to marine mammals.

Due to the higher exposure levels or longer exposure durations required to induce hearing loss, only a few types of human-made sound sources have the potential to cause a threshold shift to a marine mammal in the wild. Along with some sonars and other transducers, these include impulsive sound sources such as air guns and impact pile driving, neither of which will be used as part of the training activities being covered in this Supplement.

Southall et al. (2019c) evaluated Southall et al. (2007) and used updated scientific information to propose revised noise exposure criteria to predict onset of auditory effects in marine mammals (i.e., PTS and TTS onset). Southall et al. (2019c) note that the quantitative processes described and the resulting exposure criteria (i.e., thresholds and auditory weighting functions) are largely identical to those in (U.S. Department of the Navy, 2017a) and NMFS (2016h, 2018a). However, they differ in that the Southall et al. (2019c) exposure criteria are more broadly applicable as they include all marine mammal species (rather than those only under NMFS jurisdiction) for all noise exposures (both in air and underwater for amphibious species), and that while the hearing group compositions are identical they renamed the hearing groups. The thresholds discussed in the paper (TTS/PTS only) are the same as Navy's criteria and NMFS criteria.

Threshold Shift due to Sonar and Other Transducers

Temporary Threshold Shift in mid-frequency cetaceans exposed to non-impulsive sound has been investigated in multiple studies (Finneran et al., 2010a; Finneran et al., 2005b; Finneran & Schlundt, 2013; Mooney et al., 2009a; Mooney et al., 2009b; Nachtigall et al., 2003; Nachtigall et al., 2004; Popov et al., 2014; Popov et al., 2013; Schlundt et al., 2000) from two species, bottlenose dolphins and beluga whales. Two high-frequency cetacean species have been studied for TTS due to non-impulsive sources: the harbor porpoise (Kastelein et al., 2013a; Kastelein et al., 2015b; Kastelein et al., 2017a; Kastelein et al., 2014a; Kastelein et al., 2014b) and the finless porpoise (*Neophocaena phocaenoides*) (Popov et al., 2011). Temporary Threshold Shift from non-impulsive sounds has also been investigated in three pinniped species: harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*), and Northern elephant seal (*Mirounga angustirostris*) (e.g., Kastak et al., 2005; Kastelein et al., 2012a). These data are reviewed in detail in Finneran (2015) as well as the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report (U.S. Department of the Navy, 2017a), and the major findings are summarized above.

Several studies of threshold shift in marine mammals exposed to non-impulsive sounds have been published since development of the technical report. Kastelein et al. (2017a) examined threshold shift in harbor porpoises (high-frequency cetaceans) exposed to 3.5–4.1 kHz sonar playbacks. Small amounts of TTS (5–6 dB) were observed after exposures with cumulative, weighted SELs of ~156–162 dB SEL, (~3–9 dB above the TTS onset threshold). The data are therefore consistent with the Phase III thresholds. Popov et al. (2017) measured AEPs at 45 kHz in a beluga (a mid-frequency cetacean) before and after 10-minute exposure to half-octave noise centered at 32 kHz with SPL 170 dB re 1 µPa (weighted SEL = 198 decibels referenced to 1 micropascal squared seconds [dB re 1 µPa^{2}s]). After exposure, AEP amplitude vs. stimulus SPL functions were shifted to the right, but returned to baseline values over time. Maximum threshold shift was 23–25 dB, five minutes post-exposure. For these exposures, Phase III criteria over-estimate the observed effects (i.e., Phase III criteria predict 40 dB of TTS for SEL of 198 dB re 1 µPa^{2}s). Kastelein et al. (2020c) showed a much higher onset of TTS for a 88.4 kHz exposure as compared to lower exposure frequencies (i.e., 16 kHz (Kastelein et al., 2019f) 1.5 kHz and 6.5 kHz (Kastelein et al., 2020b). For the 88.4 kHz test frequency, a 185 dB re 1 µPa^{2}s exposure resulted in 3.6 dB of TTS, and a 191 dB re 1 µPa^{2}s exposure produced 5.2 dB of TTS at 100 kHz and 5.4 dB of TTS at 125 kHz. Together, these new studies demonstrate that the criteria for HF cetacean auditory impacts is likely to be conservative.

Kastelein et al. (2019b) measured behavioral hearing thresholds for simulated sonar signals (helicopter long range active sonar at 1.3–1.4 kHz) in two captive harbor seals. Thresholds reported in this study (mean of 51 dB re 1 µPa) are slightly lower than those observed in a prior study of harbor seal behavioral hearing thresholds for tones (Kastelein et al., 2009). The authors suggest this small difference may be due to characteristics of the helicopter long range active sonar signal (duration and/or harmonics) or changes in the test animals' performance over time. The data in this study would not affect the conclusions for acoustic impacts to marine mammals.

Additionally, Kastelein et al. (2019e) exposed two captive harbor seals to 6.5 kHz continuous, sinusoidal sound for one hour in water, resulting in a cumulative SEL between 159 and 195 dB re 1 µPa^{2}s, then measured TTS using behavioral hearing thresholds. The highest TTSs were produced in the one-half octave band above the exposure frequency, but individual seals showed variation in the magnitude of

TTS produced. Both seals recovered within one to two hours for up to 6 dB of threshold shift. One seal showed 19 dB of TTS after a 195 dB re 1 µPa^{2}s exposure and recovered within 24 hours. Similarly, Kastelein et al. (2020b) exposed the same seals to 32 kHz, continuous, band-limited noise for one hour, resulting in a cumulative SEL between 128 and 188 dB re 1 µPa^{2}s, and measured less than 6 dB of threshold shift at 32 kHz, which recovered within one hour. At a post-exposure test frequency of 45 kHz (a half-octave above the exposure frequency), the maximum TTS observed in this study were after a ~188 and ~191 dB re 1 µPa^{2}s exposure, which resulted in approximately 34 and 45 dB of TTS, respectively. Recovery occurred over four days for both TTSs. Recovery was gradual for the 34 dB shift, but recovery from the 45 dB shift was not observed until between 4 and 24 hours post-exposure. No TTS was observed at a test frequency of 63 kHz for any sound exposure level. Overall, these studies, combined with previous work, showed that for harbor seals, times to recovery are consistent for similar-magnitude TTS, regardless of the type of sound exposure (impulsive, continuous noise band, or sinusoidal (Kastelein et al., 2020d). However, recovery patterns may be less gradual for higher-magnitude TTS (above 45 dB). Overall, this study, combined with previous work, showed that for harbor seals, recovery times are consistent for similar-magnitude TTS, regardless of the type of sound exposure (impulsive, continuous noise band, or sinusoidal).

A longitudinal study tracked the hearing of a single harbor seal over more than ten years (Reichmuth et al., 2019). The harbor seal was originally exposed to a 4.1 kHz tone, which increased incrementally in SPL and duration over time, and was tested at 5.8 kHz. No reliable TTS was observed until the harbor seal was exposed to 60 s of the tone at 181 dB re 1 µPa, which resulted in a large threshold shift (> 47 dB). The harbor seal's hearing at 4.1 kHz recovered within two days, but his hearing at one-half (5.8 kHz) and one (8.2 kHz) octave above the frequency of the noise resulted in PTS (8-11 dB) for over 10 and 2 years, respectively. This study contradicts common assumptions about the relationship of TTS and PTS: there was no gradual growth of TTS with increased levels of SEL before onset of PTS, and there were no behavioral fluctuations to indicate that damage to hair cells had occurred. As a result, researchers might not be able to observe gradual TTS with increasing exposure levels, and it is possible for permanent hearing damage to occur without measurable behavioral changes.

Threshold Shift due to Impulsive Sound Sources

Cetacean TTS data from impulsive sources are limited to two studies with measured TTS of 6 dB or more. Finneran et al. (2002) reported behaviorally measured TTSs of 6 and 7 dB in a beluga exposed to single impulses from a seismic water gun and Lucke et al. (2009) reported AEP-measured TTS of 7 to 20 dB in a harbor porpoise exposed to single impulses from a seismic air gun.

In addition to these studies, a number of impulsive noise exposure studies have been conducted without behaviorally measurable TTS of 6 dB or more. The results of these studies are either consistent with the Navy Phase III criteria and thresholds (e.g., exposure levels were below those predicted to cause TTS, and TTS did not occur) or suggest that the Phase III thresholds over-estimate the potential for impact (e.g., exposure levels were above Navy Phase III TTS threshold, but TTS did not occur). The individual studies are summarized below:

- Finneran et al. (2000) exposed dolphins and belugas to single impulses from an “explosion simulator” and Finneran et al. (2015) exposed three dolphins to sequences of 10 impulses from a seismic air gun (maximum cumulative SEL = 193 to 195 dB re 1 µPa^{2}s, peak SPL = 196 to 210 dB re 1 µPa) without measurable TTS. Finneran et al. (2003b) exposed two sea lions to single impulses from an arc-gap transducer with no measurable TTS (maximum unweighted SEL = 163 dB re 1 µPa^{2}s, peak SPL = 183 dB re 1 µPa).

- Kastelein et al. (2015a) behaviorally measured mean TTS of 4 dB at 8 kHz and 2 dB at 4 kHz after a harbor porpoise was exposed to simulated impact pile driving sound. The cumulative SEL was approximately 180 dB re 1 µPa^{2}s (weighted SEL ~144 dB re 1 µPa^{2}s, 4 dB above the TTS onset threshold). Using similar, simulated pile driving noise, but varying total exposure duration from 15 to 360 minutes, Kastelein et al. (2016) found only small amounts of TTS (< 6 dB) in two harbor porpoises. The maximum weighted, cumulative SEL was 156 dB SEL (16 dB above Phase III threshold), but resulted in only ~5 dB of TTS.
- Reichmuth et al. (2016) measured behavioral hearing thresholds in two spotted seals and two ringed seals before/after exposure to single air gun impulses and found no TTS. The maximum weighted SEL was ~156 dB re 1 uPa^{2}s (14 dB below TTS-onset) and the maximum peak-to-peak SPL was ~204 dB re 1 µPa (~8 dB below TTS onset).
- Kastelein et al. (2017c) measured TTS in a harbor porpoise after exposure to multiple air gun impulses. Either a single or double air gun arrangement was used. Maximum exposure peak pressure was 194/199 dB re 1 µPa for single/double air guns. Maximum cumulative, weighted SEL was 127/130 dB re 1 µPa^{2}s. Maximum TTS occurred at 4 kHz and was 3 dB/4 dB for single/double air guns. Kastelein et al. (2020e) exposed the same harbor porpoise again to multiple airgun sounds; however, no TTS was found, despite higher single-shot and cumulative sound exposure levels. These studies demonstrate that TTS can be context-dependent and may not be consistent within the same animal exposed to similar sounds.
- Kastelein et al. (2018a) measured TTS in two harbor seals after exposure to playbacks of impact pile-driving recordings. The maximum weighted cumulative SEL is estimated to be ~182 dB re 1 µPa^{2}s (~12 dB above Navy Phase III threshold). Maximum peak pressure is estimated to be 176 dB re 1 µPa, ~36 dB below the Navy Phase III threshold. Small amounts (4 dB maximum) of TTS were observed at 4 kHz after the maximum exposure. Use of Navy Phase III criteria and thresholds would have over-estimated measured effects.
- Kastelein et al. (2019e) found that when two harbor seals were exposed to a 6.5 kHz center frequency fatiguing sound in water, the frequency at which maximum TTS occurred depended on the sound exposure level. For lower sound exposure levels (~179 dB re 1 µPa^{2}s and below), maximum TTS occurred at the center frequency of the fatiguing sound, and was between 0 and 5 dB. For ~183 - 195 dB SEL exposures, maximum TTS occurred at a frequency half an octave above the center frequency of the fatiguing sound (9.2 kHz), and was between 4 and 19 dB. Seals recovered at different rates, but TTS of up to 6 dB recovered within one to two hours and TTS of up to 19 dB recovered within 24 hours.

3.8.3.1.1.3 Physiological Stress

The growing field of conservation physiology relies in part on the ability to monitor stress hormones in populations of animals, particularly those that are threatened or endangered. The ability to make predictions from stress hormones about impacts on individuals and populations exposed to various forms of stressors, natural and human-caused, relies on understanding the linkages between changes in stress hormones and resulting physiological impacts. At this time, the sound characteristics that correlate with specific stress responses in marine mammals are poorly understood, as are the ultimate consequences due to these changes. Navy-funded efforts are underway to try to improve the understanding of and the ability to predict how stressors ultimately affect marine mammal populations (e.g., King et al., 2015; New et al., 2013a; Pirotta et al., 2015a). With respect to acoustically induced stress, this includes not only determining how and to what degree various types of anthropogenic sound cause stress in marine mammals, but what factors can mitigate those responses. Factors potentially affecting an animal's response to a stressor include the mammal's life history stage, sex, age, reproductive status, overall physiological and behavioral plasticity, and whether they are naïve or experienced with the sound (e.g., prior experience with a stressor may result in a reduced response due to habituation (Finneran & Branstetter, 2013; St. Aubin & Dierauf, 2001)). Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, the Navy assumes in its effect analysis that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to disease and naturally occurring toxins, lack of prey availability, and interactions with predators all contribute to the stress a marine mammal experiences (Atkinson et al., 2015). Breeding cycles, periods of fasting, social interactions with members of the same species, and molting (for pinnipeds) are also stressors, although they are natural components of an animal's life history. Anthropogenic activities have the potential to provide additional stressors beyond those that occur naturally (Fair et al., 2014; Meissner et al., 2015; Rolland et al., 2012). Anthropogenic stressors potentially include such things as fishery interactions, pollution, tourism, and ocean noise.

The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor (Moberg & Mench, 2000). Over short periods (i.e., hours/days), stress responses can provide access to energetic resources that can be beneficial in life-threatening situations. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). The generalized stress response is classically characterized by the release of cortisol, a hormone that has many functions including elevation of blood sugar, suppression of the immune system, and alteration of the biochemical pathways that affect fat, protein, and carbohydrate metabolism. However, it is now known that the endocrine response (glandular secretions of hormones into the blood) to a stressor can extend to other hormones. For instance, thyroid hormones can also vary under the influence of certain stressors, particularly food deprivation. These types of responses typically occur on the order of minutes to days. The "fight or flight" response, an acute stress response, is characterized by the very rapid release of hormones that stimulate glucose release, increase heart rate, and increase oxygen consumption. Chronic stressors can occur over the course of weeks or months. Rolland et al. (2017) compared acute (death by ship strike) to chronic (entanglement or live-stranding) stressors in North Atlantic right whales, and found that whales subject to chronic stressors had higher levels of glucocorticoid stress hormones (cortisol and corticosterone) than either healthy whales or those killed by ships. Authors presume that whales subject to acute stress here may have died too quickly for increases in fecal glucocorticoids to be detected.

What is known about the function of the various stress hormones is based largely upon observations of the stress response in terrestrial mammals. The endocrine response of marine mammals to stress may not be the same as that of terrestrial mammals because of the selective pressures marine mammals faced during their evolution in an ocean environment (Atkinson et al., 2015). For example, due to the necessity of breath-holding while diving and foraging at depth, the physiological role of epinephrine and norepinephrine (the catecholamines) might be different in marine versus other mammals. Catecholamines increase during breath-hold diving in seals, co-occurring with a reduction in heart rate, peripheral vasoconstriction (constriction of blood vessels), and an increased reliance on anaerobic metabolism during extended dives (Hance et al., 1982; Hochachka et al., 1995; Hurford et al., 1996); the catecholamine increase is not associated with an increased heart rate, glycemic release, and increased oxygen consumption typical of terrestrial mammals. Other hormone functions may also be different, such as aldosterone, which has been speculated to not only contribute to electrolyte balance, but possibly also the maintenance of blood pressure during periods of vasoconstriction (Houser et al., 2011). In marine mammals, aldosterone is thought to play a particular role in stress mediation because of its noted response to handling stress (St. Aubin & Dierauf, 2001; St. Aubin & Geraci, 1989).

Relatively little information exists on the linkage between anthropogenic sound exposure and stress in marine mammals, and even less information exists on the ultimate consequences of sound-induced stress responses (either acute or chronic). Most studies to date have focused on acute responses to sound either by measuring catecholamines or by measuring heart rate as an assumed proxy for an acute stress response. Belugas demonstrated no catecholamine response to the playback of oil drilling sounds (Thomas et al., 1990b) but showed a small but statistically significant increase in catecholamines following exposure to impulsive sounds produced from a seismic water gun (Romano et al., 2004). A bottlenose dolphin exposed to the same seismic water gun signals did not demonstrate a catecholamine response, but did demonstrate a statistically significant elevation in aldosterone (Romano et al., 2004), albeit the increase was within the normal daily variation observed in this species (St. Aubin et al., 1996) and was likely of little biological significance with respect to mitigating stress. Increases in heart rate were observed in bottlenose dolphins to which known calls of other dolphins were played, although no increase in heart rate was observed when background tank noise was played back (Miksis et al., 2001). Unfortunately, in this study, it cannot be determined whether the increase in heart rate was due to stress or an anticipation of being reunited with the dolphin to which the vocalization belonged. Similarly, a young beluga's heart rate was observed to increase during exposure to noise, with increases dependent upon the frequency band of noise and duration of exposure, and with a sharp decrease to normal or below normal levels upon cessation of the exposure (Lyamin et al., 2011). Spectral analysis of heart rate variability corroborated direct measures of heart rate (Bakhchina et al., 2017). This response might have been in part due to the conditions during testing, the young age of the animal, and the novelty of the exposure; a year later the exposure was repeated at a slightly higher received level and there was no heart rate response, indicating the beluga whale had potentially habituated to the noise exposure. Kvadsheim et al. (2010a) measured the heart rate of captive hooded seals during exposure to sonar signals and found an increase in the heart rate of the seals during exposure periods versus control periods when the animals were at the surface. When the animals dove, the normal dive-related bradycardia (decrease in heart rate) was not impacted by the sonar exposure. Similarly, Thompson et al. (1998) observed a rapid but short-lived decrease in heart rates in harbor and grey seals exposed to seismic air guns (cited in Gordon et al., 2003). Williams et al. (2017) recently monitored the heart rates of narwhals released from capture and found that a profound dive bradycardia persisted, even though exercise effort increased dramatically as part of their escape response following release. Thus, although some limited evidence suggests that tachycardia might occur as part of the acute stress response of animals that are at the surface, the bradycardia typical of diving in marine mammals appears to be dominant to any stress-related tachycardia and might even be enhanced in response to an acute stressor. Houser et al. (2020) measured cortisol and epinephrine obtained from 30 bottlenose dolphins exposed to simulated U.S. Navy mid-frequency sonar, and found no correlation between sound pressure level and stress hormone levels. In the same experiment (Houser et al., 2013b), behavioral responses were shown to increase in severity with increasing received sound pressure levels. These results suggest that behavioral reactions to sonar signals are not necessarily indicative of a hormonal stress response.

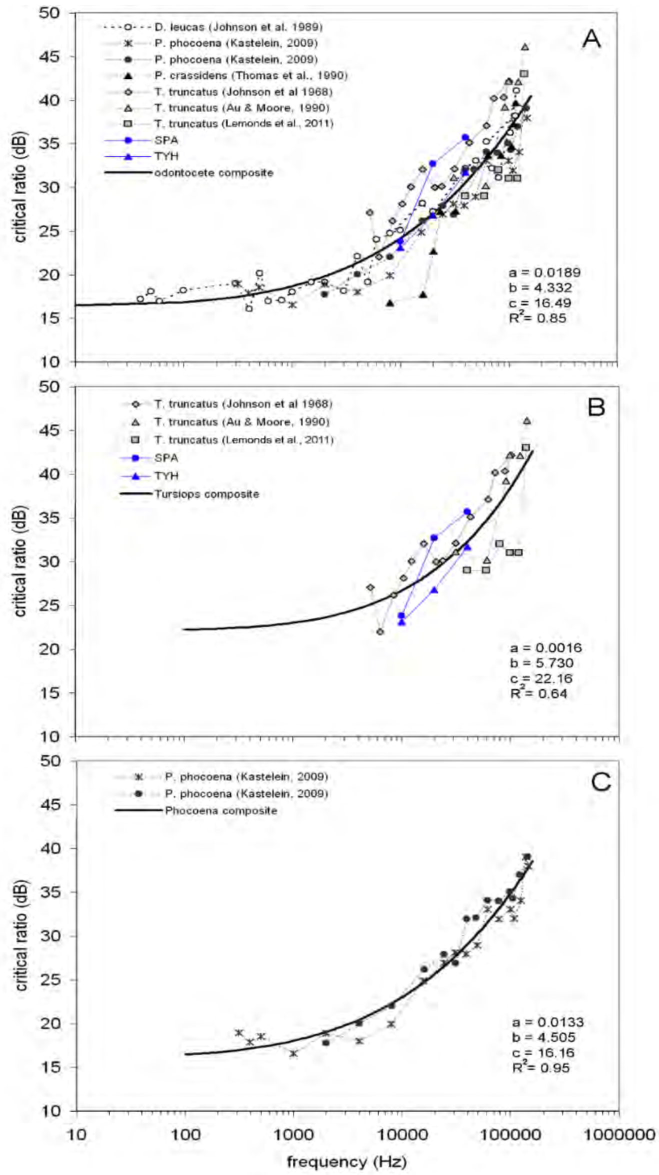
Whereas a limited amount of work has addressed the potential for acute sound exposures to produce a stress response, almost nothing is known about how chronic exposure to acoustic stressors affects stress hormones in marine mammals, particularly as it relates to survival or reproduction. In what is probably the only study of chronic noise exposure in marine mammals associating changes in a stress hormone with changes in anthropogenic noise, Rolland et al. (2012) compared the levels of cortisol metabolites in North Atlantic right whale feces collected before and after September 11, 2001. Following the events of September 11, shipping was significantly reduced in the region where fecal collections were made, and regional ocean background noise declined. Fecal cortisol metabolites significantly decreased during the period of reduced ship traffic and ocean noise (Rolland et al., 2012). Considerably more work has been conducted in an attempt to determine the potential effect of boating on smaller cetaceans, particularly killer whales (Bain, 2002; Erbe, 2002; Lusseau, 2006; Noren et al., 2009; Pirotta et al., 2015b; Read et al., 2014; Rolland et al., 2012; Williams et al., 2009; Williams et al., 2014b; Williams et al., 2014c; Williams et al., 2006). Most of these efforts focused primarily on estimates of metabolic costs associated with altered behavior or inferred consequences of boat presence and noise, but did not directly measure stress hormones. However, Ayres et al. (2012) investigated Southern Resident killer whale fecal thyroid hormone and cortisol metabolites to assess two potential threats to the species' recovery: lack of prey (salmon) and impacts from exposure to the physical presence of vessel traffic (but without measuring vessel traffic noise). Ayres et al. (2012) concluded from these stress hormone measures that the lack of prey overshadowed any population-level physiological impacts on Southern Resident killer whales due to vessel traffic. Collectively, these studies indicate the difficulty in teasing out factors that are dominant in exerting influence on the secretion of stress hormones, including the separate and additive effects of vessel presence and vessel noise. Nevertheless, although the reduced presence of the ships themselves cannot be ruled out as potentially contributing to the reduction in fecal cortisol metabolites in North Atlantic right whales, and there are potential issues in pseudoreplication and study design, the work of Rolland et al. (2012) represents the most provocative link between ocean noise and cortisol in cetaceans to date.

Navy-funded efforts are underway to try and improve our understanding and ability to predict how stressors ultimately affect marine mammal populations (e.g., King et al., 2015; New et al., 2013a; Pirotta et al., 2015a), and to determine whether a marine mammal being naïve or experienced with the sound (e.g., prior experience with a stressor) may result in a reduced response due to habituation (St. Aubin & Dierauf, 2001).

3.8.3.1.1.4 Masking

Masking occurs when one sound (i.e., noise) interferes with the detection, discrimination, or recognition of another sound (i.e., signal). The quantitative definition of masking is the amount in dB an auditory detection, discrimination, or recognition threshold is raised in the presence of a masker (Erbe et al., 2016). As discussed in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise (with the potential exception of reverberations from impulsive noise). Masking can lead to vocal changes such as the Lombard effect (increasing amplitude), other noise-induced vocal modifications such as changing frequency (Hotchkin & Parks, 2013), and behavioral changes (e.g., cessation of foraging, leaving an area) to both signalers and receivers, in an attempt to compensate for noise levels (Erbe et al., 2016).

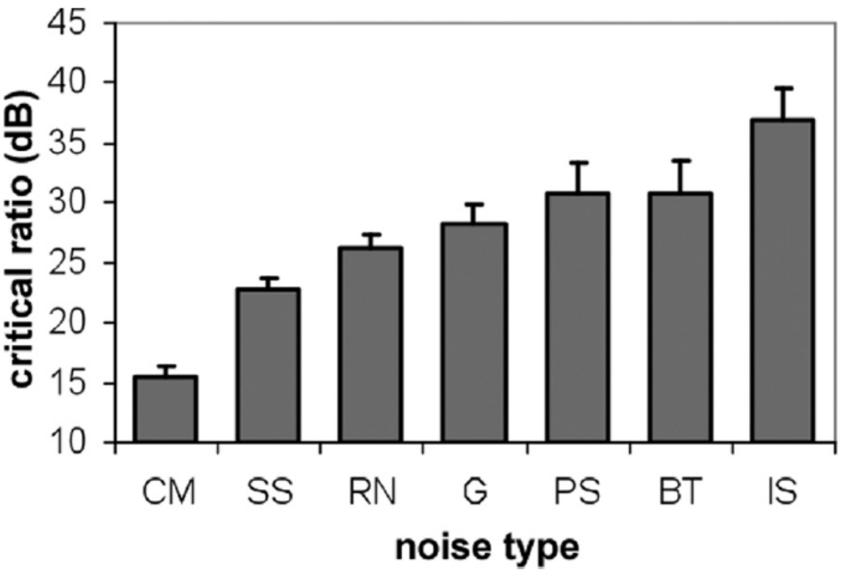
Critical ratios are the lowest signal-to-noise ratio in which detection under masking conditions occurs (Finneran & Branstetter, 2013; Johnson et al., 1989; Southall et al., 2000). When expressed in dB, critical ratios can easily be calculated by subtracting the noise level (in dB re 1 μPa^2/Hz) from the signal level (in dB re 1 µPa) at threshold. Critical ratios have been measured for pinnipeds (Southall et al., 2000, 2003), odontocetes (Au & Moore, 1990; Branstetter et al., 2017b; Johnson et al., 1989; Kastelein & Wensveen, 2008; Lemonds et al., 2011; Thomas et al., 1990a), and sea otters (Ghoul & Reichmuth, 2014b). Critical ratios increase as a function of signal frequency (Au & Moore, 1990; Lemonds et al., 2011). Higher frequency noise is more effective at masking higher frequency signals. Composite critical ratio functions have been estimated for odontocetes (Figure 3.8-4), which allow predictions of masking if the spectral density of noise is known (Branstetter et al., 2017b). Although critical ratios are typically estimated in controlled laboratory conditions using Gaussian (white) noise, critical ratios can vary considerably (see Figure 3.8-5) depending on the noise type (Branstetter et al., 2013; Trickey et al., 2010). Signal type (e.g., whistles, burst-pulse, sonar clicks) and spectral characteristics (e.g., frequency modulation and/or harmonics) may further influence masked detection thresholds (Branstetter et al., 2016; Branstetter & Finneran, 2008; Branstetter et al., 2013; Cunningham et al., 2014).



Source: Branstetter et al. (2017b)

Notes: (1) Odontocete critical ratios and composite model: CR = $a[\log_{10}(f)]^b + c$, where *a, b,* and *c* are model coefficients and *f* is the signal frequency in Hz. Equation 1 was fit to aggregate data for all odontocetes. (2) *T. truncatus.* critical ratios and composite model. (3) *P. phocoena.* critical ratios and composite model. Parameter values for composite models are displayed in the lower right of each panel.

Figure 3.8-4: Odontocete Critical Ratios



Source: Branstetter et al. (2013)

Notes: CM = comodulated, SS = snapping shrimp, RN = rain noise, G = Gaussian, PS = pile saw, BT = boat engine noise, and IS = ice squeaks

Figure 3.8-5: Critical Ratios for Different Noise Types

Clark et al. (2009) developed a model for estimating masking effects on communication signals for low-frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, the model estimates that a right whale's optimal communication space (around 20 km) is decreased by 84 percent when two commercial ships pass through it. Similarly, Aguilar de Soto et al. (2006) found that a 15 dB increase in background noise due to vessels led to a communication range of only 18 percent of its normal value for foraging beaked whales. This method relies on empirical data on source levels of calls (which is unknown for many species) and requires many assumptions such as pre-industrial ambient noise conditions and simplifications of animal hearing and behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Erbe (2016) developed a model with a noise source-centered view of masking to examine how a call may be masked from a receiver by a noise as a function of caller, receiver, and noise-source location, distance relative to each other, and received level of the call.

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Vocalization changes include increasing the source level, modifying the frequency, increasing the call repetition rate of vocalizations, or ceasing to vocalize in the presence of increased noise (Hotchkin & Parks, 2013). In cetaceans, vocalization changes were reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying (Gordon et al., 2003; Holt et al., 2011; Holt et al., 2008; Lesage et al., 1999; McDonald et al., 2009; Rolland et al., 2012) as well as changes in the natural acoustic environment (Caruso et al., 2020; Dunlop et al., 2014; Helble et al., 2020). Vocal changes can be temporary, or can be persistent, as seen in the increase in starting frequency for the North Atlantic right whale upcall over the last 50 years (Tennessen & Parks, 2016). Model simulation suggests that the frequency shift resulted in increased detection ranges between right whales; the frequency shift, coupled with an increase in call intensity by 20 dB, led to a call detectability range of less than 3 km to over 9 km (Tennessen & Parks, 2016). In some cases, these vocal changes may have fitness consequences, such as an increase in metabolic rates and oxygen consumption, as was found for bottlenose dolphins when increasing their call amplitude (Holt et al., 2015). A switch from vocal communication to physical, surface-generated sounds such as pectoral fin slapping or breaching was observed for humpback whales in the presence of increasing natural background noise levels, indicating that adaptations to masking may not be limited to vocal modifications (Dunlop et al., 2010). These changes all represent possible tactics by the sound-producing animal to reduce the impact of masking. The receiving animal can also reduce masking by using active listening strategies such as orienting to the sound source, moving to a quieter location, or reducing self-noise from hydrodynamic flow by remaining still.

Spatial Release from Masking

Spatial release from masking (SRM) will occur when a noise and signal are separated in space, resulting in a reduction or elimination of masking (Holt & Schusterman, 2007; Popov et al., 2020). The relative position of sound sources can act as one of the most salient cues that allow the listener to segregate multiple sounds in a complex auditory scene. Many sounds are emitted from a directional source that is spatially separated from biologically relevant signals. Under such conditions, minimal masking will occur, and existing models of auditory masking will overestimate the amount of actual masking. Marine mammals have excellent sound source localization capabilities (Branstetter & Mercado, 2006; Byl et al., 2019; Renaud & Popper, 1975) and a directional receiving beam pattern (see Section 3.8.2.1.4, Hearing and Vocalization), which likely combine to aid in separating auditory events, thus improving detection performance.

Spatial release from masking has been empirically demonstrated using behavioral methods in a harbor seal and a California sea lion for 1, 8, and 16 kHz tones in air (Holt & Schusterman, 2007), where maximal SRM was 19 and 12 dB for each species respectively. Byl et al. (2019) used psychophysical methods to test the horizontal underwater sound-localization acuity of harbor seals for two noise bands (8–16 kHz and 14–16 kHz). When compared to sound-localization results for tonal stimuli in the same subjects (Byl et al., 2016), these results show better sound localization for stimuli with more spectral information.

Popov et al. (2020) measured the auditory-evoked potential (AEP) in a single bottlenose dolphin and observed 32 dB of masking when there was no separation between a 64 kHz signal and noise presented directly in front of the animal. Spatial release from masking occurred when the masker was moved 30 degrees or more off-axis, but smaller angular separations between signal and noise were not tested. Approximately 16–24 dB of SRM was observed, but thresholds did not return to baseline even when the masker was 90 degrees to the left or right of center. While these results are pertinent, some of the brain structures that produce the AEP receive information from both ears, which might reduce the ability of this method (as opposed to behavioral methods) to fully describe SRM.

Informational Masking

Much emphasis has been placed on signal detection in noise and, as a result, most masking studies and communication space models have focused on masked detection thresholds. However, from a fitness perspective, signal detection is almost meaningless without the ability to determine the sound source location and recognize “what” is producing the sound. Marine mammals use sound to recognize conspecifics, prey, predators, or other biologically significant sources (Branstetter et al., 2016). Masked recognition thresholds (often called informational masking) for whistle-like sounds, have been measured for bottlenose dolphins (Branstetter et al., 2016) and are approximately 4 dB above detection thresholds (energetic masking) for the same signals. It should be noted that the term "threshold" typically refers to the listener's ability to detect or recognize a signal 50 percent of the time. For example, human speech communication, where only 50 percent of the words are recognized, would result in poor communication (Branstetter et al., 2016). Likewise, recognition of a conspecific call or the acoustic signature of a predator at only the 50 percent level could have severe negative impacts. If "quality communication" is arbitrarily set at 90 percent recognition (which may be more appropriately related to animal fitness), the output of communication space models (which are based on 50 percent detection) would likely result in a significant decrease in communication range (Branstetter et al., 2016).

Marine mammals use sound to recognize predators (Allen et al., 2014; Cummings & Thompson, 1971; Curé et al., 2015; Fish & Vania, 1971). Auditory recognition may be reduced in the presence of a masking noise, particularly if it occurs in the same frequency band. Therefore, the occurrence of masking may prevent marine mammals from responding to the acoustic cues produced by their predators. Whether this is a possibility depends on the duration of the masking and the likelihood of encountering a predator during the time that detection and recognition of predator cues are impeded. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by mammal-eating killer whales. The seals acoustically discriminate between the calls of mammal-eating and fish-eating killer whales (Deecke et al., 2002), a capability that should increase survivorship while reducing the energy required to attend to all killer whale calls. Similarly, sperm whales (Curé et al., 2016; Isojunno et al., 2016), long-finned pilot whales (Visser et al., 2016), and humpback whales (Curé et al., 2015) changed their behavior in response to killer whale vocalization playbacks; these findings indicating that some recognition of predator cues could be missed if the killer whale vocalizations were masked.

Masking by Sonar and Other Transducers

Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Because traditional military sonars typically have low duty cycles, relatively short duration, and narrow bandwidth that does not overlap with vocalizations for most marine mammal species, the effects of such masking would be limited when compared with continuous sources (e.g., vessel noise). Dolphin whistles and mid-frequency active sonar are similar in frequency, so masking is possible but less likely due to the low-duty cycle of most sonars. Low-frequency active sonar could also overlap with mysticete vocalizations (e.g., minke and humpback whales). For example, in the presence of low-frequency active sonar, humpback whales were observed to increase the length of their songs (Fristrup et al., 2003; Miller et al., 2000), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar.

Newer high-duty cycle or continuous active sonars have more potential to mask vocalizations, particularly for delphinids and other mid-frequency cetaceans. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high-frequency acoustic sources such as pingers that operate at higher repetition rates (e.g., 2–10 kHz with harmonics up to 19 kHz, 76–77 pings per minute (Culik et al., 2001)), also operate at lower source levels. While the lower source levels limit the range of impact compared to traditional systems, animals close to the sonar source are likely to experience masking on a much longer time scale than those exposed to traditional sonars. The frequency range at which high-duty cycle systems operate overlaps the vocalization frequency of many mid-frequency cetaceans. Continuous noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically mediated cooperative behaviors such as foraging or reproductive activities. Similarly, because the systems are mid-frequency, there is the potential for the sonar signals to mask important environmental cues like predator vocalizations (e.g., killer whales), possibly affecting survivorship for targeted animals. While there are currently no available studies of the impacts of high-duty cycle sonars on marine mammals, masking due to these systems is likely analogous to masking produced by other continuous sources (e.g., vessel noise and low-frequency cetaceans), and will likely have similar short-term consequences, though longer in duration due to the duration of the masking noise. These may include changes to vocalization amplitude and frequency (Brumm & Slabbekoorn, 2005; Hotchkin & Parks, 2013) and behavioral impacts such as avoidance of the area and interruptions to foraging or other essential behaviors (Gordon et al., 2003). Long-term consequences could include changes to vocal behavior and vocalization structure (Foote et al., 2004; Parks et al., 2007), abandonment of habitat if masking occurs frequently enough to significantly impair communication (Brumm & Slabbekoorn, 2005), a potential decrease in survivorship if predator vocalizations are masked (Brumm & Slabbekoorn, 2005), and a potential decrease in recruitment if masking interferes with reproductive activities or mother-calf communication (Gordon et al., 2003).

Masking by Vessel Noise

Masking is more likely to occur in the presence of broadband, relatively continuous noise sources such as vessels. For example, right whales were observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al., 2007) as well as increasing the amplitude (intensity) of their calls (Parks, 2009; Parks et al., 2011). Right whales also had their communication space reduced by up to 84 percent in the presence of vessels (Clark et al., 2009). Cholewiak et al. (2018) found that right whale gunshot calls had the lowest loss of communication space in Stellwagen National Sanctuary (5 percent), while fin and humpback whales lost up to 99 percent of their communication space with increased ambient noise and shipping noise combined. Although humpback whales off Australia did not change the frequency or duration of their vocalizations in the presence of ship noise, their source levels were lower than expected based on source level changes to wind noise, potentially indicating some signal masking (Dunlop, 2016). Vessel noise decreased the 4 km of humpback whale modeled communication space (with wind noise up to 100 dB re 1 µPa) to 3 km at the same received level, and at 105 dB re 1 µPa of noise communication space decreased again to 2 km for low-frequency signals and 1 km for high-frequency signals (Dunlop, 2019). Communication space loss due to vessels in Glacier Bay National Park was estimated to be lower for singing humpback whales than for calling whales and was highest for roaring harbor seals, but synchronizing the arrival and departure times of ships into the park restored some of that communication space for the calling whales and seals (Gabriele et al., 2018). Fournet et al. (2018) found humpback whales increase their call source levels by 0.8 dB and decrease the probability of calling by 9 percent for every 1 dB increase in ambient sound, which included vessel noise.

Multiple delphinid species have also been shown to increase the minimum or maximum frequencies of their whistles in the presence of anthropogenic noise (Papale et al., 2015). More specifically, Williams et al. (2014b) found that in median noise conditions in Haro Strait, killer whales lose 62 percent of their acoustic communication space in the frequency band of their social calls (1.5–3.5 kHz) out to 8 km due to vessel traffic noise, and in peak traffic hours lose up to 97 percent of that space; however, when looking at a smaller area or higher frequency bands, less communication space is lost. In fact, at the higher frequency band of their echolocation clicks (18–30 kHz), no communication space was lost out to 2 km. Holt et al. (2011; 2008) showed that Southern Resident killer whales in the waters surrounding the San Juan Islands increased their call source level as vessel noise increased. In the presence of boats off the Southern end of Vancouver, Southern Resident killer whales changed the duration of 16 out of 21 discrete call types (Wieland et al., 2010). Most of those call types (n=14) increased mean duration, while 2 call types decreased in duration. Hermannsen et al. (2014) estimated that broadband vessel noise could extend up to 160 kHz at ranges from 60 to 1,200 m, and that the higher frequency portion of that noise might mask harbor porpoise clicks. However, this may not be an issue as harbor porpoises may avoid vessels and may not be close enough to have their clicks masked (Dyndo et al., 2015; Polacheck & Thorpe, 1990; Sairanen, 2014). Furthermore, Hermannsen et al. (2014) estimated that a 6 dB elevation in noise would decrease the hearing range of a harbor porpoise by 50 percent, and a 20 dB increase in noise would decrease the hearing range by 90 percent. Gervaise et al. (2012) estimated that beluga whales in the St. Lawrence Marine Park had their communication space reduced to 30 percent during average vessel traffic. During peak traffic, communication space was further reduced to 15 percent. Lesage et al. (1999) found belugas in the St. Lawrence River estuary reduced overall call rates but increased the production of certain call types when ferry and small outboard motor boats were approaching. Furthermore, these belugas increased the vocalization frequency band when vessels were in close proximity. Liu et al. (2017) found that broadband shipping noise could cause masking of humpback dolphin whistles within 1.5–3 km, and masking of echolocation clicks within 0.5–1.5 km.

Masking by Impulsive Sound

Potential masking from weapon noise is likely to be similar to masking studied for other impulsive sounds, such as air guns. Masking could occur in mysticetes due to the overlap between their low-frequency vocalizations and the dominant frequencies of impulsive sources, however, masking in odontocetes or pinnipeds is less likely unless the activity is in close range when the pulses are more broadband. For example, differential vocal responses in marine mammals were documented in the presence of seismic survey noise. An overall decrease in vocalizations during active surveying was noted in large marine mammal groups (Potter et al., 2007), while blue whale feeding/social calls increased when seismic exploration was underway (Di Lorio & Clark, 2010), indicative of a possible compensatory response to the increased noise level. Furthermore, in the presence of biological interference from conspecific echolocation clicks (i.e., sonar jamming), cetaceans exhibit compensatory behaviors. Kloepper and Branstetter (2019) showed that individual bottlenose dolphins responded to jamming signals by omitting clicks (i.e., utilized a temporal response) or increasing click bandwidth (i.e., utilized a spectral response). Bowhead whales were found to increase call rates in the presence of seismic air gun noise at lower received levels (below 100 dB re: 1 $\mu Pa^2 s$ cumulative SEL), but once the received level rose above 127 dB re 1 $\mu Pa^2 s$ cumulative SEL the call rate began decreasing, and stopped altogether once received levels reached 170 dB re 1 $\mu Pa^2 s$ cumulative SEL (Blackwell et al., 2015). Nieukirk et al. (2012) recorded both seismic surveys and fin whale 20 Hz calls at various locations around the mid-Atlantic Ocean, and hypothesized that distant seismic noise could mask those calls thereby decreasing the communication range of fin whales, whose vocalizations may propagate over 400 km to reach conspecifics (Spiesberger & Fristrup, 1990). Two captive seals (one spotted and one ringed) were exposed to seismic air gun sounds recorded within 1 km and 30 km of an air gun survey conducted in shallow (<40 m) water. They were then tested on their ability to detect a 500-millisecond upsweep centered at 100 Hz at different points in the air gun pulse (start, middle, and end). Based on these results, a 100 Hz vocalization with a source level of 130 dB re 1 μPa would not be detected above a seismic survey 1 km away unless the animal was within 1–5 m, and would not be detected above a survey 30 km away beyond 46 m (Sills et al., 2017).

3.8.3.1.1.5 Behavioral Reactions

As discussed in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), any stimulus in the environment can cause a behavioral response in marine mammals. These stimuli include noise from anthropogenic sources such as vessels, sonar, or aircraft, but could also include the physical presence of a vessel or aircraft. However, stimuli such as the presence of predators, prey, or conspecifics could also influence how or if a marine mammal responds to a sound. Furthermore, the response of a marine mammal to an anthropogenic sound may depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and their behavioral state (i.e., what the animal is doing and their energetic needs at the time of the exposure) (Ellison et al., 2011). The distance from the sound source and whether it is approaching or moving away can also affect the way an animal responds to a sound (Wartzok et al., 2003).

For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson et al. (1995b). Other reviews (Nowacek et al., 2007; Southall et al., 2007) addressed studies conducted since 1995 and focused on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated, and also examined the role of context. Southall et al. (2007) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels, and Southall et al. (2016) reviewed the range of experimental field studies that have been conducted to measure behavioral responses of cetaceans to sonar. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al., 2007; Southall et al., 2016). Ellison et al. (2011) outlined an approach to assessing the effects of sound on marine mammals that incorporates these contextual-based factors. They recommend considering not just the received level of sound, but also in what activity the animal is engaged, the nature and novelty of the sound (i.e., is this a new sound from the animal's perspective), and the distance between the sound source and the animal. They submit that this "exposure context," as described, greatly influences the type of behavioral response exhibited by the animal (see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a)). Forney et al. (2017) also point out that an apparent lack of response (e.g., no displacement or avoidance of a sound source) may not necessarily mean there is no cost to the individual or population, as some resources or habitats may be of such high value that animals may choose to stay, even when experiencing stress or hearing loss. Forney et al. (2017) recommend considering both the costs of remaining in an area of noise exposure such as TTS, PTS, or masking, which could lead to an increased risk of predation or other threats or a decreased capability to forage, and the costs of displacement, including potential increased risk of vessel strike or bycatch, increased risks of predation or competition for resources, or decreased habitat suitable for foraging, resting, or socializing.

Behavioral reactions could result from a variety of sound sources such as sonar and other transducers (e.g., pingers), vessel noise, and aircraft noise. There are data on the reactions of some species in different behavioral states, providing evidence on the importance of context in gauging a behavioral response. However, for most species, little or no data exist on behavioral responses to any sound source, and so all species have been grouped into broad taxonomic groups from which general response information can be inferred (see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a)).

Behavioral Reactions to Sonar and Other Transducers

Sonar and other transducers can range in frequency from less than 1 kHz (e.g., low-frequency active sonar) to over 200 kHz (e.g., fish finders), with duty cycles that range from one ping per minute to an almost continuous sound. Although very high-frequency sonars are out of the hearing range of most marine mammals, some of these sources may contain artifacts at lower frequencies that could be detected (Deng et al., 2014; Hastie et al., 2014). High-duty cycle sonar systems operate at lower source levels, but with a more continuous sound output. These sources can be stationary, or on a moving platform, and there can be more than one source present at a time. Guan et al. (2017) also found that sound levels in the mid-frequency sonar bandwidth remained elevated at least 5 dB above background levels for the first 7–15 seconds (within 2 km) after the emission of a sonar ping; depending on the length of the sonar ping and the inter-ping interval, this reverberation could increase cumulative SEL estimates during periods of active sonar. This variability in parameters associated with sonar and other transducers makes the estimation of behavioral responses to these sources difficult, with observed responses ranging from no apparent change in behavior to more severe responses that could lead to some costs to the animal. As discussed in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) and Section 3.8.3.1.1.5 (Behavioral Reactions), responses may also occur in the presence of different contextual factors regardless of received level, including the proximity and number of vessels, the behavioral state and prior experience of an individual, and even characteristics of the signal itself or the propagation of the signal through the environment.

In order to explore this complex question, behavioral response studies have been conducted through the collaboration of various research and government organizations in Bahamian, United States (off Southern California), Mediterranean, Australian, and Norwegian waters. These studies have attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to understand better their potential impacts. While controlling for as many variables as possible (e.g., the distance and movement of the source), these studies also introduce additional variables that do not normally occur in a real Navy training activity, including the tagging of whales, following the tagged animals with multiple vessels, and continually approaching the animal to create a dose escalation. In addition, distances of the sound source from the whales during behavioral response studies were always within 1–8 km. Some of these studies have suggested that ramping up a source from a lower source level would act as a mitigation measure to protect against higher order (e.g., TTS or PTS) impacts of some active sonar sources; however, this practice may only be effective for more responsive animals, and for short durations (e.g., five minutes) of ramp-up (von Benda-Beckmann et al., 2014; von Benda-Beckmann et al., 2016; Wensveen et al., 2017). Therefore, while these studies have provided the most information to date on behavioral responses of marine mammals to sonar, there are still many contextual factors to be teased apart, and determining what might produce a significant behavioral response is not a trivial task. Additional information about active sonar ramp-up procedures, including why the Navy will not implement them as mitigation under the Proposed Action, is provided in Section 5.5.1 (Active Sonar).

Passive acoustic monitoring and visual observational behavioral response studies have also been conducted on Navy ranges, taking advantage of the existing seafloor hydrophones and real training activity and associated sources to assess behavioral responses (Deakos & Richlen, 2015; Henderson et al., 2016; Manzano-Roth et al., 2016; Martin et al., 2015; McCarthy et al., 2011; Mobley & Deakos, 2015; Moretti et al., 2014; Tyack et al., 2011). In addition, extensive aerial, visual, and passive acoustic monitoring have been conducted before, during, and after training events to watch for behavioral responses during training and look for injured or stranded animals after training (Falcone et al., 2017; Farak et al., 2011; Henderson et al., 2016; Manzano-Roth et al., 2016; Mobley, 2011; Norris et al., 2012a; Norris et al., 2012b; Smultea & Mobley, 2009; Smultea et al., 2009; Trickey et al., 2015; U.S. Department of the Navy, 2011c, 2013b, 2014b, 2015). During all of these monitoring efforts, very few behavioral responses were observed, and no injured or dead animal was observed that was directly related to a training event (some dead animals were observed but typically before the event or appeared to have been deceased prior to the event; e.g., Smultea et al., 2011). While passive acoustic studies are limited to observations of vocally active marine mammals, and visual studies are limited to what can be observed at the surface, these study types have the benefit of occurring in the absence of some of the added contextual variables in the controlled exposure studies. Furthermore, when visual and passive acoustic data collected during a training event are combined with ship movements and sonar use, and with tagged animal data when possible, they provide a unique and realistic scenario for analysis, as in Falcone et al. (2017), Manzano-Roth et al. (2016), or Baird et al. (2017). In addition to these types of observational behavioral response studies, Harris and Thomas (2015) highlighted additional research approaches that may provide further information on behavioral responses to sonar and other transducers beyond behavior response type studies or passive acoustic monitoring, including conducting controlled exposures on captive animals with scaled (smaller sized and deployed at closer proximity) sources, on wild animals with both scaled and real but directed sources, and predator playback studies, all of which will be discussed below.

The above behavioral response studies and observations have been conducted on a number of mysticete and odontocete species, which can be extrapolated to other similar species in these taxonomic groups. No field studies of pinniped behavioral responses to sonar have been conducted; however, there are several captive studies on some pinniped and odontocete species that can provide insight into how these animals may respond in the wild. The captive studies typically represent a more controlled approach, which allow researchers to better estimate the direct impact of the received level of sound leading to behavioral responses, and to potentially link behavioral to physiological responses. However, there are still contextual factors that must be acknowledged, including previous training to complete tasks and the presence of food rewards upon completion. There are no corresponding captive studies on mysticete whales; therefore, some of the responses to higher-level exposures must be extrapolated from odontocetes.

Mysticetes

The responses of mysticetes to sonar and other duty-cycled tonal sounds are highly dependent upon the characteristics of the signal, the behavioral state of the animal, the particular sensitivity and previous experience of an individual, and other contextual factors including distance of the source, movement of the source, and the physical presence of vessels in addition to the sonar (Goldbogen et al., 2013; Harris et al., 2015; Martin et al., 2015; Sivle et al., 2015). Behavioral response studies have been conducted over a variety of contextual and behavioral states, helping to identify which contextual factors may lead to a response beyond just the received level of the sound. Observed reactions during behavioral response studies have not been consistent across individuals based on received sound levels alone, and likely were the result of complex interactions between these contextual factors.

Surface feeding blue whales did not show a change in behavior in response to mid-frequency simulated and real sonar sources with received levels between 90 and 179 dB re 1 µPa, but deep feeding and non-feeding whales showed temporary reactions including cessation of feeding, reduced initiation of deep foraging dives, generalized avoidance responses, and changes to dive behavior. The behavioral responses they observed were generally brief, of low to moderate severity, and highly dependent on exposure context (behavioral state, source-to-whale horizontal range, and prey availability) (DeRuiter et al., 2017; Goldbogen et al., 2013; Sivle et al., 2015; Southall et al., 2019c). Similarly, while the rates of foraging lunges decreased in humpback whales due to sonar exposure, there was variability in the response across individuals, with one animal ceasing to forage completely and another animal starting to forage during the exposure (Sivle et al., 2016). In addition, lunges decreased (although not significantly) during a no-sonar control vessel approach prior to the sonar exposure, and lunges decreased less during a second sonar approach than during the initial approach, possibly indicating some response to the vessel and some habituation to the sonar and vessel after repeated approaches. In the same experiment, most of the non-foraging humpback whales did not respond to any of the approaches (Sivle et al., 2016). These humpback whales also showed variable avoidance responses, with some animals avoiding the sonar vessel during the first exposure but not the second, while others avoided the sonar during the second exposure, and only one avoided both. In addition, almost half of the animals that avoided were foraging before the exposure but the others were not; the animals that avoided while not feeding responded at a slightly lower received level and greater distance than those that were feeding (Wensveen et al., 2017). These findings indicate that the behavioral state of the animal plays a role in the type and severity of a behavioral response. In fact, when the prey field was mapped and used as a covariate in similar models looking for a response in the same blue whales, the response in deep-feeding behavior by blue whales was even more apparent, reinforcing the need for contextual variables to be included when assessing behavioral responses (Friedlaender et al., 2016). Further, it was found that the probability of a moderate behavioral response increased when the range to source was closer for these foraging blue whales, although there was a high degree of uncertainty in that relationship (Southall et al., 2019b). However, even when responses did occur the animals quickly returned to their previous behavior after the sound exposure ended (Goldbogen et al., 2013; Sivle et al., 2015). In another study, humpback whales exposed to a 3 kHz pinger meant to act as a net alarm to prevent entanglement did not respond or change course, even when within 500 m (Harcourt et al., 2014). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives; in this case, the alarm was comprised of a mixture of signals with frequencies from 500 to 4,500 Hz, was long in duration (lasting several minutes), and was purposely designed to elicit a reaction from the animals as a prospective means to protect them from ship strikes (Nowacek et al., 2004). Although the animals' received SPL was similar in the latter two studies (133–150 dB re 1 μPa^2s), the frequency, duration, and temporal pattern of signal presentation were different. Harris et al. (2019a) suggest that differences in responses between species may be due to contextual factors such as location, time of year, sound source characteristics, or exposure context through the comparison of differences in changes in lunge feeding between blue, fin, and humpback whales observed during sonar controlled exposure experiments.

Humpback whales in another behavioral response experiment in Australia also responded to a 2 kHz tone stimulus by changing their course during migration to move more offshore and surfaced more frequently, but otherwise did not respond (Dunlop et al., 2013). Humpback whales in the Norwegian behavioral response study may have habituated slightly between the first and second sonar exposure (Sivle et al., 2015), and actually responded more severely to killer whale vocalization playbacks than they did to the sonar playbacks. Several humpback whales have been observed during aerial or visual surveys during Navy training events involving sonar; no avoidance or other behavioral responses were ever noted, even when the whales were observed within 5 km of a vessel with active (or possibly active) sonar and maximum received levels were estimated to be between 135 and 161 dB re 1 μPa (Mobley, 2011; Mobley & Milette, 2010; Mobley & Pacini, 2012; Mobley et al., 2012; Smultea et al., 2009). In fact, one group of humpback whales approached a vessel with active sonar so closely that the sonar was shut down and the vessel slowed; the animals continued approaching and swam under the bow of the vessel (U.S. Department of the Navy, 2011b). Another group of humpback whales continued heading towards a vessel with active sonar as the vessel was moving away for almost 30 minutes, with an estimated median received level of 143 dB re 1 µPa. This group was observed producing surface active behaviors such as pec slaps, tail slaps, and breaches; however, these are very common behaviors in competitive pods during the breeding season and were not considered to have occurred in response to the sonar (Mobley et al., 2012). In addition, Henderson et al. (2019) examined the dive and movement behavior of humpback whales tagged at the U.S. Navy's Pacific Missile Range Facility, including whales incidentally exposed to sonar during Navy training activities. Tracking data showed that individual humpbacks spent limited time, no more than a few days, in the vicinity of Kaua'i. Potential behavioral responses to sonar exposure were limited and may have been influenced by engagement in breeding and social behaviors.

The strongest baleen whale response in any behavioral response study was observed in a minke whale in the 3S2 study, which responded at 146 dB re 1 µPa by strongly avoiding the sound source (Kvadsheim et al., 2017; Sivle et al., 2015). Although the minke whale increased its swim speed, directional movement, and respiration rate, none of these were greater than rates observed in baseline behavior, and its dive behavior remained similar to baseline dives. A minke whale tagged in the Southern California behavioral response study also responded by increasing its directional movement, but maintained its speed and dive patterns, and so did not demonstrate as strong of a response (Kvadsheim et al., 2017). In addition, the 3S2 minke whale demonstrated some of the same avoidance behavior during the controlled ship approach with no sonar, indicating at least some of the response was to the vessel (Kvadsheim et al., 2017). Martin et al. (2015) found that the density of calling minke whales was reduced during periods of Navy training involving sonar relative to the periods before training, and increased again in the days after training was completed. The responses of individual whales could not be assessed, so in this case it is unknown whether the decrease in calling animals indicated that the animals left the range, or simply ceased calling. Similarly, minke whale detections made using Marine Acoustic Recording Instruments off Jacksonville, FL, were reduced or ceased altogether during periods of sonar use (Norris et al., 2012b; U.S. Department of the Navy, 2013b), especially with an increased ping rate (Charif et al., 2015). Harris et al. (2019b) utilized acoustically generated minke whale tracks at the U.S. Navy's Pacific Missile Range Facility to statistically demonstrate changes in the spatial distribution of minke whale acoustic presence Before, During, and After surface ship mid-frequency active sonar training. The spatial distribution of probability of acoustic presence was different in the During phase compared to the Before phase, and the probability of presence at the center of ship activity for the During phase was close to zero for both years. The After phases for both years retained lower probabilities of presence suggesting the return to baseline conditions may take more than five days. The results show a clear spatial redistribution of calling minke whales during surface ship mid-frequency active sonar training, however a limitation of passive acoustic monitoring is that one cannot conclude if the whales moved away, went silent, or a combination of the two. Two minke whales also stranded in shallow water after the U.S. Navy training event in the Bahamas in 2000, although these animals were successfully returned to deep water with no physical examinations; therefore, no final conclusions were drawn on whether the sonar led to their stranding (Filadelfo et al., 2009a; Filadelfo et al., 2009b; U.S. Department of Commerce & U.S. Department of the Navy, 2001).

Baleen whales have also been exposed to lower and much higher frequency sonars, with the hypothesis that these whales may react more strongly to lower frequency sounds that overlap with their vocalization range. One series of studies was undertaken in 1997–1998 pursuant to the Navy's Low-Frequency Sound Scientific Research Program. The frequency bands of the low-frequency sonars used were between 100 and 500 Hz, with received levels between 115 and 150 dB re 1 µPa, and the source was always stationary. Fin and blue whales were targeted on foraging grounds, singing humpback whales were exposed on breeding grounds, and gray whales were exposed during migratory behavior. These studies found only short-term responses to low-frequency sound by some fin and humpback whales, including changes in vocal activity and avoidance of the source vessel, while other fin, humpback, and blue whales did not respond at all. When the source was in the path of migrating gray whales they changed course up to 2 km to avoid the sound, but when the source was outside their path, little response was observed although received levels were similar (Clark & Fristrup, 2001; Croll et al., 2001; Fristrup et al., 2003; Miller et al., 2000; Nowacek et al., 2007). Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source were also not found to affect dive times of humpback whales in Hawaiian waters (Frankel & Clark, 2000). Frankel and Stein (2020) exposed migrating gray whales to moored-source IMAPS sonar transmissions in the 21–25 kHz frequency band (estimated RL = 148 dB re 1 μPa^2) and showed that whales changed their path and moved closer to the shore when the vessel range was 1–2 km during sonar transmissions.

Opportunistic passive acoustic based studies have also detected behavioral responses to sonar, although definitive conclusions are harder to draw. Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low-frequency calls usually associated with feeding behavior, beginning at received levels of 110–120 dB re 1 µPa (Melcón et al., 2012); however, without visual observations it is unknown whether there was another factor that contributed to the reduction in foraging calls, such as the presence of conspecifics. In another example, Risch et al. (2012, 2014) determined that humpback whale song produced in the Stellwagen Bank National Marine Sanctuary was reduced, and since the timing was concurrent with an Ocean Acoustic Waveguide Remote Sensing experiment occurring 200 km away, they concluded that the reduced song was a result of the Ocean Acoustic Waveguide Remote Sensing. However, Gong et al. (2014) analyzed the same data set while also looking at the presence of herring in the region, and found that the singing humpbacks were actually located on nearby Georges Bank and not on Stellwagen, and that the song rate in their data did not change in response to Ocean Acoustic Waveguide Remote Sensing, but could be explained by natural causes.

Although some strong responses have been observed in mysticetes to sonar and other transducers (e.g., the single minke whale), for the most part mysticete responses appear to be fairly moderate across all received levels. While some responses such as cessation of foraging or changes in dive behavior could carry short-term impacts, in all cases behavior returned to normal after the signal stopped. Mysticete responses also seem to be highly mediated by behavioral state, with no responses occurring in some behavioral states, and contextual factors and signal characteristics having more impact than received level alone. Many of the contextual factors resulting from the behavioral response studies (e.g., close approaches by multiple vessels or tagging) would never be introduced in real Navy training scenarios. While data are lacking on behavioral responses of mysticetes to continuously active sonars, these species are known to be able to habituate to novel and continuous sounds (Nowacek et al., 2004), suggesting that they are likely to have similar responses to high-duty cycle sonars. Therefore, mysticete behavioral responses to Navy sonar will likely be a result of the animal's behavioral state and prior experience rather than external variables such as ship proximity; thus, if significant behavioral responses occur they will likely be short term. In fact, no significant behavioral responses such as panic, stranding, or other severe reactions have been observed during monitoring of actual training exercises (Smultea et al., 2009; U.S. Department of the Navy, 2011c, 2014a; Watwood et al., 2012).

Odontocetes

Behavioral response studies have been conducted on odontocete species since 2007, with a focus on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge et al., 2009; Defence Science and Technology Laboratory, 2007; Falcone et al., 2017; Henderson et al., 2015; Henderson et al., 2016; Isojunno et al., 2020; Manzano-Roth et al., 2016; Manzano-Roth et al., 2013; McCarthy et al., 2011; Moretti et al., 2009; Southall et al., 2014; Southall et al., 2013; Southall et al., 2015; Southall et al., 2012a; Southall et al., 2011; Southall et al., 2012b; Tyack et al., 2011). Through analyses of these behavioral response studies, a preliminary overarching effect of greater sensitivity to most anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al., 2009).

Observed reactions by Blainville's, Cuvier's, and Baird's beaked whales to mid-frequency sonar sounds have included cessation of clicking, decline in group vocal periods, termination of foraging dives, changes in direction to avoid the sound source, slower ascent rates to the surface, longer deep and shallow dive durations, and other unusual dive behavior (Boyd et al., 2008; Defence Science and Technology Laboratory, 2007; DeRuiter et al., 2013b; Miller et al., 2015; Southall et al., 2011; Stimpert et al., 2014; Tyack et al., 2011). Similar responses have been observed in northern bottlenose whales, one of which conducted the longest and deepest dive on record for that species after the sonar exposure and continued swimming away from the source for over seven hours (Miller et al., 2015; Wensveen et al., 2019). Responses have occurred at received levels between 95 and 150 dB re 1 µPa. Many of these exposures occurred within 1–8 km of the focal animal, within a few hours of tagging the animal, and with one or more boats within a few kilometers to observe responses and record acoustic data. One Cuvier's beaked whale was also incidentally exposed to real Navy sonar located over 100 km away, and the authors did not detect similar responses at comparable received levels. Received levels from the mid-frequency active sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa, respectively, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor in the responses to the simulated sonars (DeRuiter et al., 2013b). However, in a remote environment where sonar exposure is rare, similar responses in northern bottlenose whales were detected in whales up to 28 km away from the source at modeled received levels estimated at 117–126 dB re 1 µPa with no vessel nearby (von Benda-Beckmann et al., 2019; Wensveen et al., 2019). One northern bottlenose whale did approach the ship and circle the source, then resumed foraging after the exposure, but the source level was only 122 dB re 1 µPa.

Falcone et al. (2017) modeled deep and shallow dive durations, surface interval durations, and inter-deep dive intervals of Cuvier's beaked whales against predictor values that included helicopter dipping, mid-power mid-frequency active sonar and hull-mounted, high-power mid-frequency active sonar along with other, non-mid-frequency active sonar predictors. They found both shallow and deep dive durations to increase as the proximity to both mid- and high-powered sources decreased, and found surface intervals and inter-deep dive intervals to also increase in the presence of both types of sonars, although surface intervals shortened during periods of no mid-frequency active sonar. The responses to the mid-power mid-frequency active sonar at closer ranges were comparable to the responses to the higher Source Level ship sonar, again highlighting the importance of proximity. This study also supports context as a response factor, as helicopter dipping sonars are shorter duration and randomly located, so more difficult for beaked whales to predict or track and therefore potentially more likely to cause a response, especially when they occur at closer distances (6–25 km in this study). Sea floor depths and quantity of light are also important variables to consider in Cuvier's beaked whale behavioral response studies, as their foraging dive depth increased with sea floor depth up to sea floor depths of 2,000 m. The fraction of time spent at foraging depths and likely foraging was greater at night, although they spent more time near the surface during the night as well, particularly on dark nights with little moonlight, likely avoiding predation by staying deeper during periods of bright lunar illumination (Barlow et al., 2020). Sonar occurred during 10 percent of the dives studied and had little effect on the resulting dive metrics. Watwood et al. (2017) found that helicopter dipping events occurred more frequently but with shorter durations than periods of hull-mounted sonar, and also found that the longer the duration of a sonar event, the greater reduction in detected Cuvier's beaked whale group dives. Therefore, when looking at the number of detected group dives there was a greater reduction during periods of hull-mounted sonar than during helicopter dipping sonar. Similar results were found by DiMarzio et al. (2019).

Long-term tagging work has demonstrated that the longer duration dives considered a behavioral response by DeRuiter et al. (2013b) fell within the normal range of dive durations found for eight tagged Cuvier's beaked whales on the Southern California Offshore Range (Schorr et al., 2014). However, the longer inter-deep dive intervals found by DeRuiter et al. (2013b), which were among the longest found by Schorr et al. (2014) and Falcone et al. (2017), could indicate a response to sonar. In addition, Williams et al. (2017) note that in normal deep dives or during fast swim speeds, beaked whales and other marine mammals use strategies to reduce their stroke rates, including leaping or wave surfing when swimming, and interspersing glides between bouts of stroking when diving. They determined that in the post-exposure dives by the tagged Cuvier's beaked whales described in DeRuiter et al. (2013b), the whales ceased gliding and swam with almost continuous strokes. This change in swim behavior was calculated to increase metabolic costs about 30.5 percent and increase the amount of energy expending on fast swim speeds from 27 to 59 percent of their overall energy budget. This repartitioning of energy was detected in the model up to 1.7 hours after the single sonar exposure. Therefore, while the overall post-exposure dive durations were similar, the metabolic energy calculated by Williams et al. (2017) was higher. However, Southall et al. (2019a) found that prey availability was higher in the western area of the Southern California Offshore Range where Cuvier's beaked whales preferentially occurred, while prey resources were lower in the eastern area and moderate in the area just north of the Range. This high prey availability may indicate that fewer foraging dives are needed to meet metabolic energy requirements than would be needed in another area with fewer resources.

Wensveen et al. (2019) examined the roles of sound source distance and received level in northern bottlenose whales in an environment without frequent sonar activity using controlled exposure experiments. They observed behavioral avoidance of the sound source over a wide range of distances (0.8–28 km) and estimated avoidance thresholds ranging from received SPLs of 117–126 dB re 1 µPa. The behavioral response characteristics and avoidance thresholds were comparable to those previously observed in beaked whale studies; however, they did not observe an effect of distance on behavioral response and found that onset and intensity of behavioral response were better predicted by received SPL. Joyce et al. (2019) examined modeled received sound levels, dive data, and horizontal movement of seven satellite-tagged Blainville's beaked whales before, during, and after mid-frequency active sonar training at the Atlantic Undersea Test and Evaluation Center instrumented range. They found a decline in deep dives at the onset of the training and an increase in time spent on foraging dives as individuals moved away from the range. Predicted received levels at which presumed responses were observed were comparable to those previously observed in beaked whale studies. Acoustic data indicated that vocal periods were detected on the range within 72 hours after training ended.

On Navy ranges, Blainville's beaked whales located on the range appear to move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge et al., 2009; Henderson et al., 2015; Manzano-Roth et al., 2016; McCarthy et al., 2011; Moretti et al., 2009; Tyack et al., 2011). For example, five Blainville's beaked whales that were estimated to be within 2–29 km of the Atlantic Undersea Test and Evaluation Center range at the onset of sonar were displaced a maximum of 28–68 km from the range after moving away from the range, although one whale approached the range during the period of active sonar (Joyce et al., 2019). However, Blainville's beaked whales remain on the range to forage throughout the rest of the year (Henderson et al., 2016), possibly indicating that this a preferred foraging habitat regardless of the effects of the noise, or it could be that there are no long-term consequences of the sonar activity. Similarly, photo-identification studies in the SOCAL Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years, with re-sightings up to seven years apart, indicating a possibly resident population on the range (Falcone & Schorr, 2014; Falcone et al., 2009).

Beaked whales may respond similarly to shipboard echosounders, commonly used for navigation, fisheries, and scientific purposes, with frequencies ranging from 12 to 400 kHz and source levels up to 230 dB re 1 µPa but typically a very narrow beam (Cholewiak et al., 2017). During a scientific cetacean survey, an array of echosounders was used in a one-day-on, one-day-off paradigm. Beaked whale acoustic detections occurred predominantly (96 percent) when the echosounder was off, with only 4 detections occurring when it was on. Beaked whales were sighted fairly equally when the echosounder was on or off, but sightings were further from the ship when the echosounder was on (Cholewiak et al., 2017). These findings indicate that the beaked whales may be avoiding the area and may cease foraging near the echosounder. On the other hand, Varghese et al. (2020) analyzed group vocal periods from Cuvier's beaked whales during multibeam echosounder activity recorded in the Southern California Antisubmarine Warfare Range and failed to find any clear evidence of behavioral response due to the echosounder survey. The whales did not leave the range or cease foraging, and in fact group vocal periods increased during and after multibeam echosounder surveys. Since echosounders are highly directional and the sound doesn't propagate horizontally, the difference in these results may be due to the locations of beaked whales relative to the echosounder; in fact one of the surveys by Varghese et al. (2020) was largely conducted on a portion of the range little used by Cuvier's beaked whales.

Tyack et al. (2011) hypothesized that beaked whale responses to sonar may represent an anti-predator response. To test this idea, vocalizations of a potential predator—a killer whale—were also played back to a Blainville's beaked whale. This exposure resulted in a similar but more pronounced reaction than that elicited by sonar playback, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area (Allen et al., 2014; Tyack et al., 2011). De Soto et al. (2020) hypothesized that the high degree of vocal synchrony in beaked whales during their deep foraging dives, coupled with their silent, low-angled ascents, have evolved as an anti-predator response to killer whales. Since killer whales do not dive deep when foraging and so may be waiting at the surface for animals to finish a dive, these authors speculated that by diving in spatial and vocal cohesion with all members of their group, and by surfacing silently and up to a km away from where they were vocally active during the dive, they minimize the ability of killer whales to locate them when at the surface. This may lead to a trade-off for the larger, more fit animals that could conduct longer foraging dives, such that all members of the group remain together and are better protected by this behavior. The authors further speculate that this may explain the long, slow, silent, and shallow ascents that beaked whales make when sonar occurs during a deep foraging dive. However, these hypotheses are based only on the dive behavior of tagged beaked whales, with no observations of predation attempts by killer whales, and need to be tested further to be validated. This anti-predator hypothesis was also tested by playing back killer whale vocalizations to pilot whales, sperm whales, and even other killer whales, to determine responses by both potential prey and conspecifics (Miller, 2012; Miller et al., 2011). Results varied, from no response by killer whales to an increase in group size and attraction to the source in pilot whales (Curé et al., 2012). Gotz et al. (2020) tested startle responses in bottlenose dolphins and found that these responses can occur at moderate received levels and mid-frequencies, and that the relationship between rise time and startle response was more gradual than expected in an odontocete. They therefore hypothesize that the extreme responses of beaked whales to sonar could be a form of startle response, rather than an anti-predator response.

While there has been a focus on beaked whale responses to sonar, other species have been studied during behavioral response studies as well, including pilot whales, killer whales, and sperm whales. Responses by these species have also included horizontal avoidance, reduced breathing rates, changes in behavioral state, and changes in dive behavior (Antunes et al., 2014; Isojunno et al., 2018; Isojunno et al., 2017; Isojunno et al., 2020; Miller, 2012; Miller et al., 2011; Miller et al., 2014). Additionally, separation of a killer whale calf from its group during exposure to mid-frequency sonar playback was observed (Miller et al., 2011). Received level thresholds at the onset of avoidance behavior were generally higher for pilot whales (mean 150 dB re 1 µPa) and sperm whales (mean 140 dB re 1 µPa) than killer whales (mean 129 dB re 1 µPa) (Antunes et al., 2014; Miller, 2012; Miller et al., 2014). A close examination of the tag data from the Norwegian killer whales indicated that responses were mediated by behavior, signal frequency, or received sound energy. For example, killer whales only changed their dive behavior when doing deep dives at the onset of 1−2 kHz sonar (sweeping across frequencies), but did not change their dive behavior if they were deep-diving during 6−7 kHz sonar (sweeping across frequencies). Nor did they change their dive behavior if they were conducting shallow dives at the onset of either type of sonar. Similarly, pilot whales and sperm whales performed normal deep dives during 6−7 kHz sonar (and more deep foraging dives than during baseline for the pilot whales), while during 1−2 kHz sonar the pilot whales conducted fewer deep dives and the sperm whales performed shorter and shallower dives (Sivle et al., 2012). In addition, pilot whales were also more likely to respond to lower received levels when non-feeding than feeding during 6−7 kHz sonar exposures, but were more likely to respond at higher received levels when non-feeding during 1−2 kHz sonar exposures. Foraging time in pilot whales was reduced during the initial sonar exposure (both mid-frequency active sonar and low-frequency active sonar), with a concurrent increase in travel behavior; however, foraging increased again during subsequent exposures, potentially indicating some habituation (Isojunno et al., 2017). No reduction in foraging was observed during killer whale playbacks. Cessation of foraging appeared to occur at a lower received level of 145–150 dB re 1 µPa than had been observed previously for avoidance behavior (around 170 dB re 1 µPa; Antunes et al., 2014). Pilot whales also exhibited reduced breathing rates relative to their diving behavior when the low frequency active sonar levels were high (reaching 180 dB re 1 µPa), but only on the first sonar exposure; on subsequent exposures their breathing rates increased (Isojunno et al., 2018) indicating a change in response tactic with additional exposures. Furthermore, pilot whales exposed to a 38 kHz downward-facing echosounder did not change their dive and foraging behavior during exposure periods, although the animals' heading variance increased and fewer deep dives were conducted (Quick et al., 2017). In contrast, killer whales were more likely to respond to either sonar type when non-feeding than when feeding (Harris et al., 2015). Sperm whales were exposed to pulsed active sonar (1-2 kHz) at moderate source levels and high source levels, as well as continuously active sonar at moderate levels for which the summed energy (SEL) equaled the summed energy of the high source level pulsed sonar (Isojunno et al., 2020). Foraging behavior did not change during exposures to moderate source level sonar, but non-foraging behavior increased during exposures to high source level sonar and to the continuous sonar, indicating that the energy of the sound (the sound exposure level) was a better predictor of response than SPL. However, the time of day of the exposure was also an important covariate in determining the amount of non-foraging behavior, as were order effects (e.g. the SEL of the previous exposure). These results again demonstrate that the behavioral state and environment of the animal mediates the likelihood of a behavioral response, as do the characteristics (e.g., frequency, energy level) of the sound source itself. Further, the highly flexible activity time budgets observed for pilot whales, with a large amount of time spent resting at the surface, may indicate context-dependency on some behaviors, such as the presence of prey driving periods of foraging. Therefore, that time may be more easily re-allocated to missed foraging opportunities, leading to less severe population consequences of periods of reduced foraging (Isojunno et al., 2017).

Other responses during behavioral response studies included the synchronization of pilot whale surfacings with sonar pulses during one exposure, possibly as a means of mitigating the sound (Wensveen et al., 2015), and mimicry of the sonar with whistles by pilot whales (Alves et al., 2014), false killer whales (DeRuiter et al., 2013a) and Risso's dolphins (Smultea et al., 2012). In contrast, in another study melon-headed whales had "minor transient silencing" (a brief, non-lasting period of silence) after each 6–7 kHz signal, and (in a different oceanographic region) pilot whales had no apparent response (DeRuiter et al., 2013a). The probability of detecting delphinid vocalizations (whistles, clicks, and buzzes) increased during periods of sonar relative to the period prior to sonar in a passive acoustic study using Marine Autonomous Recording Units in the Jacksonville Range Complex, while there was no impact of sonar to the probability of detecting sperm whale clicks (Charif et al., 2015; U.S. Department of the Navy, 2013a).

In addition, killer whale sighting data from the same region in Norway as the behavioral response study were used to compare the presence or absence of whales from other years against the period with sonar. The authors found a strong relationship between the presence of whales and the abundance of herring, and only a weak relationship between the whales and sonar activity (Kuningas et al., 2013). Baird et al. (2014; 2017; 2013) also tagged four shallow-diving odontocete species (rough-toothed dolphins, pilot whales, bottlenose dolphins, and false killer whales) in Hawaii off the Pacific Missile Range Facility before Navy training events. None of the tagged animals demonstrated a large-scale avoidance response to the sonar as they moved on or near the range, in some cases even traveling towards areas of higher noise levels, while estimated received SPLs varied from 130 to 168 dB re 1 µPa and distances from sonar sources ranged between 3.2 and 94.4 km. However, one pilot whale did have reduced dive rates (from 2.6 dives per hour before to 1.6 dives per hour during) and deeper dives (from a mean of 124 m to 268 m) during a period of sonar exposure. Baird et al. (2016) also tagged four short-finned pilot whales from both the resident island-associated population and from the pelagic population. The core range for the pelagic population was over 20 times larger than for the pelagic population, leading Baird et al. (2016) to hypothesize that that likelihood of exposure to mid-frequency active sonar, and therefore the potential for response, would be very different between the two populations. These diverse examples demonstrate that responses can be varied, are often context- and behavior-driven, and can be species and even exposure specific.

Other opportunistic observations of behavioral responses to sonar have occurred as well, although in those cases it is difficult to attribute observed responses directly to the sonar exposure, or to know exactly what form the response took. For example, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test, with transmissions centered at 57 Hz and up to 220 dB re 1 µPa (Bowles et al., 1994), although it could not be determined whether the animals ceased sound production or left the area. In May 2003, killer whales in Haro Strait, Washington, exhibited what were believed by some observers to be aberrant behaviors, during which time the USS Shoup was in the vicinity and engaged in mid-frequency active sonar operations. Sound fields modeled for the USS Shoup transmissions (Fromm, 2009; National Marine Fisheries Service, 2005; U.S. Department of the Navy, 2004) estimated a mean received SPL of approximately 169 dB re 1 µPa at the location of the killer whales at the closest point of approach between the animals and the vessel (estimated SPLs ranged from 150 to 180 dB re 1 µPa). However, attributing the observed behaviors to any one cause is problematic given there were six nearby whale watch vessels surrounding the pod, and subsequent research has demonstrated that “Southern Residents modify their behavior by increasing surface activity (breaches, tail slaps, and pectoral fin slaps) and swimming in more erratic paths when vessels are close” (National Oceanic and Atmospheric Administration, 2014). Several odontocete species, including bottlenose dolphins, Risso’s dolphins, Pacific white-sided dolphins, and common dolphins have been observed near the Southern California Offshore Range during periods of mid-frequency active sonar; responses included changes in or cessation of vocalizations, changes in behavior, and leaving the area, and at the highest received levels animals were not present in the area at all (Henderson et al., 2014). However, these observations were conducted from a vessel off-range, and so any observed responses could not be attributed to the sonar with any certainty. Research on sperm whales in the Caribbean in 1983 coincided with the U.S. intervention in Grenada, where animals were observed scattering and leaving the area in the presence of military sonar, presumably from nearby submarines (Watkins et al., 1985; Watkins & Schevill, 1975). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull; therefore, it was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general.

During aerial and visual monitoring of Navy training events involving sonar, rough-toothed dolphins and unidentified dolphins were observed approaching the vessel with active sonar as if to bow ride, while spotted dolphins were observed nearby but did not avoid or approach the vessel (Mobley, 2011; U.S. Department of the Navy, 2011b; Watwood et al., 2012). During small boat surveys near the Southern California Offshore Range in southern California, more dolphins were encountered in June compared to a similar survey conducted the previous November after seven days of mid-frequency sonar activity; it was not investigated if this change was due to the sonar activity or was due to the poor weather conditions in November that may have prevented animals from being seen (Campbell et al., 2010). There were also fewer passive acoustic dolphin detections during and after longer sonar activities in the Mariana Islands Range Complex, with the post-activity absence lasting longer than the mean dolphin absence of two days when sonar was not present (Munger et al., 2014; Munger et al., 2015).

Acoustic harassment devices and acoustic deterrent devices, which transmit sound into the acoustic environment similar to Navy sources, have been used to deter marine mammals from fishing gear both to prevent entanglement and to reduce depredation (taking fish). These devices have been used successfully to deter harbor porpoises and beaked whales from getting entangled in fishing nets. For example, Kyhn et al. (2015) tested two types of pingers, one with a 10 kHz tone and one with a broadband 30–160 kHz sweep. Porpoise detection rates were reduced by 65 percent for the sweep and

40 percent for the tone, and while there was some gradual habituation after the first two to four exposures, longer term exposures (over 28 days) showed no evidence of additional habituation. Omeyer et al. (2020) also tested a 50–120 kHz pinger near harbor porpoise and found a 37 percent reduction in detections at the recorder near the pinger, but only a 9 percent reduction at a recorder 100 m away, indicating a response only occurred in relatively close proximity to the pinger. While clicking returned to normal levels as soon as the pinger was shut off (implying no long-term displacement), the response to the active pinger remained consistent over the nine-month study period, indicating no habituation occurred and the pingers remained an effective deterrent. Similarly, Kindt-Larsen et al. (2019) tested two pinger types in four configurations, and found that while both pingers effectively deterred harbor porpoises, their effect decreased with increasing distance (although their effective distance was limited to a few hundred m). In addition, a species' habituation to a pinger may occur with single tones but is less likely with a mixture of signals. Additionally, sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins & Schevill, 1975). However, acoustic harassment devices used to deter marine mammals from depredating long lines or aquaculture enclosures have proven less successful. For example, Tixier et al. (2014) used a 6.5 kHz pinger with a source level of 195 dB re 1 µPa on a longline to prevent depredation by killer whales, and although two groups of killer whales fled over 700 m away during the first exposure, they began depredating again after the third and seventh exposures, indicating rapid habituation. In a review of marine mammal deterrents, Schakner & Blumstein (2013) point out that both the characteristics of deterrents and the motivation of the animal play a role in the effectiveness of acoustic harassment devices. Deterrents that are strongly aversive or simulate a predator or are otherwise predictive of a threat are more likely to be effective, unless the animal habituates to the signal or learns that there is no true threat associated with the signal. In some cases net pingers may create a "dinner bell effect," where marine mammals have learned to associate the signal with the availability of prey (Jefferson & Curry, 1996; Schakner & Blumstein, 2013). This may be why net pingers have been more successful at reducing entanglements for harbor porpoise and beaked whales since these species are not depredating from the nets but are getting entangled when foraging in the area and are unable to detect the net (Carretta et al., 2008; Schakner & Blumstein, 2013). Niu et al. (2020; 2012) exposed captive dolphins to pulsed and continuous tonal signals to investigate acoustic deterrence. For all test frequencies, the dolphins increased surfacing distance relative to transducer, surfaced more often, and reduced clicks compared to baseline. Although some acclimatization was observed during daily tests, no habituation was observed over the full duration of the studies. Bowles and Anderson (2012) exposed a variety of species in captivity to novel objects, including a fishing net and anchor with line, both with and without a gillnet pinger. Responses varied broadly by species, with three species of pinniped showing mild avoidance of the net with the pinger. In contrast, the Pacific white-sided dolphin approached the gillnet without a pinger but avoided it completely when the pinger was added, and Commerson's dolphins demonstrated strong behavioral responses to the pinger including high speed swimming and other high energy behavior, increased use of a refuge pool, and increased rates of vocalizations. In further trials meant to test habituation, the Commerson's dolphins appeared to sensitize to the pinger instead, with even stronger aversive behavior.

Similarly, a 12 kHz acoustic harassment device intended to scare seals was ineffective at deterring seals but effectively caused avoidance in harbor porpoises out to over 500 m from the source, highlighting different species- and device-specific responses (Mikkelsen et al., 2017). Likewise, in a long term study of killer whale occurrence in inland waters off British Columbia, a region that had been used regularly from 1985 to 1993 showed a significant decrease in killer whale occurrence from 1993 to 1999 when four acoustic deterrent devices were deployed on seal farms; during the same time frame there was no evidence in a reduction in seals in the same area, although they were the intended targets of the devices (Morton & Symonds, 2002). During the same time period, no reduction in killer whale occurrence was detected at an adjacent location, leading to the conclusion that the killer whales were avoiding the area ensonified by the deterrent devices. Once the devices were removed, the killer whales returned to the affected area in similar numbers as had previously occurred. Additional behavioral studies have been conducted with captive harbor porpoises using acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al., 2006; Kastelein et al., 2001). These studies have found that high-frequency sources with varied duration, interval, and sweep characteristics can prove to be effective deterrents for harbor porpoises (Kastelein et al., 2017d). Van Beest et al. (2017) modeled the long-term, population-level impacts of fisheries bycatch, pinger deterrents, and time-area closures on a population of harbor porpoises. They found that when pingers were used alone (in the absence of gillnets or time-area closures), the animals were deterred from the area often enough to cause a population-level reduction of 21 percent, greater even than the modeled level of current bycatch impacts. However, when the pingers were coupled with gillnets in the model, and time-area closures were also used (allowing a net- and pinger-free area for the porpoises to move into while foraging), the population only experienced a 0.8 percent decline even with current gillnet use levels. This demonstrates that, when used correctly, pingers can successfully deter porpoises from gillnets without leading to any negative impacts.

Controlled experiments have also been conducted on captive animals to estimate received levels at which behavioral responses occur. In one study, bottlenose dolphin behavioral responses were recorded when exposed to 3 kHz sonar-like tones between 115 and 185 dB re 1 μPa (Houser et al., 2013a), and in another study bottlenose dolphins and beluga whales were presented with one-second tones up to 203 dB re 1 μPa to measure TTS (Finneran et al., 2003a; Finneran et al., 2001; Finneran et al., 2005b; Finneran & Schlundt, 2004; Schlundt et al., 2000). During these studies, responses included changes in respiration rate, fluke slaps, and a refusal to participate or return to the location of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al., 2002; Schlundt et al., 2000). In the behavioral response study, bottlenose dolphins demonstrated a 50 percent probability of response at 172 dB re 1 μPa over 10 trials. In the TTS experiment, bottlenose dolphins exposed to one-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa; beluga whales did so at received levels of 180 to 196 dB re 1 μPa and above. In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al., 1997; Schlundt et al., 2000). While animals were commonly reinforced with food during these studies, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to noise sources.

Behavioral responses to a variety of sound sources have been studied in captive harbor porpoises, including acoustic alarms (Kastelein et al., 2006; Kastelein et al., 2001), emissions for underwater data transmission (Kastelein et al., 2005b), and tones, including 1−2 kHz and 6−7 kHz sweeps with and without harmonics (Kastelein et al., 2014c), 25 kHz with and without sidebands (Kastelein et al., 2015f; Kastelein et al., 2015g), and mid-frequency sonar tones at 3.5–4.1 kHz at 2.7 percent and 96 percent duty cycles (e.g., one tone per minute versus a continuous tone for almost a minute) (Kastelein et al., 2018b). Responses include increased respiration rates, more jumping, or swimming further from the source, but responses were different depending on the source. For example, harbor porpoises responded to the 1−2 kHz upsweep at 123 dB re 1 μPa, but not to the downsweep or the 6−7 kHz tonal at the same level (Kastelein et al., 2014c). When measuring the same sweeps for a startle response, the 50 percent response threshold was 133 and 101 dB re 1 μPa for 1−2 kHz and 6−7 kHz sweeps, respectively, when no harmonics were present, and decreased to 90 dB re 1 μPa for 1−2 kHz sweeps with harmonics present (Kastelein et al., 2014c). Harbor porpoises did not respond to the low-duty cycle mid-frequency tones at any received level, but one did respond to the high-duty cycle signal with more jumping and increased respiration rates (Kastelein et al., 2018b). Harbor porpoises responded to seal scarers with broadband signals up to 44 kHz with a slight respiration response at 117 dB re 1 μPa and an avoidance response at 139 dB re 1 μPa, but another scarer with a fundamental (strongest) frequency of 18 kHz did not have an avoidance response until 151 dB re 1 μPa (Kastelein et al., 2015e). Exposure of the same acoustic pinger to a striped dolphin under the same conditions did not elicit a response (Kastelein et al., 2006), again highlighting the importance in understanding species differences in the tolerance of underwater noise, although sample sizes in these studies was small so these could reflect individual differences as well. Lastly, Kastelein et al. (2019a) examined the potential masking effect of high sea state ambient noise on captive harbor porpoise perception of and response to high duty cycle playbacks of AN/SQS-53C sonar signals by observing their respiration rates. Results indicated that sonar signals were not masked by the high sea state noise, and received levels at which responses were observed were similar to those observed in prior studies of harbor porpoise behavior.

Behavioral responses by odontocetes to sonar and other transducers appear to range from no response at all to responses that could potentially lead to long-term consequences for individual animals (e.g., mother-calf separation). This is likely in part due to the fact that this taxonomic group is so broad and includes some of the most sensitive species (e.g., beaked whales and harbor porpoise) as well as some of the least sensitive species (e.g., bottlenose dolphins). This is also the only group for which both field behavioral response studies and captive controlled exposure experiments have been conducted, leading to the assessment of both contextually driven responses as well as dose-based responses. This wide range in both exposure situations and individual- and species-sensitivities makes reaching general conclusions difficult. However, it does appear as though exposures in close proximity, with multiple vessels that approach the animal lead to higher-level responses in most odontocete species regardless of received level or behavioral state. In contrast, in more "real-world" exposure situations, with distant sources moving in variable directions, behavioral responses appear to be driven by behavioral state, individual experience or species-level sensitivities. These responses may also occur more in-line with received level such that the likelihood of a response would increase with increased received levels. However, these "real-world" responses are more likely to be short term, lasting the duration of the exposure or even shorter as the animal assesses the sound and (based on prior experience or contextual cues) determines a threat is unlikely. Therefore, while odontocete behavioral responses to Navy sonar will vary across species, populations, and individuals, they are not likely to lead to long-term consequences or population-level effects.

Pinnipeds

Different responses displayed by captive and wild phocid seals to sound judged to be "unpleasant" or threatening have been reported, including habituation by captive seals (they did not avoid the sound), and avoidance behavior by wild seals (Götz & Janik, 2010). Captive seals received food (reinforcement) during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an animal tolerates or habituates to novel or unpleasant sounds. Another study found that captive hooded seals reacted to 1–7 kHz sonar signals, in part with displacement (i.e., avoidance) to the areas of least SPL, at levels between 160 and 170 dB re 1 µPa (Kvadsheim et al., 2010b); however, the animals adapted to the sound and did not show the same avoidance behavior upon subsequent exposures. Captive harbor seals responded differently to three signals at 25 kHz with different waveform characteristics and duty cycles. The seals responded to the frequency modulated signal at received levels over 137 dB re 1 µPa by hauling out more, swimming faster, and raising their heads or jumping out of the water, but did not respond to the continuous wave or combination signals at any received level (up to 156 dB re 1 µPa) (Kastelein et al., 2015d). Captive California sea lions were exposed to mid-frequency sonar at various received levels (125–185 dB re 1 µPa) during a repetitive task (Houser et al., 2013a). Behavioral responses included a refusal to participate, hauling out, an increase in respiration rate, and an increase in the time spent submerged. Young animals (less than two years old) were more likely to respond than older animals. Dose-response curves were developed both including and excluding those young animals. The majority of responses below 155 dB re 1 µPa were changes in respiration, whereas over 170 dB re 1 µPa more severe responses began to occur (such as hauling out or refusing to participate); many of the most severe responses came from the younger animals.

Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source centered at 75 Hz, with received levels between 118 and 137 dB re 1 µPa, were not found to overtly affect elephant seal dives (Costa et al., 2003). However, they did produce subtle effects that varied in direction and degree among the individual seals, again illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Harbor seals exposed to seal scarers (i.e., acoustic harassment devices) used to deter seals from fishing nets did not respond at levels of 109–134 dB re 1 µPa and demonstrated minor responses by occasionally hauling out at 128–138 dB re 1 µPa (Kastelein et al., 2015c). Pingers have also been used to deter marine mammals from fishing nets; in some cases, this has led to the "dinner bell effect," where the pinger becomes an attractant rather than a deterrent (Carretta & Barlow, 2011). Steller sea lions were exposed to a variety of tonal, sweep, impulse and broadband sounds. The broadband sounds did not cause a response, nor did the tones at levels below 165 dB re 1 µPa at 1 m, but the 8 kHz tone and 1–4 kHz sweep at source levels of 165 dB re 1 µPa caused the sea lions to haul out (Akamatsu et al., 1996).

Similar to the other taxonomic groups assessed, pinniped behavioral responses to sonar and other transducers seem to be mediated by the contextual factors of the exposure, including the proximity of the source, the characteristics of the signal, and the behavioral state of the animal. However, all pinniped behavioral response studies have been conducted in captivity, so while these results may be broadly applied to real-world exposure situations, it must be done with caution. Based on exposures to other sound sources in the wild (e.g., impulsive sounds and vessels), pinnipeds are not likely to respond strongly to Navy sonar that is not in close proximity to the animal or approaching the animal.

Sea Otters

There is no research on the effects of sonar on sea otters. Sea otters spend approximately 80 percent of their time on the surface of the water (Curland, 1997) with their heads above the surface, which reduces their exposure to underwater sounds. They may show similar reactions to those of pinnipeds which are also amphibious hearers. However, underwater hearing sensitivities are significantly reduced in sea otters when compared to pinnipeds (Ghoul & Reichmuth, 2014a, 2014b), so any reactions may have lower overall severity. Pinnipeds may haul out, swim faster, or increase their respiration rate in response to sonar (Houser et al., 2013a; Kastelein et al., 2015d). Pinnipeds also showed that they may avoid an area temporarily, but may habituate to sounds quickly (Kvadsheim et al., 2010a; Kvadsheim et al., 2010b). Deviations from pinniped behavior could be a result of sea otter dives being energetically costly (i.e., requiring twice the metabolic energy that phocid seals need to dive). Therefore, sea otters may not dive or travel far in response to disturbance, as they already require long periods of rest at the surface to counterbalance the high metabolic cost of foraging at sea (Yeates et al., 2007). Sea otters may also habituate to sonar signals. However, the typical sea otter habitat (water less than 100 m in depth) is far inshore of the TMAA and the location for most Navy activities and so sea otters are unlikely be exposed to or impacted by Navy use of sonar or other transducers.

Behavioral Reactions to Vessel Noise

Sound emitted from large vessels, such as cargo ships, is the principal source of low-frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Erbe et al., 2019; Hatch & Wright, 2007; Hildebrand, 2005; Richardson et al., 1995b). For example, Erbe et al. (2012) estimated the maximum annual underwater SEL from vessel traffic near Seattle was 215 dB re 1 $\mu Pa^2 s$, and Bassett et al. (2010) measured mean SPLs at Admiralty Inlet from commercial shipping at 117 dB re 1 μPa with a maximum exceeding 135 dB re 1 μPa on some occasions. Similarly, Veirs et al. (2015) found average broadband noise levels in Haro Strait to be 110 dB re 1 μPa that extended up to 40 kHz, well into the hearing range of odontocetes.

Many studies of behavioral responses by marine mammals to vessels have been focused on the short-and long-term impacts of whale watching vessels. In short-term studies, researchers noted changes in resting and surface behavior states of cetaceans to whale watching vessels (Acevedo, 1991; Aguilar de Soto et al., 2006; Arcangeli & Crosti, 2009; Au & Green, 2000; Christiansen et al., 2010; Erbe, 2002; Noren et al., 2009; Stockin et al., 2008; Williams et al., 2009). Received levels were often not reported so it is difficult to distinguish responses to the presence of the vessel from responses to the vessel noise. Most studies examined the short-term response to vessel sound and vessel traffic (Magalhães et al., 2002; Richardson et al., 1995b; Watkins, 1981), with behavioral and vocal responses occurring when received levels were over 20 dB greater than ambient noise levels. Other research has attempted to quantify the effects of whale watching using focused experiments (Meissner et al., 2015; Pirotta et al., 2015b).

The impact of vessel noise has received increased consideration, particularly as whale watching and shipping traffic has risen (McKenna et al., 2012; Pirotta et al., 2015b; Veirs et al., 2015). Odontocetes and mysticetes in particular have received increased attention relative to vessel noise and vessel traffic, with pinnipeds and sea otters less so. The impacts of ship noise on marine mammals also appear to be largely context- and species-dependent (Erbe et al., 2019). Still, not all species in all taxonomic groups have been studied, and so results do have to be extrapolated across these broad categories in order to assess potential impacts.

Mysticetes

Baleen whales demonstrate a variety of responses to vessel traffic and noise, from not responding at all to both horizontal (swimming away) and vertical (increased diving) avoidance (Baker et al., 1983; Fiori et al., 2019; Gende et al., 2011; Watkins, 1981). Other common responses include changes in vocalizations, call rate, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au & Green, 2000; Dunlop, 2019; Fournet et al., 2018; Machernis et al., 2018; Richter et al., 2003; Williams et al., 2002a).

The likelihood of response may be driven by the distance, speed, approach, or noise level of the vessel, the animal's behavioral state, or by the prior experience of the individual or population. For example, in one study fin and humpback whales largely ignored vessels that remained 100 m or more away (Watkins, 1981). In another study, minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots) at a distance of 5.5 NM. However, when the vessel drifted or moved at very slow speeds (about 1 knot), many whales approached it (Leatherwood et al., 1982). Similarly, Bernasconi et al. (2012) observed the reactions of six individual baleen whales of unknown species at distances of 50–400 m from a fishing vessel conducting an acoustic survey of pelagic fisheries, with only a slight change in swim direction when the vessel began moving around the whales. Gray whales were likely to continue feeding when approached by a vessel in areas with high motorized vessel traffic, but in areas with less motorized vessel traffic they were more likely to change behaviors, either indicating habituation to vessels in high traffic area, or indicating possible startle reactions to close-approaching non-motorized vessels (e.g., kayaks) in quieter areas (Sullivan & Torres, 2018). Changes in behavior of humpback whales when vessels came within 500 m were also dependent on behavioral state such that they would keep feeding but were more likely to start traveling if they were surface active when approached (Di Clemente et al., 2018). Changes in humpback whale behavior were also affected by time of day, season, or the type of vessel approach (Di Clemente et al., 2018; Fiori et al., 2019). Avoidance responses occurred most often after "J" type vessel approaches (i.e., traveling parallel to the whales' direction of travel, then overtaking the whales by turning in front of the group) compared to parallel or direct approaches; mother humpbacks were particularly sensitive to direct and J type approaches and spent significantly more time diving in response (Fiori et al., 2019). Humpback whales changed their acoustic and social behavior when vessels were present; their communication area was reduced by half in average vessel-dominated noise (105 dB re 1 µPa), but the physical presence of vessels was the major contributing factor to decreased social interactions (Dunlop, 2019). In contrast, for resting humpback whale mother-calf pairs, the presence of a passing vessel did not change their behavior, but fast vessels with louder low-frequency weighted source levels of 173 dB re 1 µPa, equating to weighted received levels of 133 dB re 1 µPa at an average distance of 100 m, led to a decrease in resting behavior and increase in dives, swim speeds, and respiration rates (Sprogis et al., 2020). Migrating humpback whales reacted similarly to vessels towing seismic air gun arrays, regardless of whether the air guns were active or not; this indicates that it was the presence of ships (rather than the active air guns) that reduced social interactions between males and mother-calf pairs (Dunlop et al., 2020).

In response to an approaching large commercial vessel in an area of high ambient noise levels (125–130 dB re 1 µPa), a tagged female blue whale turned around mid-ascent and descended perpendicular to the ship's path (Szesciorka et al., 2019). The whale did not respond until the ship's closest point of approach (100 m distance, 135 dB re 1 µPa), which was only 10 dB above the ambient noise levels. After the ship passed, the whale ascended to the surface again with a three-minute delay. However, other species of mysticete have demonstrated their lack of reaction to vessel noise. Sei whales have been observed ignoring the presence of vessels entirely and even passing close to the vessel (Reeves et al., 1998), and North Atlantic right whales tend not to respond to the sounds of oncoming vessels and continue to use habitats in high vessel traffic areas (Nowacek et al., 2004). Studies show that North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves. This lack of response may be due to habituation to the presence and associated noise of vessels in right whale habitat, or may be due to propagation effects that may attenuate vessel noise near the surface (Nowacek et al., 2004; Terhune & Verboom, 1999).

When baleen whales do respond to vessels, responses can be as minor as a change in breathing patterns (e.g., Baker et al., 1983; Jahoda et al., 2003), or can be evidenced by a decrease in overall presence, as was observed during a construction project in the United Kingdom, when fewer minke whales were observed as vessel traffic increased (Anderwald et al., 2013). Avoidance responses can be as simple as an alteration in swim patterns or direction by increasing speed and heading away from the vessel (Jahoda et al., 2003), or by increasing swim speed, changing direction to avoid, and staying submerged for longer periods of time (Au & Green, 2000). For example, in the presence of approaching vessels, blue whales perform shallower dives accompanied by more frequent surfacing but otherwise do not exhibit strong reactions (Calambokidis et al., 2009). In another study in Hawaii, humpback whales exhibited two forms of behavioral avoidance: horizontal avoidance (changing direction or speed) when vessels were between 2,000 m and 4,000 m away, and vertical avoidance (increased dive times and change in diving pattern) when vessels were less than 2,000 m away (Baker et al., 1983). Similarly, humpback whales in Australia demonstrated variable responses to whale watching vessels, including both horizontal avoidance, approaching, and changes in dive and surface behavior (Stamation et al., 2010). Humpback whales demonstrated similar responses to tourist vessels in Alaska, with increased respiration rates when the time spent near vessels increased, increased swim speeds and more non-linear movement (Schuler et al., 2019). In addition, while foraging and traveling behavior states were likely to be maintained in the presence of tourist vessels, surface active behavior was more likely to transition to traveling behavior. Humpback whales avoided a Navy vessel by increasing their dive times and decreasing respiration rates at the surface (Smultea et al., 2009). Williamson et al. (2016) specifically looked at close approaches to humpback whales by small research boats for the purposes of tagging. They found that while dive behavior did not change for any groups, some groups did increase their speed and change their course during or right after the approach, but resumed pre-approach speed and heading shortly thereafter. Only mother-calf groups were found to increase their speed during the approach and maintain the increased speed for longer after the approach, but these groups too resumed normal swim speeds after about 40 minutes. It should be noted that there were no responses by any groups that were approached closely but with no attempts at tagging, indicating that the responses were not due to the vessel presence but to the tagging attempt. In addition, none of the observed changes in behavior were outside the normal range of swim speeds or headings for these migrating whales.

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. Based on passive acoustic recordings and in the presence of sounds from passing vessels, Melcón et al. (2012) reported that blue whales had an increased likelihood of producing certain types of calls. While humpback whale call repetition and rate has increased in association with high vessel noise (Doyle et al., 2008), a recent study with stringent inclusion criteria found that the probability of humpback whale calls decreased as vessel noise increased (Fournet et al., 2018). The amplitude of humpback whale calls did not change in the absence or presence of vessel noise. However, feeding calls increased amplitude with higher levels of any (i.e., weather or vessel) ambient noise (Fournet et al., 2018). Boat traffic has been a cause of decreased humpback song activity near Brazil (Sousa-Lima & Clark, 2008), and decreased frequency parameters of fin whale calls (Castellote et al., 2012). Bowhead whales avoided the area around icebreaker ship noise and increased their time at the surface and number of blows (Richardson et al., 1995a). Right whales increase the amplitude or frequency of their vocalizations or call at a lower rate in the presence of increased vessel noise (Parks et al., 2007; Parks et al., 2011), and these vocalization changes may persist over long periods if background noise levels remained elevated. Humpback whales increase the source levels of their calls with increased ambient noise levels that include vessel noise, but the probability of calling is also decreased when vessel noise was part of the soundscape (Fournet et al., 2018).

The long-term consequences of vessel noise are not well understood (see Section 3.8.3.1.1.7, Long-Term Consequences). In a short-term study, minke whales on feeding grounds in Iceland responded to increased whale watching vessel traffic with a decrease in foraging, both during deep dives and at the surface (Christiansen et al., 2013). They also increased their avoidance of the boats while decreasing their respiration rates, likely leading to an increase in their metabolic rates. Christiansen and Lusseau (2015) and Christiansen et al. (2014) followed up this study by modeling the cumulative impacts of whale watching boats on minke whales, but found that although the boats cause temporary feeding disruptions, there were not likely to be long-term consequences as a result. This suggests that short-term responses may not lead to long-term consequences and that over time animals may habituate to the presence of vessel traffic. However, in an area of high whale watch activity, vessels were within 2,000 m of blue whales 70 percent of the time, with a maximum of 8 vessels observed within 400 m of one whale at the same time. This study found reduced surface time, fewer breaths at the surfaced, and shorter dive times when vessels were within 400 m (Lesage et al., 2017). Since blue whales in this area forage 68 percent of the time, and their foraging dive depths are constrained by the location of prey patches, these reduced dive durations may indicate reduced time spent foraging by over 36 percent. In the short term this reduction may be compensated for, but prolonged exposure to vessel traffic could lead to long-term consequences. Using historical records, Watkins (1986) showed that the reactions of four species of mysticetes to vessel traffic and whale watching activities in Cape Cod had changed over the 25-year period examined (1957–1982). Reactions of minke whales changed from initially more positive reactions, such as coming towards the boat or research equipment to investigate, to more uninterested reactions towards the end of the study. Fin whales, the most numerous species in the area, showed a trend from initially more negative reactions, such as swimming away from the boat with limited surfacing, to more uninterested reactions (ignoring) allowing boats to approach within 30 m Right whales showed little change over the study period, with a roughly equal number of reactions judged to be negative and uninterested; no right whales were noted as having positive reactions to vessels. Humpback whales showed a trend from negative to positive reactions with vessels during the study period. The author concluded that the whales had habituated to the human activities over time (Watkins, 1986).

Overall baleen whale responses to vessel noise and traffic are varied but are generally minor, and habituation or disinterest seems to be the predominant long-term response. When baleen whales do avoid ships, they do so by altering their swim and dive patterns to move away from the vessel, but no strong reactions have been observed. In fact, in many cases the whales do not appear to change their behavior at all. This may result from habituation by the whales, but may also result from reduced received levels near the surface due to propagation, or due to acoustic shadowing of the propeller cavitation noise by the ship's hull. Although a lack of response in the presence of a vessel may minimize potential disturbance from passing ships, it does increase the whales' vulnerability to vessel strike, which may be of greater concern for baleen whales than vessel noise.

Odontocetes

Most odontocetes react neutrally to vessels, although both avoidance and attraction behavior have been observed (Hewitt, 1985; Würsig et al., 1998). Würsig et al. (1998) found that Kogia whales and beaked whales were the most sensitive species to vessels, and reacted by avoiding marine mammal survey vessels in 73 percent of sightings, more than any other odontocetes. Avoidance reactions include a decrease in resting behavior or change in travel direction (Bejder et al., 2006a). Incidents of attraction include common, rough-toothed, and bottlenose dolphins bow riding and jumping in the wake of a vessel (Norris & Prescott, 1961; Ritter, 2002; Shane et al., 1986; Würsig et al., 1998). A study of vessel reactions by dolphin communities in the eastern tropical Pacific found that populations that were often the target of tuna purse-seine fisheries (spotted, spinner, and common dolphins) show evasive behavior when approached; however, populations that live closer to shore (within 100 NM; coastal spotted and bottlenose dolphins) that are not set on by purse-seine fisheries tend to be attracted to vessels (Archer et al., 2010). The presence of vessels has also been shown to interrupt feeding behavior in delphinids (Meissner et al., 2015; Pirotta et al., 2015b).

Short-term displacement of dolphins due to tourist boat presence has been documented (Carrera et al., 2008), while longer term or repetitive/chronic displacement for some dolphin groups due to chronic vessel noise has been noted (Haviland-Howell et al., 2007). Delphinid behavioral states also change in the presence of tourist boats that often approach animals, with travel and/or resting increasing and foraging and social behavior decreasing (Cecchetti et al., 2017; Clarkson et al., 2020; Kassamali-Fox et al., 2020; Meissner et al., 2015). Most studies of the behavioral reactions to vessel traffic of bottlenose dolphins have documented at least short-term changes in behavior, activities, or vocalization patterns when vessels are near, although the distinction between vessel noise and vessel movement has not been made clear (Acevedo, 1991; Arcangeli & Crosti, 2009; Berrow & Holmes, 1999; Fumagalli et al., 2018; Gregory & Rowden, 2001; Janik & Thompson, 1996; Lusseau, 2004; Marega et al., 2018; Mattson et al., 2005; Scarpaci et al., 2000). Steckenreuter (2011) found bottlenose dolphin groups to feed less, become more tightly clustered, and have more directed movement when approached to 50 m than groups approached to 150 m or approached in a controlled manner. Guerra et al. (2014) demonstrated that bottlenose dolphins subjected to chronic noise from tour boats responded to boat noise by alterations in group structure and in vocal behavior but also found the dolphins' reactions varied depending on whether the observing research vessel was approaching or moving away from the animals being observed. This demonstrates that the influence of the sound exposure cannot be decoupled from the physical presence of a surface vessel, thus complicating interpretations of the relative contribution of each stimulus to the response. Indeed, the presence of surface vessels, their approach, and speed of approach, seemed to be significant factors in the response of the Indo-Pacific humpback dolphins (Ng & Leung, 2003).

The effects of tourism and whale watching have highly impacted killer whales, such as the Northern and Southern Resident populations. These animals are targeted by numerous small whale watching vessels in the Pacific Northwest and, from 1998 to 2012 during the viewing season, have had an annual monthly average of nearly 20 vessels of various types within 0.5 miles of their location during daytime hours (Clark, 2015; Eisenhardt, 2014; Erbe et al., 2014). These vessels have source levels that ranged from 145 to 169 dB re 1 µPa and produce broadband noise up to 96 kHz. While new regulations on the distance boats had to maintain were implemented, there did not seem to be a concurrent reduction in the received levels of vessel noise, and noise levels were found to increase with more vessels and faster moving vessels (Holt et al., 2017). These noise levels have the potential to result in behavioral disturbance, interfere with communication, and affect the killer whales' hearing capabilities via masking (Erbe, 2002; Veirs et al., 2015). Killer whales foraged significantly less and traveled significantly more when boats were within 100 m of the whales (Kruse, 1991; Lusseau et al., 2009; Trites & Bain, 2000; Williams et al., 2002a; Williams et al., 2009; Williams et al., 2002b). These short-term feeding activity disruptions may have important long-term population-level effects (Lusseau et al., 2009; Noren et al., 2009). As with other delphinids, the reaction of the killer whales to whale watching vessels may be in response to the vessel pursuing them rather than to the noise of the vessel itself, or to the number of vessels in their proximity. Williams et al. (2014b) modeled behavioral responses of killer whales to vessel traffic by looking at their surface behavior relative to the received level of three large classes of ships. The authors found that the severity of the response was largely dependent on seasonal data (e.g., year and month) as well as the animal's prior experience with vessels (e.g., age and sex), and the number of other vessels present, rather than the received level of the larger ships (Williams et al., 2014b).

Sperm whales generally react only to vessels approaching within several hundred m; however, some individuals may display avoidance behavior, such as quick diving (Magalhães et al., 2002; Würsig et al., 1998) or a decrease in time spent at the surface (Isojunno & Miller, 2015). One study showed that after diving, sperm whales showed a reduced timeframe before they emitted the first click than prior to a vessel interaction (Richter et al., 2006). Smaller whale watching and research vessels generate more noise in higher frequency bands and are more likely to approach odontocetes directly, and to spend more time near an individual whale. Azzara et al. (2013) also found a reduction in sperm whale clicks while a vessel was passing, as well as up to a half hour after the vessel had passed. It is unknown whether the whales left the area, ceased to click, or surfaced during this period. However, some of the reduction in click detections may be due to masking of the clicks by the vessel noise, particularly during the closest point of approach.

Little information is available on the behavioral impacts of vessels or vessel noise on beaked whales (Cox et al., 2006), although it seems most beaked whales react negatively to vessels by quick diving and other avoidance maneuvers (Würsig et al., 1998). Limited evidence suggests that beaked whales respond to vessel noise, anthropogenic noise in general, and mid-frequency sonar at similar sound levels (Aguilar de Soto et al., 2006; Tyack et al., 2011; Tyack, 2009). An observation of vocal disruption of a foraging dive by a Cuvier's beaked whale when a large, noisy vessel passed suggests that some types of vessel traffic may disturb foraging beaked whales (Aguilar de Soto et al., 2006). Tyack et al. (2011) noted the result of a controlled exposure to pseudorandom noise suggests that beaked whales would respond to vessel noise at similar received levels to those noted previously for mid-frequency sonar. Pirotta et al. (2012) found that while the distance to a vessel did not change the duration of a foraging dive, the proximity of the vessel may have restricted the movement of the group. The maximum distance at which this change was significant was 5.2 km, with an estimated received level of 135 dB re 1 µPa.

Small dolphins and porpoises may also be more sensitive to vessel noise. Both finless porpoises (Li et al., 2008) and harbor porpoises (Polacheck & Thorpe, 1990) routinely avoid and swim away from large motorized vessels, and harbor porpoises may click less when near large ships (Sairanen, 2014). A resident population of harbor porpoise in Swansea Bay are regularly near vessel traffic, but only 2 percent of observed vessels had interactions with porpoises in one study (Oakley et al., 2017). Of these, 74 percent of the interactions were neutral (no response by the porpoises) while vessels were 10 m–1 km away. Of the 26 percent of interactions in which there was an avoidance response, most were observed in groups of 1–2 animals to fast-moving or steady plane-hulling motorized vessels. Larger groups reacted less often, and few responses were observed to non-motorized or stationary vessels. Another study found that when vessels were within 50 m, harbor porpoises had an 80 percent probability of changing their swimming direction when vessels were fast moving; this dropped to 40 percent probability when vessels were beyond 400 m (Akkaya Bas et al., 2017). These porpoises also demonstrated a reduced proportion of feeding and shorter behavioral bout durations in general, if vessels were in close proximity, 62 percent of the time. Although most vessel noise is constrained to lower frequencies below 1 kHz, at close range vessel noise can extend into mid- and high-frequencies (into the tens of kHz) (Hermannsen et al., 2014; Li et al., 2015); these frequencies are what harbor porpoises are likely responding to, at M-weighted received SPLs with a mean of 123 dB re 1 µPa (Dyndo et al., 2015). Foraging harbor porpoises also have fewer prey capture attempts and have disrupted foraging when vessels pass closely and noise levels are higher (Wisniewska et al., 2018). Hermannsen et al. (2019) estimated that noise in the 16 kHz frequency band resulting from small recreational vessels not equipped with an Automatic Identification System and therefore not included in most vessel noise impact models could be elevated up to 124 dB re 1 µPa and raise ambient levels up to 51 dB; these higher levels were associated with vessel speed and range. Using the threshold levels found by Dyndo et al. (2015) and Wisniewska et al. (2018), these authors determined that recreational vessel noise in the 16 kHz band could cause behavioral responses in harbor porpoises, and that those thresholds were exceeded by 49–85 percent of high noise events.

Odontocetes have been shown to make short-term changes to vocal parameters such as intensity as an immediate response to vessel noise, as well as increase the pitch, frequency modulation, and length of whistling (May-Collado & Wartzok, 2008), with whistle frequency increasing in the presence of low-frequency noise and whistle frequency decreasing in the presence of high-frequency noise (Gospić & Picciulin, 2016). For example, bottlenose dolphins in Portuguese waters decrease their call rates and change the frequency parameters of whistles in the presence of boats (Luís et al., 2014), while dolphin groups with calves increase their whistle rates when tourist boats are within 200 m and when the boats increase their speed (Guerra et al., 2014). Likewise, modification of multiple vocalization parameters was shown in belugas residing in an area known for high levels of commercial traffic. These animals decreased their call rate, increased certain types of calls, and shifted upward in frequency content in the presence of small vessel noise (Lesage et al., 1999). Another study detected a measurable increase in the amplitude of their vocalizations when ships were present (Scheifele et al., 2005). Killer whales are also known to modify their calls during increased noise. For example, the source level of killer whale vocalizations was shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect) (Holt et al., 2008). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al., 2011). On the other hand, long-term modifications to vocalizations may be indicative of a learned response to chronic noise, or of a genetic or physiological shift in the populations. This type of change has been observed in killer whales off the northwestern coast of the United States between 1973 and 2003. This population increased the duration of primary calls once a threshold in observed vessel density (e.g., whale watching) was reached, which is suggested as being a long-term response to increased masking noise produced by the vessels (Foote et al., 2004).

The long-term and cumulative implications of ship sound on odontocetes is largely unknown (National Academies of Sciences Engineering and Medicine, 2017; National Marine Fisheries Service, 2007a), although some long-term consequences have been reported (Lusseau & Bejder, 2007). Repeated exposure to acoustic and other anthropogenic stimuli has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins in New Zealand responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin et al., 2008). The authors speculated that repeated interruptions of the dolphins' foraging behaviors could lead to long-term implications for the population. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found stronger and longer lasting reactions in populations of animals that were exposed to lower levels of vessel traffic overall. The authors indicated that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Similar to mysticetes, odontocete responses to vessel noise are varied, although many odontocete species seem to be more sensitive to vessel presence and vessel noise, and these two factors are difficult to tease apart. Some species, in particular killer whales and porpoises, may be sensitized to vessels and respond at further distances and lower received levels than other delphinids. In contrast, many odontocete species also approach vessels to bow ride, indicating either that these species are less sensitive to vessels, or that the behavioral drive to bow ride supersedes any impact of the associated noise. With these broad and disparate responses, it is difficult to assess the impacts of vessel noise on odontocetes.

Pinnipeds

Pinniped reactions to vessels are variable and reports include a wide spectrum of possibilities from avoidance and alert, to cases where animals in the water are attracted, and cases on land where there is lack of significant reaction suggesting habituation to or tolerance of vessels (Richardson et al., 1995b). Specific case reports in Richardson et al. (1995b) vary based on factors such as routine anthropogenic activity, distance from the vessel, engine type, wind direction, and ongoing subsistence hunting. As with reactions to sound reviewed by Southall et al. (2007), pinniped responses to vessels are affected by the context of the situation and by the animal’s experience.

Anderwald et al. (2013) investigated grey seal reactions to an increase in vessel traffic off Ireland’s coast in association with construction activities, and their data suggest the number of vessels had an indeterminate effect on the seals’ presence. Harbor seals haul out on tidewater glaciers in Alaska, and most haul outs occur during pupping season. Blundell & Pendleton (2015) found that the presence of any vessel reduces haul out time, but cruise ships and other large vessels in particular shorten haul out times. Another study of reactions of harbor seals hauled out on ice to cruise ship approaches in Disenchantment Bay, Alaska, revealed that animals are more likely to flush and enter the water when cruise ships approach within 500 m and four times more likely when the cruise ship approaches within 100 m (Jansen et al., 2010). Karpovich et al. (2015) also found that harbor seal heart rates increased when vessels were present during haul out periods, and increased further when vessels approached and animals re-entered the water. Harbor seals responded more to vessels passing by haul out sites in areas with less overall vessel activity, and the model best predicting their flushing behavior included the number of boats, type of boats, and distance to boats. More flushing occurred to non-motorized vessels (e.g., kayaks), likely because they tended to occur in groups rather than as single vessels, and tended to pass closer (25–184 m) to the haul out sites than motorized vessels (55–591 m) (Cates & Acevedo-Gutiérrez, 2017). Jones et al. (2017) modeled the spatial overlap of vessel traffic and grey and harbor seals in the UK, and found most overlap to occur within 50 km of the coast, and high overlap occurring within 5 of 13 grey seal Special Areas of Conservation and within 6 of 12 harbor seal Special Areas of Conservation. They also estimated received levels of shipping noise and found maximum daily M-weighted cumulative SEL values from 170 to 189 dB, with the upper confidence intervals of those estimates sometimes exceeding TTS values. However, there was no evidence of reduced population size in an of these high overlap areas.

Mikkelsen et al. (2019) used long-term biologgers (DTAGs) on harbor seals and grey seals to opportunistically examine behaviors. The data showed that seals were exposed to vessel noise between 2.2 and 20.5 percent of their time in water. Potential responses to vessels included interruption of resting and foraging behaviors.

Sea Otters

Sea otters have similar in-air hearing sensitivities as pinnipeds (Ghoul & Reichmuth, 2014a, 2014b), and may react in a similar fashion when approached by vessels. Sea otters depend on visual acuity to forage, so while their eyes are able to focus both in air and underwater (Riedman & Estes, 1990), their underwater hearing sensitivities are significantly reduced compared to pinnipeds (Ghoul & Reichmuth, 2014a, 2014b). While reactions to underwater vessel noise may occur, they will have lower overall severity to those of pinnipeds. Sea otters in Monterey, CA that were living in areas of disturbance from human activity such as recreational boating spent more time engaged in travel than resting (Curland, 1997). Sea otters in undisturbed areas spent 5 percent of their time travelling; otters in areas of disturbance due to vessels were shown to spend 13 percent of their time travelling (Curland, 1997). While this may not appear to be a large change in behavior, sea otter dives are very costly and require twice the metabolic energy that phocid seals need to dive; therefore sea otters may not dive or travel far in response to disturbance, as they already require long periods of rest at the surface to counterbalance the high cost of foraging at sea (Yeates et al., 2007). For example, when a single air gun vessel passed a large raft of otters, several otters were mildly alarmed (e.g., rolled over on their sides or bellies and looked intently at the vessel as it approached) but did not leave the raft. However, they reacted to the vessel every time it passed, even though the air gun was only operational for two of the four passes. This indicates that otters were either responding to the loud airborne sounds of the boat engines and compressor, or to the close approach of the vessel itself, rather than the seismic sounds (Reidman, 1983). However, sea otters may habituate quickly. Even when purposefully harassed in an effort to cause a behavioral response, sea otters generally moved only a short distance (100 to 200 m) before resuming normal activity, and nearby boats, nets, and floating oil containment booms were sometimes an attractant (Davis et al., 1988). Although Barrett (2019) found that sea otters have high metabolic rate and are at risk of increased energetic costs when disturbed, there was less than a 10 percent chance of disturbance when small vessels were more 54 m away from sea otters.

Behavioral Reactions to Aircraft Noise

The following paragraphs summarize what is known about the reaction of various marine mammal species to overhead flights of many types of fixed-wing aircraft and rotary-wing aircraft (i.e., helicopters), as well as unmanned aerial systems. Thorough reviews of the subject and available information is presented in Richardson et al. (1995b) and elsewhere (e.g., Efroymson et al., 2001; Holst et al., 2011; Luksenburg & Parsons, 2009; Smith et al., 2016). The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping) (Nowacek et al., 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Holst et al., 2011; Manci et al., 1988). Richardson et al. (1995b) noted that marine mammal reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations lacking clear distinction between reactions potentially caused by the noise of the aircraft and the visual cue an aircraft presents. In addition, it was suggested that variations in the responses noted were due to generally other undocumented factors associated with overflights (Richardson et al., 1995b). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (altitude, centered on the animal, off to one side, circling, level and slow), environmental factors (e.g., wind speed, sea state, cloud cover), and locations where native subsistence hunting continues and animals are more sensitive to anthropogenic impacts, including the noise from aircraft. Erbe et al. (2018) measured airplane noise levels underwater at sites about 1 and 10 km from an airport runway and found median noise levels up to 117 dB re 1 µPa and 10 kHz at the close site, and up to 91 dB re 1 µPa and 2 kHz at the more distant site; both would be audible to a number of marine mammals at those levels and frequencies. Christiansen et al. (2016b) measured the in-air and underwater noise levels of two unmanned aerial vehicles, and found that in air, the broadband source levels were around 80 dB re 20 µPa, while at a meter underwater received levels were 95−100 dB re 1 µPa when the vehicle was only 5−10 m above the surface, and were not quantifiable above ambient noise levels when the vehicle was higher. Therefore, if an animal is near the surface and the unmanned aerial vehicle is low, it may be detected, but in most cases these vehicles are operated at much higher altitudes (e.g., over 30 m) and so are not likely to be heard.

The impact of aircraft overflights is one of the least well-known sources of potential behavioral response by any species or taxonomic group, and so many generalities must be made based on the little data available. There are some data for each taxonomic group; taken together it appears that in general, marine mammals have varying levels of sensitivity to overflights depending on the species and context.

Mysticetes

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Koski et al., 1998). Richardson (1985; 1995b) found no evidence that single or occasional aircraft flying above mysticetes causes long-term displacement of these mammals.

Bowhead whales in the Beaufort Sea exhibited a transient behavioral response to fixed-wing aircraft and vessels. Reactions were frequently observed at less than 1,000 ft. above sea level, infrequently observed at 1,500 ft., and not observed at all at 2,000 ft. (Richardson et al., 1985). Bowhead whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns. Behavioral reactions decreased in frequency as the altitude of the helicopter increased to 150 m or higher. The bowheads exhibited fewer behavioral changes than did the odontocetes in the same area (Patenaude et al., 2002). It should be noted that bowhead whales in this study may have more acute responses to anthropogenic activity than many other marine mammals since these animals were presented with restricted egress due to limited open water between ice floes. Additionally, these animals are hunted by Alaska Natives, which could lead to animals developing additional sensitivity to human noise and presence.

A pilot study was conducted on the use of unmanned aerial systems to observe bowhead whales; flying at altitudes between 120 and 210 m above the surface, no behavioral responses were observed in any animals (Koski et al., 2015; Koski et al., 1998). Similarly, Christiansen et al. (2016a) did not observe any responses to an unmanned aerial vehicle flown 30–120 m above the water when taking photos of humpback whales to conduct photogrammetry and assess fitness. In a follow-on study, Christiansen et al. (2020) also did not observe any behavioral response in the form of changes in swim speeds, respiration rates, turning angles, or interbreath intervals to an unmanned aerial vehicle flown over 10 southern right whale mother-calf pairs. In addition, some of the animals were equipped with DTAGs to measure the sound of the unmanned aerial vehicle; the received levels in the 100–1,500 Hz band were 86 ± 4 dB re 1 µPa, very similar to ambient noise levels measured at 81 ± 7 dB in the same frequency band. Acevedo-Whitehouse et al. (2010) successfully maneuvered a remote controlled helicopter over large baleen whales to collect samples of their blows, with no more avoidance behavior than noted for typical photo-identification vessel approaches. These vehicles are much smaller and quieter than typical aircraft and so are less likely to cause a behavioral response, although they may fly at much lower altitudes (Smith et al., 2016).

Odontocetes

Variable responses to aircraft have been observed in toothed whales, though overall little change in behavior has been observed during flyovers. Some toothed whales dove, slapped the water with their flukes or flippers, or swam away from the direction of the aircraft during overflights; others did not visibly react (Richardson et al., 1995b). Würsig et al. (1998) found that beaked whales were the most sensitive cetacean and reacted by avoiding marine mammal survey aircraft in 89 percent of sightings and at more than twice the rate as Kogia whales, which was the next most reactive of the odontocetes in 39 percent of sightings; these are the same species that were sensitive to vessel traffic.

During standard marine mammal surveys at an altitude of 750 ft., some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after being sighted. Other authors have corroborated the variability in sperm whales' reactions to fixed-wing aircraft or helicopters (Green et al., 1992; Richter et al., 2006; Richter et al., 2003; Smultea et al., 2008; Würsig et al., 1998). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors (Richardson et al., 1995b). A group of sperm whales responded to a circling aircraft (altitude of 800 to 1,100 ft.) by moving closer together and forming a defensive fan-shaped semicircle, with their heads facing outward. Several individuals in the group turned on their sides, apparently to look up toward the aircraft (Smultea et al., 2008). Whale watching aircraft (fixed-wing airplanes and helicopters) apparently caused sperm whales to turn more sharply but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al., 2003).

Smaller delphinids generally react to overflights either neutrally or with a startle response (Würsig et al., 1998). The same species that show strong avoidance behavior to vessel traffic (Kogia species and beaked whales) show similar reactions to aircraft (Würsig et al., 1998). Beluga whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns to a greater extent than mysticetes in the same area (Patenaude et al., 2002). These reactions increased in frequency as the altitude of the helicopter dropped below 150 m. A change in travel direction was noted in a group of pilot whales as the aircraft circled while conducting monitoring (State of Hawaii, 2015). No changes in group cohesion or orientation behavior were observed for groups of Risso's dolphins, common dolphins, or killer whales when a survey airplane flew at altitudes of 213–610 m, but this may be due to the plane maintaining lateral distances greater than 500 m in all (Smultea & Lomac-MacNair, 2016).

Much like mysticetes, odontocetes have demonstrated no responses to unmanned aerial systems. For example, Durban et al. (2015) conducted photogrammetry studies of killer whales using a small helicopter flown 35–40 m above the animals with no disturbance noted. However, it is possible that odontocete responses could increase with use at reduced altitudes, due either to noise or the shadows created by the vehicle (Smith et al., 2016). Bottlenose dolphins responded to a small portion of unmanned aerial vehicles by briefly orienting when the vehicle was relatively close (10–30 m high), but in most cases did not respond at all (Ramos et al., 2018).

Pinnipeds

Richardson et al. (1995b) noted that responsiveness to aircraft overflights generally was dependent on the altitude of the aircraft, the abruptness of the associated aircraft sound, and life cycle stage (breeding, molting, etc.). In general pinnipeds are unresponsive to overflights, and may startle, orient towards the sound source or increase vigilance, or may briefly re-enter the water, but typically remain hauled out or immediately return to their haul out location (Blackwell et al., 2004; Gjertz & Børset, 1992). Adult females, calves and juveniles are more likely to enter the water than males, and stampedes resulting in mortality to pups (by separation or crushing) can occur when disturbance is severe, although they are rare (Holst et al., 2011). Responses may also be dependent on the distance of the aircraft. For example, reactions of walruses on land varied in severity and included minor head raising at a distance of 2.5 km, orienting toward or entering the water at less than 150 m and 1.3 km in altitude, to full flight reactions at horizontal ranges of less than 1 km at altitudes as high as 1,000–1,500 m (Richardson et al., 1995b).

Helicopters are used in studies of several species of seals hauled out and are considered an effective means of observation (Bester et al., 2002; Gjertz & Børset, 1992), although they have been known to elicit behavioral reactions such as fleeing (Hoover, 1988). For California sea lions and Steller sea lions at a rocky haulout off Crescent City in northern California, helicopter approaches to landing sites typically caused the most severe response of diving into the water (National Oceanic and Atmospheric Administration, 2010). Responses were also dependent on the species, with Steller sea lions being more sensitive and California sea lions more tolerant. Depending on the time between subsequent approaches, animals hauled out in between and fewer animals reacted upon subsequent exposures (National Oceanic and Atmospheric Administration, 2010).

Pinniped reactions to rocket launches and overflight at San Nicolas Island were studied from August 2001 to October 2008 (Holst et al., 2011). California sea lions startled and increased vigilance for up to two minutes after a rocket overflight, with some individuals moving down the beach or returning to the water. Northern elephant seals showed little reaction to any overflight. Harbor seals had the most pronounced reactions of the three species observed with most animals within approximately 4 km of the rocket trajectory leaving their haulout sites for the water and not returning for several hours. The authors concluded that the effects of the rocket launches were minor with no effects on local populations evidenced by the growing populations of pinnipeds on San Nicolas Island (Holst et al., 2011).

Pinnipeds may be more sensitive to unmanned aerial systems, especially those flying at low altitudes, due to their possible resemblance to predatorial birds (Smith et al., 2016), which could lead to flushing behavior (Olson, 2013). Responses may also vary by species, age class, behavior, and habituation to other anthropogenic noise, as well as by the type, size, and configuration of unmanned aerial vehicle used (Pomeroy et al., 2015). However, in general pinnipeds have demonstrated little to no response to unmanned aerial systems, with some orienting towards the vehicle, other alerting behavior, or short-term flushing possible (Moreland et al., 2015; Sweeney et al., 2015).

Sea Otters

Sea otters spend approximately 80 percent of their time on the surface of the water (Curland, 1997) with their heads above the surface. Recordings of underwater noise produced by helicopter overflights did not appear to affect sea otter foraging behavior, foraging success, or daily activity patterns when projected underwater 1–1.5 km from a group of otters in Lobos Cove (Reidman, 1983). Sea otters have similar in-air hearing sensitivities as pinnipeds (Ghoul & Reichmuth, 2014a, 2014b), and may react in a similar fashion when exposed to aircraft noise. Pinnipeds in general are unresponsive but may react depending on the altitude of the aircraft or the abruptness of the associated sound (Richardson et al., 1995b), with reactions ranging from unresponsiveness to flushing into the water location (Blackwell et al., 2004; Gjertz & Børset, 1992). Sea otters may dive below the surface of the water or flush into the water to avoid aircraft noise. However, sea otter dives are very costly and require twice the metabolic energy that phocid seals need to dive; therefore sea otters may not dive or travel so readily in response to disturbance, as they already require long periods of rest at the surface to counterbalance the high cost of foraging at sea (Yeates et al., 2007). So far, there has been no evidence that any aircraft has had adverse effects on a well-monitored translocated colony of sea otters at San Nicolas Island, which has a landing field operated by the U.S. Navy (U.S. Fish and Wildlife Service, 2012, 2015).

Behavioral Reactions to Impulsive Noise

Impulsive signals (i.e., weapon noise and explosions), particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle responses or avoidance responses. However, at long distances the rise time increases as the signal duration lengthens (similar to a “ringing” sound), making the impulsive signal more similar to a non-impulsive signal. Behavioral reactions from explosive sounds are likely to be similar to reactions studied for other impulsive sounds, such as those produced by air guns and impact pile driving. Data on behavioral responses to impulsive sound sources are limited across all marine mammal groups, with only a few studies available for mysticetes, odontocetes, pinnipeds, and sea otters. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks) and typically utilize large multi-air gun arrays that fire repeatedly. While seismic data provide the best available science for assessing behavioral responses to impulsive sounds by marine mammals, it is likely that these responses represent a worst-case scenario as compared to responses to explosives used in Navy activities, which would typically consist of single impulses or a cluster of impulses, rather than long-duration, repeated impulses.

Mysticetes

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, attraction to the source, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Gordon et al., 2003; McCauley et al., 2000; Richardson et al., 1985; Southall et al., 2007). Studies have been conducted on many baleen whale species, including gray, humpback, blue, fin and bowhead whales; it is assumed that these responses are representative of all baleen whale species. The behavioral state of the whale seems to be an integral part of whether or not the animal responds and how they respond, as does the location and movement of the sound source, more than the received level of the sound.

Migratory behavior seems to lead to a higher likelihood of response, with some species demonstrating more sensitivity than others do. For example, migrating gray whales showed avoidance responses to seismic vessels at received levels between 164 and 190 dB re 1 µPa (Malme et al., 1986, 1988). Similarly, migrating humpback whales showed avoidance behavior at ranges of 5–8 km from a seismic array during observational studies and controlled exposure experiments in one Australian study (McCauley et al., 1998), and in another Australian study decreased their dive times and reduced their swimming speeds (Dunlop et al., 2015). However, when comparing received levels and behavioral responses using ramp-up versus a constant noise level of air guns, humpback whales did not change their dive behavior but did deviate from their predicted heading and decreased their swim speeds (Dunlop et al., 2016). In addition, the whales demonstrated more course deviation during the constant source trials but reduced travel speeds more in the ramp-up trials; in either case there was no dose-response relationship with the received level of the air gun noise, and similar responses were observed in control trials with vessel movement but no air guns so some of the response was likely due to the presence of the vessel and not the received level of the air guns. When looking at the relationships between proximity, received level, and behavioral response, Dunlop et al. (2017) used responses to two different air guns and found responses occurred more towards the smaller, closer source than to the larger source at the same received level, demonstrating the importance of proximity. Responses were found to be more likely when the source was within 3 km or above 140 dB re 1 µPa, although responses were variable and some animals did not respond at those values while others responded below them. In addition, responses were generally small, with course deviations of only around 500 m, and short term (Dunlop et al., 2017). McDonald et al. (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 10 km from the seismic vessel (estimated received level 143 dB re 1 µPa peak-to-peak). Bowhead whales seem to be the most sensitive species, perhaps due to a higher overlap between bowhead whale distribution and seismic surveys in Arctic and sub-Arctic waters, as well as a recent history of being hunted. While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson et al., 1995b), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 µPa. Additionally, Malme et al. (1988) observed clear changes in diving and breathing patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 µPa. Bowhead whales may also avoid the area around seismic surveys, from 6 to 8 km (Koski and Johnson 1987, as cited in Gordon et al., 2003) out to 20 or 30 km (Richardson et al., 1999). However, work by Robertson (2013) supports the idea that behavioral responses are contextually dependent, and that during seismic operations bowhead whales may be less "available" for counting due to alterations in dive behavior but that they may not have left the area after all.

In contrast, noise from seismic surveys was not found to impact feeding behavior or exhalation rates in western gray whales while resting or diving off the coast of Russia (Gailey et al., 2007; Yazvenko et al., 2007); however, the increase in vessel traffic associated with the surveys and the proximity of the vessels to the whales did affect the orientation of the whales relative to the vessels and shortened their dive-surface intervals (Gailey et al., 2016). Todd et al. (1996) found no clear short-term behavioral responses by foraging humpbacks to explosions associated with construction operations in Newfoundland but did see a trend of increased rates of net entanglement closer to the noise source, possibly indicating a reduction in net detection associated with the noise through masking or TTS. Distributions of fin and minke whales were modeled with a suite of environmental variables along with the occurrence or absence of seismic surveys, and no evidence of a decrease in sighting rates relative to seismic activity was found for either species (Vilela et al., 2016). Their distributions were driven entirely by environmental variables, particularly those linked to prey including warmer sea surface temperatures, higher chlorophyll-a values, and higher photosynthetically available radiation (a measure of primary productivity). Sighting rates based on over 8,000 hours of baleen and toothed whale survey data were compared on regular vessel surveys versus both active and passive periods of seismic surveys (Kavanagh et al., 2019). Models of sighting numbers were developed, and it was determined that baleen whale sightings were reduced by 88 and 87 percent during active and inactive phases of seismic surveys, respectively, compared to regular surveys. These results seemed to occur regardless of geographic location of the survey; however, when only comparing active versus inactive periods of seismic surveys the geographic location did seem to affect the change in sighting rates.

Vocal responses to seismic surveys have been observed in a number of baleen whale species, including a cessation of calling, a shift in frequency, increases in amplitude or call rate, or a combination of these strategies. Blue whale feeding/social calls were found to increase when seismic exploration was underway, with seismic pulses at average received SELs of 131 dB re 1 $\mu Pa^2 s$ (Di Lorio & Clark, 2010), a potentially compensatory response to increased noise level. Responses by fin whales to a 10-day seismic survey in the Mediterranean Sea included possible decreased 20-Hz call production and movement of animals from the area based on lower received levels and changes in bearings (Castellote et al., 2012).

However, similarly distant seismic surveys elicited no apparent vocal response from fin whales in the mid-Atlantic Ocean; instead, Nieukirk et al. (2012) hypothesized that 20-Hz calls may have been masked from the receiver by distant seismic noise. Models of humpback whale song off Angola showed significant seasonal and diel variation, but also showed a decrease in the number of singers with increasing received levels of air gun pulses (Cerchio et al., 2014). Bowhead whale calling rates decreased significantly at sites near seismic surveys (41−45 km) where median received levels were between 116 and 129 dB re 1 µPa, and did not decrease at sites further from the seismic surveys (greater than 104 km) where median received levels were 99–108 dB re 1 µPa (Blackwell et al., 2013). In fact, bowhead whale calling rates increased at the lower received levels, began decreasing at around 127 dB re 1 $\mu Pa^2 s$ cumulative SEL, and ceased altogether at received levels over 170 dB re 1 $\mu Pa^2 s$ cumulative SEL (Blackwell et al., 2015). Similar patterns were observed for bowhead vocalizations in the presence of tonal sounds associated with drilling activities, and were amplified in the presence of both the tonal sounds and air gun pulses (Blackwell et al., 2017).

Mysticetes seem to be the most sensitive taxonomic group of marine mammals to impulsive sound sources, with possible avoidance responses occurring out to 30 km and vocal changes occurring in response to sounds over 100 km away. However, responses appear to be behaviorally mediated, with most avoidance responses occurring during migration behavior and little observed response during feeding behavior. These response patterns are likely to hold true for Navy impulsive sources; however, Navy impulsive sources would largely be stationary (e.g., explosives fired at a fixed target), and short term (on the order of hours rather than days or weeks) than were found in these studies and so responses would likely occur in closer proximity or not at all.

Odontocetes

Few data are available on odontocete responses to impulsive sound sources, with only a few studies on responses to seismic surveys, pile driving and construction activity available. However, odontocetes appear to be less sensitive to impulsive sound than mysticetes, with responses occurring at much closer distances. This may be due to the predominance of low-frequency sound associated with these sources that propagates long distances and overlaps with the range of best hearing for mysticetes but is below that range for odontocetes. The exception to this is the harbor porpoise, which has been shown to be highly sensitive to most sound sources, avoiding both stationary (e.g., pile driving) and moving (e.g., seismic survey vessels) impulsive sound sources out to approximately 20 km (e.g., Haelters et al., 2014; Pirotta et al., 2014). However, even this response is short term, with porpoises returning to the area within hours after the cessation of the noise.

Madsen et al. (2006) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic air gun surveys. Sound sources were from approximately 2 to 7 NM away from the whales, and received levels were as high as 162 dB SPL re 1 µPa (Madsen et al., 2006). The whales showed no horizontal avoidance, however one whale rested at the water's surface for an extended period of time until air guns ceased firing (Miller et al., 2009). While the remaining whales continued to execute foraging dives throughout exposure, tag data suggested there may have been subtle effects of noise on foraging behavior (Miller et al., 2009). Similarly, Weir (2008) observed that seismic air gun surveys along the Angolan coast did not significantly reduce the encounter rate of sperm whales during the 10-month survey period, nor were avoidance behaviors to air gun impulsive sounds observed. In contrast, Atlantic spotted dolphins did show a significant, short-term avoidance response to air gun impulses within approximately 1 km of the source (Weir, 2008). The dolphins were observed at greater distances from the vessel when the air gun was in use, and when the air gun was not in use they readily approached the vessel to bow ride. Kavanagh et al. (2019) also found that toothed whales were more adverse to active airguns, as sightings of several species of odontocetes were reduced by 53 and 29 percent during active and inactive phases of seismic surveys, respectively, compared to regular surveys.

Captive bottlenose dolphins sometimes vocalized or were reluctant to return to the test station after exposure to single impulses from a seismic water gun (Finneran et al., 2002). When exposed to multiple impulses from a seismic air gun, some dolphins turned their heads away from the sound source just before the impulse, showing that they could anticipate the timing of the impulses and perhaps reduce the received level (Finneran et al., 2015). During construction (including the blasting of old bastions) of a bridge over a waterway commonly used by the Tampa Bay, FL stock of bottlenose dolphins, the use of the area by females decreased while males displayed high site fidelity and continued using the area, perhaps indicating differential habitat uses between the sexes (Weaver, 2015).

A study was conducted on the response of harbor porpoises to a seismic survey using aerial surveys and C-PODs (an autonomous recording device that counts odontocete clicks); the animals appeared to have left the area of the survey, and decreased their foraging activity within 5–10 km, as evidenced by both a decrease in vocalizations near the survey and an increase in vocalizations at a distance (Pirotta et al., 2014; Thompson et al., 2013). However, the animals returned within a day after the air gun operation ceased, and the decrease in occurrence over the survey period was small relative to the observed natural seasonal decrease compared to the previous year. A number of studies (Brandt et al., 2011; Dähne et al., 2014; Haelters et al., 2014; Thompson et al., 2010; Tougaard et al., 2005; Tougaard et al., 2009) also found strong avoidance responses by harbor porpoises out to 20 km during pile driving; however, all studies found that the animals returned to the area after the cessation of pile driving. When bubble curtains were deployed around pile driving, the avoidance distance appeared to be reduced to half that distance (12 km), and the response only lasted about five hours rather than a day before the animals returned to the area (Dähne et al., 2017).

However, not all harbor porpoise behavioral response studies ended in habitat displacement. Sarnocińska et al. (2020) also placed C-PODs near oil and gas platforms and control sites 15 km away and found a dose-response effect with the lowest amount of porpoise activity closest to the seismic vessel ($SEL_{single\ shot}$ = 155 dB re 1 µPa^2s) and then increasing porpoise activity out to 8–12 km, outside of which levels were similar to baseline. Distance to the seismic vessel was a better model predictor of porpoise activity than sound level. Despite these smaller-scale responses, a large-scale response was not detected, and overall porpoise activity in the seismic area was similar to the control stations; this may indicate that the porpoises were moving around the seismic area to avoid the ship, but not leaving the area entirely (Sarnocińska et al., 2020).

When exposing a captive harbor porpoise to impact pile driving sounds, Kastelein et al. (2013b) found that above 136 dB re 1 µPa (zero-to-peak) the animal's respiration rates increased, and at higher levels it jumped more frequently. Bergstrom et al. (2014) found that although there was a high likelihood of acoustic disturbance during wind farm construction (including pile driving), the impact was short term. Graham et al. (2017) assessed the occurrence of bottlenose dolphins and harbor porpoises over different area and time scales with and without impact and vibratory pile driving. While there were fewer hours with bottlenose dolphin detections and reduced detection durations within the pile driving area and increased detection durations outside the area, the effects sizes were small, and the reduced harbor porpoise encounter duration was attributed to seasonal changes outside the influence of the pile driving. However, received levels in this area were lower due to propagation effects than in the other areas described above, which may have led to the lack of or reduced response. In another impulsive pile driving study, Graham et al. (2019) found that the distance at which behavioral responses were probable decreased over the course of the construction project, suggesting habituation to pile-driving noise in the local harbor porpoise population.

Odontocete behavioral responses to impulsive sound sources are likely species- and context-dependent, with most species demonstrating little to no apparent response. Responses might be expected within close proximity to a noise source, under specific behavioral conditions such as females with offspring, or for sensitive species such as harbor porpoises.

Pinnipeds

A review of behavioral reactions by pinnipeds to impulsive noise can be found in Richardson et al. (1995b) and Southall et al. (2007). Blackwell et al. (2004) observed that ringed seals exhibited little or no reaction to pipe-driving noise with mean underwater levels of 157 dB re 1 µPa and in-air levels of 112 dB re 20 µPa, suggesting that the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an underwater impulsive source at levels of 165–170 dB re 1 µPa (Finneran et al., 2003b). Harbor and grey seals were also observed to avoid a seismic air gun by rapidly swimming away, and ceased foraging during exposure, but returned to normal behavior afterwards (Thompson et al. 1998, cited in Gordon et al., 2003). In another study, few responses were observed by New Zealand fur seals to a towed air gun array operating at full power; rather, when responses were observed it seemed to be to the physical presence of the vessel and tow apparatus, and these only occurred when the vessel was within 200 m and sometimes as close as 5 m (Lalas & McConnell, 2016). Captive Steller sea lions were exposed to a variety of tonal, sweep, impulsive and broadband sounds to determine what might work as a deterrent from fishing nets. The impulsive sound had a source level of 120 dB re 1 µPa at 1 m, and caused the animals to haul out and refuse to eat fish presented in a net (Akamatsu et al., 1996). Steller sea lions exposed to in-air explosive blasts increased their activity levels and often re-entered the water when hauled out (Demarchi et al., 2012). However, these responses were short-lived and within minutes, the animals had hauled out again, and there were no lasting behavioral impacts in the days following the blasts.

Experimentally, Götz & Janik (2011) tested underwater startle responses to a startling sound (sound with a rapid rise time and a 93 dB sensation level [the level above the animal's hearing threshold at that frequency]) and a nonstartling sound (sound with the same level, but with a slower rise time) in wild-captured gray seals. The animals exposed to the startling treatment avoided a known food source, whereas animals exposed to the nonstartling treatment did not react or habituated during the exposure period. The results of this study highlight the importance of the characteristics of the acoustic signal in an animal’s response of habituation.

Pinnipeds may be the least sensitive taxonomic group to most noise sources, although some species may be more sensitive than others, and are likely to only respond to loud impulsive sound sources at close ranges by startling, jumping into the water when hauled out, or even cease foraging, but only for brief periods before returning to their previous behavior (e.g., (Southall et al., 2007)). Pinnipeds may even experience TTS (see Section 3.8.3.1.1.2, Hearing Loss) before exhibiting a behavioral response (Southall et al., 2007).

Sea Otters

There are few available studies on responses of sea otters to impulsive sounds. A playback study of multiple and single air guns had no significant impact on sea otters in California. During the multiple air gun exposures, otters rested 1 percent more and foraged 1 percent less. They were successful at obtaining prey during 84 percent of their foraging dives when the air gun vessel was 50 NM away, and success rate only decreased by 5 percent when the multiple air gun vessel moved closer (0.5 NM away). Overall, foraging and dive behaviors remained undisturbed, as did the density and distribution of sea otters in the area. This study caveats that the data were collected under rough weather conditions which could have affected the otters' perception of the seismic sounds. In addition, otters kept close to shore in relatively sheltered coves (Reidman, 1983).

During the single air gun experiment, the air gun ship approached a raft of otters (at a minimum of 730 m), and several otters were mildly alarmed (e.g., rolled over on their sides or bellies and looked intently at the vessel as it approached) but did not leave the raft. Of the four times the vessel passed the group of otters, the air gun was operational during only two of the transects. However, the otters reacted to the vessel every time it passed, indicating that otters were either responding to the loud airborne sounds of the boat engines and compressor, or to the close approach of the vessel itself, rather than the seismic sounds (Reidman, 1983).

In a follow-up study, Riedman (1984) monitored sea otter reactions to drilling platform sounds and air gun firing projected from a source vessel 0.9 to 1.6 km away from groups of sea otters. No behavioral reactions or movements were observed in 14 days of observations with 15-38 individual sea otters present on any given day. Sound pressure levels from the air gun were reported as 166 dB re 1 µPa at 1.1 km, which means that two otters may have been subjected to levels greater than this at ranges of 900 m on the one day the pair foraged closer to the air gun ship for one hour. Most of the otters would have been subjected to just under this level, since the majority of otters foraged 1.3–1.6 m away from the sound sources, and propagation loss due to distance and the kelp environment needs to be considered. In a survey of the local coastline, no change in numbers of sea otters was evident between just prior to the sound stimuli and on day ten of the emissions. No changes in feeding dive times or feeding success was seen during the study either.

When conducting impact and vibratory pile driving for the Parsons Slough estuarine restoration, the Elkhorn Slough National Estuarine Research Reserve (2011) recorded the abundance and behavior of sea otters in the area. Disturbances within 30 m of the pile driving site included otters raising their heads, swimming away without startling, or startle diving. Usually only single adult males with an established territory that included the construction site traveled within 30 m. Otters further away (> 180 m) were observed swimming away with startling, including mother-pup pairs. However, sea otter behavioral disturbances 30-180 m away from the pile driving site were difficult to tease apart from the impacts of pedestrian vessels and other construction activities.

Sea otters spend approximately 80 percent of their time on the surface of the water (Curland, 1997) with their heads above the surface, which reduces their exposure to underwater sounds. They require long periods of undisturbed rest at the surface to counterbalance high metabolic costs associated with forging at sea (Yeates et al., 2007). If reactions to Navy impulsive noise were to occur, they may be similar to those of pinnipeds, which show temporary avoidance responses or cessation of foraging behavior (Thompson et al., 1998, cited in Gordon et al., 2003). However, underwater hearing sensitivities are significantly reduced in sea otters when compared to pinnipeds (Ghoul & Reichmuth, 2014a, 2014b), so reactions may not be as strong, if they occur at all.

3.8.3.1.1.6 Stranding

When a marine mammal (alive or dead) swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a "stranding" (Geraci et al., 1999; Geraci & Lounsbury, 2005; Perrin & Geraci, 2002). A stranding can also occur away from the shore if the animal is unable to cope in its present situation (e.g., disabled by a vessel strike, out of habitat) (Geraci & Lounsbury, 2005). Specifically, under U.S. law, a stranding is an event in the wild in which: " (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance" (16 United States Code [U.S.C.] section 1421h).

Marine mammals are subjected to a variety of natural and anthropogenic factors, acting alone or in combination, which may cause a marine mammal to strand (Geraci et al., 1999; Geraci & Lounsbury, 2005). Natural factors related to strandings include limited food availability or following prey inshore, predation, disease, parasitism, natural toxins, echolocation disturbance, climatic influences, solar activity-based disruption of magnetoreception, and aging (Bradshaw et al., 2006; Culik, 2004; Geraci et al., 1999; Geraci & Lounsbury, 2005; Granger et al., 2020; Huggins et al., 2015; National Research Council, 2006; Perrin & Geraci, 2002; Walker et al., 2005). Anthropogenic factors include pollution (Hall et al., 2006; Jepson et al., 2005), vessel strike (Geraci & Lounsbury, 2005; Laist et al., 2001), fisheries interactions (Read et al., 2006), entanglement (Baird & Gorgone, 2005; Saez et al., 2013; Saez et al., 2012), human activities (e.g., feeding, gunshot) (Dierauf & Gulland, 2001; Geraci & Lounsbury, 2005), and noise (Cox et al., 2006; National Research Council, 2003; Richardson et al., 1995b). For some stranding events, environmental factors (e.g., ocean temperature and wind speed and geographic conditions) can be utilized in predictive models to aid in understanding why marine mammals strand in certain areas more than others (Berini et al., 2015). Decomposition, buoyancy, scavenging by other marine species, wave damage, and other oceanic conditions complicate the assessment of marine mammal carcasses (Moore et al., 2020). In most instances, even for the more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for strandings remains undetermined.

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 12,545 cetacean strandings and 39,104 pinniped strandings (51,649 total) per year (National Marine Fisheries Service, 2016b). Several mass strandings (strandings that involve two or more individuals of the same species, excluding a single mother-calf pair) that have occurred over the past two decades have been associated with anthropogenic activities that introduced sound into the marine environment such as naval operations and seismic surveys. U.S. Navy sonar has been identified as a contributing factor in a small number of strandings; none of these have occurred in the Study Area. U.S. Navy sonar has been identified as a contributing factor in a small number of strandings; none of these have occurred in the Study Area.

Sonar use during exercises involving the U.S. Navy has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira Island, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Cox et al., 2006; Fernandez, 2006; U.S. Department of the Navy, 2017c), as described in the Navy's technical report titled *Marine Mammal Strandings Associated with U.S. Navy Sonar Activities* (U.S. Department of the Navy, 2017c). These five mass strandings have resulted in about 40 known cetacean deaths consisting mostly of beaked whales and with close linkages to mid-frequency active sonar activity. In these circumstances, exposure to non-impulsive acoustic energy was considered a potential indirect cause of death of the marine mammals (Cox et al., 2006). Factors that were associated with these beaked whales strandings included steep bathymetry, multiple hull-mounted platforms using sonar simultaneously, constricted channels, and strong surface ducts. An in-depth discussion of these strandings and these factors is in the technical report titled *Marine Mammal Strandings Associated with U.S. Navy Sonar Activities* (available at www.goaeis.com). Strandings of other marine mammal species have not been as closely linked to sonar exposure, but rather, have typically been attributed to natural or other anthropogenic factors. The Navy has reviewed training requirements, standard operating procedures, and potential mitigation measures, and has implemented changes to reduce the potential for acoustic related strandings to occur in the future. Discussions of procedures associated with these and other training events are presented in Chapter 5 (Mitigation).

Simonis et al. (2020a) relied on substantially incomplete or inaccurate assumptions about U.S. Navy sonar use around the Mariana Islands (i.e., publicly available press releases and news reports about named Navy activities, which may or may not have involved sonar, rather than actual records of sonar use) to claim a correlation between sonar and beaked whale strandings in the Mariana Islands (outside of the MITT Study Area). Simonis et al. (2020a) found that there was a 1 percent probability of the strandings and sonar co-occurring randomly. In response to the preliminary analysis of Simonis et al. (2020a), the Navy provided additional information to the researchers indicating that the assumptions about sonar use in their analysis were incorrect or incomplete; therefore, their published findings were not valid. In discussions with NMFS following Simonis et al.'s findings, including NMFS researchers who participated in Simonis et al.'s study, the Navy agreed to examine the classified sonar record around the Mariana Islands for correlation with beaked whale strandings. The Center for Naval Analysis conducted a statistical study of correlation of beaked whale strandings around the Mariana Islands with the use of U.S. Navy sonar, finding that no statistically significant correlation exists (Center for Naval Analysis, 2020). The Center for Naval Analysis study used the complete classified record of all U.S. Navy sonar used between 2007 and 2019, including major training events, joint exercises, and unit-level training/testing. Sonar sources in this record conservatively included both hull-mounted and non-hull-mounted sources, rather than solely hull-mounted sources (which have been previously associated with a limited number of beaked whale strandings outside of this study area). The analysis also included the complete beaked whale stranding record for the Mariana Islands through 2019. Following the methods in Simonis et al. (2020), the Center for Naval Analysis conducted a Poisson distribution analysis and found no statistically significant correlation between sonar use and beaked whale strandings when considering the complete sonar use record. The unclassified summary of the Center for Naval Analysis's study was provided to NMFS and their scientists. The Navy is supporting continued efforts to gain a better understanding of beaked whale occurrence and potential effects from Navy activities in the Mariana Islands.

Multiple hypotheses regarding the relationship between non-impulsive sound exposure and stranding have been proposed (see Bernaldo de Quirós et al., 2019). These range from direct impact of the sound on the physiology of the marine mammal, to behavioral reactions contributing to altered physiology (e.g., "gas and fat embolic syndrome") (Fernandez et al., 2005; Jepson et al., 2003; Jepson et al., 2005), to behaviors directly contributing to the stranding (e.g., beaching of fleeing animals). Unfortunately, without direct observation of not only the event but also the underlying process, and given the potential for artefactual evidence (e.g., chronic condition, previous injury) to complicate conclusions from the post-mortem analyses of stranded animals (Cox et al., 2006), it has not been possible to determine with certainty the exact mechanism underlying these strandings. Based on examination of the above sonar-associated strandings, Bernaldo de Quirós et al. (2019) list diagnostic features, the presence of all of which suggest gas and fat embolic syndrome for beaked whales stranded in association with sonar exposure. Bernaldo de Quirós et al. (2019) observed that, to date, strandings which have a confirmed association with naval exercise have exhibited all seven of the following diagnostic features:

1. Individual or multiple animals stranded within hours or a few days of an exercise in good body condition
2. Food remnants in the first gastric compartment ranging from undigested food to squid beaks
3. Abundant gas bubbles widely distributed in veins (subcutaneous, mesenteric, portal, coronary, subarachnoid veins, etc.) composed primarily of nitrogen in fresh carcasses
4. Gross subarachnoid and/or acoustic fat hemorrhages
5. Microscopic multi-organ gas and fat emboli associated with bronchopulmonary shock
6. Diffuse, mild to moderate, acute, monophasic myonecrosis (hyaline degeneration) with ”disintegration” of the interstitial connective tissue and related structures, including fat deposits, and their replacement by amorphous hyaline material (degraded material) in fresh and well-preserved carcasses
7. Multi-organ microscopic hemorrhages of varying severity in lipid-rich tissues such as the central nervous system, spinal cord, and the coronary and kidney fat when present

Historically, stranding reporting and response efforts have been inconsistent, although they have improved considerably over the last 25 years. Although reporting forms have been standardized nationally, data collection methods, assessment methods, detail of reporting and procedures vary by region and are not yet standardized across the United States. Conditions such as weather, time, location, and decomposition state may also affect the ability to thoroughly examine a specimen (Carretta et al., 2016b; Moore et al., 2013). Because of this, the current ability to interpret long-term trends in marine mammal stranding is limited. While the investigation of stranded animals provides insight into the types of threats marine mammal populations face, investigations are only conducted on a small fraction of the total number of strandings that occur, limiting the understanding of the causes of strandings (Carretta et al., 2016a). Although many marine mammals likely strand due to natural or anthropogenic causes, the majority of reported type of occurrences in marine mammal strandings in the Pacific include fisheries interactions, entanglement, vessel strike, and predation (Carretta et al., 2019a; Carretta et al., 2019b; Carretta et al., 2017a; Helker et al., 2019; Helker et al., 2017; National Oceanic and Atmospheric Administration, 2018e, 2019a).

Stranded marine mammals are reported along the entire western coast of the United States each year. Marine mammals strand due to natural or anthropogenic causes, the majority of reported type of occurrences in marine mammal strandings in this region include fishery interactions, illness, predation, and vessel strikes (Carretta et al., 2017a; Helker et al., 2017; National Marine Fisheries Service, 2016g). It is important to note that the mass stranding of pinnipeds along the west coast considered part of a NMFS declared Unusual Morality Event are still being evaluated. The likely cause of this event is the lack of available prey near rookeries due to warming ocean temperatures (National Oceanic and Atmospheric Administration, 2018a). Carretta et al. (2016b; 2013) provide additional information and data on the threats from human-related activities and the potential causes of strandings for the U.S. Pacific coast marine mammal stocks.

3.8.3.1.1.7 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate (see Section 3.0.4.3, Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). Physical effects that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions and short-term or chronic instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual, or for very small populations to the population as a whole; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposure to many sound-producing activities over significant periods.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area (Wartzok et al., 2003). Highly resident or localized populations may also stay in an area of disturbance because the cost of displacement may be higher than the cost of remaining (Forney et al., 2017). Longer term displacement can lead to changes in abundance or distribution patterns of the species in the affected region (Bejder et al., 2006b; Blackwell et al., 2004; Teilmann et al., 2006). Gray whales in Baja California abandoned a historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. However, whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al., 1984). Mysticetes in the northeast tended to adjust to vessel traffic over a number a of years, trending towards more neutral responses to passing vessels (Watkins, 1986), indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity. Related population characteristics, such as if a population is open or closed, can influence the sensitivity of population disturbance as well (New et al., 2020). New et al. (2020) found that closed populations could not withstand a higher probability of disturbance, compared to open populations with no limitation on food.

Moore and Barlow (2013) noted a decline in the overall beaked whale population in a broad area of the Pacific Ocean along the U.S. West Coast. Moore and Barlow (2013) provide several hypotheses for the decline of beaked whales in those waters, one of which is anthropogenic sound including the use of sonar by the U.S. Navy; however, new data have been published raising uncertainties over whether a decline in the beaked whale population occurred off the U.S. West Coast between 1996 and 2014 (Barlow, 2016). Moore and Barlow (2017) have since incorporated information from the entire 1991 to 2014 time series, which suggests an increasing abundance trend and a reversal of the declining trend along the U.S. West Coast that had been noted in their previous (2013) analysis.

In addition, studies on the Atlantic Undersea Test and Evaluation Center instrumented range in the Bahamas have shown that some Blainville's beaked whales may be resident during all or part of the year in the area. Individuals may move off the range for several days during and following a sonar event, but return within a few days (Joyce et al., 2019; McCarthy et al., 2011; Tyack et al., 2011). Photo-identification studies in the SOCAL Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years and re-sightings up to seven years apart (Falcone & Schorr, 2014; Falcone et al., 2009). These results indicate long-term residency by individuals in an intensively used Navy training area, which may suggest a lack of long-term consequences as a result of exposure to Navy training activities, but could also be indicative of high-value resources that exceed the cost of remaining in the area. Long-term residency does not mean there has been no impact on population growth rates and there are no data existing on the reproductive rates of populations inhabiting the Navy range area around San Clemente Island as opposed to beaked whales from other areas. In that regard however, recent results from photo-identifications are beginning to provide critically needed calving and weaning rate data for resident animals on the Navy's Southern California range. Three adult females that had been sighted with calves in previous years were again sighted in 2016, one of these was associated with her second calf, and a fourth female that was first identified in 2015 without a calf, was sighted in 2016 with a calf (Schorr et al., 2017). Resident females documented with and without calves from year to year will provide the data for this population that can be applied to future research questions.

Research involving three tagged Cuvier's beaked whales in the SOCAL Range Complex reported on by Falcone and Schorr (2012, 2014) has documented movements in excess of hundreds of kilometers by some of those animals. Schorr et al. (2014) reported the results for an additional eight tagged Cuvier's beaked whales in the same area. Five of these eight whales made journeys of approximately 250 km from their tag deployment location, and one of these five made an extra-regional excursion over 450 km south to Mexico and back again. Given that some beaked whales may routinely move hundreds of kilometers as part of their normal pattern (Schorr et al., 2014), temporarily leaving an area to avoid sonar or other anthropogenic activity may have little cost.

Another approach to investigating long-term consequences of anthropogenic noise exposure has been an attempt to link short-term effects to individuals from anthropogenic stressors with long-term consequences to populations using population models. Population models are well known from many fields in biology including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population, such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. Unfortunately, for acoustic and explosive impacts on marine mammal populations, many of the inputs required by population models are not known. Nowacek et al. (2016) reviewed new technologies, including passive acoustic monitoring, tagging, and the use of unmanned aerial vehicles that can improve scientists' abilities to study these model inputs and link behavioral changes to individual life functions and ultimately population-level effects. The linkage between immediate behavioral or physiological effects to an individual due to a stressor such as sound, the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and in turn the consequences for the population have been reviewed in National Research Council (2005).

The Population Consequences of Acoustic Disturbance model (National Research Council 2005) proposes a conceptual model for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population. In 2009, the U.S. Office of Naval Research set up a working group to transform the Population Consequences of Acoustic Disturbance framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population

Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al., 2016a; Costa et al., 2016b; Harwood & King, 2014; Hatch et al., 2012; King et al., 2015; McHuron et al., 2018; New et al., 2014; New et al., 2013a; Pirotta et al., 2018a; Pirotta et al., 2018b). Currently, the Population Consequences of Disturbance model provides a theoretical framework and identifies types of data that would be needed to assess population-level impacts using this process. The process is complicated and provides a foundation for the type of data that are needed, which are currently lacking for many marine mammal species (Booth et al., 2020). Relevant data needed for improving these analytical approaches for population-level consequences resulting from disturbances will continue to be collected during projects funded by the Navy's marine species monitoring program.

Costa et al. (2016a) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance can lead to markedly different impact results. For example, Costa et al. (2016a) modeled seismic surveys with different radii of impacts on the foraging grounds of Bering Sea humpback whales, West Antarctic Peninsula humpback whales, and California Current blue whales, and used data from tagged whales to determine foraging locations and effort on those grounds. They found that for the blue whales and the West Antarctic humpback whales, less than 19 percent and 16 percent (respectively) of each population would be exposed, and less than 19 percent and 6 percent (respectively) of foraging behavior would be disturbed. This was likely due to the fact that these populations forage for krill over large areas. In contrast, the Bering Sea population of humpback whales had over 90 percent of the population exposed when the disturbance zones extended beyond 50 km, but 100 percent of their foraging time would occur during an exposure when the zone was 25 km or more. These animals forage for fish over a much smaller area, thereby having a limited range for foraging that can be disturbed. Similarly, Costa et al. (2016b) placed disturbance zones in the foraging and transit areas of northern elephant seals and California sea lions. Again, the location and radius of disturbance impacted how many animals were exposed and for how long, with California sea lions disturbed for a longer period than elephant seals, which extend over a broader foraging and transit area. However, even the animals exposed for the longest periods had negligible modeled impacts on their reproduction and pup survival rates. Energetic costs were estimated for western gray whales that migrated to possible wintering grounds near China or to the Baja California wintering grounds of eastern gray whales versus the energetic costs of the shorter migration of eastern gray whales (Villegas-Amtmann et al., 2017). Researchers found that when the time spent on the breeding grounds was held constant for both populations, the energetic requirements for the western gray whales were estimated to be 11 and 15 percent greater during the migration to Baja California and China, respectively, than for the migration of eastern gray whales, and therefore this population would be more sensitive to energy lost through disturbance.

Pirotta et al. (2018b) modeled one reproductive cycle of a female North Pacific blue whale, starting with leaving the breeding grounds off Baja California to begin migrating north to feeding grounds off California, and ending with her returning to the breeding grounds, giving birth, and lactating. They modeled this scenario with no disturbance and found 95 percent calf recruitment; under a "normal" environmental perturbation (El Niño-Southern Oscillation) there was a very small reduction in recruitment, and, under an "unprecedented" environmental change, recruitment was reduced to 69 percent. An intense, localized anthropogenic disturbance was modeled (although the duration of the event was not provided); if the animals were not allowed to leave the area, they did not forage and recruitment dropped to 63 percent. However, if animals could leave the area of the disturbance then there was almost no change to the recruitment rate. A weak but broader spatial disturbance, where foraging was reduced by 50 percent, caused only a small decrease in calf recruitment to 94 percent. Similarly, Hin et al. (2019) looked at the impacts of disturbance on long-finned pilot whales and found that the timing of the disturbance with seasonally-available resources is important. If a disturbance occurred during periods of low resource availability, the population-level consequences were greater than if the disturbance occurred during periods when resource levels were high.

Using the Population Consequences of Disturbance framework, modeling of the long-term consequences of exposure has been conducted for a variety of marine mammal species and stressors. Even when high and frequent exposure levels are included, few long-term consequences have been predicted. For example, De Silva et al. (2014) conducted a population viability analysis on the long-term impacts of pile driving and construction noise on harbor porpoises and bottlenose dolphins. Despite including the extreme and unlikely assumptions that 25 percent of animals that received PTS would die, and that behavioral displacement from an area would lead to breeding failure, the model only found short-term impacts on the population size and no long-term effects on population viability. Similarly, King et al. (2015) developed a Population Consequences of Disturbance framework using expert elicitation data on impacts from wind farms on harbor porpoises, and even under the worst case scenarios predicted less than a 0.5 percent decline in harbor porpoise populations. Nabe-Nelson et al. (2014) also modeled the impact of noise from wind farms on harbor porpoises and predicted that even when assuming a 10 percent reduction in population size if prey is impacted up to two days, the presence of ships and wind turbines did not deplete the population. In contrast, Heinis and De Jong (2015) used the Population Consequences of Disturbance framework to estimate impacts from both pile driving and seismic exploration on harbor porpoises and found a 23 percent decrease in population size over six years, with an increased risk for further reduction with additional disturbance days. These seemingly contradictory results demonstrate that refinements to models need to be investigated to improve consistency and interpretation of model results.

Recent studies have investigated the potential consequences of fasting for harbor porpoises because their high metabolic rate may leave them especially vulnerable to disturbances that prevent them from feeding. Kastelein et al. (2019c) used an opportunistic experimental approach whereby four stranded wild harbor porpoises were able to consume 85–100 percent of their daily food mass intake in a short time period with no physical problems, suggesting they can compensate for periods of missed feeding if food is available. Similarly, using a modelled approach, Booth (2019) found that harbor porpoises are capable of recovering from lost foraging opportunities, largely because of their varied diet, high foraging rates, and high prey capture success. By modeling their foraging behavior and known prey species and sizes, the porpoises' generalist feeding behavior, in most scenarios, would enable them to obtain more than 100 percent of their energetic needs through typical foraging behavior, and therefore would largely be robust to short-term disturbances to foraging.

The Population Consequences of Disturbance model developed by New et al. (2013b) predicted that beaked whales require energy dense prey and high quality habitat, and that non-lethal disturbances that displace whales from that habitat could lead to long-term impacts on fecundity and survival; however, the authors were forced to use many conservative assumptions within their model since many parameters are unknown for beaked whales. As discussed above in Schorr et al. (2014), beaked whales have been tracked roaming over distances of 250 km or more, indicating that temporary displacement from a small area may not preclude finding energy dense prey or high quality habitat. Farmer et al. (2018) developed a bioenergetics framework to examine the impact of foraging disruption on body reserves of individual sperm whales. The authors examined rates of daily foraging disruption to predict the number of days to terminal starvation for various life stages, assuming exposure to seismic surveys. Mothers with calves were found to be most vulnerable to disruptions. In addition, Derous et al. (2020) propose that blubber thickness, which has been used to measure cetacean energy stores and health, is not an appropriate metric because marine mammals may not use their fat stores in a similar manner to terrestrial mammals. These results may be useful in the development of future Population Consequences of Multiple Stressors and Population Consequences of Disturbance models since they should seek to qualify cetacean health in a more ecologically relevant manner.

Another Population Consequences of Disturbance model developed in New et al. (2014) predicted elephant seal populations to be relatively robust even with a greater than 50 percent reduction in foraging trips (only a 0.4 percent population decline in the following year). McHuron et al. (2018) modeled the introduction of a generalized disturbance at different times throughout the breeding cycle of California sea lions, with the behavior response being an increase in the duration of a foraging trip by the female. Very short duration disturbances or responses led to little change, particularly if the disturbance was a single event, and changes in the timing of the event in the year had little effect. However, with even relatively short disturbances or mild responses, when a disturbance was modeled as recurring there were resulting reductions in population size and pup recruitment. Often, the effects weren't noticeable for several years, as the impacts on pup recruitment did not affect the population until those pups were mature.

Population Consequences of Disturbance models can also be used to assess the impacts of multiple stressors. For example, Farmer et al. (2018) modeled the combined impacts of an oil spill and acoustic disturbance due to seismic airgun surveys. They found that the oil spill led to declines in the population over 10 years, and some models that included behavioral response to airguns found further declines. However, the amount of additional population decline due to acoustic disturbance depended on the way the dose-response of the noise levels were modeled, with a single step-function leading to higher impacts than a function with multiple steps and frequency weighting. In addition, the amount of impact from both disturbances was mediated when the metric in the model that described animal resilience was changed to increase resilience to disturbance (e.g., able to make up reserves through increased foraging).

It should be noted that, in all of these models, assumptions were made and many input variables were unknown and so were estimated using available data. It is still not possible to utilize individual short-term behavioral responses to estimate long-term or population-level effects.

The best assessment of long-term consequences from Navy training activities will be to monitor the populations over time within the Study Area. A U.S. workshop on Marine Mammals and Sound (Fitch et al., 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed and implemented comprehensive monitoring plans since 2009 for protected marine mammals occurring on Navy ranges with the goal of assessing the impacts of training activities on marine species and the effectiveness of the Navy's mitigation measures. The results of this long-term monitoring are now being compiled and analyzed for trends in occurrence or abundance over time (e.g., Martin et al., 2017); preliminary results of this analysis at Pacific Missile Range Facility off Kauai, Hawaii indicate no changes in detection rates for several species over the past decade, demonstrating that Navy activities may not be having long-term population-level impacts. This type of analysis can be expanded to the other Navy ranges, such as in the Pacific Northwest. Continued analysis of this 15-year dataset and additional monitoring efforts over time are necessary to fully understand the long-term consequences of exposure to military readiness activities.

3.8.3.1.2 Impacts from Sonar and Other Transducers

Sonar and other transducers proposed for use could be used throughout the Study Area. Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of these systems are described in Section 3.0.4.1 (Acoustic Sources).

Sonar-induced acoustic resonance and bubble formation phenomena are very unlikely to occur under realistic conditions, as discussed in Section 3.8.3.1.1.1 (Injury). Non-auditory injury (i.e., other than PTS) and mortality from sonar and other transducers is so unlikely as to be discountable under normal conditions and is therefore not considered further in this analysis.

The most probable impacts from exposure to sonar and other transducers are PTS, TTS, behavioral reactions, masking, and physiological stress (Sections 3.8.3.1.1.2, Hearing Loss; 3.8.3.1.1.3, Physiological Stress; 3.8.3.1.1.4, Masking; and 3.8.3.1.1.5, Behavioral Reactions).

3.8.3.1.2.1 Methods for Analyzing Impacts from Sonar and Other Transducers

The Navy performed a quantitative analysis to estimate the number of times that marine mammals could be affected by sonars and other transducers used during Navy training activities. The Navy's quantitative analysis to determine impacts on marine mammals uses the Navy Acoustic Effects Model to produce initial estimates of the number of times that animals may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of procedural mitigation measures. The steps of this quantitative analysis are described in Section 3.0.1.2 (Navy's Quantitative Analysis to Determine Impacts to Sea Turtles and Marine Mammals), which takes into account

- criteria and thresholds used to predict impacts from sonar and other transducers (see below);
- the species density (U.S. Department of the Navy, 2020b) and spatial distribution (Watwood et al., 2018) of marine mammals; and
- the influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation when estimating the received sound level on the animals.

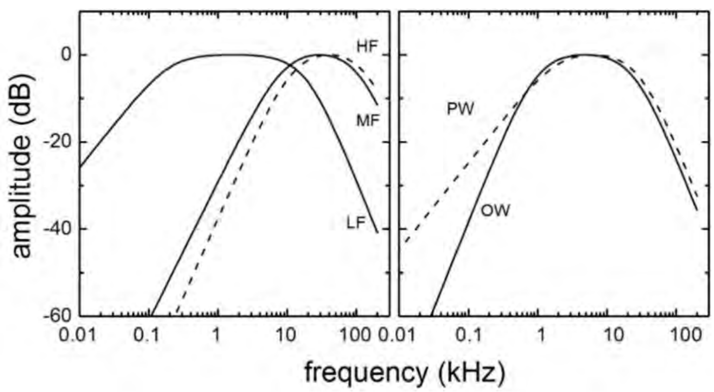
A detailed explanation of this analysis is provided in the technical report titled *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018d).

Criteria and Thresholds Used to Estimate Impacts from Sonar and Other Transducers

See the technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a) for detailed information on how the criteria and thresholds were derived. The marine mammal criteria and thresholds developed for that technical report were relied on by National Marine Fisheries Service in establishing guidance for assessing the effects of sound on marine mammal hearing (National Marine Fisheries Service, 2016h) and were re-affirmed in the 2018 revision (National Marine Fisheries Service, 2018a). In addition, these auditory impact criteria were recently published by Southall et al. (2019c).

Auditory Weighting Functions

Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions are used (Figure 3.8-6). Auditory weighting functions are mathematical functions that adjust received sound levels to emphasize ranges of best hearing and de-emphasize ranges with less or no auditory sensitivity. They are based on a generic band pass filter and incorporates species-specific hearing abilities to calculate a weighted received sound level in units SPL or SEL. Due to the band pass nature of auditory weighting functions, they resemble an inverted "U" shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range (i.e., the pass-band), while the frequencies below and above this range (where amplitude declines) are de-emphasized.



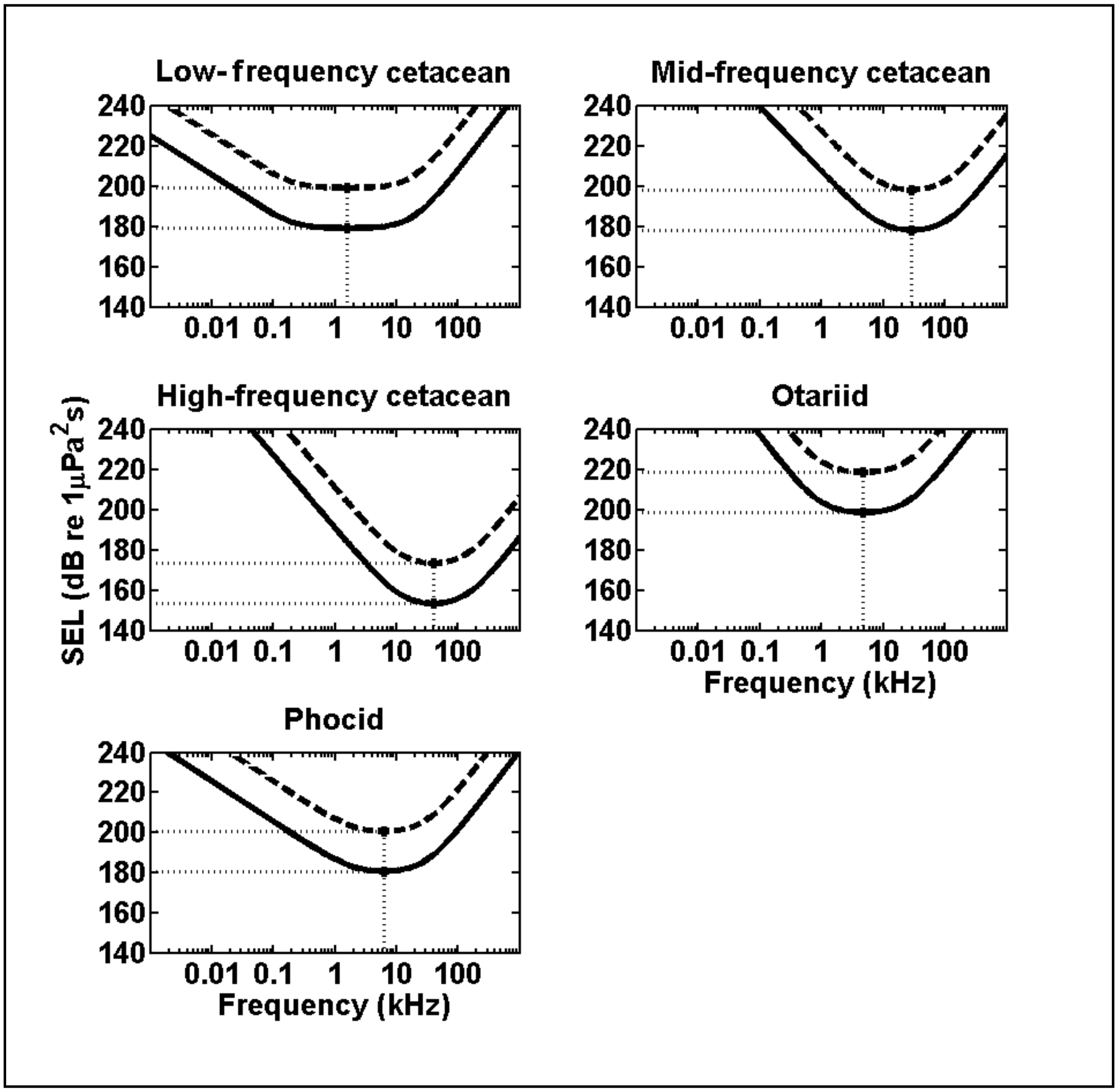
Source: For parameters used to generate the functions and more information on weighting function derivation, see the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report (U.S. Department of the Navy (2017a))

Notes: HF = high-frequency cetacean, LF = low-frequency cetacean, MF = mid-frequency cetacean, PW = phocid (in-water), and OW = otariid (in-water).

Figure 3.8-6: Navy Auditory Weighting Functions for All Species Groups

Hearing Loss from Sonar and Other Transducers

Defining the TTS and PTS exposure functions (Figure 3.8-7) requires identifying the weighted exposures necessary for TTS and PTS onset from sounds produced by sonar and other transducers. The criteria used to define threshold shifts from non-impulsive sources (e.g., sonar) determines TTS onset as the SEL necessary to induce 6 dB of threshold shift. An SEL 20 dB above the onset of TTS is used in all hearing groups of marine mammals underwater to define the PTS threshold (Southall et al., 2007).



Notes: The solid curve is the exposure function for TTS onset and the large dashed curve is the exposure function for PTS onset. Small dashed lines and asterisks indicate the SEL threshold for TTS and PTS onset in the frequency range of best hearing.

Figure 3.8-7: TTS and PTS Exposure Functions for Sonar and Other Transducers

Behavioral Responses from Sonar and Other Transducers

Behavioral response criteria are used to estimate the number of animals that may exhibit a behavioral response to sonar and other transducers. See the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report for detailed information on how the Behavioral Response Functions were derived (U.S. Department of the Navy, 2017a). Developing the new behavioral criteria involved multiple steps. All peer-reviewed published behavioral response studies conducted both in the field and on captive animals were examined in order to understand the breadth of behavioral responses of marine mammals to sonar and other transducers.

The data from the behavioral studies were analyzed by looking for significant responses, or lack thereof, for each experimental session. The terms "significant response" or "significant behavioral response" are used in describing behavioral observations from field or captive animal research that may rise to the level of "harassment" for military readiness activities. Under the MMPA, for military readiness activities, such as Navy training, behavioral "harassment" is "any act that *disturbs* or is likely to *disturb* a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering*, to a point where such behavioral patterns are abandoned or significantly altered*" (16 U.S.C. section 1362(3)(18)(B)). Under the ESA, NMFS has issued interim guidance on the term "harass," defining it as an action that "creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering."

The likelihood of injury due to disruption of normal behaviors would depend on many factors, such as the duration of the response, from what the animal is being diverted, and life history of the animal. Due to the nature of behavioral response research to date, it is not currently possible to ascertain the types of observed reactions that would lead to an abandonment or significant alteration of a natural behavior pattern. Therefore, the Navy has developed a methodology to estimate the possible significance of behavioral reactions and impacts on natural behavior patterns.

Behavioral response severity is described herein as "low," "moderate," or "high." These are derived from the Southall et al. (2007) severity scale. Low severity responses are those behavioral responses that fall within an animal's range of typical (baseline) behaviors and are unlikely to disrupt an individual to a point where natural behavior patterns are significantly altered or abandoned. Low severity responses include an orientation or startle response, change in respiration, change in heart rate, and change in group spacing or synchrony.

Moderate severity responses could become significant if sustained over a longer duration. What constitutes a long-duration response is different for each situation and species, although it is likely dependent upon the magnitude of the response and species characteristics such as age, body size, feeding strategy, and behavioral state at the time of the exposure. In general, a response could be considered "long-duration" if it lasted for tens of minutes to a few hours, or enough time to significantly disrupt an animal's daily routine.

Moderate severity responses included:

- alter migration path
- alter locomotion (speed, heading)
- alter dive profiles
- stop/alter nursing
- stop/alter breeding
- stop/alter feeding/foraging
- stop/alter sheltering/resting
- stop/alter vocal behavior if tied to foraging or social cohesion
- avoid area near sound source

For the derivation of behavioral criteria, a significant duration was defined as a response that lasted for the duration of exposure or longer, regardless of how long the exposure session may have been. This assumption was made because it was not possible to tell if the behavioral responses would have continued if the exposure had continued. The costs associated with these observed behavioral reactions were not measured so it is not possible to judge whether reactions would have risen to the level of significance as defined above, although it was conservatively assumed the case. High severity responses include those responses with immediate consequences (e.g., stranding, mother-calf separation), and were always considered significant behavioral reactions regardless of duration.

Marine mammal species were placed into behavioral criteria groups based on their known or suspected behavioral sensitivities to sound (Figure 3.8-8 through Figure 3.8-11). In most cases, these divisions are driven by taxonomic classifications (e.g., mysticetes, pinnipeds). The Odontocete group combines most of the mid- and high-frequency cetaceans, without the beaked whales or harbor porpoises, while the Pinniped group combines the otariids and phocids. These groups are combined as there are not enough data to separate them for behavioral responses.

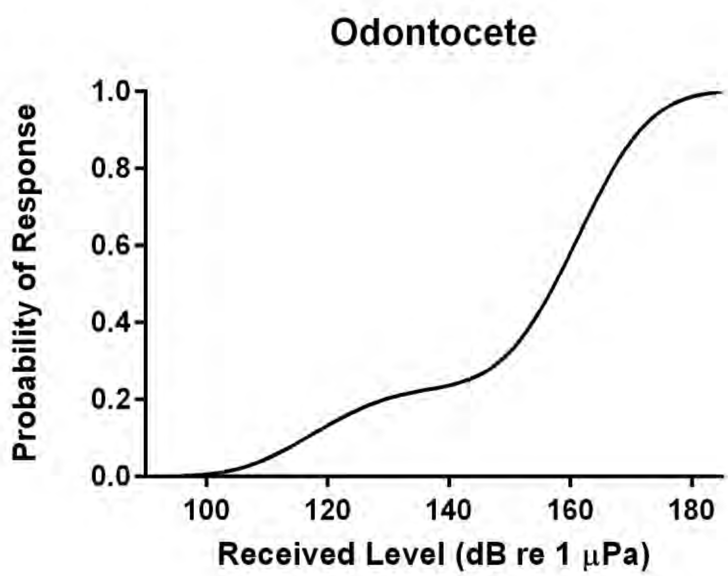


Figure 3.8-8: Behavioral Response Function for Odontocetes

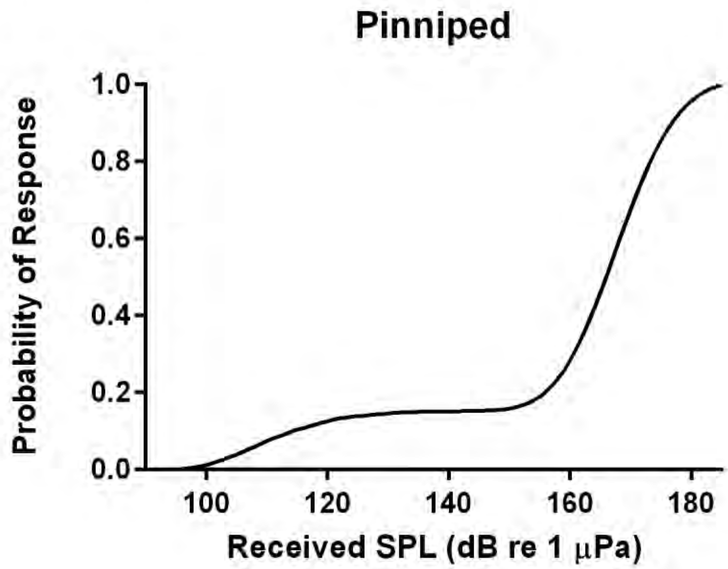


Figure 3.8-9: Behavioral Response Function for Pinnipeds

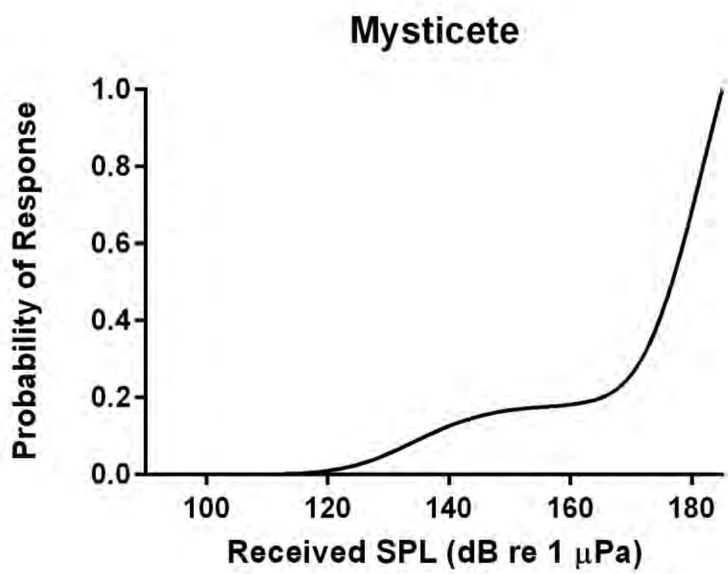


Figure 3.8-10: Behavioral Response Function for Mysticetes

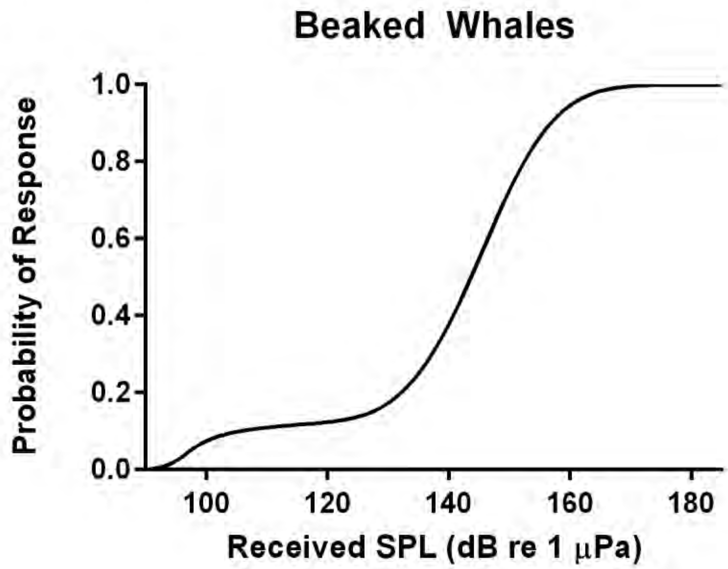


Figure 3.8-11: Behavioral Response Function for Beaked Whales

The information currently available regarding harbor porpoises suggests a very low threshold level of response for both captive and wild animals. Threshold levels at which both captive (Kastelein et al., 2000; Kastelein et al., 2005b) and wild harbor porpoises (Johnston, 2002) responded to sound (e.g., acoustic harassment devices, acoustic deterrent devices, or other non-impulsive sound sources) are very low, approximately 120 dB re 1 µPa. Therefore, a SPL of 120 dB re 1 µPa is used in this analysis as a threshold for predicting behavioral responses in harbor porpoises.

Although there is no research on the effects of sonar on sea otters, based on their low reactivity to other acoustic and anthropogenic stressors, sea otters exposed to sonar received levels below the threshold for TTS are assumed to be unlikely to exhibit behavioral responses that would be considered "harassment" under the MMPA for military readiness activities.

The behavioral response functions only consider one aspect of an acoustic exposure, the received level. While the behavioral response functions applied in this analysis are an improvement from historical behavioral step functions (Tyack & Thomas, 2019), marine mammal behavioral response research suggests that the context of an exposure also affects a potential response (Ellison et al., 2011; also Section 3.8.3.1.1.5, Behavioral Reactions). The distance between the animal and the sound source is a strong factor in determining that animal's potential reaction (e.g., DeRuiter et al., 2013b). For all taxa, therefore, distances beyond which significant behavioral responses to sonar and other transducers are unlikely to occur, denoted as "cutoff distances," were defined based on existing data (Table 3.8-3). These cutoff distances include even the most distant detected responses to date (e.g., 28 km in northern bottlenose whales (Wensveen et al., 2019). For training activities that contain multiple platforms or tactical sonar sources that exceed 215 dB re 1 µPa at 1 m, this cutoff distance is substantially increased (i.e., doubled) from values derived from the literature. The use of multiple platforms and intense sound sources are factors that probably increase responsiveness in marine mammals overall. There are currently few behavioral observations under these circumstances; therefore, the Navy will conservatively predict significant behavioral responses at farther ranges for these more intense activities.

Table 3.8-3: Cutoff Distances for Moderate Source Level, Single Platform Training Events and for All Other Events with Multiple Platforms or Sonar with Source Levels at or Exceeding 215 dB re 1 µPa at 1 m

Criteria Group	*Moderate SL/Single Platform Cutoff Distance*	*High SL/Multi-Platform Cutoff Distance*
Odontocetes	10 km	20 km
Pinnipeds and Mustelids	5 km	10 km
Mysticetes	10 km	20 km
Beaked Whales	25 km	50 km
Harbor Porpoise	20 km	40 km

Notes: dB re 1 µPa at 1 m= decibels referenced to 1 micropascal at 1 meter, km= kilometer, SL= source level

Assessing the Severity of Behavioral Responses from Sonar Under Military Readiness

As discussed above, the terms "significant response" or "significant behavioral response" are used in describing behavioral reactions that may lead to an abandonment or significant alteration of a natural behavior pattern. Due to the limited amount of behavioral response research to date and relatively short durations of observation, it is not possible to ascertain the true significance of the majority of the observed reactions. When deriving the behavioral criteria, it was assumed that most reactions that lasted for the duration of the sound exposure or longer were significant, even though many of the exposures lasted for 30 minutes or less. Furthermore, the experimental designs used during many of the behavioral response studies were unlike Navy activities in many important ways. These differences include tagging subject animals, following subjects for sometimes hours before the exposure, vectoring towards the subjects after animals began to avoid the sound source, and making multiple close passes on focal groups. This makes the estimated behavioral impacts from Navy activities using the criteria derived from these experiments difficult to interpret. While the state of science does not currently support definitively distinguishing between significant and insignificant behavioral reactions, as described in the technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a), Navy's analysis incorporates conservative assumptions to account for this uncertainty and therefore likely overestimates the potential impacts.

The estimated behavioral reactions from the Navy's quantitative analysis are grouped into several categories based on the most powerful sonar source, the number of platforms, the duration, and geographic extent of each Navy activity attributed to the predicted impact.

Low severity responses are within an animal's range of typical (baseline) behaviors and are unlikely to disrupt an individual to a point where natural behavior patterns are significantly altered or abandoned. Although the derivation of the Navy's behavioral criteria did not count low severity responses as significant behavioral responses, in practice, some reactions estimated using the behavioral criteria are likely to be low severity (Figure 3.8-12).

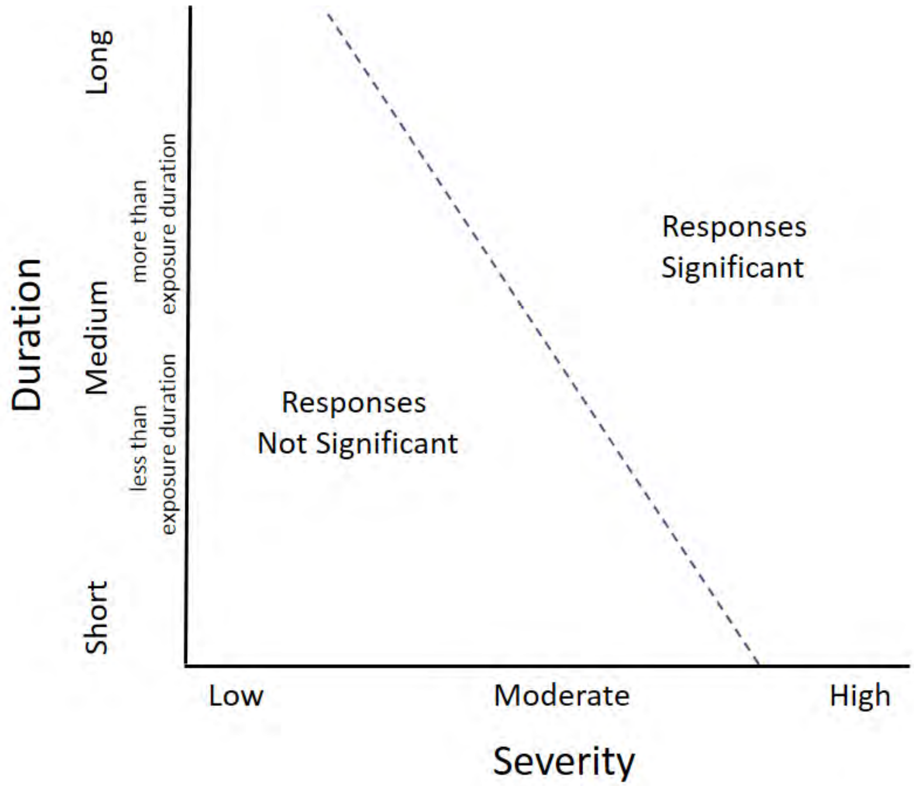


Figure 3.8-12: Relative Likelihood of a Response Being Significant Based on the Duration and Severity of Behavioral Reactions

High severity responses are those with a higher potential for direct consequences to growth, survivability, or reproduction. Examples include prolonged separation of females and dependent offspring, panic, flight, stampede, or stranding. High severity reactions would always be considered significant; however, these types of reactions are probably rare under most conditions and may still not lead to direct consequences on survivability. For example, a separation of a killer whale mother-calf pair was observed once during a behavioral response study to an active sonar source (Miller et al., 2014), but the animals were rejoined as soon as the ship had passed. Therefore, although this was a severe response, it did not lead to a negative outcome. Five beaked whale strandings have also occurred associated with U.S. Navy active sonar use as discussed above (see Section 3.8.3.1.1.6, Stranding), but the confluence of factors that contributed to those strandings is now better understood, and the avoidance of those factors has resulted in no known marine mammal strandings associated with U.S. Navy sonar activities for over a decade. The Navy is unable to predict these high severity responses for any activities since the probability of occurrence is apparently very low, although the Navy acknowledges that severe reactions could occasionally occur. In fact, no significant behavioral responses such as panic, stranding or other severe reactions have been observed during monitoring of actual training activities.

Many of the responses estimated using the Navy's quantitative analysis are most likely to be moderate severity. Moderate severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As mentioned previously, the behavioral response functions used within the Navy's quantitative analysis were primarily derived from experiments using short-duration sound exposures lasting, in many cases, for less than 30 minutes. If animals exhibited moderate severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However, the experiments did not include measurements of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences. Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to sonar that may exceed an animal's behavioral threshold for only a single ping to several minutes. While the state of science does not currently support definitively distinguishing between significant and insignificant behavioral reactions, as described in the technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a), the Navy's analysis incorporates conservative assumptions to account for this uncertainty and therefore likely overestimates the potential impacts.

Accounting for Mitigation

The Navy will implement mitigation measures to avoid or reduce potential impacts from active sonar on marine mammals, as described in Section 5.3.2.1 (Active Sonar). The benefits of mitigation are conservatively factored into the analysis for Alternative 1 of the Proposed Action. Procedural mitigation measures include a power down or shut down (i.e., power off) of applicable active sonar sources when a marine mammal is observed in a mitigation zone. The mitigation zones for active sonar activities were designed to avoid the potential for marine mammals to be exposed to levels of sound that could result in auditory injury (i.e., PTS) from active sonar to the maximum extent practicable. The mitigation zones for active sonar extend beyond the respective average ranges to auditory injury (including PTS). Therefore, the impact analysis considers the potential for procedural mitigation to reduce the risk of PTS. Two factors are considered when quantifying the effectiveness of procedural mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018d).

The impact analysis does not consider the potential for mitigation to reduce TTS or behavioral effects, even though mitigation could also reduce the likelihood of these effects. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species that may be near or within the mitigation zone.

The ability to observe the ranges to PTS was estimated for each training event. The ability of Navy Lookouts to detect marine mammals within a mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as group size or surface active behavior). The behaviors and characteristics of some species may make them easier to detect. Certain behaviors, such as leaping and breaching, are visible from a great distance and likely increase sighting distances and detections of those species. Environmental conditions under which the training activity could take place are also considered, such as sea surface conditions, weather (e.g., fog or rain), and day versus night.

The Navy will also implement mitigation measures for certain active sonar activities within the North Pacific Right Whale Mitigation Area from June 1 through September 30, as described in Section 5.4 (Geographic Mitigation to be Implemented). Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. The benefits of mitigation areas are discussed qualitatively in terms of the context of impact avoidance or reduction.

Marine Mammal Avoidance of Sonar and other Transducers

Because a marine mammal is assumed to initiate avoidance behavior after an initial startle reaction when exposed to relatively high received levels of sound, a marine mammal could reduce its cumulative sound energy exposure over a sonar event with multiple pings (i.e., sound exposures). This would reduce risk of both PTS and TTS, although the quantitative analysis conservatively only considers the potential to reduce instances of PTS by accounting for marine mammals swimming away to avoid repeated high-level sound exposures. All reductions in PTS impacts from likely avoidance behaviors are instead considered TTS impacts.

3.8.3.1.2.2 Impact Ranges for Sonar and Other Transducers

The following section provides range to effects for sonar and other transducers to specific criteria determined using the Navy Acoustic Effects Model. Marine mammals within these ranges would be predicted to receive the associated effect. Range to effects is important information in not only predicting acoustic impacts, but also in verifying the accuracy of model results against real-world situations and assessing the level of impact that will likely be mitigated within applicable mitigation zones.

The ranges are the distance where the threshold is not exceeded at any depth where animals could be present (excluding negligible small convergence points in some instances). Thus, portions of the water column within the ranges shown would not exceed threshold (i.e., the range does not represent a cylinder of effect in the water column). In some instances, a significant portion of the water column within the ranges shown may not exceed threshold. These differences in propagation are captured in the actual estimation of takes within the Navy Acoustic Effects Model.

The ranges to the PTS threshold for an exposure of 30 seconds are shown in Table 3.8-4 relative to the marine mammal's functional hearing group. This period (30 seconds) was chosen based on examining the maximum amount of time a marine mammal would realistically be exposed to levels that could cause the onset of PTS based on platform (e.g., ship) speed and a nominal animal swim speed of approximately 1.5 meters per second. The ranges provided in the table include the average range to PTS, as well as the range from the minimum to the maximum distance at which PTS is possible for each hearing group. Since any hull-mounted sonar, such as the SQS-53, engaged in anti-submarine warfare training would be moving at between 10 and 15 knots and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 257 m during the time between those pings (note: 10 knots is the speed used in the Navy Acoustic Effects Model). As a result, there is little overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). For all other bins (besides MF1), PTS ranges are short enough that marine mammals (with a nominal swim speed of approximately 1.5 meters per second) should be able to avoid higher sound levels capable of causing onset PTS within this 30-second period.

For a SQS-53C (i.e., bin MF1) sonar transmitting for 30 seconds at 3 kHz and a source level of 235 dB re 1 µPa^{2}s at 1 m, the average range to PTS for the most sensitive species (the high-frequency cetaceans) extends from the source to a range of 180 m. For all other functional hearing groups (low-frequency cetaceans, mid-frequency cetaceans, otariids, phocids and mustelids), 30-second average PTS zones are substantially shorter, as shown in Table 3.8-4. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship, however, the close distances required make PTS exposure unlikely. For a military vessel moving at a nominal 10 knots, it is unlikely a marine mammal could maintain the speed to parallel the ship and receive adequate energy over successive pings to suffer PTS.

The tables below illustrate the range to TTS for 1, 30, 60, and 120 seconds from five representative sonar systems (Table 3.8-4 through Table 3.8-7). Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer. Therefore, successive pings can be expected to add together, further increasing the range to TTS onset. For some hearing groups and bins, the ranges to PTS and TTS are zero because the source level is low relative to threshold shift susceptibility at the relevant hearing frequency.

Table 3.8-4: Range to Permanent Threshold Shift for Three Representative Sonar Systems

Hearing Group	*Approximate PTS (30 seconds) Ranges (meters)*[1]		
	Sonar bin MF1	*Sonar bin MF4*	*Sonar bin MF5*
High-frequency cetaceans	180 (180–180)	31 (30–35)	9 (8–10)
Low-frequency cetaceans	65 (65–65)	13 (0–15)	0 (0–0)
Mid-frequency cetaceans	16 (16–16)	3 (3–3)	0 (0–0)
Otariids and Mustelids	6 (6–6)	0 (0–0)	0 (0–0)
Phocids	45 (45–45)	11 (11–11)	0 (0–0)

[1]PTS ranges extend from the sonar or other transducer sound source to the indicated distance. The average range to PTS is provided as well as the range from the estimated minimum to the maximum range to PTS in parenthesis.

Notes: MF = mid-frequency, PTS = permanent threshold shift seals are separated from other phocids due to their dive behavior, which is much deeper than the other phocids analyzed

Table 3.8-5: Ranges to Temporary Threshold Shift for Sonar Bin MF1 over a Representative Range of Environments Within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin MF1			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	3,554 (1,525–6,775)	3,554 (1,525–6,775)	5,325 (2,275–9,525)	7,066 (2,525–13,025)
Low-frequency cetaceans	920 (850–1,025)	920 (850–1,025)	1,415 (1,025–2,025)	2,394 (1,275–4,025)
Mid-frequency cetaceans	209 (200–210)	209 (200–210)	301 (300–310)	376 (370–390)
Otariids and Mustelids	65 (65–65)	65 (65–65)	100 (100–110)	132 (130–140)
Phocids	673 (650–725)	673 (650–725)	988 (900–1,025)	1,206 (1,025–1,525)

[1]Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.
Notes: HF = high frequency, TTS = temporary threshold shift

Table 3.8-6: Ranges to Temporary Threshold Shift for Sonar Bin MF4 over a Representative Range of Environments Within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin MF4			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	318 (220–550)	686 (430–1,275)	867 (575–1,525)	1,225 (825–2,025)
Low-frequency cetaceans	77 (0–100)	175 (130–340)	299 (190–550)	497 (280–1,000)
Mid-frequency cetaceans	22 (22–22)	35 (35–35)	50 (50–50)	71 (70–75)
Otariids and Mustelids	8 (8–8)	15 (15–15)	19 (19–19)	25 (25–25)
Phocids	67 (65–70)	123 (110–150)	172 (150–210)	357 (240–675)

[1]Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.
Notes: HF = high frequency, TTS = temporary threshold shift

Table 3.8-7: Ranges to Temporary Threshold Shift for Sonar Bin MF5 over a Representative Range of Environments Within the Study Area

Hearing Group	***Approximate TTS Ranges (meters)[1]***			
	Sonar Bin MF5			
	1 second	***30 seconds***	***60 seconds***	***120 seconds***
High-frequency cetaceans	117 (110–140)	117 (110–140)	176 (150–320)	306 (210–800)
Low-frequency cetaceans	9 (0–12)	9 (0–12)	13 (0–17)	19 (0–24)
Mid-frequency cetaceans	5 (0–9)	5 (0–9)	12 (11–13)	18 (17–18)
Otariids and Mustelids	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Phocids	9 (8–10)	9 (8–10)	14 (14–15)	21 (21–22)

[1]Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.
Notes: HF = high frequency, TTS = temporary threshold shift

The range to received sound levels in 6 dB steps from five representative sonar bins and the percentage of animals that may exhibit a significant behavioral response under each behavioral response function (or step function in the case of the harbor porpoise) are shown in Table 3.8-8 through Table 3.8-10, respectively. See Section 3.8.3.1.2.1 (Methods for Analyzing Impacts from Sonar and Other Transducers) for details on the derivation and use of the behavioral response functions, thresholds, and the cutoff distances.

Table 3.8-8: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF1 over a Representative Range of Environments Within the Study Area

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin MF1				
		Beaked whales	Harbor Porpoise	Mysticetes	Odontocetes	Pinnipeds
196	105 (100–110)	100%	100%	100%	100%	100%
190	240 (240–240)	100%	100%	98%	100%	100%
184	498 (490–525)	100%	100%	88%	99%	98%
178	1,029 (950–1,275)	100%	100%	59%	97%	92%
172	3,798 (1,525–7,025)	99%	100%	30%	91%	76%
166	8,632 (2,775–14,775)	97%	100%	20%	78%	48%
160	15,000 (3,025–26,525)	93%	100%	18%	58%	27%
154	23,025 (3,275–47,775)	83%	100%	17%	40%	18%
148	47,693 (10,275–54,025)	66%	100%	16%	29%	16%
142	53,834 (12,025–72,025)	45%	100%	13%	25%	15%
136	60,035 (13,275–74,525)	28%	100%	9%	23%	15%
130	72,207 (14,025–75,025)	18%	100%	5%	20%	15%
124	73,169 (17,025–75,025)	14%	100%	2%	17%	14%
118	72,993 (25,025–75,025)	12%	0%	1%	12%	13%
112	72,940 (27,525–75,025)	11%	0%	0%	6%	9%
106	73,016 (28,525–75,025)	11%	0%	0%	3%	5%
100	73,320 (30,025–75,025)	8%	0%	0%	1%	2%

Notes: (1) Cells are shaded if the mean range value for the specified received level exceeds the distance cut-off range for a particular hearing group. Any impacts within the cut-off range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels or multiple platforms.
(2) dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

Table 3.8-9: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF4 over a Representative Range of Environments Within the Study Area

Received Level (dB re 1 µPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin MF4*				
		Beaked whales	*Harbor Porpoise*	*Mysticetes*	*Odontocetes*	*Pinnipeds*
196	8 (0–8)	100%	100%	100%	100%	100%
190	17 (0–17)	100%	100%	98%	100%	100%
184	34 (0–35)	100%	100%	88%	99%	98%
178	69 (0–75)	100%	100%	59%	97%	92%
172	156 (120–190)	99%	100%	30%	91%	76%
166	536 (280–1,000)	97%	100%	20%	78%	48%
160	1,063 (470–1,775)	93%	100%	18%	58%	27%
154	2,063 (675–4,275)	83%	100%	17%	40%	18%
148	5,969 (1,025–9,275)	66%	100%	16%	29%	16%
142	12,319 (1,275–26,025)	45%	100%	13%	25%	15%
136	26,176 (1,775–40,025)	28%	100%	9%	23%	15%
130	42,963 (2,275–54,775)	18%	100%	5%	20%	15%
124	53,669 (2,525–65,775)	14%	100%	2%	17%	14%
118	63,387 (2,775–75,025)	12%	0%	1%	12%	13%
112	71,709 (3,025–75,025)	11%	0%	0%	6%	9%
106	73,922 (22,775–75,025)	11%	0%	0%	3%	5%
100	73,923 (25,525–75,025)	8%	0%	0%	1%	2%

Notes: (1) Cells are shaded if the mean range value for the specified received level exceeds the distance cut-off range for a particular hearing group. Any impacts within the cut-off range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels or multiple platforms.
(2) dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

Table 3.8-10: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF5 over a Representative Range of Environments Within the Study Area

Received Level (dB re 1 µPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin MF5*				
		Beaked whales	*Harbor Porpoise*	*Mysticetes*	*Odontocetes*	*Pinnipeds*
196	0 (0–0)	100%	100%	100%	100%	100%
190	1 (0–3)	100%	100%	98%	100%	100%
184	4 (0–7)	100%	100%	88%	99%	98%
178	14 (0–15)	100%	100%	59%	97%	92%
172	29 (0–30)	99%	100%	30%	91%	76%
166	59 (0–65)	97%	100%	20%	78%	48%
160	130 (0–170)	93%	100%	18%	58%	27%
154	349 (0–1,025)	83%	100%	17%	40%	18%
148	849 (410–2,275)	66%	100%	16%	29%	16%
142	1,539 (625–3,775)	45%	100%	13%	25%	15%
136	2,934 (950–8,525)	28%	100%	9%	23%	15%
130	6,115 (1,275–10,275)	18%	100%	5%	20%	15%
124	9,764 (1,525–16,025)	14%	100%	2%	17%	14%
118	13,830 (1,775–24,775)	12%	0%	1%	12%	13%
112	18,970 (2,275–30,775)	11%	0%	0%	6%	9%
106	25,790 (2,525–38,525)	11%	0%	0%	3%	5%
100	36,122 (2,775–46,775)	8%	0%	0%	1%	2%

Notes: (1) Cells are shaded if the mean range value for the specified received level exceeds the distance cut-off range for a particular hearing group. Any impacts within the cut-off range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels or multiple platforms.
(2) dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

3.8.3.1.2.3 Impacts from Sonar and Other Transducers Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.8.3.1.2.4 Impacts from Sonar and Other Transducers Under Alternative 1

Sonar and other transducers proposed for use are typically transient and temporary because activities that involve sonar and other transducers take place at different locations and many platforms are generally moving throughout the TMAA. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training under Alternative 1 are described in Section 3.0.4.1 (Acoustic Sources). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). The proposed use of sonar for training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Most estimated impacts are due to anti-submarine warfare sonar activities, which could vary in duration and intensity. The number of hours these sonars would be operated under Alternative 1 is described in Section 3.0.4.1 (Acoustic Sources). Although the existing baseline conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, a detailed re-analysis of Alternative 1 with respect to marine mammals is provided here to supplant previous analysis based on available new literature, adjusted sound exposure criteria, and new acoustic effects modeling.

Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts on marine mammals from sonar and other transducers (Section 3.8.3.1.2.1, Methods for Analyzing Impacts from Sonar and Other Transducers) are discussed below. The numbers of potential impacts estimated for individual species and stocks of marine mammals from exposure to sonar for training activities under Alternative 1 is shown in Appendix C (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training Activities) and presented below in tables for each species of marine mammal with any estimated effects. All impacts from sonar and other transducers within the TMAA are limited to training activities conducted over 21 consecutive days during April to October of any given year. There is a potential for impacts to occur anywhere within the TMAA where sound from sonar and the species overlap. It is important to note when examining the results of the quantitative analysis that the behavioral response functions used to predict the numbers of reactions in this analysis are largely derived from several studies (see Section 3.8.3.1.1.5, Behavioral Reactions). The best available science, including behavioral response studies, was used for deriving these criteria; however, many of the factors inherent in these studies that potentially increased the likelihood and severity of observed responses (e.g., close approaches by multiple vessels, tagging animals, and vectoring towards animals that have already begun avoiding the sound source) would not occur during Navy activities. Because the Navy purposely avoids approaching marine mammals, many of the behavioral responses estimated by the quantitative analysis are unlikely to occur or unlikely to rise to the severity observed during many of the behavioral response studies.

Although the statutory definition of Level B harassment for military readiness activities under the MMPA requires that the natural behavior patterns of a marine mammal be significantly altered or abandoned, the current state of science for determining those thresholds is somewhat unsettled. Therefore, in its analysis of impacts associated with acoustic sources, the Navy is adopting a conservative approach that overestimates the number of takes by Level B harassment. The responses estimated using the Navy's quantitative analysis are most likely to be moderate severity. Moderate severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As discussed in Section 3.8.3.1.2.1 (Methods for Analyzing Impacts from Sonar and Other Transducers), the behavioral response functions used within the Navy's quantitative analysis were primarily derived from experiments using short-duration sound exposures lasting, in many cases, for less than 30 minutes. If animals exhibited moderate severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However, the experiments did not include measurements of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences. Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to sound that may exceed an animal's behavioral threshold for only a single exposure up to several minutes. It is likely that many of the estimated behavioral reactions within the Navy's quantitative analysis would not constitute significant behavioral reactions; however, the numbers of significant verses non-significant behavioral reactions are currently impossible to predict. Consequently, there is a high likelihood that significant numbers of marine mammals exposed to acoustic sources are not significantly altering or abandoning their natural behavior patterns. As such, the overall impact of acoustic sources from military readiness activities on marine mammal species and stocks is negligible (i.e., cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stocks through effects on annual rates of recruitment or survival).

Mysticetes

Mysticetes may be exposed to sound from sonar and other transducers associated with training activities between April and October in the TMAA. Most low- (less than 1 kHz) and mid- (1–10 kHz) frequency sonars and other transducers produce sounds that are likely to be within the hearing range of mysticetes (Section 3.8.2.1.4, Hearing and Vocalization). Some high-frequency sonars (greater than 10 kHz) also produce sounds that should be audible to mysticetes, although only smaller species of mysticetes such as minke whales are likely to be able to hear higher frequencies, presumably up to 30 kHz. Therefore, some high-frequency sonars and other transducers with frequency ranges between 10 and 30 kHz may also be audible to some mysticetes. If a sound is within an animal's hearing range then behavioral reactions, physiological stress, masking and hearing loss are potential impacts that must be analyzed. If a marine mammal cannot hear a sound, then behavioral reactions, physiological stress, masking, or hearing loss is not likely to occur. Impact ranges for mysticetes are discussed under low-frequency cetaceans in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers).

Behavioral reactions in mysticetes resulting from exposure to sonar could occur based on the quantitative analysis. Considering best available data on observed mysticete responses to sound exposure, behavioral responses would not be expected to occur beyond 20 km from events with multiple sound source platforms or high source levels, nor beyond 10 km from moderate source level, single platform events. Any predicted behavioral reactions are much more likely to occur within a few kilometers of the sound source. As discussed above in *Assessing the Severity of Behavioral Responses from Sonar* a*nd other Transducers Under Military Readiness*, the quantitative analysis very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions. Research shows that if mysticetes do respond they may react in a number of ways, depending on the characteristics of the sound source, their experience with the sound source, and whether they are migrating or on seasonal grounds (i.e., breeding or feeding). Behavioral reactions may include alerting, breaking off feeding dives and surfacing, or diving or swimming away. Overall, mysticetes have been observed to be more reactive to acoustic disturbance when a noise sources is located directly on their migration route. Mysticetes disturbed while migrating could pause their migration or route around the disturbance. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Therefore, behavioral reactions from mysticetes are likely to be short term and low to moderate severity.

Some mysticetes may avoid a larger activity such as a major training exercise as it moves through an area. Vessels and aircraft associated with training activities are typically in transit during an event (they are not stationary) and activities typically do not use the same training locations day after day during multi-day activities. If an event otherwise focuses on a fixed location, mysticetes may avoid the location of the activity for the duration of the event. If animals are displaced, they would likely return quickly after the event subsides. In the ocean, the use of sonar and other transducers is transient and is unlikely to expose the same population of animals repeatedly over a short period except around homeports and fixed instrumented ranges, which are not present in the TMAA. Overall, a few behavioral reactions per year by a single individual are unlikely to produce long-term consequences for that individual.

Behavioral research indicates that mysticetes most likely avoid sound sources at levels that would cause any hearing loss (i.e., TTS) (Section 3.8.3.1.1.5, Behavioral Reactions). Therefore, it is likely that the quantitative analysis overestimates TTS in marine mammals because it does not account for animals avoiding sound sources at closer ranges. Mysticetes that do experience PTS or TTS from sonar sounds may have reduced ability to detect biologically important sounds around the frequency band of the sonar until their hearing recovers. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. Temporary Threshold Shift would be recoverable and PTS would leave some residual hearing loss. Most TTS, if it does actually occur, would be more likely to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours (see Section 3.8.3.1.1.2, Hearing Loss). Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the period that a mysticete had hearing loss, social calls from conspecifics could be more difficult to detect or interpret if they fell in the octave band of the sonar frequency. Killer whales are a primary predator of mysticetes. Some hearing loss could make killer whale calls more difficult to detect at farther ranges until hearing recovers. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether hearing loss would affect a mysticete's ability to locate prey or rate of feeding. A single or even a few minor TTS (less than 20 dB of TTS) to an individual mysticete per year are unlikely to have any long-term consequences for that individual.

Research and observations of masking in marine mammals are discussed in Section 3.8.3.1.1.4 (Masking). Most anti-submarine warfare sonars and countermeasures use mid-frequency ranges, and a few use low-frequency ranges. Most of these sonar signals are limited in the temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Systems typically operate with low-duty cycles for most tactical sources, but some systems may operate nearly continuously or with higher duty cycles. Nevertheless, masking may be more prevalent at closer ranges to these high-duty cycle and continuous active sonar systems. Most anti-submarine warfare activities are geographically dispersed and last for only a few hours, often with intermittent sonar use even within this period. Most anti-submarine warfare sonars also have a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant masking in mysticetes. High-frequency (greater than 10 kHz) sonars fall outside of the best hearing and vocalization ranges of mysticetes (see Section 3.8.2.1.4, Hearing and Vocalization). Furthermore, high frequencies (above 10 kHz) attenuate more rapidly in the water due to absorption than do lower frequency signals, thus producing only a small zone of potential masking. High-frequency sonars are typically used for mine hunting, navigation, and object detection (avoidance). Masking in mysticetes due to exposure to high-frequency sonar is unlikely. Potential costs to mysticetes from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively pinging and the effect is over the moment the sound has ceased. By contrast, hearing loss lasts beyond the exposure for a period. Nevertheless, mysticetes that do experience some masking for a short period from low- or mid-frequency sonar may have their ability to communicate with conspecifics reduced, especially at further ranges. However, larger mysticetes (e.g., blue whale, fin whale, sei whale) communicate at frequencies below those of mid-frequency sonar and even most low-frequency sonars. Mysticetes that communicate at higher frequencies (e.g., minke whale) may be affected by some short-term and intermittent masking. Sounds from mid-frequency sonar could mask killer whale vocalizations, making them more difficult to detect, especially at further ranges. It is unknown whether masking would affect a mysticete's ability to feed since it is unclear how or if mysticetes use sound for finding prey or feeding. A single or even a few short periods of masking, if it were to occur, to an individual mysticete per year are unlikely to have any long-term consequences for that individual.

North Pacific Right Whales (Endangered Species Act-Listed)

North Pacific right whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although North Pacific right whales are considered rare in the TMAA due to their low abundance, their occurrence in the TMAA is year round, and they are most likely to be present June through September. The quantitative analysis estimates TTS under Alternative 1 (Table 3.8-11). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Eastern North Pacific Stock (Table 3.8-11).

As described for mysticetes above, even if an individual right whale experiences TTS a couple times over the course of a year, impacts are unlikely to have any significant costs or long-term consequences for that individual. In addition to implementing procedural mitigation for active sonar, from June through September (i.e., the months when North Pacific right whales are most likely to be present in the TMAA), the Navy will not use surface ship hull-mounted MF1 mid-frequency active sonar within the North Pacific Right Whale Mitigation Area. This mitigation area encompasses the portion of the biologically important habitat identified by Ferguson et al. (2015) for North Pacific right whale feeding that overlaps the TMAA. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of North Pacific right whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 1 may affect ESA-listed North Pacific right whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Table 3.8-11: Estimated Impacts on Individual North Pacific Right Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Eastern North Pacific	0	2	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Humpback Whales (some DPSs are Endangered Species Act-Listed)

Humpback whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although the timing of humpback whale migrations may change year to year, they are most likely to be present in the TMAA June through September. Impacts have been modeled for the Hawaii DPS (Central North Pacific stock) population of humpback whales, which are not ESA-listed, and for the Mexico DPS (California, Oregon, and Washington stock) and Western North Pacific DPS (Western North Pacific stock) populations of humpback whales, which are ESA-listed.

The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-12). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (Table 3.8-12). In addition to procedural mitigation, the Navy will implement mitigation within mitigation areas, which will further help avoid or reduce potential impacts from active sonar on humpback whales. The Navy will issue annual seasonal awareness notification messages to alert ships and aircraft operating within the TMAA to the possible presence of increased concentrations of humpback whales from June 1 to September 30. To maintain safety of navigation and to avoid interactions with large whales, the Navy will instruct vessels to remain vigilant to the presence of large whales that may be vulnerable to vessel strikes or potential impacts from training activities. Platforms will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during training activities and to aid in the implementation of procedural mitigation during activities using active sonar. The Navy will not use surface ship hull-mounted MF1 mid-frequency active sonar from June 1 to September 30 within the North Pacific Right Whale Mitigation Area, which overlaps a portion of the proposed humpback whale critical habitat.

As described for mysticetes above, minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Sound from sonars and other transducers during training activities would overlap proposed critical habitat for the ESA-listed Mexico DPS, and Western North Pacific DPS of humpback whales in the TMAA (whales belonging to the Central America DPS should not be present in the GOA or the TMAA; see National Marine Fisheries Service (2016d, 2019b, 2019c)). As described in Section 3.8.2.3 (Humpback Whale [*Megaptera novaeangliae*]), one essential feature was identified for humpback whale critical habitat, and that essential feature is defined as prey species, primarily euphausiids and small pelagic schooling fishes, of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth. This essential feature would not be adversely affected by sonar use proposed in this action, as follows.

In the TMAA, the humpback whale's diet is consistently dominated by euphausiids and small pelagic fishes, such as northern anchovy, Pacific herring, Pacific sardine, and capelin (Fleming et al., 2016; Gabriele et al., 2017; Keen et al., 2017; Santora et al., 2010; Straley et al., 2017; Szabo, 2015; Witteveen & Wynne, 2017). As described in Section 3.6 (Fishes), non-impulsive sound sources, such as sonar and other transducers, have not been known to cause direct injury or mortality to fish under conditions that would be found in the wild (Halvorsen et al., 2012; Kane et al., 2010; Popper et al., 2007) and would only be expected to result in behavioral reactions or potential masking in marine invertebrates. Most sources proposed for use during training activities overlapping the critical habitat in the TMAA would not fall within the frequency range of marine invertebrate or fish hearing, thereby presenting no plausible route of effect on either species. The few sources used within invertebrate and fish hearing ranges would be limited, temporary, and transient, as described in Appendix A (Navy Activities Descriptions) and examined in Section 3.6.3.1.2 (Impacts from Sonar and Other Transducers) of Section 3.6 (Fishes). Additionally, the use of active sonar would not chronically elevate background noise or cause a reduction in foraging space in critical habitat for humpback whales. Brief periods of masking due to spatially and temporally isolated exposures are accounted for in the quantitative assessment of the potential for direct behavioral disturbance as a level-based response, as explained in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017d).

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of humpback whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 1 may affect ESA-listed humpback whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA. The use of sonar and other transducers during training activities would have no effect on proposed critical habitat for humpback whales.

Table 3.8-12: Estimated Impacts on Individual Humpback Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
California, Oregon, & Washington	1	8	0
Central North Pacific	4	66	0
Western North Pacific	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Blue Whales (Endangered Species Act-Listed)

Blue whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although blue whales' occurrence in the TMAA is year round, they are most likely to be present June through December. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-13). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (Table 3.8-13).

As described for mysticetes above, minor to moderate behavioral reactions and TTS to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of blue whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 1 may affect ESA-listed blue whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Table 3.8-13: Estimated Impacts on Individual Blue Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Central North Pacific	0	3	0
Eastern North Pacific	3	32	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Fin Whales (Endangered Species Act-Listed)

Fin whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although fin whales' occurrence in the TMAA is year round, they are most likely to be present June through August. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-14). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Northeast Pacific stock (Table 3.8-14).

As described for mysticetes above, minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of fin whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 1 may affect ESA-listed fin whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Table 3.8-14: Estimated Impacts on Individual Fin Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Northeast Pacific	104	1,125	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although sei whales' occurrence in the TMAA is year round, they are considered rare, even during the summer time period. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-15). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Eastern North Pacific stock (Table 3.8-15).

As described for mysticetes above, minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of sei whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 1 may affect ESA-listed sei whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Table 3.8-15: Estimated Impacts on Individual Sei Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Eastern North Pacific	2	34	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Minke Whales

Minke whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Even though very few minke whales have been seen during surveys in the area, their occurrence in the TMAA is considered year round. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-16). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Alaska stock (Table 3.8-16).

As described for mysticetes above, minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of minke whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-16: Estimated Impacts on Individual Minke Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Alaska	4	44	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Gray Whales (one DPS is Endangered Species Act-Listed)

Gray whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although Western North Pacific gray whales are rare, both stocks of gray whales are migratory and their occurrence in the TMAA would be seasonal with their highest likelihood of occurring being between June and August. Impacts have been modeled for the Eastern North Pacific stock of gray whales, which are not ESA-listed, and for the Western North Pacific stock of gray whales, which are ESA-listed.

The quantitative analysis estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). In addition to procedural mitigation, the Navy will implement mitigation within mitigation areas, which will further help avoid the already low potential for impacts from active sonar on gray whales. The Navy will issue annual seasonal awareness notification messages to alert ships and aircraft operating within the TMAA to the possible presence of increased concentrations of gray whales from April 1 to August 31. To maintain safety of navigation and to avoid interactions with large whales, the Navy will instruct vessels to remain vigilant to the presence of large whales that may be vulnerable to vessel strikes or potential impacts from training activities. Platforms will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during training activities and to aid in the implementation of procedural mitigation during activities using active sonar. This mitigation area overlaps habitat within the northernmost corner and southwestern edge of the TMAA that has been identified by Ferguson et al. (2015) as biologically important gray whale migration habitat. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would not result in the incidental taking of gray whales.

Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 1 may affect ESA-listed gray whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Odontocetes

Odontocetes may be exposed to sound from sonar and other transducers associated with training activities throughout the year. Low- (less than 1 kHz), mid- (1–10 kHz), high-frequency (10–100 kHz), and very high-frequency (100–200 kHz) sonars produce sounds that are likely to be within the audible range of odontocetes (see Section 3.8.2.1.4, Hearing and Vocalization). If a sound is within an animal's hearing range, then behavioral reactions, physiological stress, masking and hearing loss are potential impacts that must be analyzed. If a marine mammal cannot hear a sound, then behavioral reactions, physiological stress, masking, or hearing loss could not occur. Impact ranges for odontocetes are discussed under mid-frequency cetaceans in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers).

Behavioral reactions in odontocetes (except beaked whales and harbor porpoise) resulting from exposure to sonar could take place at distances of up to 20 km. Beaked whales and harbor porpoise have demonstrated a high level of sensitivity to human-made noise and activity; therefore, the quantitative analysis assumes that some harbor porpoises and some beaked whales could experience significant behavioral reactions at a distance of up to 50 km from the sound source. Behavioral reactions, however, are much more likely within a few kilometers of the sound source for most species of odontocetes such as delphinids and sperm whales. Even for harbor porpoise and beaked whales, as discussed above in *Assessing the Severity of Behavioral Responses from Sonar Under Military Readiness*, the quantitative analysis has very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions.

Research shows that if odontocetes do respond they may react in a number of ways, depending on the characteristics of the sound source and their experience with the sound source. Behavioral reactions may include alerting; breaking off feeding dives and surfacing; or diving or swimming away. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Therefore, most behavioral reactions from odontocetes are likely to be short term and low to moderate severity.

Large odontocetes such as killer whales and pilot whales have been the subject of behavioral response studies (see Section 3.8.3.1.1.5, Behavioral Reactions). Based on these studies, a number of reactions could occur such as a short-term cessation of natural behavior such as feeding, avoidance of the sound source, or even attraction towards the sound source as seen in pilot whales. Due to the factors involved in Navy training exercises versus the conditions under which pilot whales and killer whales were exposed during behavioral response studies, large odontocetes are unlikely to have more than short-term and moderate severity reactions to sounds from sonar or other human disturbance, and typically only at ranges within a few kilometers. Most estimated impacts are due to anti-submarine warfare sonar activities. Major training exercises involve multiple sonar systems and can last for a period of days, making significant response more likely. A single or few short-lived TTS or behavioral reactions per year are unlikely to have any significant costs or long-term consequences for individuals.

Small odontocetes have been the subject of behavioral response studies and observations in the field (see Section 3.8.3.1.1.5, Behavioral Reactions). Based on these studies, small odontocetes (dolphins) appear to be less sensitive to sound and human disturbance than other cetacean species. If reactions did occur, they could consist of a short-term behavior response such as cessation of feeding, avoidance of the sound source, or even attraction towards the sound source. Small odontocetes are unlikely to have more than short-term and moderate severity reactions to sounds from sonar or other human disturbance, and typically only at ranges within a few kilometers. Most estimated impacts are due to anti-submarine warfare sonar activities, which could vary in duration and intensity. Major training exercises involve multiple sonar systems and can last for a period of days, making significant response more likely. A single or few short-lived TTS or behavioral reactions per year are unlikely to have any significant costs or long-term consequences for individuals.

Some odontocetes may avoid larger activities such as a major training exercise as it moves through an area. Vessels and aircraft associated with training activities are typically in transit during an event (they are not stationary) and activities typically do not use the same training locations day-after-day during multi-day activities. If an event otherwise focuses on a fixed location, sensitive species of odontocetes, such as beaked whales, may avoid the location of the activity for the duration of the event. Section 3.8.3.1.1.5 (Behavioral Reactions) discusses these species' observed reactions to sonar and other transducers. If animals are displaced, they would likely return after the sonar activity subsides within an area, as seen in Blainville's beaked whales in the Bahamas (Tyack et al., 2011) and Hawaii (Henderson et al., 2015; Henderson et al., 2016; Manzano-Roth et al., 2016). This would allow the animal to recover from any energy expenditure or missed resources, reducing the likelihood of long-term consequences for the individual. Outside of Navy instrumented ranges and homeports, the use of sonar and other transducers is transient and is unlikely to expose the same population of animals repeatedly over a short period. However, a few behavioral reactions per year from a single individual are unlikely to produce long-term consequences for that individual.

Behavioral research indicates that most odontocetes avoid sound sources at levels that would cause any temporary hearing loss (i.e., TTS) (see Section 3.8.3.1.1.5, Behavioral Reactions). TTS and even PTS is more likely for high-frequency cetaceans, such as Dall's porpoises and harbor porpoises, because hearing loss thresholds for these animals are lower than for all other marine mammals. These species, especially harbor porpoises, have demonstrated a high level of sensitivity to human-made sound and activities and may avoid at further distances. This increased distance could avoid or minimize hearing loss for these species as well, especially as compared to the estimates from the quantitative analysis. Therefore, it is likely that the quantitative analysis overestimates TTS and PTS in marine mammals because it does not account for animals avoiding sound sources at closer ranges. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. TTS would be recoverable and PTS would leave some residual hearing loss. Most TTS, if it does actually occur, would be more likely to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the period that an odontocete had hearing loss, social calls from conspecifics could be more difficult to detect or interpret. Killer whales are a primary predator of odontocetes. Some hearing loss could make killer whale calls more difficult to detect at further ranges until hearing recovers. Odontocetes use echolocation clicks to find and capture prey. These echolocation clicks and vocalizations are at frequencies above a few tens of kHz for delphinids, beaked whales, and sperm whales, and above 100 kHz for porpoises. Echolocation associated with feeding and navigation in odontocetes is unlikely to be affected by threshold shift at lower frequencies and should not have any significant effect on an odontocete's ability to locate prey or navigate, even in the short term. Therefore, a single or even a few minor TTS (less than 20 dB of TTS) to an individual odontocete per year are unlikely to have any long-term consequences for that individual. Minor PTS (a few dB or less) in an individual could have no to minor long-term consequences for individuals.

Research and observations of masking in marine mammals are discussed in Section 3.8.3.1.1.4 (Masking). Many anti-submarine warfare sonars and countermeasures use low- and mid-frequency sonar. Most low- and mid-frequency sonar signals (i.e., sounds) are limited in their temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Some systems operate with higher duty cycles or nearly continuously, but typically use lower power. Nevertheless, masking may be more prevalent at closer ranges to these high-duty cycle and continuous active sonar systems. Most anti-submarine warfare activities are geographically dispersed and last for only a few hours, often with intermittent sonar use even within this period. Most anti-submarine warfare sonars also have a narrow frequency band (typically much less than one-third octave). These factors reduce the likelihood of sources causing significant masking in odontocetes due to exposure to sonar used during anti-submarine warfare activities. Odontocetes may experience some limited masking at closer ranges from high-frequency sonars and other transducers; however, the frequency band of the sonar is narrow, limiting the likelihood of masking. High-frequency sonars are typically used for mine hunting, navigation, and object detection (avoidance). Potential costs to odontocetes from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively pinging and the effect is over the moment the sound has ceased.

Nevertheless, odontocetes that do experience some masking from sonar or other transducers may have their ability to communicate with conspecifics reduced, especially at further ranges. Sounds from mid-frequency sonar could mask killer whale vocalizations, making them more difficult to detect, especially at further ranges. As discussed above for TTS, odontocetes use echolocation to find prey and navigate. The echolocation clicks of odontocetes are above the frequencies of most sonar systems. Therefore, echolocation associated with feeding and navigation in odontocetes is unlikely to be masked by sounds from sonars or other transducers. A single or even a few short periods of masking, if it were to occur, to an individual odontocete per year are unlikely to have any long-term consequences for that individual.

Sperm Whales (Endangered Species Act-Listed)

Sperm whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although sperm whales' occurrence in the TMAA is year round, they are most likely to be present June through September. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-17). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the North Pacific stock (Table 3.8-17).

As described for odontocetes above, minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of sperm whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 1 may affect ESA-listed sperm whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Table 3.8-17: Estimated Impacts on Individual Sperm Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
North Pacific	107	5	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Killer Whales

Killer whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although killer whales' occurrence in the TMAA is year round, the one offshore population and the two transient types are more likely to be present in the majority of the TMAA given the deep and far offshore waters of the Navy training area. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-18). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (Table 3.8-18).

As described for odontocetes above, minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of killer whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-18: Estimated Impacts on Individual Killer Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Alaska Resident	0	0	0
AT1 Transient	0	0	0
Eastern Pacific Offshore	64	17	0
Gulf of Alaska, Aleutian Island, & Bering Sea Transient	119	24	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Pacific White-Sided Dolphins

Pacific white-sided dolphins may be exposed to sounds from sonar and other transducers associated with training activities April through October. The Navy has determined the Pacific white-sided dolphins' occurrence in the TMAA would be likely year round. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-19). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the North Pacific stock (Table 3.8-19).

As described for odontocetes above, minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of Pacific white-sided dolphins incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-19: Estimated Impacts on Individual Pacific White-Sided Dolphin Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
North Pacific	1,102	472	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Harbor Porpoises

Harbor porpoises may be exposed to sounds from sonar and other transducers associated with training activities April through October. The Navy has determined the harbor porpoises' occurrence in the TMAA would be likely year round in the nearshore locations to the shelf break. The quantitative analysis estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers).

TTS and PTS thresholds for high-frequency cetaceans, including Harbor porpoise, are lower than for all other marine mammals, which leads to a higher number of estimated impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans). Harbor porpoises are particularly sensitive to human-made noise and disturbance and will avoid sound levels between 120 and 140 dB re 1 µPa at distances up to 30 km for more intense activities (as discussed below). This means that the quantitative analysis greatly overestimates hearing loss in harbor porpoises because most animals would avoid sound levels that could cause TTS or PTS.

Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would not result in the incidental taking of harbor porpoises.

Dall's Porpoises

Dall's porpoises may be exposed to sounds from sonar and other transducers associated with training activities April through October. The Navy has determined the Dall's porpoises' occurrence in the TMAA would be likely year round. The quantitative analysis estimates behavioral reactions, TTS, and PTS under Alternative 1 (Table 3.8-20). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the Alaska stock (Table 3.8-20).

TTS and PTS thresholds for high-frequency cetaceans, including Dall's porpoises, are lower than for all other marine mammals, which leads to a higher number of estimated impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans). The information available on harbor porpoise behavioral reactions to human disturbance (a closely related species) suggests that these species may be more sensitive and avoid human activity, and sound sources, to a longer range than most other odontocetes. This would make Dall's porpoises less susceptible to hearing loss; therefore, it is likely that the quantitative analysis over-predicted hearing loss impacts (i.e., TTS and PTS) in Dall's porpoises.

As described for odontocetes above, minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, hearing loss beyond a minor TTS is unlikely and a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that Dall's porpoise rely upon if it did occur. Nevertheless, PTS could have minor long-term consequences for individuals if it were to occur. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stock. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of Dall's porpoises incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-20: Estimated Impacts on Individual Dall's Porpoise Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Alaska	310	8,710	19

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Beaked Whales

Beaked whales may be exposed to sounds from sonar and other transducers associated with training activities April through October. Beaked whales within the GOA TMAA include Baird's beaked whale, Cuvier's beaked whale, and Stejneger's beaked whale. Although beaked whales' occurrence in the TMAA would be likely year round, Cuvier's beaked whales are most likely to be present April through June. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-21 through Table 3.8-23). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts to Baird's beaked whales, Cuvier's beaked whale, and Stejneger's beaked whales apply to the Alaska stocks (Table 3.8-21, Table 3.8-22, and Table 3.8-23).

As discussed above for odontocetes overall, the quantitative analysis overestimates hearing loss in marine mammals because behavioral response research has shown that most marine mammals are likely to avoid sound levels that could cause more than minor to moderate TTS (6–20 dB). Specifically for beaked whales, behavioral response research discussed below and in Section 3.8.3.1.1.5 (Behavioral Reactions) has demonstrated that beaked whales are sensitive to sound from sonars and usually avoid sound sources by 10 or more kilometers. These are well beyond the ranges to TTS for mid-frequency cetaceans such as beaked whales. Therefore, any TTS predicted by the quantitative analysis is unlikely to occur in beaked whales.

Research and observations (Section 3.8.3.1.1.5, Behavioral Reactions) show that if beaked whales are exposed to sonar or other transducers they may startle, break off feeding dives, and avoid the area of the sound source at levels ranging between 95 and 157 dB re 1 µPa (McCarthy et al., 2011). Furthermore, in research done at the Navy's fixed tracking range in the Bahamas and Hawaii, animals leave the immediate area of the anti-submarine warfare training exercise but return within a few days after the event ends (Henderson et al., 2015; Henderson et al., 2016; Manzano-Roth et al., 2016; Tyack et al., 2011). Populations of beaked whales and other odontocetes on Navy fixed ranges that have been operating for decades appear to be stable, and analysis is ongoing. Significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers, especially for prolonged periods (a few hours or more), since this is one of the most sensitive marine mammal groups to human-made sound of any species or group studied to date.

Based on the best available science, the Navy believes beaked whales that exhibit a significant behavioral reaction due to sonar and other transducers during training activities would generally not have long-term consequences for individuals or populations. However, because of a lack of scientific consensus regarding the causal link between sonar and stranding events, NMFS has stated in a letter to the Navy dated October 2006 that it "cannot conclude with certainty the degree to which mitigation measures would eliminate or reduce the potential for serious injury or mortality." The Navy does not anticipate that marine mammal strandings or mortality will result from the operation of sonar during Navy exercises within the TMAA. Additionally, through the MMPA process (which allows for adaptive management), NMFS and the Navy will determine the appropriate way to proceed in the event that a causal relationship were to be found between Navy activities and a future stranding.

As described for odontocetes above, minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of Baird's, Cuvier's, and Stejneger's beaked whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-21: Estimated Impacts on Individual Baird's Beaked Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Alaska	106	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Table 3.8-22: Estimated Impacts on Individual Cuvier's Beaked Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Alaska	429	3	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Table 3.8-23: Estimated Impacts on Individual Stejneger's Beaked Whale Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Alaska	467	15	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Pinnipeds and Mustelids

Pinnipeds include phocid seals (true seals) and otariids (sea lions and fur seals), and mustelids include sea otters.

Pinnipeds may be exposed to sound from sonar and other transducers associated with training activities throughout the year. Low- (less than 1 kHz), mid- (1–10 kHz), and high-frequency (10–100 kHz) sonars produce sounds that are likely to be within the audible range of pinnipeds (see Section 3.8.2.1.4, Hearing and Vocalization). Comparatively, hearing sensitivities are significantly reduced in mustelids and exposure to these sounds may have lower overall severity. If a sound is within an animal's hearing range then behavioral reactions, physiological stress, masking and hearing loss are potential impacts that must be analyzed. If a marine mammal cannot hear a sound, then behavioral reactions, physiological stress, masking, or hearing loss could not occur. Impact ranges for pinnipeds and mustelids are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers).

There is no research on the effects of sonar on sea otters. As described in Section 3.8.3.1.1.5 (Behavioral Reactions), mustelids have similar or reduced hearing capabilities compared to pinnipeds (specifically otariids). Thus, it is reasonable to assume that mustelids use their hearing similarly to that of otariids, and the types of impacts from exposure to sonar and other transducers may also be similar to those described below for pinnipeds, including behavioral reactions, physiological stress, masking, and hearing loss; however, because mustelids spend the majority of their time with their heads above or at the water's surface and live near shore, they are less likely to be exposed to or impacted by sonars and other transducers used in training activities.

A few behavioral reactions by pinnipeds resulting from exposure to sonar could take place at distances of up to 10 km. Behavioral reactions, however, are much more likely within a kilometer or less of the sound source (see Section 3.8.3.1.1.5, Behavioral Reactions). As discussed above in *Assessing the Severity of Behavioral Responses from Sonar Under Military Readiness*, the quantitative analysis very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions. Research shows that pinnipeds in the water are generally tolerant of human-made sound and activity, while mustelids have reduced underwater hearing abilities (see Section 3.8.3.1.1.5, Behavioral Reactions). If pinnipeds or mustelids are exposed to sonar or other transducers, they may react in various ways, depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Pinnipeds or mustelids may not react at all until the sound source is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases, and long-term consequences for individual pinnipeds or mustelids from a single or several impacts per year are unlikely. Behavioral research indicates that most pinnipeds probably avoid sound sources at levels that could cause higher levels of TTS (greater than 20 dB of TTS) and PTS. Recovery from TTS begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. Most TTS, if it does actually occur, would be more likely to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the short period that a pinniped had TTS, social calls from conspecifics could be more difficult to detect or interpret. Killer whales are a primary predator of pinnipeds. Some TTS could make killer whale calls more difficult to detect at further ranges until hearing recovers. Pinnipeds probably use sound and vibrations to find and capture prey underwater. Therefore, it could be more difficult for pinnipeds with TTS to locate food for a short period before their hearing recovers. Because TTS would likely be minor to moderate (less than 20 dB of TTS), costs would be short term and could be recovered. A single or even a few mild to moderate TTS per year are unlikely to have any long-term consequences for that individual.

Research and observations of masking in marine mammals are discussed in Section 3.8.3.1.1.4 (Masking). Many low- (less than 1 kHz), mid- (1–10 kHz), and high-frequency (10–100 kHz) sonars produce sounds that are likely to be within the hearing range of pinnipeds and potentially mustelids. Most anti-submarine warfare sonar use low- and mid-frequency sonar signals (i.e., sounds) which are limited in the temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Some systems operate with higher duty cycles or nearly continuously, but typically use lower power and have a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant masking in pinnipeds due to exposure to sonar used during anti-submarine warfare activities. Pinnipeds and mustelids may experience some limited masking at closer ranges from high-frequency sonars and other transducers; however, the frequency band of the sonar is narrow, limiting the likelihood of masking. Sonars that employ high frequencies are typically used for mine hunting, navigation, and object detection (avoidance). Potential costs to pinnipeds and mustelids from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively transmitting and the effect is over the moment the sound has ceased. Nevertheless, pinnipeds that do experience some masking for a short period from sonar or other transducers may have their ability to communicate with conspecifics reduced, especially at further ranges. Sounds from mid-frequency sonar could mask killer whale vocalizations making them more difficult to detect, especially at further ranges. Pinnipeds probably use sound and vibrations to find and capture prey underwater. Therefore, it could be more difficult for pinnipeds to locate food if masking is occurring. A single or even a few short periods of masking, if it were to occur, to an individual pinniped or mustelid per year are unlikely to have any long-term consequences for that individual.

Steller Sea Lions (one DPS is Endangered Species Act-Listed)

Steller sea lions may be exposed to sounds from sonar and other transducers associated with training activities April through October. The Navy has determined the Steller sea lions' occurrence in the TMAA would be likely year round. Impacts have been modeled for the Eastern U.S. stock of Steller sea lions, which are not ESA-listed, and for the Western U.S. stock of Steller sea lions, which are ESA-listed.

The quantitative analysis estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would not result in the incidental taking of Steller sea lions.

Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 1 may affect ESA-listed Steller sea lions. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

California Sea Lions

California sea lions may be exposed to sounds from sonar and other transducers associated with training activities April through October. The Navy has determined the California sea lions' occurrence in the TMAA would be seasonal and are most likely to be present April through May. The quantitative analysis estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would not result in the incidental taking of California sea lions.

Northern Fur Seals

Northern fur seals may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although northern fur seals are most likely to be present in the TMAA December through July, males may potentially be present year round. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-24). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to multiple stocks (Table 3.8-24).

As described above, minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of northern fur seals incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-24: Estimated Impacts on Individual Northern Fur Seal Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
Eastern Pacific	2,836	25	0
California	58	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Northern Elephant Seals

Northern elephant seals may be exposed to sounds from sonar and other transducers associated with training activities April through October. The Navy has determined the northern elephant seals' occurrence in the TMAA would be seasonal and are most likely to be present March through October. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-25). Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Estimated impacts apply to the California stock (Table 3.8-25).

As described above, minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stock. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would result in the unintentional taking of northern elephant seals incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-25: Estimated Impacts on Individual Northern Elephant Seal Stocks Within the Study Area per Year from Sonar and Other Transducers Used During Training Under Alternative 1

Estimated Impacts by Effect			
Stock	***Behavioral***	***TTS***	***PTS***
California	898	1,634	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Harbor Seals

Harbor seals may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although harbor seals' occurrence in the TMAA is year round, they are rarely found more than 20 km from shore and are therefore more likely to be present in the inshore water locations of the GOA, versus being found beyond the slope or further offshore within the TMAA. The quantitative analysis estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would not result in the incidental taking of harbor seals.

Ribbon Seals

Ribbon seals may be exposed to sounds from sonar and other transducers associated with training activities April through October. Although ribbon seals are considered rare in the TMAA, their occurrence is year round, and they are most likely to be present in the TMAA July through September. The quantitative analysis estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would not result in the incidental taking of harbor seals.

Northern Sea Otters (one DPS is Endangered Species Act-Listed)

Northern sea otters are unlikely to be exposed to sounds from sonar and other transducers associated with training activities April through October. Although northern sea otters occur in the nearshore margins of the Gulf of Alaska year round, they would rarely be present in the TMAA since the normal range and habitat of sea otters is well inland of the TMAA boundaries. Sea otters seldom range more than 2 km from shore, and in this region they are mainly concentrated within 400 m from shore because they are benthic foragers. (Bodkin, 2015) notes that sea otters can be found many kilometers from shore in locations where there are shoals far from land, but there are no known offshore populations near the TMAA. Individuals from the Southwest Alaska stock (ESA-listed) are not expected to be present in the TMAA. It is possible that vagrant individuals from the Southcentral Alaska stock or the Southeast Alaska stock of sea otters (neither are ESA-listed) could potentially occur in the nearshore margins of the TMAA. Some individuals, particularly juvenile males, may travel farther offshore (Calambokidis et al., 1987; Laidre et al., 2009; Muto et al., 2017; Riedman & Estes, 1990).

Ghoul and Reichmuth (2014b) have shown that sea otters are not especially well adapted for hearing underwater, which suggests that the function of this sense has been less important in their survival and evolution than in comparison to pinnipeds. Due to their low sensitivity to underwater sounds, their preferred habitat, behavioral pattern of spending a majority of their time above water, and the short range to effects for phocids as described in Section 3.8.3.1.2.2 (Impact Ranges for Sonar and Other Transducers), impacts to northern sea otters from Navy training activities involving sonar and other transducers are highly unlikely to occur. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training activities as described under Alternative 1 would not result in the incidental taking of Northern sea otters.

Pursuant to the ESA, the use of sonar and other transducers during training activities as described under Alternative 1 may affect ESA-listed Northern sea otters. The Navy will consult with USFWS as required by Section 7(a)(2) of the ESA.

3.8.3.1.3 Impacts from Vessel Noise

3.8.3.1.3.1 Impacts from Vessel Noise Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.8.3.1.3.2 Impacts from Vessel Noise Under Alternative 1

Training activities within the TMAA involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels). Marine mammals may be exposed to noise from vessel movement throughout the TMAA. A detailed description of the acoustic characteristics and typical sound levels of vessel noise are in Section 3.0.4.1.2 (Vessel Noise). Proposed training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Section 3.8.3.1.1 (Background) summarizes and synthesizes available information on behavioral reactions, masking, and physiological stress due to noise exposure, including vessel noise (Sections 3.8.3.1.1.2, Hearing Loss; 3.8.3.1.1.3, Physiological Stress; 3.8.3.1.1.4, Masking; and 3.8.3.1.1.5, Behavioral Reactions).

Alternative 1 for this SEIS/OEIS remains consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Because the existing baseline conditions have not changed appreciably, and no new Navy training activities are being proposed for use in the TMAA in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to marine mammals is not warranted. The Navy will implement mitigation measures for vessel movement to avoid the potential for marine mammal vessel strikes, as discussed in Section 5.3.4.1 (Vessel Movement). The mitigation for vessel movement (i.e., maneuvering to maintain a specified distance from a marine mammal) will also help the Navy avoid or reduce potential impacts from vessel noise on marine mammals.

Sound from naval vessels would overlap proposed critical habitat for the ESA-listed Western North Pacific and Mexico DPSs of humpback whales. As described in Section 3.8.2.3 (Humpback Whale [*Megaptera novaeangliae*]), one essential feature was identified for humpback whale critical habitat: prey species, primarily euphausiids and small pelagic schooling fishes, of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth. Although vessel noise may elicit a brief response from individual prey species in close proximity to a vessel, noise from naval vessels presents no plausible route of impact to prey species of sufficient quantity, abundance, and accessibility.

Pursuant to the MMPA, sound produced by vessel movement during training activities as described under Alternative 1 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, sound produced by vessel movement during training activities as described under Alternative 1 may affect ESA-listed marine mammals. The Navy will consult with NMFS as required by section 7(a)(2) of the ESA. Vessel noise during training activities would have no effect on the proposed critical habitat for humpback whales.

Pursuant to the ESA, vessel noise during training activities as described under Alternative 1 may affect Northern sea otters. The Navy will consult with USFWS as required by Section 7(a)(2) of the ESA.

3.8.3.1.4 Impacts from Aircraft Noise

3.8.3.1.4.1 Impacts from Aircraft Noise Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.8.3.1.4.2 Impacts from Aircraft Noise Under Alternative 1

Many ongoing and proposed training activities within the TMAA involve maneuvers by various types of fixed, rotary-wing, and tilt-rotor aircraft (collectively referred to as aircraft). Most aircraft noise would be concentrated around airbases and fixed ranges within the range complex, especially in the waters immediately surrounding aircraft carriers at sea during takeoff and landing. Other aircraft overflights include commercial air traffic in addition to U.S. Navy aircraft. Aircraft produce extensive airborne noise from either turbofan or turbojet engines. An infrequent type of aircraft noise is the sonic boom, produced when the aircraft exceeds the speed of sound. Rotary-wing aircraft produce low-frequency sound and vibration (Pepper et al., 2003). Section 3.8.3.1.1 (Background) summarizes and synthesizes available information on behavioral reactions, masking, and physiological stress due to noise exposure, including aircraft noise (Sections 3.8.3.1.1.2, Hearing Loss; 3.8.3.1.1.3, Physiological Stress; 3.8.3.1.1.4, Masking; and 3.8.3.1.1.5, Behavioral Reactions).

Marine mammals may be exposed to aircraft-generated noise throughout the TMAA. A detailed description of aircraft noise as a stressor is in Section 3.0.4.1.3 (Aircraft Noise) of this document and the 2011 GOA Final EIS/OEIS. Proposed training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Alternative 1 for this SEIS/OEIS remains consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Because the existing baseline conditions have not changed appreciably, and no new Navy training activities are being proposed for use in the TMAA in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to marine mammals is not warranted.

Sound from naval aircraft would overlap proposed critical habitat for the ESA-listed Western North Pacific and Mexico DPSs of humpback whales. As described in Section 3.8.2.3 (Humpback Whale [*Megaptera novaeangliae*]), one essential feature was identified for humpback whale critical habitat: prey species, primarily euphausiids and small pelagic schooling fishes, of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth. Although aircraft noise may elicit a brief response from individual prey species in close proximity to a low-flying aircraft, noise from aircraft presents no plausible route of impact to prey species of sufficient quantity, abundance, and accessibility.

Pursuant to the MMPA, aircraft noise during training activities as described under Alternative 1 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, aircraft noise during training activities as described under Alternative 1 may affect ESA-listed marine mammals. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA. Aircraft noise during training activities would have no effect on the proposed critical habitat for humpback whales.

Pursuant to the ESA, aircraft noise during training activities as described under Alternative 1 may affect Northern sea otters. The Navy will consult with USFWS as required by Section 7(a)(2) of the ESA.

3.8.3.1.5 Impacts from Weapon Noise

3.8.3.1.5.1 Impacts from Weapon Noise Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.8.3.1.5.2 Impacts from Weapon Noise Under Alternative 1

Marine mammals may be exposed to sounds caused by the firing of weapons, objects in flight, and inert impact of non-explosive munitions on the water's surface, which are described in Section 3.0.4.1.4 (Weapon Noise). In general, these are impulsive sounds generated in close vicinity to or at the water surface, with the exception of items that are launched underwater. The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated in air by firing a gun (muzzle blast) and a crack sound due to a low amplitude shock wave generated by a supersonic projectile flying through the air. Most in-air sound would be reflected at the air-water interface.

Underwater sounds would be strongest just below the surface and directly under the firing point. Any sound that enters the water only does so within a narrow cone below the firing point or path of the projectile. Vibration from the blast propagating through a ship’s hull, the sound generated by the impact of an object with the water surface, and the sound generated by launching an object underwater are other sources of impulsive sound in the water. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange.

Section 3.8.3.1.1 (Background) summarizes and synthesizes available information on behavioral reactions, masking, and physiological stress due to impulsive noise exposure (Sections 3.8.3.1.1.2, Hearing Loss; 3.8.3.1.1.3, Physiological Stress; 3.8.3.1.1.4, Masking; and 3.8.3.1.1.5, Behavioral Reactions).

Alternative 1 for this SEIS/OEIS remains consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Because the existing baseline conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to marine mammals is not warranted. The Navy will implement mitigation measures to avoid or reduce potential impacts from weapon noise during large-caliber gunnery activities, as discussed in Section 5.3.2.2 (Weapon Firing Noise).

Weapon noise would overlap proposed critical habitat for the ESA-listed Western North Pacific and Mexico DPSs of humpback whales in the Offshore Area, although implementation of the North Pacific Right Whale and Portlock Bank Mitigation Areas would limit any potential overlap of weapon noise with the proposed critical habitat in the Offshore Area during training, as described in Chapter 5 (Mitigation). As described in Section 3.8.2.3 (Humpback Whale [*Megaptera novaeangliae*]), one essential feature was identified for humpback whale critical habitat: prey species, primarily euphausiids and small pelagic schooling fishes, of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth. Weapon noise would not remove humpback prey items or reduce the quality of prey in terms of nutritional content.

Pursuant to the MMPA, weapon noise during training activities as described under Alternative 1 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, weapon noise during training activities as described under Alternative 1 may affect ESA-listed marine mammals. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA. Weapon noise during training activities would have no effect on the proposed critical habitat for humpback whales.

Pursuant to the ESA, weapon noise during training activities as described under Alternative 1 may affect Northern sea otters. The Navy will consult with USFWS as required by Section 7(a)(2) of the ESA.

3.8.3.2 Explosive Stressors

Assessing whether an explosive detonation may disturb or injure a marine mammal involves understanding the characteristics of the explosive sources, the marine mammals that may be present near the sources, the physiological effects of a close explosive exposure, and the effects of impulsive sound on marine mammal hearing and behavior. Many other factors besides just the received level or pressure wave of an explosion such as the animal's physical condition and size, prior experience with the explosive sound, and proximity to the explosion may influence physiological effects and behavioral reactions.

The ways in which an explosive exposure could result in immediate effects or lead to long-term consequences for an animal are explained in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). The following Background section discusses what is currently known about explosive effects to marine mammals.

Due to new acoustic impact criteria, marine mammal densities, and revisions to the Navy Acoustic Effects Model, the analysis provided in Section 3.8.3.2.2 (Impacts from Explosives) of this SEIS/OEIS supplants the 2016 GOA Final SEIS/OEIS for marine mammals and changes estimated impacts for some species since the 2016 GOA Final SEIS/OEIS.

3.8.3.2.1 Background

3.8.3.2.1.1 Injury

Injury refers to the direct effects on the tissues or organs of an animal due to exposure to pressure waves. Injury in marine mammals can be caused directly by exposure to explosions. Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on injury and the framework used to analyze this potential impact.

Injury due to Explosives

Explosive injury to marine mammals would consist of primary blast injury, which refers to those injuries that result from the compression of a body exposed to a blast wave and is usually observed as barotrauma of gas-containing structures (e.g., lung and gut) and structural damage to the auditory system (Greaves et al., 1943; Office of the Surgeon General, 1991; Richmond et al., 1973). The near instantaneous high magnitude pressure change near an explosion can injure an animal where tissue material properties significantly differ from the surrounding environment, such as around air-filled cavities such as in the lungs or gastrointestinal tract. Large pressure changes at tissue-air interfaces in the lungs and gastrointestinal tract may cause tissue rupture, resulting in a range of injuries depending on degree of exposure. The lungs are typically the first site to show any damage, while the solid organs (e.g., liver, spleen, and kidney) are more resistant to blast injury (Clark & Ward, 1943). Recoverable injuries would include slight lung injury, such as capillary interstitial bleeding, and contusions to the gastrointestinal tract. More severe injuries, such as tissue lacerations, major hemorrhage, organ rupture, or air in the chest cavity (pneumothorax), would significantly reduce fitness and likely cause death in the wild. Rupture of the lung may also introduce air into the vascular system, producing air emboli that can cause a stroke or heart attack by restricting oxygen delivery to critical organs.

If an animal is exposed to an explosive blast underwater, the likelihood of injury depends on the charge size, the geometry of the exposure (distance to the charge, depth of the animal and the charge), and the size of the animal. In general, an animal would be less susceptible to injury near the water surface because the pressure wave reflected from the water surface would interfere with the direct path pressure wave, reducing positive pressure exposure. Susceptibility would increase with depth, until normal lung collapse (due to increasing hydrostatic pressure) and increasing ambient pressures again reduce susceptibility. See Appendix B (Acoustic and Explosives Concepts) for an overview of explosive propagation and an explanation of explosive effects on gas cavities.

The only known occurrence of mortality or injury to a marine mammal due to a Navy training event involving explosives occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area had been used for underwater demolitions training for at least three decades without prior known incident. On this occasion, however, a group of approximately 100–150 long-beaked common dolphins entered the mitigation zone surrounding an area where a time-delayed firing device had been initiated on an explosive with a net explosive weight of 8.76 pounds (lb.) (3.97 kilograms [kg]) placed at a depth of 48 ft. (14.6 m). Approximately one minute after detonation, three animals were observed dead at the surface. The Navy recovered those animals and transferred them to the local stranding network for necropsy. A fourth animal was discovered stranded and dead 42 NM to the north of the detonation three days later. It is unknown exactly how close those four animals were to the detonation. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil & St Leger, 2011). In the TMAA, there is no known occurrence of mortality or injury to marine mammals due to Navy training events involving explosives.

Relatively little is known about auditory system trauma in marine mammals resulting from explosive exposure, although it is assumed that auditory structures would be vulnerable to blast injuries. Auditory trauma was found in two humpback whales that died following the detonation of a 5,000 kg explosive used off Newfoundland during demolition of an offshore oil rig platform (Ketten et al., 1993), but the proximity of the whales to the detonation was unknown. Eardrum rupture was examined in submerged terrestrial mammals exposed to underwater explosions (Richmond et al., 1973; Yelverton et al., 1973); however, results may not be applicable to the anatomical adaptations for underwater hearing in marine mammals. In this discussion, primary blast injury to auditory tissues is considered gross structural tissue damage distinct from threshold shift or other auditory effects (see Section 3.8.3.2.1.2, Hearing Loss).

Controlled tests with a variety of lab animals (mice, rats, dogs, pigs, sheep, and other species) are the best data sources on actual injury to mammals due to underwater exposure to explosions. In the early 1970s, the Lovelace Foundation for Medical Education and Research conducted a series of tests in an artificial pond at Kirtland Air Force Base, New Mexico, to determine the effects of underwater explosions on mammals, with the goal of determining safe ranges for human divers. The resulting data were summarized in two reports (Richmond et al., 1973; Yelverton et al., 1973). Specific physiological observations for each test animal are documented in Richmond et al. (1973). Gas-containing internal organs, such as lungs and intestines, were the principle damage sites in submerged terrestrial mammals; this is consistent with earlier studies of mammal exposures to underwater explosions in which lungs were consistently the first areas to show damage, with less consistent damage observed in the gastrointestinal tract (Clark & Ward, 1943; Greaves et al., 1943). Results from all of these tests suggest two explosive metrics are predictive of explosive injury: peak pressure and impulse.

Impulse as a Predictor of Explosive Injury

In the Lovelace studies, acoustic impulse was found to be the metric most related to degree of injury, and size of an animal's gas-containing cavities was thought to play a role in blast injury susceptibility. The lungs of most marine mammals are similar in proportion to overall body size as those of terrestrial mammals, so the magnitude of lung damage in the tests may approximate the magnitude of injury to marine mammals when scaled for body size. Within the marine mammals, mysticetes and deeper divers (e.g., Kogiidae, Physeteridae, Ziphiidae) tend to have lung to body size ratios that are smaller and more similar to terrestrial animal ratios than the shallow diving odontocetes (e.g., Phocoenidae, Delphinidae) and pinnipeds (Fahlman et al., 2014a; Piscitelli et al., 2010). The use of test data with smaller lung-to-body ratios to set injury thresholds may result in a more conservative estimate of potential for damaging effects (i.e., lower thresholds) for animals with larger lung-to-body ratios.

For these shallow exposures of small terrestrial mammals (masses ranging from 3.4 to 50 kg) to underwater detonations, Richmond et al. (1973) reported that no blast injuries were observed when exposures were less than 6 pounds per square inch per millisecond (psi-ms) (40 pascal seconds [Pa-s]), no instances of slight lung hemorrhage occurred below 20 psi-ms (140 Pa-s), and instances of no lung damage were observed in some exposures at higher levels up to 40 psi-ms (280 Pa-s). An impulse of 34 psi-ms (230 Pa-s) resulted in about 50 percent incidence of slight lung hemorrhage. About half of the animals had gastrointestinal tract contusions (with slight ulceration, i.e., some perforation of the mucosal layer) at exposures of 25–27 psi-ms (170-190 Pa-s). Lung injuries were found to be slightly more prevalent than gastrointestinal tract injuries for the same exposure.

The Lovelace subject animals were exposed near the water surface; therefore, depth effects were not discernible in this data set. In addition, this data set included only small terrestrial animals, whereas marine mammals may be several orders of magnitude larger and have respiratory structures adapted for the high pressures experienced at depth. The anatomical differences between the terrestrial animals used in the Lovelace tests and marine mammals are summarized in Fetherston (2019). Goertner (1982) examined how lung cavity size would affect susceptibility to blast injury by considering both marine mammal size and depth in a bubble oscillation model of the lung; however, the Goertner (1982) model did not consider how tissues surrounding the respiratory air spaces would reflect shock wave energy or constrain oscillation (Fetherston et al., 2019). Animal depth relates to injury susceptibility in two ways: injury is related to the relative increase in explosive pressure over hydrostatic pressure, and lung collapse with depth reduces the potential for air cavity oscillatory damage. The period over which an impulse must be delivered to cause damage is assumed to be related to the natural oscillation period of an animal's lung, which depends on lung size.

Because gas-containing organs are more vulnerable to primary blast injury, adaptations for diving that allow for collapse of lung tissues with depth may make animals less vulnerable to lung injury with depth. Adaptations for diving include a flexible thoracic cavity, distensible veins that can fill space as air compresses, elastic lung tissue, and resilient tracheas with interlocking cartilaginous rings that provide strength and flexibility (Ridgway, 1972). Denk et al. (2020) found intra-species differences in the compliance of tracheobronchial structures of post-mortem cetaceans and pinnipeds under diving hydrostatic pressures, which would affect depth of alveolar collapse. Older literature suggested complete lung collapse depths at approximately 70 m for dolphins (Ridgway & Howard, 1979) and 20–50 m for phocid seals (Falke et al., 1985; Kooyman et al., 1972). Follow-on work by Kooyman and Sinnett (1982), in which pulmonary shunting was studied in harbor seals and sea lions, suggested that complete lung collapse for these species would be about 170 m and about 180 m, respectively. More recently, evidence in sea lions suggests that complete collapse might not occur until depths as great as 225 m; although the depth of collapse and depth of the dive are related, sea lions can affect the depth of lung collapse by varying the amount of air inhaled on a dive (McDonald & Ponganis, 2012). This is an important consideration for all divers who can modulate lung volume and gas exchange prior to diving via the degree of inhalation and during diving via exhalation (Fahlman et al., 2009); indeed, there are noted differences in pre-dive respiratory behavior, with some marine mammals exhibiting pre-dive exhalation to reduce the lung volume (e.g., phocid seals (Kooyman et al., 1973)).

Peak Pressure as a Predictor of Explosive Injury

High instantaneous peak pressures can cause damaging tissue distortion. Goertner (1982) suggested a peak overpressure gastrointestinal tract injury criterion because the size of gas bubbles in the gastrointestinal tract are variable, and their oscillation period could be short relative to primary blast wave exposure duration. The potential for gastrointestinal tract injury, therefore, may not be adequately modeled by the single oscillation bubble methodology used to estimate lung injury due to impulse. Like impulse, however, high instantaneous pressures may damage many parts of the body, but damage to the gastrointestinal tract is used as an indicator of any peak pressure-induced injury due to its vulnerability.

Older military reports documenting exposure of human divers to blast exposure generally describe peak pressure exposures around 100 pounds per square inch (psi) (237 dB re 1 µPa peak) to feel like slight pressure or stinging sensation on skin, with no enduring effects (Christian & Gaspin, 1974). Around 200 psi, the shock wave felt like a blow to the head and chest. Data from the Lovelace Foundation experiments show instances of gastrointestinal tract contusions after exposures up to 1,147 psi peak pressure, while exposures of up to 588 psi peak pressure resulted in many instances of no observed gastrointestinal tract effects. The lowest exposure for which slight contusions to the gastrointestinal tract were reported was 237 dB re 1 µPa peak. As a vulnerable gas-containing organ, the gastrointestinal tract is vulnerable to both high peak pressure and high impulse, which may vary to differing extents due to blast exposure conditions (i.e., animal depth, distance from the charge). This likely explains the range of effects seen at similar peak pressure exposure levels and shows the utility of considering both peak pressure and impulse when analyzing the potential for injury due to explosives.

3.8.3.2.1.2 Hearing Loss

Exposure to intense sound may result in noise-induced hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received SPL, temporal pattern, and duration. The frequencies affected by hearing loss may vary depending on the exposure frequency, with frequencies at and above the exposure frequency most strongly affected. The amount of hearing loss may range from slight to profound, depending on the ability of the individual to hear at the affected frequencies. Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on hearing loss and the framework used to analyze this potential impact.

Hearing loss has only been studied in a few species of marine mammals, although hearing studies with terrestrial mammals are also informative. There are no direct measurements of hearing loss in marine mammals due to exposure to explosive sources. The sound resulting from an explosive detonation is considered an impulsive sound and shares important qualities (i.e., short duration and fast rise time) with other impulsive sounds such as those produced by air guns. General research findings regarding TTS and PTS in marine mammals as well as findings specific to exposure to other impulsive sound sources are discussed in Section 3.8.3.1.1.2 (Hearing Loss) and Section 3.8.3.1.1.1 (Injury) under Acoustic Stressors above.

3.8.3.2.1.3 Physiological Stress

Marine mammals naturally experience stress within their environment and as part of their life histories. The stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. However, if the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the organism (e.g., decreased immune function, decreased reproduction). Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on physiological stress and the framework used to analyze this potential impact.

There are no direct measurements of physiological stress in marine mammals due to exposure to explosive sources. General research findings regarding physiological stress in marine mammals due to exposure to sound and other stressors are discussed in detail in Section 3.8.3.1.1.3 (Physiological Stress) under Acoustic Stressors above. Because there are many unknowns regarding the occurrence of acoustically induced stress responses in marine mammals, it is assumed that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

3.8.3.2.1.4 Masking

Masking occurs when one sound, distinguished as the "noise," interferes with the detection, discrimination, or recognition of another sound. The quantitative definition of masking is the amount in decibels an auditory detection, discrimination, or recognition threshold is raised in the presence of a masker (Erbe et al., 2016). As discussed in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise (with the potential exceptions of reverberations from impulsive noise). Masking can lead to vocal changes, such as the Lombard effect (increasing amplitude) or other noise-induced vocal modifications, such as changing frequency (Hotchkin & Parks, 2013); and behavioral changes (e.g., cessation of foraging, leaving an area) to both signalers and receivers, in an attempt to compensate for noise levels (Erbe et al., 2016).

There are no direct observations of masking in marine mammals due to exposure to explosive sources. General research findings regarding masking in marine mammals due to exposure to sound and other stressors are discussed in detail in Section 3.8.3.1.1.4 (Masking) under Acoustic Stressors above. Potential masking from explosive sounds is likely to be similar to masking studied for other impulsive sounds such as air guns.

3.8.3.2.1.5 Behavioral Reactions

As discussed in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), any stimuli in the environment can cause a behavioral response in marine mammals, including noise from explosions. There are few direct observations of behavioral reactions from marine mammals due to exposure to explosive sounds. Lammers et al. (2017) recorded dolphin detections near naval mine neutralization exercises and found that although the immediate response (within 30 seconds of the explosion) was an increase in whistles relative to the 30 seconds before the explosion, there was a reduction in daytime acoustic activity during the day of and the day after the exercise within 6 km. However, the nighttime activity did not seem to be different than that prior to the exercise, and two days after there appeared to be an increase in daytime acoustic activity, indicating a rapid return to the area by the dolphins (Lammers et al., 2017). Vallejo et al. (2017) report on boat-based line-transect surveys which were run over 10 years in an area where an offshore wind farm was built; these surveys included the periods of preconstruction, construction, and postconstruction. Harbor porpoise were observed throughout the area during all three phases, but were not detected within the footprint of the windfarm during the construction phase, and were overall less frequent throughout the study area. However, they returned after the construction was completed at a slightly higher level than in the preconstruction phase. Furthermore, there was no large-scale displacement of harbor porpoises during construction, and in fact their avoidance behavior only occurred out to about 18 km, in contrast to the approximately 25 km avoidance distance found in other windfarm construction and pile driving monitoring efforts.

Impulsive signals, particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle responses or avoidance responses. However, at long distances the rise time increases as the signal duration lengthens (similar to a “ringing” sound), making the impulsive signal more similar to a non-impulsive signal (Hastie et al., 2019; Martin et al., 2020). Behavioral reactions from explosive sounds are likely to be similar to reactions studied for other impulsive sounds, such as those produced by air guns and impact pile driving. Data on behavioral responses to impulsive sound sources are limited across all marine mammal groups, with only a few studies available for mysticetes and odontocetes. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks), and typically utilize large multi-air gun arrays that fire repeatedly. While seismic data provide the best available science for assessing behavioral responses to impulsive sounds by marine mammals, it is likely that these responses represent a worst-case scenario compared to responses to explosives used in Navy activities, which would typically consist of single impulses or a cluster of impulses, rather than long-duration, repeated impulses.

See Section 3.8.3.1.1.5 (Behavioral Reactions) under Section 3.8.3.1 (Acoustic Stressors) for a summary of information on marine mammal reactions to impulsive sounds.

3.8.3.2.1.6 Stranding

When a marine mammal (alive or dead) swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a "stranding" (Geraci et al., 1999; Geraci & Lounsbury, 2005; Perrin & Geraci, 2002). Specifically, under U.S. law, a stranding is an event in the wild where: "(A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance" (16 U.S.C. section 1421h).

Impulsive sources (e.g., explosions) also have the potential to contribute to strandings, but such occurrences are even less common than those that have been related to certain sonar activities. During a Navy training event on March 4, 2011, at the Silver Strand Training Complex in San Diego, California, three long-beaked common dolphins were killed by an underwater detonation. Further details are provided above. Discussions of mitigation measures associated with these and other training events are presented in Chapter 5 (Mitigation).

3.8.3.2.1.7 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. For additional information on the determination of long-term consequences, see Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions, masking and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences.

3.8.3.2.2 Impacts from Explosives

Marine mammals could be exposed to energy, sound, and fragments from explosions in the water and near the water surface associated with the proposed activities. Energy from an explosion is capable of causing mortality, injury, hearing loss, a behavioral response, masking, or physiological stress, depending on the level and duration of exposure.

The death of an animal would eliminate future reproductive potential, which is considered in the analysis of potential long-term consequences to the population. Exposures that result in non-auditory injuries or PTS may limit an animal's ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or impact its ability to successfully reproduce. TTS can also impair an animal's abilities, but the individual is likely to recover quickly with little significant effect.

Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds, which are within the audible range of most marine mammals, could cause behavioral reactions, masking, and elevated physiological stress. Behavioral responses can include shorter surfacings, shorter dives, fewer blows (breaths) per surfacing, longer intervals between blows, ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (National Research Council 2005). Sounds from explosives could also mask biologically important sounds; however, the duration of individual sounds is very short, reducing the likelihood of substantial auditory masking.

3.8.3.2.2.1 Methods for Analyzing Impacts from Explosives

The Navy performed a quantitative analysis to estimate the number of times that marine mammals could be impacted by explosions used during Navy training activities. The Navy's quantitative analysis to determine impacts on marine mammals uses the Navy Acoustic Effects Model to produce initial estimates of the number of instances that animals may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of procedural mitigation measures. The steps of this quantitative analysis are described in Section 3.0.1.2 (Navy's Quantitative Analysis to Determine Impacts to Sea Turtles and Marine Mammals), which takes into account:

- criteria and thresholds used to predict impacts from explosives (see below);
- the density (U.S. Department of the Navy, 2020b) and spatial distribution (Watwood et al., 2018) of marine mammals; and
- the influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation and explosive energy when estimating the received sound level and pressure on the animals.

A detailed explanation of this analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018d).

Criteria and Thresholds used to Estimate Impacts on Marine Mammals from Explosives

Mortality and Injury from Explosives

As discussed above in Section 3.8.3.2.1.1 (Injury), two metrics have been identified as predictive of injury: impulse and peak pressure. Peak pressure contributes to the "crack" or "stinging" sensation of a blast wave, compared to the "thump" associated with received impulse. Older military reports documenting exposure of human divers to blast exposure generally describe peak pressure exposures around 100 psi (237 dB re 1 µPa SPL peak) to feel like slight pressure or stinging sensation on skin, with no enduring effects (Christian & Gaspin, 1974).

Because data on explosive injury do not indicate a set threshold for injury, rather a range of risk for explosive exposures, two sets of criteria are provided for use in non-auditory injury assessment. The exposure thresholds are used to estimate the number of animals that may be affected during Navy training activities (Table 3.8-26). The thresholds for the farthest range to effect are based on the received level at which 1 percent risk of onset is predicted and are useful for assessing potential effects to marine mammals and the level of potential impacts covered by the mitigation zones. Increasing animal mass and increasing animal depth both increase the impulse thresholds (i.e., decrease susceptibility), whereas smaller mass and decreased animal depth reduce the impulse thresholds (i.e., increase susceptibility). For impact assessment, marine mammal populations are assumed to be 70 percent adult and 30 percent calf/pup. Sub-adult masses are used to determine onset of effect, in order to estimate the farthest range at which an effect may first be observable. The derivation of these injury criteria and the species mass estimates are provided in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a).

Table 3.8-26: Criteria to Quantitatively Assess Non-Auditory Injury Due to Explosions in Water

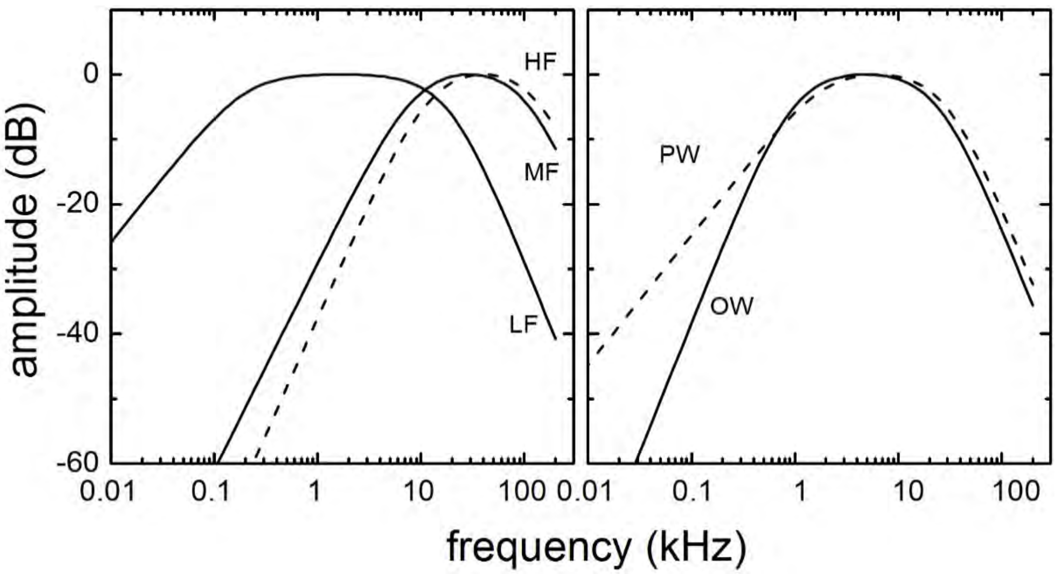
Impact Category	*Impact Threshold*	*Threshold for Farthest Range to Effect*[2]
Mortality[1]	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s	$103\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
Injury[1]	$65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s	$47.5M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
	243 dB re 1 µPa SPL peak	237 dB re 1 µPa SPL peak

[1] Impulse delivered over 20 percent of the estimated lung resonance period. See U.S. Department of the Navy (2017a).
[2] Threshold for one percent risk used to assess mitigation effectiveness.
Notes: D = animal depth (m), dB re 1 µPa = decibels referenced to 1 micropascal, M = animal mass (kg), Pa-s = Pascal-second, SPL = sound pressure level.

When explosive ordnance (e.g., bomb or missile) detonates, fragments of the weapon are thrown at high-velocity from the detonation point, which can injure or kill marine mammals if they are struck. Risk of fragment injury reduces exponentially with distance as the fragment density is reduced. Fragments underwater tend to be larger than fragments produced by in-air explosions (Swisdak & Montanaro, 1992). Underwater, the friction of the water would quickly slow these fragments to a point where they no longer pose a threat. On the other hand, the blast wave from an explosive detonation moves efficiently through the seawater. Because the ranges to mortality and injury due to exposure to the blast wave are likely to far exceed the zone where fragments could injure or kill an animal, the above thresholds are assumed to encompass risk due to fragmentation.

Auditory Weighting Functions

Animals are not equally sensitive to noise at all frequencies. To capture the frequency-dependent nature of the effects of noise, auditory weighting functions are used (Figure 3.8-13). Auditory weighting functions are mathematical functions based on a generic band-pass filter and incorporate species-specific hearing abilities to calculate a weighted received sound level in units SPL or SEL. Due to the band pass nature of auditory weighting functions, they resemble an inverted "U" shape with amplitude plotted as a function of frequency. The flatter portion of the plotted function, where the amplitude is closest to zero, is the emphasized frequency range (i.e., the pass-band), while the frequencies below and above this range (where amplitude declines) are de-emphasized.

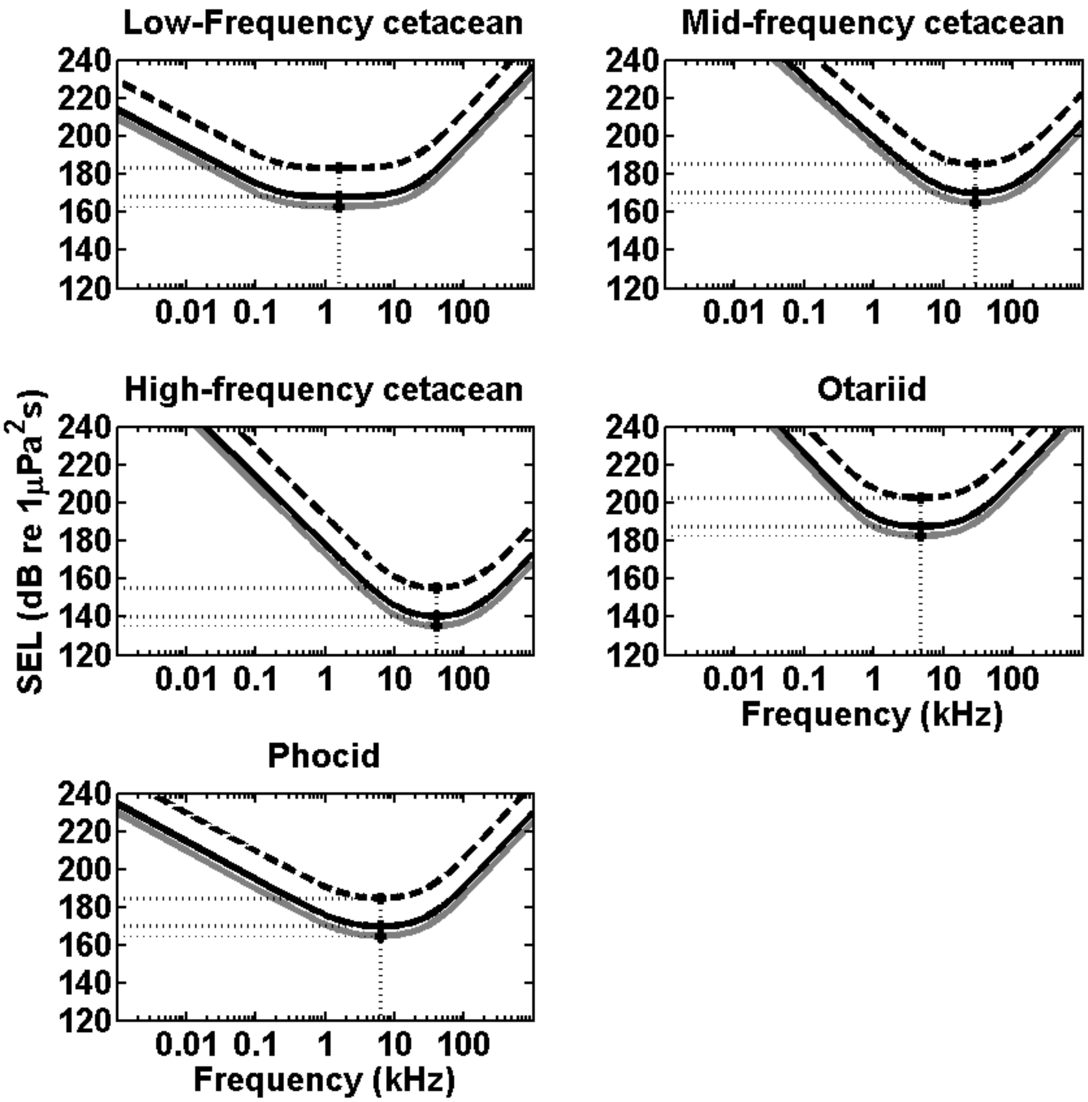


Source: See U.S. Department of the Navy (2017a) for parameters used to generate the functions and more information on weighting function derivation.
Notes: MF = mid-frequency cetacean, HF = high-frequency cetacean, LF = low-frequency cetacean, PW = phocid (in-water), and OW = otariid and other non-phocid marine carnivores (in-water)

Figure 3.8-13: Navy Phase III Weighting Functions for All Species Groups

Hearing Loss from Explosives

Criteria used to define threshold shifts from explosions are derived from the two known studies designed to induce TTS in marine mammals from impulsive sources. Finneran et al. (2002) reported behaviorally measured TTS of 6 and 7 dB in a beluga exposed to single impulses from a seismic water gun and Lucke et al. (2009) reported AEP-measured TTS of 7 to 20 dB in a harbor porpoise exposed to single impulses from a seismic air gun. Since marine mammal PTS data from impulsive noise exposures do not exist, onset-PTS levels for all groups were estimated by adding 15 dB to the threshold for non-impulsive sources. This relationship was derived by Southall et al. (2007) from impulsive noise TTS growth rates in chinchillas. These frequency dependent thresholds are depicted by the exposure functions for each group's range of best hearing (Figure 3.8-14). Weighted sound exposure thresholds for underwater explosive sounds used in the analysis are shown in Table 3.8-27).



Notes: The dark dashed curve is the exposure function for PTS onset, the solid black curve is the exposure function for TTS onset, and the light grey curve is the exposure function for behavioral response. Small dashed lines indicate the SEL threshold for behavioral response, TTS, and PTS onset at each group's most sensitive frequency (i.e., the weighted SEL threshold).

Figure 3.8-14: Navy Phase III Behavioral, TTS, and PTS Exposure Functions for Explosives

Table 3.8-27: Navy Phase III Weighted Sound Exposure Thresholds for Underwater Explosive Sounds

Hearing Group	Explosive Sound Source				
	Behavior (SEL) weighted (dB)	TTS (SEL) weighted (dB)	TTS (Peak SPL) unweighted (dB)	PTS (SEL) weighted (dB)	PTS (Peak SPL) unweighted (dB)
Low-frequency Cetacean (LF)	163	168	213	183	219
Mid-frequency Cetacean (MF)	165	170	224	185	230
High-frequency Cetacean (HF)	135	140	196	155	202
Otariids[1] in water (OW)	183	188	226	203	232
Phocid seal in water (PW)	165	170	212	185	218

[1] Threshold shift for mustelids (sea otters) is assessed using the otariid sound exposure thresholds. Any behavioral reactions by sea otters are assumed to occur within the TTS threshold.

Notes: dB = decibels, PTS = permanent threshold shift, SEL = sound exposure level, SPL = sound pressure level, and TTS = temporary threshold shift.

Behavioral Responses from Explosives

Marine mammals may be exposed to isolated impulses in their natural environment (e.g., lightning). For single explosions at received sound levels below hearing loss thresholds, the most likely behavioral response is a brief alerting or orienting response; therefore, the analysis assumes that any modeled instance of temporally or spatially separated detonations occurring in a single 24-hour period could result in harassment under the MMPA for military readiness activities within the range to TTS. Some multiple explosive exercises, such as certain naval gunnery exercises, may be treated as a single event because a few explosions occur closely spaced within a very short time (a few seconds). Since no further sounds follow the initial brief impulses, significant behavioral reactions would not be expected to occur. This reasoning was applied to previous shock trials (63 FR 230; 66 FR 87; 73 FR 143) and is extended to the criteria used in this analysis.

If more than one explosive event occurs within any given 24-hour period within a training activity, criteria are applied to predict the number of animals that may have a behavioral reaction at a behavioral threshold 5 dB less than the TTS onset threshold (in SEL). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulsive TTS testing (Schlundt et al., 2000).

Although there is no research on the effects of explosives on sea otter behavior, based on their low reactivity to other acoustic and anthropogenic stressors, sea otters exposed to received levels below the threshold for TTS are assumed to be unlikely to exhibit behavioral responses that would be considered "harassment" under the MMPA for military readiness activities, if behavioral reactions to distant sounds occur at all.

Accounting for Mitigation

The Navy will implement mitigation measures to avoid or reduce potential impacts from explosives on marine mammals, as described in Section 5.3.3 (Explosive Stressors). Procedural mitigation measures include delaying or ceasing applicable detonations when a marine mammal is observed in a mitigation zone. The mitigation zones for explosives extend beyond the respective average ranges to mortality. Navy impact analyses typically consider the potential for procedural mitigation to reduce the risk of mortality due to exposure to explosives; however, the Navy Acoustic Effects Model estimated zero mortality takes for all marine mammal species in the TMAA. Therefore, mitigation for explosives is discussed qualitatively but was not factored into the quantitative analysis for marine mammals under Alternative 1. A detailed explanation of the quantitative analysis process is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018d).

The Navy will also implement mitigation measures to prohibit the use of explosives at or near the surface from June 1 through September 30 in the North Pacific Right Whale Mitigation Area, and from April 1 through October 31 in the Portlock Bank Mitigation Area. Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. The benefits of mitigation areas are discussed qualitatively in terms of the context of impact avoidance or reduction.

3.8.3.2.2.2 Impact Ranges for Explosives

The following section provides the range (distance) over which specific physiological or behavioral effects are expected to occur based on the explosive criteria and the explosive propagation calculations from the Navy Acoustic Effects Model (Section 3.8.3.2.2.1, Methods for Analyzing Impacts from Explosives). The range to effects is shown for a range of explosive bins, from E5 (greater than 5–10 lb. net explosive weight) to E12 (greater than 650 lb. to 1,000 lb. net explosive weight). Ranges are determined by modeling the distance that noise from an explosion will need to propagate to reach exposure level thresholds specific to a hearing group that will cause behavioral response, TTS, PTS, and non-auditory injury. Range to effects is important information in not only predicting impacts from explosives, but also in verifying the accuracy of model results against real-world situations and assessing the level of impact that will likely be mitigated within applicable mitigation zones.

The ranges are the distance where the threshold is not exceeded at any depth where animals could be present (excluding negligible small convergence points in some instances). Thus, portions of the water column within the ranges shown would not exceed threshold (i.e., the range does not represent a cylinder of effect in the water column). In some instances, a significant portion of the water column within the ranges shown may not exceed threshold. These differences in propagation are captured in the actual estimation of takes within the Navy Acoustic Effects Model.

Table 3.8-28 shows the minimum, average, and maximum ranges due to varying propagation conditions to non-auditory injury as a function of animal mass and explosive bin. Ranges to gastrointestinal tract injury typically exceed ranges to slight lung injury; therefore, the maximum range to effect is not mass-dependent. Animals within these water volumes would be expected to receive minor injuries at the outer ranges, increasing to more substantial injuries, and finally mortality as an animal approaches the detonation point. Ranges to mortality, based on animal mass, are shown in Table 3.8-29.

Table 3.8-30 through Table 3.8-41 show the minimum, average, and maximum ranges to onset of auditory and behavioral effects based on the thresholds described in Section 3.8.3.2.2.1 (Methods for Analyzing Impacts from Explosives) are provided for a representative source depth and cluster size (the number of rounds fired [or buoys dropped] within a very short duration) for each bin. For events with multiple explosions, sound from successive explosions can be expected to accumulate and increase the range to the onset of an impact based on SEL thresholds. Modeled ranges to TTS and PTS based on peak pressure for a single explosion generally exceed the modeled ranges based on SEL even when accumulated for multiple explosions. Peak pressure-based ranges are estimated using the best available science; however, data on peak pressure at far distances from explosions are very limited. For additional information on how ranges to impacts from explosions were estimated, see the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing Ranges* (U.S. Department of the Navy, 2018d).

Table 3.8-28: Ranges to Non-Auditory Injury (in meters) for All Marine Mammal Hearing Groups

Bin[1]	*Range to Non-Auditory Injury (meters)*[2]
E5	40 (40–40)
E9	121 (90–130)
E10	152 (100–160)
E12	190 (110–200)

[1]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
[2]Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
Notes: All ranges to non-auditory injury within this table are driven by gastrointestinal tract injury thresholds regardless of animal mass.

Table 3.8-29: Ranges to Mortality (in meters) for All Marine Mammal Hearing Groups as a Function of Animal Mass

Bin[1]	*Animal Mass Intervals (kg)*[2]					
	10	*250*	*1,000*	*5,000*	*25,000*	*72,000*
E5	13 (12–14)	7 (4–11)	3 (3–4)	2 (1–3)	1 (1–1)	1 (0–1)
E9	35 (30–40)	20 (13–30)	10 (9–13)	7 (6–9)	4 (3–4)	3 (2–3)
E10	43 (40–50)	25 (16–40)	13 (11–16)	9 (7–11)	5 (4–5)	4 (3–4)
E12	55 (50–60)	30 (20–50)	17 (14–20)	11 (9–14)	6 (5–7)	5 (4–6)

[1]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
[2]Average distance to mortality (meters) is depicted above the minimum and maximum distances, which are in parentheses for each animal mass interval.

Table 3.8-30: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for High-Frequency Cetaceans

Range to Effects for Explosives: High-frequency cetaceans[1]					
Bin[2]	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***	***Behavioral***
E5	0.1	1	910 (850–975)	1,761 (1,275–2,275)	2,449 (1,775–3,275)
		7	1,275 (1,025–1,525)	3,095 (2,025–4,525)	4,664 (2,275–7,775)
E9	0.1	1	1,348 (1,025–1,775)	3,615 (2,025–5,775)	5,365 (2,525–8,525)
E10	0.1	1	1,546 (1,025–2,025)	4,352 (2,275–7,275)	5,949 (2,525–9,275)
E12	0.1	1	1,713 (1,275–2,025)	5,115 (2,275–7,775)	6,831 (2,775–10,275)

[1]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances, which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 3.8-31: Peak Pressure-Based Ranges to Onset PTS and Onset TTS (in meters) for High-Frequency Cetaceans

Range to Effects for Explosives: High-frequency cetaceans[1]				
Bin[2]	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***
E5	0.1	1	1,161 (1,000–1,525)	1,789 (1,025–2,275)
		7	1,161 (1,000–1,525)	1,789 (1,025–2,275)
E9	0.1	1	2,331 (1,525–2,775)	5,053 (2,025–9,275)
E10	0.1	1	2,994 (1,775–4,525)	7,227 (2,025–14,775)
E12	0.1	1	4,327 (2,025–7,275)	10,060 (2,025–22,275)

[1]Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 3.8-32: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Low-Frequency Cetaceans

Range to Effects for Explosives: Low-frequency cetaceans[1]					
Bin[2]	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***	***Behavioral***
E5	0.1	1	171 (100–190)	633 (230–825)	934 (310–1,525)
		7	382 (170–450)	1,552 (380–5,775)	3,712 (600–13,025)
E9	0.1	1	453 (180–550)	3,119 (550–9,025)	6,462 (1,275–19,275)
E10	0.1	1	554 (210–700)	4,213 (600–13,025)	9,472 (1,775–27,275)
E12	0.1	1	643 (230–825)	6,402 (1,275–19,775)	13,562 (2,025–34,775)

[1]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances, which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 3.8-33: Peak Pressure-Based Ranges to Onset PTS and Onset TTS (in meters) for Low-Frequency Cetaceans

Range to Effects for Explosives: Low-frequency cetaceans[1]				
Bin[2]	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***
E5	0.1	1	419 (170–500)	690 (210–875)
		7	419 (170–500)	690 (210–875)
E9	0.1	1	855 (270–1,275)	1,269 (400–1,775)
E10	0.1	1	953 (300–1,525)	1,500 (450–2,525)
E12	0.1	1	1,135 (360–1,525)	1,928 (525–4,775)

[1]Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 3.8-34: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Mid-Frequency Cetaceans

Range to Effects for Explosives: Mid-frequency cetaceans[1]					
Bin[2]	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***	***Behavioral***
E5	0.1	1	79 (75–80)	363 (360–370)	581 (550–600)
		7	185 (180–190)	777 (650–825)	1,157 (800–1,275)
E9	0.1	1	215 (210–220)	890 (700–950)	1,190 (825–1,525)
E10	0.1	1	275 (270–280)	974 (750–1,025)	1,455 (875–1,775)
E12	0.1	1	340 (340–340)	1,164 (825–1,275)	1,746 (925–2,025)

[1]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances, which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 3.8-35: Peak Pressure-Based Ranges to Onset PTS and Onset TTS (in meters) for Mid-Frequency Cetaceans

Range to Effects for Explosives: Mid-frequency cetaceans[1]				
Bin[2]	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***
E5	0.1	1	158 (150–160)	295 (290–300)
		7	158 (150–160)	295 (290–300)
E9	0.1	1	463 (430–470)	771 (575–850)
E10	0.1	1	558 (490–575)	919 (625–1,025)
E12	0.1	1	679 (550–725)	1,110 (675–1,275)

[1]Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 3.8-36: SEL Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Otariids and Mustelids

Range to Effects for Explosives: Otariids[1]					
Bin[2]	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***	***Behavioral***
E5	0.1	1	25 (24–25)	110 (110–110)	185 (180–190)
		7	58 (55–60)	265 (260–270)	443 (430–450)
E9	0.1	1	68 (65–70)	320 (310–330)	512 (490–525)
E10	0.1	1	88 (85–90)	400 (390–410)	619 (575–675)
E12	0.1	1	105 (100–110)	490 (470–500)	733 (650–825)

[1]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances, which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 3.8-37: Peak Pressure-Based Ranges to Onset PTS and Onset TTS (in meters) for Otariids and Mustelids

Range to Effects for Explosives: Otariids[1]				
Bin[2]	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***
E5	0.1	1	128 (120–130)	243 (240–250)
		7	128 (120–130)	243 (240–250)
E9	0.1	1	383 (380–390)	656 (600–700)
E10	0.1	1	478 (470–480)	775 (675–850)
E12	0.1	1	583 (550–600)	896 (750–1,025)

[1]Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
[2]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 3.8-38: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Phocids[1]

Range to Effects for Explosives: Phocids[1]					
Bin[2]	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***	***Behavioral***
E5	0.1	1	150 (150–150)	681 (675–700)	1,009 (975–1,025)
		7	360 (350–370)	1,306 (1,025–1,525)	1,779 (1,275–2,275)
E9	0.1	1	425 (420–430)	1,369 (1,025–1,525)	2,084 (1,525–2,775)
E10	0.1	1	525 (525–525)	1,716 (1,275–2,275)	2,723 (1,525–4,025)
E12	0.1	1	653 (650–675)	1,935 (1,275–2,775)	3,379 (1,775–5,775)

[1]Excluding elephant seals
[2]Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
[3]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 3.8-39: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for Phocids[1]

Range to Effects for Explosives: Phocids[1]				
Bin[2]	***Source Depth (m)***	***Cluster Size***	***PTS***	***TTS***
E5	0.1	1	537 (525–550)	931 (875–975)
		7	537 (525–550)	931 (875–975)
E9	0.1	1	1,150 (1,025–1,275)	1,845 (1,275–2,525)
E10	0.1	1	1,400 (1,025–1,775)	2,067 (1,275–2,525)
E12	0.1	1	1,713 (1,275–2,025)	2,306 (1,525–2,775)

[1]Excluding elephant seals
[2]Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
[3]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 3.8-40: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Phocids (Elephant Seals)[1]

Range to Effects for Explosives: Phocids (Elephant Seals)[2]					
Bin[3]	*Source Depth (m)*	*Cluster Size*	*PTS*	*TTS*	*Behavioral*
E5	0.1	1	150 (150–150)	688 (675–700)	1,025 (1,025–1,025)
		7	360 (350–370)	1,525 (1,525–1,525)	2,345 (2,275–2,525)
E9	0.1	1	425 (420–430)	1,775 (1,775–1,775)	2,858 (2,775–3,275)
E10	0.1	1	525 (525–525)	2,150 (2,025–2,525)	3,421 (3,025–4,025)
E12	0.1	1	656 (650–675)	2,609 (2,525–3,025)	4,178 (3,525–5,775)

[1]Elephant seals are separated from other phocids due to their dive behavior, which far exceeds the dive depths of the other phocids analyzed.
[2]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.
[3]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 3.8-41: Peak Pressure-Based Ranges to Onset PTS and Onset TTS (in meters) for Phocids (Elephant Seals)[1]

Range to Effects for Explosives: Phocids (Elephant Seals)[2]				
Bin[3]	*Source Depth (m)*	*Cluster Size*	*PTS*	*TTS*
E5	0.1	1	537 (525–550)	963 (950–975)
		7	537 (525–550)	963 (950–975)
E9	0.1	1	1,275 (1,275–1,275)	2,525 (2,525–2,525)
E10	0.1	1	1,775 (1,775–1,775)	3,046 (3,025–3,275)
E12	0.1	1	2,025 (2,025–2,025)	3,539 (3,525–3,775)

[1]Elephant seals are separated from other phocids due to their dive behavior, which far exceeds the dive depths of the other phocids analyzed
[2]Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
[3]Bin (net explosive weight, lb.): E5 (> 5–10), E9 (> 100–250), E10 (> 250–500), E12 (> 650–1,000)
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

3.8.3.2.2.3 Impacts from Explosives Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.8.3.2.2.4 Impacts from Explosives Under Alternative 1

Training activities under Alternative 1 would involve detonations in-air at altitudes above 10 m and higher and detonations at or near the surface occurring at or below 10 m in altitude. As noted previously, those detonations occurring at or near the surface were modeled as if they occurred underwater and were analyzed for their potential underwater acoustic effects on marine mammals. The use of explosives would occur throughout the TMAA and are typically dispersed in space and time. The number and type (i.e., source bin) of explosives that would be used during training under Alternative 1 are described in Section 3.0.4.2 (Explosive Stressors). Activities using explosives would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). The proposed use of explosives for training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Although the existing baseline conditions have not changed appreciably, and no new Navy training activities are being proposed for use in the TMAA in this SEIS/OEIS, a detailed re-analysis of Alternative 1 with respect to marine mammals is provided here to supplant previous analysis based on available new literature, adjusted sound exposure criteria, and new acoustic effects modeling.

<u>Presentation of Estimated Impacts from the Quantitative Analysis</u>

The results of the analysis of potential impacts on marine mammals from explosives (see above Section 3.8.3.2.2.1, Methods for Analyzing Impacts from Explosives) are discussed below. The numbers of potential impacts estimated for individual species of marine mammals from exposure to explosive energy and sound for training activities under Alternative 1 are shown in Appendix C (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training Activities).

Since training activities involving explosions for this SEIS/OEIS only occur in the TMAA, the predictions of numbers of marine mammals that may be affected are assessed solely within the TMAA. The number of explosive sources in this SEIS/OEIS compared with the totals analyzed in the 2016 GOA Final SEIS/OEIS are described in Table 2.6-1 (Current and Proposed Training Activities). Estimated numbers of potential impacts from the quantitative analysis for each species are presented below and estimated impacts for all species can be found in Appendix C (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training Activities).

Mysticetes

Mysticetes may be exposed to sound and energy from explosions associated with training activities throughout the year. Explosions produce sounds that are within the hearing range of mysticetes (see Section 3.8.2.1.4, Hearing and Vocalization). Potential impacts from explosive energy and sound include non-auditory injury, behavioral reactions, physiological stress, masking, and hearing loss. The quantitative analysis estimates behavioral reactions, TTS, and PTS in mysticetes. Impact ranges for mysticetes exposed to explosive sound and energy are discussed under low-frequency cetaceans in Section 3.8.3.2.2.2 (Impact Ranges for Explosives).

Mysticetes that do experience threshold shift from explosive sounds may have reduced ability to detect biologically important sounds (e.g., social vocalizations) until their hearing recovers. Recovery from threshold shift begins almost immediately after the noise exposure ceases and can take a few minutes to a few days, depending on the severity of the initial shift, to recover. TTS would recover fully and PTS would leave some residual hearing loss. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. Noise from explosions is broadband with most energy below a few hundred Hertz; therefore, any hearing loss from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. During the short period that a mysticete had TTS, or permanently for PTS, social calls from conspecifics could be more difficult to detect or interpret, the ability to detect predators may be reduced, and the ability to detect and avoid sounds from approaching vessels or other stressors might be reduced. It is unclear how or if mysticetes use sound for finding prey or feeding; therefore, it is unknown whether a TTS would affect a mysticete's ability to locate prey or rate of feeding.

Research and observations of auditory masking in marine mammals due to impulsive sounds are discussed in Section 3.8.3.2.1.4 (Masking). Explosions introduce low-frequency, broadband sounds into the environment, which could mask hearing thresholds in mysticetes that are nearby, although sounds from explosions last for only a few seconds at most. Masking due to time-isolated detonations would not be significant. Activities that have multiple detonations such as some naval gunfire exercises could create some masking for mysticetes in the area over the short duration of the event. Potential costs to mysticetes from masking are similar to those discussed above for TTS, with the primary difference being that the effects of masking are only present when the sound from the explosion is present within the water and the effect is over the moment the sound has ceased.

Research and observations (see Behavioral Responses from Explosives) show that if mysticetes are exposed to impulsive sounds such as those from explosives, they may react in a variety of ways, which may include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, changing vocalization, or showing no response at all. Overall, mysticetes have been observed to be more reactive to acoustic disturbance when a noise sources is located directly on their migration route. Mysticetes disturbed while migrating could pause their migration or route around the disturbance. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Because noise from most activities using explosives is short term and intermittent, and because detonations usually occur within a small area, behavioral reactions from mysticetes are likely to be short-term and low to moderate severity.

Physiological stress could be caused by injury or hearing loss and could accompany any behavioral reaction as well. Research and observations of physiological stress in marine mammals are discussed in Section 3.8.3.2.1.3 (Physiological Stress). Due to the short-term and intermittent use of explosives, physiological stress is also likely to be short term and intermittent. Long-term consequences from physiological stress due to the sound of explosives would not be expected.

North Pacific Right Whales (Endangered Species Act-Listed)

North Pacific right whales may be exposed to sound or energy from explosions associated with training activities April through October. Although North Pacific right whales are considered rare in the TMAA due to their low abundance, their occurrence in the TMAA is year round and are most likely to be present June through September. The quantitative analysis estimates a behavioral reaction under Alternative 1 (Table 3.8-42). Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the Eastern North Pacific Stock (Table 3.8-42).

Even if an individual right whale experiences a behavioral reaction a few times over the course of a year, impacts are unlikely to have any significant costs or long-term consequences for that individual. In addition to implementing procedural mitigation for explosives, from June through September (i.e., the months when North Pacific right whales are most likely to be present in the TMAA) the Navy will not use explosives at or near the surface within the North Pacific Right Whale Mitigation Area. This mitigation area encompasses the portion of the biologically important habitat identified by Ferguson et al. (2015) for North Pacific right whale feeding that overlaps the TMAA. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would result in the unintentional taking of North Pacific right whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed North Pacific right whales. The Navy will consult with NMFS as required by section 7(a)(2) of the ESA.

Table 3.8-42: Estimated Impacts on Individual North Pacific Right Whale Stocks Within the Study Area per Year from Explosions Used During Training Under Alternative 1

Estimated Impacts by Effect				
Stock	***Behavioral***	***TTS***	***PTS***	***Injury***
Eastern North Pacific	1	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Humpback Whales (some DPSs are Endangered Species Act-Listed)

Humpback whales may be exposed to sound or energy from explosions associated with training activities April through October. Although the timing of humpback whale migrations may change year to year, they are most likely to be present in the TMAA June through September. Impacts have been modeled for the Hawaii (Central North Pacific stock) population of humpback whales, which are not ESA-listed, and for the Mexico (California, Oregon, and Washington stock), Central America (California, Oregon, and Washington stock), and Western North Pacific DPS (Western North Pacific stock)populations of humpback whales, which are ESA-listed.

The quantitative analysis, using the maximum number of explosions per year, estimates behavioral reactions and TTS under Alternative 1 (Table 3.8-43). Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Estimated impacts apply to multiple stocks (Table 3.8-43). In addition to procedural mitigation, the Navy will implement mitigation within mitigation areas, which will further help avoid or reduce potential impacts from explosives on humpback whales. The Navy will issue annual seasonal awareness notification messages to alert ships and aircraft operating within the TMAA to the possible presence of increased concentrations of humpback whales from June 1 to September 30. To maintain safety of navigation and to avoid interactions with large whales, the Navy will instruct vessels to remain vigilant to the presence of large whales that may be vulnerable to vessel strikes or potential impacts from training activities. Platforms will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during training activities and to aid in the implementation of procedural mitigation during activities using explosives. The Navy will not use explosives at or near the surface from June 1 to September 30 within the North Pacific Right Whale Mitigation Area or from April 1 to October 31 in the Portlock Bank Mitigation Area, which overlap a portion of the proposed humpback whale critical habitat. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

As described in Section 3.8.2.3 (Humpback Whale [*Megaptera novaeangliae*]), proposed critical habitat for the ESA-listed Western North Pacific and Mexico DPS of humpback whales (NMFS designated Region/Units 5, 7, and 8) overlaps the northwestern portion of the TMAA over the continental shelf.

As described in Section 3.8.2.3 (Humpback Whale [*Megaptera novaeangliae*]), one essential feature was identified for humpback whale critical habitat: prey species, primarily euphausiids and small pelagic schooling fishes, of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth. This essential feature has the potential to be affected by explosives used under the Proposed Action. The best available science and description of methods used to assess explosive impacts to fishes (i.e., prey species) are provided in Section 3.6.3.2 (Explosive Stressors). The thresholds applied to estimate potential mortality impacts on fishes are based on a conservative application of available data. As shown in Table 3.6-8 in Section 3.6.3.2.2.1 (Methods for Analyzing Impacts from Explosives), the average range to fish mortality due to an explosive in bin E12 (> 650–1,000 lb. net explosive weight [NEW]), the largest explosive proposed in the TMAA, is 800 m. The ranges for smaller explosive bins are correspondingly shorter. Fish that occur within the estimated ranges to mortality could be killed, and those that are killed within the proposed critical habitat would no longer be available as prey items. Other potential impacts from exposure to explosions include injury, TTS, physiological stress, and behavioral reactions. The ranges to these lower level impacts would be considerably larger than the range to mortality. However, these impacts would not be anticipated to remove individual fish (i.e., prey species) from the population, nor would any non-mortal temporary or isolated impacts to prey items be expected to reduce the quality of prey in terms of nutritional content.

Crustaceans have been shown to be relatively resilient to explosive exposures, and it is anticipated that other invertebrates (including euphausiids) would respond similarly to explosive exposures. Although individuals of widespread marine invertebrate species could be killed during an explosion, the number of such invertebrates affected would be small relative to overall population sizes, and activities would be unlikely to impact survival, growth, recruitment, or reproduction of populations or subpopulations. Impacts of a limited number of explosions on widespread invertebrate populations, and therefore humpback prey items, would likely be undetectable.

Overall, if prey items are killed within the critical habitat, it is likely that only a low number of individuals and therefore a small portion of prey species populations may be killed. Although some prey items could be killed within the described mortality ranges during an explosive activity, other prey items would likely be available to humpback whales in the immediate area surrounding the activity or would return to the area after the activity is complete. Exposure to explosions would be highly dependent on the limited number of explosive activities that overlap proposed critical habitat and the actual presence of prey species at the time explosive activities occur. The portion of proposed critical habitat that overlaps the TMAA is limited, and only a small number of explosive training activities could potentially occur within the proposed critical habitat. This would result in a minimal change in the overall quantity or availability of prey items within the habitat as a whole. Although some individual prey items may be killed, long-term consequences for fish and invertebrate populations and the effect on overall quantity, quality and availability of prey items would be insignificant. Population-level impacts on fishes and invertebrates in the TMAA from explosive training activities are not anticipated and would not impact humpback whales through a reduction in prey availability.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would result in the unintentional taking of humpback whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed humpback whales and proposed critical habitat. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Table 3.8-43: Estimated Impacts on Individual Humpback Whale Stocks Within the Study Area per Year from Explosions Used During Training Under Alternative 1

Estimated Impacts by Effect				
Stock	***Behavioral***	***TTS***	***PTS***	***Injury***
California, Oregon, & Washington	1	0	0	0
Central North Pacific	7	2	0	0
Western North Pacific	0	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Blue Whales (Endangered Species Act-Listed)

Blue whales may be exposed to sound or energy from explosions associated with training activities April through October. Although blue whales' occurrence in the TMAA is year round, they are most likely to be present June through December. The quantitative analysis, using the maximum number of explosives per year, estimates behavioral reaction under Alternative 1 (Table 3.8-44). Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the Eastern North Pacific stock (Table 3.8-44).

Even if an individual blue whale experiences behavioral reactions a few times over the course of a year, impacts are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would result in the unintentional taking of blue whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed blue whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Table 3.8-44: Estimated Impacts on Individual Blue Whale Stocks Within the Study Area per Year from Explosions Used During Training Under Alternative 1

Estimated Impacts by Effect				
Stock	***Behavioral***	***TTS***	***PTS***	***Injury***
Central North Pacific	0	0	0	0
Eastern North Pacific	1	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Fin Whales (Endangered Species Act-Listed)

Fin whales may be exposed to sound or energy from explosions associated with training activities April through October. Although fin whales' occurrence in the TMAA is year round, they are most likely to be present June through August. The quantitative analysis, using the maximum number of explosions per year, estimates behavioral reaction, TTS and PTS under Alternative 1 (Table 3.8-45). Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the Northeast Pacific stock (Table 3.8-45).

As described for mysticetes above, minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. PTS could reduce an animal's ability to detect biologically important sounds; however, as discussed above, hearing loss beyond a minor TTS is unlikely, and a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that fin whales rely upon if it did occur. Nevertheless, PTS could have minor long-term consequences for individuals if it were to occur. This minor consequence for an individual is unlikely to have any long-term consequences for the species or stock. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would result in the unintentional taking of fin whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed fin whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Table 3.8-45: Estimated Impacts on Individual Fin Whale Stocks Within the Study Area per Year from Explosions Used During Training Under Alternative 1

Estimated Impacts by Effect				
Stock	***Behavioral***	***TTS***	***PTS***	***Injury***
Northeast Pacific	11	2	2	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sound or energy from explosions associated with training activities April through October. Although sei whales' occurrence in the TMAA is year round, they are considered rare, even during the summer time period. The quantitative analysis, using the maximum number of explosions per year, estimates behavioral reaction under Alternative 1 (Table 3.8-46). Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the Eastern North Pacific stock (Table 3.8-46).

Even if an individual sei whale experiences behavioral reactions a few times over the course of a year, impacts are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would result in the unintentional taking of sei whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed sei whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Table 3.8-46: Estimated Impacts on Individual Sei Whale Stocks Within the Study Area per Year from Explosions Used During Training Under Alternative 1

Estimated Impacts by Effect				
Stock	***Behavioral***	***TTS***	***PTS***	***Injury***
Eastern North Pacific	1	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Minke Whales

Minke whales may be exposed to sound or energy from explosions associated with training activities April through October. Even though very few minke whales have been seen during surveys in the area, their occurrence in the TMAA is considered year round. The quantitative analysis, using the maximum number of explosions per year, estimates behavioral reactions under Alternative 1 (Table 3.8-47). Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the Alaska stock (Table 3.8-47).

Even if an individual minke whale experiences behavioral reactions a few times over the course of a year, impacts are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would result in the unintentional taking of minke whales incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-47: Estimated Impacts on Individual Minke Whale Stocks Within the Study Area per Year from Explosions Used During Training Under Alternative 1

Estimated Impacts by Effect				
Stock	***Behavioral***	***TTS***	***PTS***	***Injury***
Alaska	2	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Gray Whales (one DPS is Endangered Species Act-Listed)

Gray whales may be exposed to sound or energy from explosions associated with training activities April through October. Although Western North Pacific gray whales are rare, both stocks of gray whales are migratory and their occurrence in the TMAA would be seasonal with their highest likelihood of occurring being between June and August. Impacts have been modeled for the Eastern North Pacific stock of gray whales, which are not ESA-listed, and for the Western North Pacific stock of gray whales, which are ESA-listed.

The quantitative analysis, using the maximum number of explosions per year, estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives).

In addition to procedural mitigation, the Navy will implement mitigation within mitigation areas, which will further help avoid the already low potential for impacts from explosives on gray whales. The Navy will issue annual seasonal awareness notification messages to alert ships and aircraft operating within the TMAA to the possible presence of increased concentrations of gray whales from April 1 to August 31. To maintain safety of navigation and to avoid interactions with large whales, the Navy will instruct vessels to remain vigilant to the presence of large whales that may be vulnerable to vessel strikes or potential impacts from training activities. Platforms will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during training activities and to aid in the implementation of procedural mitigation during activities using active sonar. This mitigation area overlaps habitat within the northernmost corner and southwestern edge of the TMAA that has been identified by Ferguson et al. (2015) as biologically important gray whale migration habitat. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of gray whales.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed gray whales.

Odontocetes

Odontocetes may be exposed to sound and energy from explosives associated with training activities from April to October. Explosions produce sounds that are within the hearing range of odontocetes (see Section 3.8.2.1.4, Hearing and Vocalization). Potential impacts from explosive energy and sound include non-auditory injury, behavioral reactions, physiological stress, masking, and hearing loss. Impact ranges for odontocetes exposed to explosive sound and energy are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives) under mid-frequency cetaceans for most species, and under high-frequency cetaceans for Dall's porpoises and harbor porpoises.

Non-auditory injuries to odontocetes, if they did occur, could include anything from mild injuries that are recoverable and are unlikely to have long-term consequences, to more serious injuries, including mortality. It is possible for marine mammals to be injured or killed by an explosion in isolated instances. Individuals that sustain injury from explosives could have long-term consequences. Considering that dolphin species for which these impacts are predicted have populations with tens to hundreds of thousands of animals, removing several animals from the population would be unlikely to have measurable long-term consequences for the species or stocks. As discussed in Section 5.3.3 (Explosive Stressors), the Navy will implement procedural mitigation measures to delay or cease detonations when a marine mammal is sighted in a mitigation zone to avoid or reduce potential explosive impacts.

Odontocetes that do experience a hearing threshold shift from explosive sounds may have reduced ability to detect biologically important sounds (e.g., social vocalizations) until their hearing recovers. Recovery from a hearing threshold shift begins almost immediately after the noise exposure ceases. A threshold shift can take a few minutes to a few days, depending on the severity of the initial shift, to recover. TTS would recover fully and PTS would leave some residual hearing loss. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. Noise from explosions is broadband with most energy below a few hundred Hertz; therefore, any hearing loss from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. During the period that an odontocete had hearing loss, social calls from conspecifics and sounds from predators such as killer whale vocalizations could be more difficult to detect or interpret, although many of these sounds may be above the frequencies of the threshold shift. Odontocetes use echolocation clicks to find and capture prey. These echolocation clicks and vocalizations are at frequencies above a few kHz, which are less likely to be affected by threshold shift at lower frequencies, and should not affect odontocete's ability to locate prey or rate of feeding.

Research and observations of masking in marine mammals due to impulsive sounds are discussed in Section 3.8.3.2.1.4 (Masking). Explosions introduce low-frequency, broadband sounds into the environment, which could mask hearing thresholds in odontocetes that are nearby, although sounds from explosions last for only a few seconds at most. Also, odontocetes typically communicate, vocalize, and echolocate at higher frequencies that would be less affected by masking noise at lower frequencies such as those produced by an explosion. Masking due to time-isolated detonations would not be significant. Activities that have multiple detonations such as some naval gunfire exercises could create some masking for odontocetes in the area over the short duration of the event. Potential costs to odontocetes from masking are similar to those discussed above for TTS, with the primary difference being that the effects of masking are only present when the sound from the explosion is present within the water and the effect is over the moment the sound has ceased.

Research and observations (see Section 3.8.3.2.1.5, Behavioral Reactions) show that odontocetes do not typically show strong behavioral reactions to impulsive sounds such as explosions. Reactions, if they did occur, would likely be limited to short ranges, within a few kilometers of multiple explosions. Reactions could include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, change in vocalization, or showing no response at all. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Because noise from most activities using explosives is short term and intermittent, and because detonations usually occur within a small area, behavioral reactions from odontocetes are likely to be short term and low to moderate severity.

Physiological stress could be caused by injury or hearing loss and could accompany any behavioral reaction as well. Research and observations of physiological stress in marine mammals are discussed in Section 3.8.3.2.1.3 (Physiological Stress). Due to the short-term and intermittent use of explosives, physiological stress is also likely to be short term and intermittent. Long-term consequences from physiological stress due to the sound of explosives would not be expected.

Sperm Whales (Endangered Species Act-Listed)

Sperm whales may be exposed to sound or energy from explosions associated with training activities April through October. Although sperm whales' occurrence in the TMAA is year round, they are most likely to be present June through September. The quantitative analysis, using the maximum number of explosions per year, estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of sperm whales.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed sperm whales. The Navy will consult with NMFS as required by Section 7(a)(2) of the ESA.

Killer Whales

Killer whales may be exposed to sound or energy from explosions associated with training activities April through October. Although killer whales' occurrence in the TMAA is year round, the one offshore population and the two transient types are more likely to be present in the majority of the TMAA given the deep and far offshore waters of the Navy training area. The quantitative analysis, using the maximum number of explosions per year, estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of killer whales.

Pacific White-Sided Dolphins

Pacific white-sided dolphins may be exposed to sound or energy from explosions associated with training activities April through October. The Navy has determined the Pacific white-sided dolphins' occurrence in the TMAA would be likely year round. The quantitative analysis, using the maximum number of explosions per year, estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of Pacific white-sided dolphins.

Harbor Porpoises

Harbor porpoises may be exposed to sound or energy from explosions associated with training activities April through October. The Navy has determined the harbor porpoises' occurrence in the TMAA would be likely year round in the nearshore locations to the shelf break. The quantitative analysis, using the maximum number of explosions per year, estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of harbor porpoises.

Dall's Porpoises

Dall's porpoises may be exposed to sound or energy from explosions associated with training activities April through October. The Navy has determined the Dall's porpoises' occurrence in the TMAA would be likely year round. The quantitative analysis, using the maximum number of explosions per year, estimates behavioral reaction, TTS, and PTS (Table 3.8-48). Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the Alaska stock (Table 3.8-48).

TTS and PTS thresholds for high-frequency cetaceans, including Dall's porpoises, are lower than for all other marine mammals, which leads to a higher number of estimated impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans). The information available on harbor porpoise behavioral reactions to human disturbance (a closely related species) suggests that these species may be more sensitive and avoid human activity, and sound sources, to a longer range than most other odontocetes. This would make Dall's porpoises less susceptible to hearing loss; therefore, it is likely that the quantitative analysis over-predicted hearing loss impacts (i.e., TTS and PTS) in Dall's porpoises.

As described for odontocetes above, minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals, although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would result in the unintentional taking of Dall's porpoises incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-48: Estimated Impacts on Individual Dall's Porpoise Stocks Within the Study Area per Year from Explosions Used During Training Under Alternative 1

Estimated Impacts by Effect				
Stock	***Behavioral***	***TTS***	***PTS***	***Injury***
Alaska	38	229	45	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Beaked Whales

Beaked whales may be exposed to sound or energy from explosions associated with training activities April through October. Beaked whales within the GOA TMAA include Baird's beaked whale, Cuvier's beaked whale, and Stejneger's beaked whale. Although beaked whales' occurrence in the TMAA would be likely year round, Cuvier's beaked whales are most likely to be present April through June. The quantitative analysis, using the maximum number of explosions per year, estimates behavioral reaction for Cuvier's beaked whale and no impacts on Baird's or Stejneger's beaked whales under Alternative 1 (Table 3.8-49). Impact ranges for these species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the Alaska stock of Cuvier's beaked whales (Table 3.8-49).

Research and observations (see *Behavioral Responses from Explosives*) show that beaked whales are sensitive to human disturbance including noise from sonars, although no research on specific reactions to impulsive sounds or noise from explosions is available. Odontocetes overall have shown little responsiveness to impulsive sounds, although it is likely that beaked whales are more reactive than most other odontocetes. Reactions could include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, change in vocalization, or showing no response at all. Beaked whales on Navy ranges have been observed leaving the area for a few days during sonar training exercises. It is reasonable to expect that animals may leave an area of more intense explosive activity for a few days; however, most explosive use during Navy activities is short duration, consisting of only a single or few closely timed explosions (i.e., detonated within a few minutes) with a limited footprint due to a single detonation point. Because noise from most activities using explosives is short term and intermittent and because detonations usually occur within a small area, behavioral reactions from beaked whales are likely to be short term and moderate severity.

Even if an individual Cuvier's beaked whale experiences behavioral reactions a few times over the course of a year, impacts are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that would be conducted as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of Baird's beaked whales and Stejneger's beaked whales.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would result in the incidental taking of Cuvier's beaked whales. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-49: Estimated Impacts on Individual Cuvier's Beaked Whale Stocks Within the Study Area per Year from Explosions Used During Training Under Alternative 1

Estimated Impacts by Effect				
Stock	***Behavioral***	***TTS***	***PTS***	***Injury***
Alaska	1	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Pinnipeds and Mustelids

Pinnipeds include phocid seals (true seals) and otariids (sea lions and fur seals), and mustelids include sea otters.

As described in Section 3.8.3.2.1.5 (Behavioral Reactions), mustelids have similar or reduced hearing capabilities compared to pinnipeds (specifically otariids). Thus, it is reasonable to assume that mustelids use their hearing similarly to that of otariids, and the types of impacts from exposure explosions may also be similar to those described below for pinnipeds, including behavioral reactions, physiological stress, masking, and hearing loss.

If a pinnipeds or mustelid were to experience TTS from explosive sounds, it may have reduced ability to detect biologically important sounds until their hearing recovers. Recovery from TTS begins almost immediately after the noise exposure ceases and can take a few minutes to a few days, depending on the severity of the initial shift, to fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. Noise from explosions is broadband with most energy below a few hundred Hertz; therefore, any hearing loss from exposure to explosive sounds is likely to be broadband with effects predominantly at lower frequencies. During the short period that a pinniped had TTS, social calls from conspecifics could be more difficult to detect or interpret; however, most pinniped vocalizations may be above the frequency of TTS induced by an explosion. Killer whales are one of the pinniped primary predators. Killer whale vocalizations are typically above a few kHz, well above the region of hearing that is likely to be affected by exposure to explosive energy. Therefore, TTS in pinnipeds due to sound from explosions is unlikely to reduce detection of killer whale calls. Pinnipeds may use sound underwater to find prey and feed; therefore, a TTS could have a minor and temporary effect on a phocid seal's ability to locate prey.

Research and observations of auditory masking in marine mammals due to impulsive sounds are discussed in Section 3.8.3.2.1.4 (Masking). Explosions introduce low-frequency, broadband sounds into the environment, which could mask hearing thresholds in pinnipeds that are nearby, although sounds from explosions last for only a few seconds at most. Masking due to time-isolated detonations would not be significant. Activities that have multiple detonations such as some naval gunfire exercises could create some masking for pinnipeds in the area over the short duration of the event. Potential costs to pinnipeds and mustelids from masking are similar to those discussed above for TTS, with the primary difference being that the effects of masking are only present when the sound from the explosion is present within the water and the effect is over the moment the sound has ceased.

Research and observations (see Behavioral Responses from Explosives) show that pinnipeds may be the least sensitive taxonomic group to most noise sources. They are likely to only respond to loud impulsive sound sources at close ranges by startling, jumping into the water when hauled out, or even cease foraging, but only for brief periods before returning to their previous behavior. Pinnipeds may even experience TTS before exhibiting a behavioral response (Southall et al., 2007). Because noise from most activities using explosives is short term and intermittent, and because detonations usually occur within a small area, behavioral reactions from phocid seals are likely to be short term and low severity.

Physiological stress could be caused by injury or hearing loss and could accompany any behavioral reaction as well. Research and observations of physiological stress in marine mammals are discussed in Section 3.8.3.2.1.3 (Physiological Stress). Due to the short-term and intermittent use of explosives, physiological stress is also likely to be short term and intermittent. Long-term consequences from physiological stress due to the sound of explosives would not be expected.

Steller Sea Lions (one DPS is Endangered Species Act-Listed)

Steller sea lions may be exposed to sound or energy from explosions associated with training activities April through October. The Navy has determined the Steller sea lions' occurrence in the TMAA would be likely year round. Impacts have been modeled for the Eastern U.S. stock of Steller sea lions, which are not ESA-listed, and for the Western U.S. stock of Steller sea lions, which are ESA-listed. The quantitative analysis, using the maximum number of explosions per year, estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of Steller sea lions.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed Steller sea lions.

California Sea Lions

California sea lions may be exposed to sound or energy from explosions associated with training activities April through October. The Navy has determined the California sea lions' occurrence in the TMAA would be seasonal and are most likely to be present April through May. The quantitative analysis, using the maximum number of explosions per year, estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of California sea lions.

Northern Fur Seals

Northern fur seals may be exposed to sound or energy from explosions associated with training activities April through October. Although northern fur seals are most likely to be present in the TMAA December through July, males may potentially be present year round. The quantitative analysis, using the maximum number of explosions per year, estimates no impacts under Alternative 1. Impact ranges for these species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of northern fur seals.

Northern Elephant Seals

Northern elephant seals may be exposed to sound or energy from explosions associated with training activities April through October. The Navy has determined the northern elephant seals' occurrence in the TMAA would be seasonal and are most likely to be present March through October. The quantitative analysis, using the maximum number of explosions per year, estimates behavioral reaction, TTS, and PTS (Table 3.8-50). Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Estimated impacts apply to the California stock (Table 3.8-50).

As described above, minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have significant costs or long-term consequences for that individual. PTS in an individual could have no to minor long-term consequences for individuals although a single minor long-term consequence for an individual is unlikely to lead to long-term consequences for a population. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would result in the unintentional taking of northern elephant seals incidental to those activities. The Navy will request authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Table 3.8-50: Estimated Impacts on Individual Northern Elephant Seal Stocks Within the Study Area per Year from Explosions Used During Training Under Alternative 1

Estimated Impacts by Effect				
Stock	***Behavioral***	***TTS***	***PTS***	***Injury***
California	6	9	8	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Harbor Seals

Harbor seals may be exposed to sound or energy from explosions associated with training activities April through October. Although harbor seals' occurrence in the TMAA is year round, they are rarely found more than 20 km from shore and are therefore more likely to be present in the inshore water locations. The quantitative analysis, using the maximum number of explosions per year, estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stocks would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of harbor seals.

Ribbon Seals

Ribbon seals may be exposed to sound or energy from explosions associated with training activities April through October. Although ribbon seals are considered rare in the TMAA, their occurrence is year round and are most likely to be present in the TMAA July through September. The quantitative analysis, using the maximum number of explosions per year, estimates no impacts under Alternative 1. Impact ranges for this species are discussed in Section 3.8.3.2.2.2 (Impact Ranges for Explosives). Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of ribbon seals.

Northern Sea Otters (one DPS is Endangered Species Act-Listed)

Northern sea otters are unlikely to be exposed to sound or energy from explosions associated with training activities April through October. Although northern sea otters occur in the Gulf of Alaska year round, they would rarely be present in the TMAA since the normal range and habitat of sea otters is well inland of the TMAA boundaries. Sea otters seldom range more than 2 km from shore, and in this region are mainly concentrated within 400 m from shore because they are benthic foragers. (Bodkin, 2015) notes that sea otters can be found many kilometers from shore in locations where there are shoals far from land, but there are no known offshore populations near the TMAA. Individuals from the Southwest Alaska stock (ESA-listed) are not expected to be present in the TMAA. It is possible that individual sea otters from the Southcentral Alaska stock or the Southeast Alaska stock (neither are ESA-listed) could potentially occur in the nearshore margins of the TMAA. Juvenile males in particular may travel farther offshore (Calambokidis et al., 1987; Laidre et al., 2009; Muto et al., 2017; Riedman & Estes, 1990).

Detonations would generally occur further offshore than the nearshore areas that sea otters inhabit. Impacts are highly unlikely due to limited use of explosives nearshore and the unlikely occurrence of sea otters overlapping with explosions during training activities. In addition, Ghoul and Reichmuth (2014b) have shown that sea otters are not especially well adapted for hearing underwater, which suggests that the function of this sense has been less important in their survival and evolution than in comparison to pinnipeds. Due to their low sensitivity to underwater sounds, their preferred habitat, and the lack of normal geographical overlap between sea otter habitat and training activities, impacts to northern sea otters from Navy training activities involving explosives are highly unlikely to occur. Considering these factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species or stock would not be expected.

Pursuant to the MMPA, the use of explosives during training activities as described under Alternative 1 would not result in the incidental taking of Northern sea otters.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect ESA-listed Northern sea otters. The Navy will consult with USFWS as required by Section 7(a)(2) of the ESA.

3.8.3.3 Secondary Stressors

Navy training activities could pose indirect impacts on marine mammals via habitat or prey as a result of explosives by-products, metals, chemicals, and transmission of disease and parasites. Analysis of the potential impacts on sediment and water quality are discussed in Section 3.3 (Water Resources) of the 2016 GOA Final SEIS/OEIS. The relatively low solubility of most explosives and their degradation products, metals, and chemicals means that concentrations of these contaminants in the marine environment, including those associated with either high-order or low-order detonations, are relatively low and readily diluted. For example, in the Study Area the concentration of unexploded ordnance, explosion byproducts, metals, and other chemicals would never exceed that of a World War II dump site. A series of studies of a World War II dump site off Hawaii have demonstrated only minimal concentrations of degradation products were detected in the adjacent sediments and that there was no detectable uptake in sampled organisms living on or in proximity to the site (Briggs et al., 2016; Carniel et al., 2019; Edwards et al., 2016; Hawaii Undersea Military Munitions Assessment, 2010; Kelley et al., 2016; Koide et al., 2016). It has also been documented that the degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Lotufo, 2017; Rosen & Lotufo, 2010). Any remnant undetonated components from explosives such as trinitrotoluene (TNT), royal demolition explosive, and high melting explosive experience rapid biological and photochemical degradation in marine systems (Carniel et al., 2019; Cruz-Uribe et al., 2007; Juhasz & Naidu, 2007; Pavlostathis & Jackson, 2002; Singh et al., 2009; Walker et al., 2006). As another example, the Canadian Forces Maritime Experimental and Test Ranges near Nanoose, British Columbia, began operating in 1965 conducting test events for both U.S. and Canadian forces, which included many of the same test events that are conducted in the TMAA. Environmental analyses of the impacts from years of testing at Nanoose were documented in 1996 and 2005 (Environmental Science Advisory Committee, 2005). These analyses concluded the Navy test activities "…had limited and perhaps negligible effects on the natural environment" (Environmental Science Advisory Committee, 2005). Therefore, based these and other similar applicable findings from multiple Navy ranges and based on the analysis in Section 3.3 (Water Resources) of the 2016 GOA Final SEIS/OEIS, indirect impacts on marine mammals from the training and testing activities in the TMAA would be negligible and would have no long-term effect on habitat.

Secondary stressors from training and testing activities were analyzed for potential indirect impacts on marine mammal prey availability. Underwater explosions could impact other species in the food web, including prey species that marine mammals feed upon. The impacts of explosions would differ depending upon the type of prey species in the area of the detonation. A reduction in availability of prey may cause animals to forage for longer periods, travel to alternate locations, or abandon foraging efforts (National Oceanic and Atmospheric Administration, 2015c). However, there are other factors such as commercial fisheries or competition between species that have much greater and widespread effect than Navy activities. For example, in the 2016 GOA Final SEIS/OEIS, the Navy analyzed effects to humpback whale prey, including zooplankton and fish species not listed under the ESA such as herring and capelin. As previously determined by Navy (U.S. Department of the Navy, 2016a) and by NMFS (National Marine Fisheries Service (2017b); 82 FR 19530), the environmental baseline for the affected environment includes previous training with sonar that has not affected humpback whale prey. Individual prey have the potential to be affected by the use of underwater explosives; however, this has not resulted in changes to overall prey availability.

The proposed Critical Habitat for humpback whales (see Figure 3.8-2) occurs on the continental shelf and does not overlap the slope or deeper waters of the TMAA where the Navy primarily operates for reasons described in the 2016 GOA Final SEIS/OEIS (see U.S. Department of the Navy (2016a), Section 3.8.3.3.2, Model Predicted Effects from Use of Sonar and Other Active Acoustic Sources; and Section 5.3.3.1.11, Avoiding Marine Species Habitats and Biologically Important Areas). Generally, the Navy does not conduct training with explosives on the shelf. Thus, there is minimal to no overlap of those activities with humpback whale prey species. In addition to explosive use occurring offshore and outside of the areas proposed as Critical Habitat, the Navy's use of the TMAA is short term—a maximum of a few weeks per year and typically occurring every other year. Under the current authorizations and consultations for Navy training activities in the TMAA, NMFS analyzed the potential effects on humpback feeding in designated Biologically Important Areas (see Ferguson et al. (2015); 82 FR 19530) and impacts on ESA-listed fish species (e.g., salmon, steelhead) pursuant to ESA consultations (National Marine Fisheries Service, 2017b). All these factors combined are the basis under which the Navy has determined that there are no national security concerns related to the proposed Critical Habitat overlap with the TMAA, given the one essential feature that should not be affected by the continuation of Navy training in the TMAA.

Based on authorizations pursuant to the MMPA reached by NMFS for all other Navy areas analyzed in the Pacific and Atlantic and because testing and training activities are similar in nature to those analyzed in the Pacific and Atlantic regions, indirect effects (secondary stressors) would be discountable, negligible, or insignificant. Pursuant to the MMPA, indirect effects (secondary stressors) are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, indirect effects may affect but are not likely to adversely affect certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats.

3.8.4 Summary of Stressor Assessment (Combined Impacts of All Stressors) on Marine Mammals

As listed in Section 3.0.4 (Stressors-Based Analysis), this section evaluates the potential for combined impacts of all identified stressors resulting from the Proposed Action. The analysis and conclusions for the potential impacts from each of the individual stressors are discussed in Sections 3.8.3.1 (Acoustic Stressors) through 3.8.3.3 (Secondary Stressors) and, for ESA-listed species, summarized in this section.

Understanding the combined effects of stressors on marine organisms in general and marine mammal populations in particular is extremely difficult to predict (National Academies of Sciences Engineering and Medicine, 2017). Recognizing the difficulties with measuring trends in marine mammal populations, the focus has been on indicators for adverse impacts, including health and other population metrics (National Academies of Sciences Engineering and Medicine, 2017). This recommended use of population indicators is the approach the Navy presented in the 2016 GOA Final EIS/OEIS Section 3.8.5 (Summary of Observations During Previous Navy Activities) and formed part of the 2017 analyses by NMFS in their MMPA authorization (National Marine Fisheries Service, 2017c), and the Biological Opinion for the 2016 GOA Final SEIS/OEIS (National Marine Fisheries Service, 2017a).

Stressors associated with the proposed activities do not typically occur in isolation, but rather occur in some combination. For example, an event involving gunfire may include elements of acoustic, physical disturbance and strike, ingestion, and secondary stressors that are all coincident in space and time. An analysis of the combined impacts of all stressors considers the potential consequences of additive stressors and synergistic stressors, as described below. This analysis makes the reasonable assumption, which is supported by the Navy Acoustic Effects Model for acoustic stressors, that the majority of exposures to stressors are non-lethal and non-injurious, and instead focuses on consequences potentially impacting marine mammal fitness (e.g., physiology, behavior, reproductive potential).

There are generally two ways that a marine mammal could be exposed to multiple additive stressors. The first would be if a marine mammal were exposed to multiple sources of stress from a single event or activity within a single event (e.g., a Gunnery Exercise event may include the use of a sound source, explosives, and a vessel). The potential for a combination of these impacts from a single activity would depend on the range to effects of each of the stressors and the response or lack of response to that stressor. Most of the activities proposed under Alternative 1 generally involve the use of moving platforms (e.g., ships and aircraft) that may produce one or more stressors; therefore, it is likely that if a marine mammal were within the potential impact range of those activities, it may be impacted by multiple stressors simultaneously. Individual stressors that would otherwise have minimal to no impact, may combine to have a measurable response. However, due to the wide dispersion of stressors, speed of the platforms, general dynamic movement of many military readiness activities, and behavioral avoidance exhibited by many marine mammal species, it is very unlikely that a marine mammal would remain in the potential impact range of multiple sources or sequential events. Exposure to multiple stressors from multiple platforms is not likely to occur in the TMAA where the proposed activities are conducted in the open ocean and participating units are separated by large distances. In such cases, a behavioral reaction resulting in avoidance of the immediate vicinity of the activity would reduce the likelihood of exposure to additional stressors.

Secondly, a marine mammal could be exposed to multiple events over the duration of the Norther Edge Exercise; however, those events are generally separated in space and time in such a way that it would be unlikely that any individual marine mammal would be exposed to stressors from multiple activities within a short timeframe.

Multiple stressors may also have synergistic effects. For example, marine mammals that experience temporary hearing loss from acoustic stressors could in theory be more susceptible to physical strike and disturbance stressors via a decreased ability to detect and avoid threats. These cumulative, synergistic, and antagonistic interactions between multiple stressors both natural and anthropogenic, have just begun to be investigated and the exact mechanisms each stressor contributes to individual fitness is poorly understood (Balmer et al., 2019; Murray et al., 2020; National Academies of Sciences Engineering and Medicine, 2017; National Marine Fisheries Service, 2018a). Based on current best available science, the effects of multiple synergistic stressors over time cannot be realistically or precisely modeled for marine mammals. The Navy's quantitative and qualitative analyses are consistently conservative and likely over-predict impacts on marine mammals.

Research and monitoring efforts have included before, during, and after-event observations and surveys, data collection through conducting long-term studies in areas of Navy activity, occurrence surveys over large geographic areas, biopsy of animals occurring in areas of Navy activity, and tagging studies where animals are exposed to Navy stressors. These efforts are intended to contribute to the overall understanding of what impacts may be occurring overall to animals in these areas. To date, the findings from the research and monitoring efforts and the regulatory conclusions from previous analyses by NMFS for the TMAA (National Marine Fisheries Service, 2017b, 2017c), have been that the majority of impacts from Navy activities are not expected to have deleterious impacts on the fitness of any individuals or long-term consequences to populations of marine mammals, and are not likely to jeopardize listed species or destroy or adversely modify critical habitat.

3.8.4.1 Summary of Monitoring and Observations During Navy Activities Since 2016

This section summarizes the information provided in detail in the 2016 GOA Final SEIS/OEIS (Section 3.8.5, Summary of Monitoring and Observations During Navy Activities). The results of previous monitoring and research since 2006 taking place in and around Navy ranges and occurring before, during, and after navy training and testing events, has been included as part of the Navy analyses as well as the prior analyses by NMFS in their MMPA authorization (National Marine Fisheries Service, 2017c), and the Biological Opinion for the 2016 GOA Final SEIS/OEIS (National Marine Fisheries Service, 2017a). As noted previously in the introductory paragraphs in Section 3.8.3 (Environmental Consequences), these reporting, monitoring, and research efforts from locations across the Pacific and in the Atlantic have added to the baseline data for understanding potential impacts to marine mammals in general. Given that this record involves many of the same Navy training activities being considered for the TMAA, and includes all the marine mammal taxonomic families present in the TMAA, many of the same species, and some of the same populations as they seasonally migrate from other range complexes, that compendium of Navy reporting is directly applicable to the TMAA. In addition, subsequent research and monitoring has continued to broaden the sample of observations regarding the general health of marine mammal populations in locations where the Navy has been conducting training and testing activities for decades. All available and applicable scientific findings have been considered in the analysis of marine mammal impacts presented in this SEIS/OEIS.

It has long been recognized that even when multiple years of marine mammal survey data are available for analysis, the ability for researchers to assess the magnitude and direction of trends in the abundance of individual marine mammal populations is often limited (Forney, 2000; Forney et al., 1991; Gerrodette, 1987; Moore & Barlow, 2017; Moore & Barlow, 2014; Taylor et al., 2007). For example, even for waters off the U.S. West Coast that have relatively good survey coverage over decades, it cannot be conclusively determined if the sperm whale population in this region is increasing, decreasing, or has remained static (Moore & Barlow, 2017). Additional types of information must therefore be considered when assessing the likely impacts of Navy activities on marine mammal populations.

Since 2006, the Navy, non-Navy marine mammal scientists, and research groups and institutions have conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where the Navy has been and proposes to continue testing and training. There have been three rounds of analysis for Navy training and testing activities at sea in various Navy range complexes in the Pacific by the Navy and NMFS (see for example 83 FR 66846, December 27, 2018). Data collected from Navy monitoring, scientific research findings, and annual reports have been provided to NMFS, and this public[5] record is an important contribution to the analysis of potential impacts on marine mammals. For example, these data provide information relevant to species distribution, habitat use, and evaluation of potential responses to Navy activities.

Monitoring is performed using a variety of methods, including visual surveys from surface vessels and aircraft, as well as passive acoustics before, during, and after Navy activities have been conducted. The

[5] Navy monitoring reports are available at the Navy website (www.navymarinespeciesmonitoring.us/) and also at the NMFS website (www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities).

Navy also has continued to contribute to funding of basic research, including behavioral response studies specifically designed to determine the effects to marine mammals from the Navy's main mid-frequency surface ship anti-submarine warfare sonar and other acoustic sources of potential impact.

The Navy and NMFS have coordinated the allocation of research across the Navy, with the intention of putting funding resources and efforts where they will be most effective. As a result, the majority of the Navy's monitoring and research effort has been focused on those other locations where Navy activities are more numerous and generally more intense. Research funded by the Navy in the TMAA since 2015 has included passive acoustic data collected using an unmanned glider, maintenance and data collection from five passive acoustic monitoring sites, and the collection and analysis of data from those sites located within the TMAA, and a line transect survey to improve our knowledge with regards to cetacean abundance and distribution in the TMAA (Klinck et al., 2016; Rice et al., 2018b; Rice et al., 2020; Rone et al., 2017; Wiggins et al., 2017; Wiggins & Hildebrand, 2018).

The training activities Navy is proposing for the TMAA are similar if not nearly identical to activities that have been occurring in Alaska waters for decades. Training in the TMAA is, by comparison to other Navy areas, less frequent and is in general smaller in scope than in other locations, so as a result the majority of the Navy's research effort has been focused elsewhere. For this reason, the vast majority of scientific field work, research, and monitoring efforts in the Pacific have been expended in the SOCAL Range Complex and Hawaii, where Navy training and testing activities have been more concentrated. In addition and since 2006, the Navy has been submitting exercise reports and monitoring reports to NMFS for the Navy's range complexes in the Pacific and the Atlantic. These publicly available exercise reports, monitoring reports, and the associated research findings have been integrated into adaptive management decisions regarding the focus for subsequent research and monitoring as determined in collaborations between Navy, NMFS, Marine Mammal Commission, and other marine resource subject matter experts. For example, see the 2019 U.S. Navy Annual Marine Species Monitoring Report for the Pacific that was made available to the public in April 2020 (U.S. Department of the Navy, 2020a).

To summarize what was presented in detail in Section 3.8.2 (Affected Environment), the evidence from reporting, monitoring, and research over more than a decade indicates that while the Proposed Action will result in the incidental harassment of marine mammals and may include auditory injury to some individuals, these impacts are expected to be inconsequential at the level of their marine mammal populations. It therefore remains that based on the best available science, including data developed in exercise and monitoring reports submitted to NMFS for over a decade, that long-term consequences for marine mammal populations are unlikely to result from Navy activities in the TMAA.

3.8.5 Endangered Species Act Determinations

As part of the analysis in this SEIS/OEIS, the Navy has considered the prior analyses from the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS as reviewed and amended by this SEIS/OEIS, the findings from the 2017 NMFS Biological Opinion (National Marine Fisheries Service, 2017a), and the USFWS determinations made in consultation with Navy (U.S. Fish and Wildlife Service, 2011b) where they remain valid. The Navy is again consulting under section 7 of the ESA with NMFS and USFWS for the ESA-listed marine mammals that may be effected by the Proposed Action.(National Marine Fisheries Service, 2017a; U.S. Fish and Wildlife Service, 2011b) As noted in this SEIS/OEIS previously, there are no new Navy training activities in the TMAA that have not been previously considered in the TMAA or elsewhere where Navy trains. There have been no new ESA-listed marine mammal species and no newly designated critical habitat in the TMAA. Critical habitat has been proposed for ESA-listed humpback whales along the Pacific coast of the U. S. (84 FR 54354; 9 October 2019), which partially overlaps the inshore portion of the TMAA, and the analysis of potential impacts to that habitat and the identified essential feature of that habitat have been considered using information available regarding that habitat (National Marine Fisheries Service, 2019b, 2019c) as detailed in prior sections of this SEIS/OEIS (see Section 3.8.3, Environmental Consequences).

Pursuant to the ESA, the Navy has determined that the continuation of the Navy's activities in the TMAA may affect the North Pacific right whale, blue whale, fin whale, Western North Pacific gray whale, Mexico DPS humpback whale, Western North Pacific DPS humpback whale, sei whale, sperm whale, Western DPS Steller sea lion and Northern sea otter. The Navy will has consulted with NMFS and USFWS as required by section 7(a)(2) of the ESA for these listed species. The Navy has also determined that Navy activities in the TMAA may affect the proposed humpback whale critical habitat.

3.8.6 Marine Mammal Protection Act Determinations

The Navy is seeking a Letter of Authorization in accordance with the MMPA from NMFS for the use of certain stressors (the use of sonar and other transducers and explosives), as described under the Preferred Alternative (Alternative 1). The use of sonar and other transducers may result in Level A and Level B harassment of certain marine mammals. The use of explosives may result in Level A harassment and Level B harassment of certain marine mammals. The acoustic modeling Refer to Section 3.8.3.1.2 (Impacts from Sonar and Other Transducers) for details on the estimated impacts from sonar and other transducers, and Section 3.8.3.2.2 (Impacts from Explosives) for impacts from explosives. The estimated acoustic effects on marine mammals were modeled consistent with recent Navy analyses (U.S. Department of the Navy, 2017a, 2018c) and with recent regulations promulgated by NMFS (83 FR 66846, December 27, 2018). The modeling results indicate that non-auditory injury (i.e., lung or digestive tract injuries) or mortality should not be expected to result from the proposed testing and training activities under any of the alternatives. The only injury effects expected are PTSs (i.e., permanent damage to cells in the ear associated with hearing), resulting in Level A harassment as defined under the MMPA.

Based on the previous analyses for the same actions in TMAA as presented in the 2011 GOA Final EIS/OEIS and the 2016 GOA SEIS/OEIS, consistent with the current MMPA authorization for Navy training and testing in the TMAA (National Marine Fisheries Service, 2017c), and consistent with recent determinations for the same activities in other locations where Navy trains and tests,[6] the Navy has determined that weapon noise, vessel noise, aircraft noise, the use of in-water electromagnetic devices, in-air electromagnetic devices, high-energy lasers, vessel strike, in-water devices, seafloor devices, wires and cables, decelerators/parachutes, biodegradable polymers, and military expended materials are not expected to result in mortality or Level A or Level B harassment of any marine mammals.

3.8.6.1 Summary of Science in the Temporary Maritime Activities Area by the Navy Related to Potential Effects on Marine Mammals Since 2006

It has long been recognized that even when multiple years of marine mammal survey data are available for analysis, the ability for researchers to assess the magnitude and direction of trends in the abundance of individual marine mammal populations is often limited (Forney, 2000; Forney et al., 1991; Gerrodette, 1987; Moore & Barlow, 2017; Moore & Barlow, 2014; Taylor et al., 2007). For example, even for waters

[6] Conclusions in this regard refer to the findings reached by the Navy and NMFS for many of the same actions in Southern California and Hawaii (FR 83[247]: 66846-67031; December 27, 2018).

off the U.S. West Coast that have relatively good survey coverage over decades, it cannot be conclusively determined if the sperm whale population in this region is increasing, decreasing, or has remained static Moore & Barlow, 2017). Additional types of information must therefore be considered when assessing the likely impacts of Navy activities on marine mammal populations.

Since 2006, the Navy, non-Navy marine mammal scientists, and research groups and institutions have conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where the Navy has been and proposes to continue testing and training. There have been three rounds of analysis for Navy training and testing activities at sea in various Navy range complexes in the Pacific by the Navy and NMFS (see for example 83 FR 66846, December 27, 2018). Data collected from Navy monitoring, scientific research findings, and annual reports have been provided to NMFS, and this public[7] record is an important contribution to the analysis of potential impacts on marine mammals. For example, these data provide information relevant to species distribution, habitat use, and evaluation of potential responses to Navy activities.

Monitoring is performed using a variety of methods, including visual surveys from surface vessels and aircraft, as well as passive acoustics before, during, and after Navy activities have been conducted. The Navy also has continued to contribute to funding of basic research, including behavioral response studies specifically designed to determine the effects to marine mammals from the Navy's main mid-frequency surface ship anti-submarine warfare sonar and other acoustic sources of potential impact.

The Navy and NMFS have coordinated the allocation of research across the Navy, with the intention of putting funding resources and efforts where they will be most effective. As a result, the majority of the Navy's monitoring and research effort has been focused on those other locations where Navy activities are more numerous and generally more intense. Research funded by the Navy in the TMAA since 2015 has included passive acoustic data collected using an unmanned glider, maintenance of five passive acoustic monitoring sites, and the collection and analysis of data from those sites located within the TMAA (Klinck et al., 2016; Rice et al., 2018b; Wiggins et al., 2017; Wiggins & Hildebrand, 2018).

The training activities Navy is proposing for the TMAA are similar if not nearly identical to activities that have been occurring in Alaska waters for decades. Training in the TMAA are, by comparison to other Navy areas, less frequent and are in general small in scope, so as a result the majority of the Navy's research effort has been focused elsewhere. For this reason, the vast majority of scientific field work, research, and monitoring efforts have been expended in the SOCAL Range Complex and Hawaii, where Navy training and testing activities have been more concentrated. Since 2006, the Navy has been submitting exercise reports and monitoring reports to NMFS for the Navy's range complexes in the Pacific and the Atlantic. These publicly available exercise reports, monitoring reports, and the associated research findings have been integrated into adaptive management decisions regarding the focus for subsequent research and monitoring as determined in collaborations between Navy, NMFS, Marine Mammal Commission, and other marine resource subject matter experts using an adaptive

[7] Navy monitoring reports are available at the Navy website (www.navymarinespeciesmonitoring.us/) and also at the NMFS website (www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities).

management approach. For example, see the 2017 U.S. Navy Annual Marine Species Monitoring Report for the Pacific that was made available to the public in April 2018 (U.S. Department of the Navy, 2018a).

As noted previously in Section 3.8.2 (Affected Environment), these reporting, monitoring, and research efforts from locations across the Pacific and in the Atlantic have added to the baseline data for marine mammals inhabiting the TMAA. In addition, subsequent research and monitoring has continued to broaden the sample of observations regarding the general health of marine mammal populations in locations where the Navy has been conducting training and testing activities for decades. All available and applicable scientific findings have been considered in the analysis of marine mammal impacts presented in this SEIS/OEIS. Given that this record involves many of the same Navy training activities being considered for the TMAA, and includes all the marine mammal taxonomic families present in the TMAA, many of the same species, and some of the same populations as they seasonally migrate from other range complexes, that compendium of Navy reporting is directly applicable to the TMAA.

To summarize what was presented in detail in Section 3.8.2 (Affected Environment), the evidence from reporting, monitoring, and research over more than a decade indicates that while the Proposed Action will result in the incidental harassment of marine mammals and may include auditory injury to some individuals, these impacts are expected to be inconsequential at the level of their marine mammal populations. It therefore remains that based on the best available science, including data developed in exercise and monitoring reports submitted to NMFS for over a decade, that long-term consequences for marine mammal populations are unlikely to result from Navy activities in the TMAA.

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3.9 Birds

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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3.9 Birds

3.9.1 Introduction

As presented in Chapter 1 (Purpose and Need), the United States (U.S.) Department of the Navy (Navy) analysis presented in this document supplements both the 2011 Gulf of Alaska (GOA) Final Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (U.S. Department of the Navy, 2011b) and the 2016 GOA Final Supplemental EIS (SEIS)/OEIS (U.S. Department of the Navy, 2016). The Proposed Action would occur over a maximum time period of up to 21 consecutive days during the months of April–October. Though the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. Consistent with the previous analysis for Alternative 1, the sinking exercise activity will not be part of the Proposed Action for this SEIS/OEIS.

The purpose of the birds section in this SEIS/OEIS is to provide any new or changed information since the 2016 GOA Final SEIS/OEIS that are relevant to an analysis of potential impacts on birds associated with the continuation of Navy training activities in the Temporary Maritime Activities Area (TMAA) beyond May 2022 as a result of the Proposed Action. The TMAA is 12 nautical miles (NM) or greater from shore, outside of the U.S. Territorial Sea.

This section also documents the Navy's continued consultation with the U.S. Fish and Wildlife Service (USFWS), pursuant to the Endangered Species Act (ESA). On March 24, 2010, the USFWS sent the Navy a letter of concurrence (consultation # 2010-0075) with the Navy's determination that the proposed training activities would not likely adversely affect the ESA-listed short-tailed albatross. In the March 24, 2010, letter of concurrence, the USFWS recognized the potential for adverse effects of the proposed training activities on the marine species, and that the Navy intended to use a watch-stander and pre-event target area clearing procedure to reduce the probability that a short-tailed albatross would be harmed by an explosion or other type of activity. On July 23, 2014, the USFWS sent an email to the Navy stating that reinitiation of consultation for the 2016 GOA Final SEIS/OEIS was not necessary as there were no changes to the actual activities, geographic parameters, or levels of activities occurring in the areas previously subject to consultation with the USFWS. In support of this SEIS/OEIS, the Navy is requesting consultation with USFWS based on new distribution information for the short-tailed albatross described in Section 3.9.2.2.3 (Distribution).

Marine birds in the TMAA include those listed under the Migratory Bird Treaty Act (MBTA) of 1918 (16 United States Code 703–712; Ch. 128; 13 July 1918; 40 Stat. 755 as amended) (U.S. Department of Defense & U.S. Fish and Wildlife Service, 2006). A migratory bird is any species or family of birds that live or reproduce in or migrate across international borders at some point during their annual life cycle. The MBTA established federal responsibilities for the protection of nearly all species of birds, eggs, and nests. In 2006, the USFWS and U.S. Department of Defense signed a Memorandum of Understanding to promote conservation of migratory birds (U.S. Department of Defense & U.S. Fish and Wildlife Service, 2006).

Through the National Defense Authorization Act, Congress determined that allowing incidental take of migratory birds as a result of military readiness activities is consistent with the MBTA. The Final Rule was published in the Federal Register (FR) on February 28, 2007 (FR Volume 72, No. 29, 28 February 2007), and may be found at 50 Code of Federal Regulations (CFR) Part 21.15. Congress defined military readiness activities as all training and operations of the Armed Forces that relate to combat and the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for the proper operation and suitability for combat use. The measure directs the Armed Forces to assess the effects of military readiness activities on migratory birds, in accordance with the National Environmental Policy Act (NEPA). It also requires the Armed Forces to develop and implement appropriate conservation measures if a proposed action may have a significant adverse effect on a migratory bird population. Specifically, 50 CFR Part 21.15 specifies a requirement to confer with the USFWS when the military readiness activities in question will have a significant adverse effect on a population of migratory bird species. An activity has a significant adverse effect if, over a reasonable period of time, it diminishes the capacity of a population of migratory bird species to maintain genetic diversity, to reproduce, and to function effectively in its native ecosystem. A population, as used in 50 CFR Part 21.3 (definitions), is defined as "a group of distinct, coexisting, same species, whose breeding site fidelity, migration routes, and wintering areas are temporally and spatially stable, sufficiently distinct geographically (at some point of the year), and adequately described so that the population can be effectively monitored to discern changes in its status."

Recent administrative actions and court decisions are further clarifying the scope of the MBTA and the Department of Interior's (DOI's) mandate to enforce and administer the MBTA. In December 2017, the DOI issued its Solicitor's Opinion, which clarified that otherwise lawful activity that results in an incidental take of a protected bird does not violate the MBTA (U.S. Department of the Interior, 2017). In February 2018, the Deputy Assistant Secretary of Defense memo clarified that DoD actions should continue current practices to minimize take of migratory birds (U.S. Department of Defense, 2018). On July 31, 2020, the United States District Court, Southern District New York, vacated the DOI Opinion (M-37050) regarding incidental take and remanded the Opinion back to the agency for further proceedings consistent with the Opinion. The vacated DOI Opinion does not change the analysis in this SEIS/OEIS regarding potential effects to migratory birds, due to the Navy's continued efforts to follow the conservative and protective policies of the Assistant Secretary of Defense.

Background information in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS for the marine bird species that occur in the TMAA will not be repeated in this section unless necessary for context in support of new information and emergent relevant best available science. This SEIS/OEIS includes marine bird species status updates, recent available literature, new distribution data for seabird species within the TMAA, and new bycatch information for seabirds since the 2016 GOA Final SEIS/OEIS. This information is presented in the subsections that follow.

3.9.2 Affected Environment

Descriptions of the TMAA ecosystem, climate, productivity, and oceanographic conditions were presented in the 2011 GOA Final EIS/OEIS and referenced in the 2016 GOA Final SEIS/OEIS. The TMAA continues to be one of the world's most productive ocean regions, and the habitats associated with these cold and turbulent waters contain identifiable collections of microhabitats that sustain resident and migratory species of birds. The waters of the TMAA provide nutrient-rich offshore areas for seabirds that rely on upwelling zones and shelf currents to transport prey to the surface.

3.9.2.1 General Background

Descriptions of the TMAA ecosystem, climate, productivity, and oceanographic conditions were presented in the 2011 GOA Final EIS/OEIS and referenced in the 2016 GOA Final SEIS/OEIS. The TMAA continues to be one of the world's most productive ocean regions, and the habitats associated with these cold and turbulent waters contain identifiable collections of microhabitats that sustain resident and migratory species of birds. The waters of the TMAA provide nutrient-rich offshore areas for seabirds that rely on upwelling zones and shelf currents to transport prey to the surface.

Similar to the Navy's 2011 GOA Final EIS/OEIS and referenced in the 2016 GOA Final SEIS/OEIS, this section provides an overview of the species, distribution, and occurrence of birds that are either resident or migratory through the TMAA, with any relevant updates to the affected environment since the completion of the Navy's 2016 GOA Final SEIS/OEIS. Table 3.9-1 contains representative bird species in the TMAA.

Table 3.9-1: Representative Bird Species Within the TMAA

Family/Subfamily	Common Name	Scientific Name
Family Diomedeidae	Black-footed Albatross[1,5]	*Phoebastria nigripes*
	Laysan Albatross[5]	*Phoebastria immutabilis*
	Short-tailed Albatross[2,3]	*Phoebastria albatrus*
Family Procellariidae	Short-tailed Shearwater[1]	*Puffinus tenuirostris*
	Northern Fulmar[1]	*Fulmarus glacialis*
	Sooty Shearwater	*Ardenna grisea*
	Buller's Shearwater	*Ardenna bulleri*
	Pink-footed shearwater[2,5]	*Ardenna creatopus*
Family Phalacrocoracidae	Double-crested Cormorant[2]	*Phalacrocorax auritus*
	Pelagic Cormorant[2]	*Phalacrocorax pelagicus*
Family Hydrobatidae	Fork-tailed Storm-Petrel	*Oceanodroma furcata*
	Leach's Storm-Petrel	*Oceanodroma leucorhoa*
	Mottled Petrel[2]	*Pterodroma inexpectata*
	Murphy's Petrel[2,5]	*Pterodroma ultima*
Family Laridae	Black-legged Kittiwake	*Rissa tridactyla*
	Red-legged Kittiwake[2,5]	*Rissa brevirostris*
	Glaucous-winged Gull	*Larus glaucescens*
	Arctic Tern[5]	*Sterna paradisaea*
	Surf Scoter	*Melanitta perspicillata*
	Sabine's Gull[5]	*Xema sabini*
	Red Phalarope[2]	*Phalaropus fulicarius*
	Herring Gull[2]	*Larus argentatus*
	Red-necked Phalarope[2]	*Phalaropus lobatus*
Family Stercorariidae	Long-tailed Jaeger	*Stercorarius longicaudus*
	Pomarine Jaeger[2]	*Stercorarius pomarinus*
	Parasitic Jaeger[2]	*Stercorarius parasiticus*

Table 3.9-1: Representative Bird Species Within the TMAA (continued)

Family/Subfamily	Common Name	Scientific Name
Family Alcidae	Common Murre	*Uria aalge*
	Thick-billed murre[2]	*Uria lomvia*
	Tufted Puffin	*Fratercula cirrhata*
	Parakeet Auklet	*Aethia psittacula*
	Horned Puffin	*Fratercula corniculata*
	Marbled Murrelet[2,4]	*Brachyramphus marmoratus*
	Cassin's Auklet[2]	*Ptychoramphus aleuticus*
	Rhinoceros Auklet[2]	*Cerorhinca monocerata*
	Ancient Murrelet[2]	*Synthliboramphus antiquus*
Family Anatidae	Northern pintail	*Anas acuta*
	Northern Shoveler[2]	*Spatula clypeata*
	Black Brant[2]	*Branta bernicla*
	Green-winged Teal[2]	*Anas carolinensis*
Family Gaviidae	Yellow-billed loon[2,5]	*Gavia adamsii*

[1] Species appear in the North Pacific Pelagic Seabird Database (Drew & Piatt, 2015) at the highest frequency and together represent greater than 66 percent of all observations. The short-tailed shearwater accounts for 32.3 percent, followed by the fork-tailed albatross (16.0 percent of all observations), northern fulmar (10.9 percent), and the black-footed albatross (7.8 percent).
[2] Indicates species that are represented in the North Pacific Pelagic Seabird Database less than 0.5 percent of all observations.
[3] Short-tailed albatross is an ESA-listed species, but accounts for less than 0.05 percent of total observations in the North Pacific Pelagic Seabird Database
[4] Marbled murrelets occurring within the TMAA are likely from Alaska breeding populations. These populations are not protected under the ESA. This species is listed as threatened by the USFWS for populations in Washington, Oregon, and California.
[5] These species are considered birds of conservation concern by the USFWS (U.S. Fish and Wildlife Service, 2008a, 2015).

As presented in the 2011 GOA Final EIS/OEIS, the habitat found within the TMAA supports a wide diversity of resident and migratory seabirds and waterfowl. Birds that are year-round residents or that migrate from northern waters frozen over in the winter use the protected embayments of Kodiak Island and the mainland shoreline to avoid harsh winter storms. Seabirds, such as alcids, shearwaters, and gulls, typically feed in open waters ranging from the shoreline and estuaries to the open ocean. Waterfowl, such as ducks and geese, are typically found near shore on the open coast and in estuaries, but some also use inland freshwater habitats. In general, seabird activity is most concentrated along the GOA coastline, while waterfowl are found primarily in the bays and shallow waters. Since the TMAA occurs mostly over the outer shelf slope and deeper ocean waters, this area is dominated by species that utilize the region seasonally and are not land-based outside the nesting season.

Since the previous analyses conducted in 2011 and 2016, the USFWS has released an updated list of Birds of Conservation Concern (BCC), with additional information specific to the GOA region that was not included in previous lists from the USFWS released in 2008 (U.S. Fish and Wildlife Service, 2008a). The USFWS maintains this list to implement and promote proactive management for species that do not warrant ESA listing status. Bird taxa considered for the BCC 2019 lists include nongame birds, gamebirds without hunting seasons or where harvest is minimal, and subsistence-hunted nongame birds in Alaska, while excluding from consideration bird species not protected under the MBTA; taxa already listed as threatened or endangered under the ESA; or taxa that only occur irregularly or peripherally in territorial seas, contiguous zones, and exclusive economic zones of the United States.

The 2019 BCC list includes 11 species of seabirds for the GOA Region (U.S. Fish and Wildlife Service, 2019). These species include marbled murrelet (*Brachyramphus marmoratus*),[1] Kittlitz's murrelet (*Brachyramphus brevirostris*), ancient murrelet (*Synthliboramphus antiquus*), red-legged kittiwake (*Rissa brevirostris*), yellow-billed loon (*Gavia adamsii*), Laysan albatross (*Phoebastria immutabilis*), Black-footed albatross (*Phoebastria nigripes*), Murphy's petrel (*Pterodroma ultima*), mottled petrel (*Pterodroma inexpectata*), Buller's shearwater (*Ardenna bulleri*), and pink-footed shearwater (*Ardenna creatopus*).

The 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS analyzed potential impacts four species protected under the authority of the ESA believed to occur within the TMAA (short-tailed albatross [*Phoebastria albatrus*], eskimo curlew [*Numenius borealis*], Steller's eider [*Polysticta stelleri*], and spectacled eider [*Somateria fischeri*]). As part of the Navy's approach to analyze potential impacts on ESA-listed bird species, the Navy conducted a literature review to include any updated information regarding these species, in particular their current regulatory status and updated information regarding their potential occurrence within the TMAA.

One important source for determining long-term trends and occurrence information included the North Pacific Pelagic Seabird Database (NPPSD), a database maintained by the U.S. Geological Survey (USGS) and includes more than 460,000 survey transects that were designed and conducted by numerous partners primarily to census seabirds at sea. The current database contains abundance and distribution information on over 20 million birds comprising 160 species observed over 40 years in a region of the North Pacific exceeding 25 million square kilometers. Survey efforts include international cooperation between the United States, Canada, Russia, and Japan. Based on this review, the Steller's eider and spectacled eider were determined to not occur within the TMAA, and are not analyzed in detail in this SEIS/OEIS. As part of the Navy's literature review, the status of the eskimo curlew was reconfirmed (extinct). In addition, the yellow-billed loon (*Gavia adamsii*) was determined to be not warranted for listing by the USFWS. Therefore, only the short-tailed albatross is analyzed in detail in accordance with the Navy's obligations under the ESA (see Section 3.9.2.2, Short-Tailed Albatross, for a summary of this species' life history and status, and Figure 3.9-1 for known occurrences within the TMAA).

3.9.2.1.1 Species Unlikely to Occur within the Temporary Maritime Activities Area

Previous Navy NEPA documents concerning activities within the Gulf of Alaska addressed potential impacts on the Steller's eider (*Polysticta stelleri*) and spectacled eider (*Somateria fischeri*). Because this SEIS addresses training activities within the TMAA, the Navy conducted a literature review for these species' occurrences in relation to the spatial extent of the TMAA and the potential for seasonal

[1] Marbled murrelets in inland waters of Alaska and pelagic environments in the Gulf of Alaska are not ESA listed.

occurrence within the TMAA during the months when training activities within the TMAA would be scheduled. The following sections provide a general background on the species previously analyzed and the Navy's justification for not analyzing them for potential impacts from training activities within the TMAA.

Steller's Eider

The Alaska breeding population of Steller's eiders was listed as threatened under the ESA in 1997 (62 FR 31748). For this SEIS/OEIS, the Navy conducted a literature search for additional information pertaining to the Steller's eider. In 2018, the USFWS announced work on a five-year status review for this species (U.S. Fish & Wildlife Service, 2018). This document does not provide any information that would warrant changes to the conclusions reached in the 2011 GOA Final EIS/OEIS or 2016 GOA Final SEIS/OEIS. During the months of April to October, when training activities are planned to occur, Steller's eiders can be found in nearshore areas, and in particular protected lagoons with tidal flats located hundreds of miles to the northwest and west of the TMAA. Critical habitat has been designated for this species in some important breeding areas on the on the Yukon-Kuskokwim River Delta and Kuskokwim Shoals, Sea Islands, Nelson Lagoon, and Izembek Lagoon in western Alaska (66 FR 8850). These locations are outside of the TMAA.

Outside of the breeding season (generally October through April), the distribution of Steller's eiders includes the nearshore areas around Kodiak Island, Cook Inlet, the southern side of the Alaska Peninsula, and the eastern Aleutian Islands. In support of this SEIS/OEIS, the Navy examined records of the USGS Alaska Science Center to determine which pelagic species overlap with the TMAA. Based on this review of records, no Steller's eider observations are reported within the TMAA, although approximately 120 observations are reported on Kodiak Island and along the Kenai Peninsula. Most of these observations (over 95 percent) are reported between November and March (Figure 3.9-1).

As stated in the 2011 GOA Final EIS/OEIS, there are no proposed activities in the TMAA during the winter, and there is no new information or circumstances that would alter analysis of the 2011 GOA Final EIS/OEIS. Therefore, the statement indicating that Steller's eiders are not likely to be present in the TMAA or be affected by any of the proposed activities remains valid. For this reason, the Navy has determined no potential impact to the Steller's eider, and the species will not be carried forward for analysis in this SEIS/OEIS.

Spectacled Eider

The spectacled eider was designated as threatened throughout its range in May 1993 (58 FR 27474). Critical habitat for the spectacled eider was designated in 2001 (66 FR 9146). However, none of the critical habitat designation overlaps with the TMAA.

Spectacled eiders are not expected to occur in the TMAA during the time period of training activities. Three primary nesting areas are known for the spectacled eider: the central coast of the Yukon-Kuskokwim Delta, the arctic coastal plain of Alaska, and the arctic coastal plain of Russia. Important late summer and fall molting areas have been identified in eastern Norton Sound and Ledyard Bay in Alaska, and in Mechigmenskiy Bay and an area offshore between the Kolyma and Indigirka River Deltas in Russia. Wintering flocks of spectacled eiders have been observed in openings in sea ice in the Bering Sea between St. Lawrence and St. Matthew Islands (U.S. Fish & Wildlife Service, 2018).

In support of this SEIS/OEIS, the Navy examined records of the USGS Alaska Science Center to determine which pelagic species overlap with the TMAA (see Figure 3.9-1). Based on this review of records, no spectacled eider observations are reported within the TMAA. One record is reported from the NPPSD on Kodiak Island from 1977, with no recent records within the last 40 years of observations on Kodiak Island or the Kenai Peninsula.

As there are no proposed activities in the TMAA during the winter, and there is no new information or circumstances that would alter analysis of the 2011 GOA Final EIS/OEIS or 2016 GOA Final SEIS/OEIS, spectacled eiders are not likely to be affected by any of the proposed activities. For this reason, the Navy has determined no potential impact to the spectacled eider, and the species will not be carried forward for analysis in this SEIS/OEIS.

3.9.2.1.2 Habitat Use

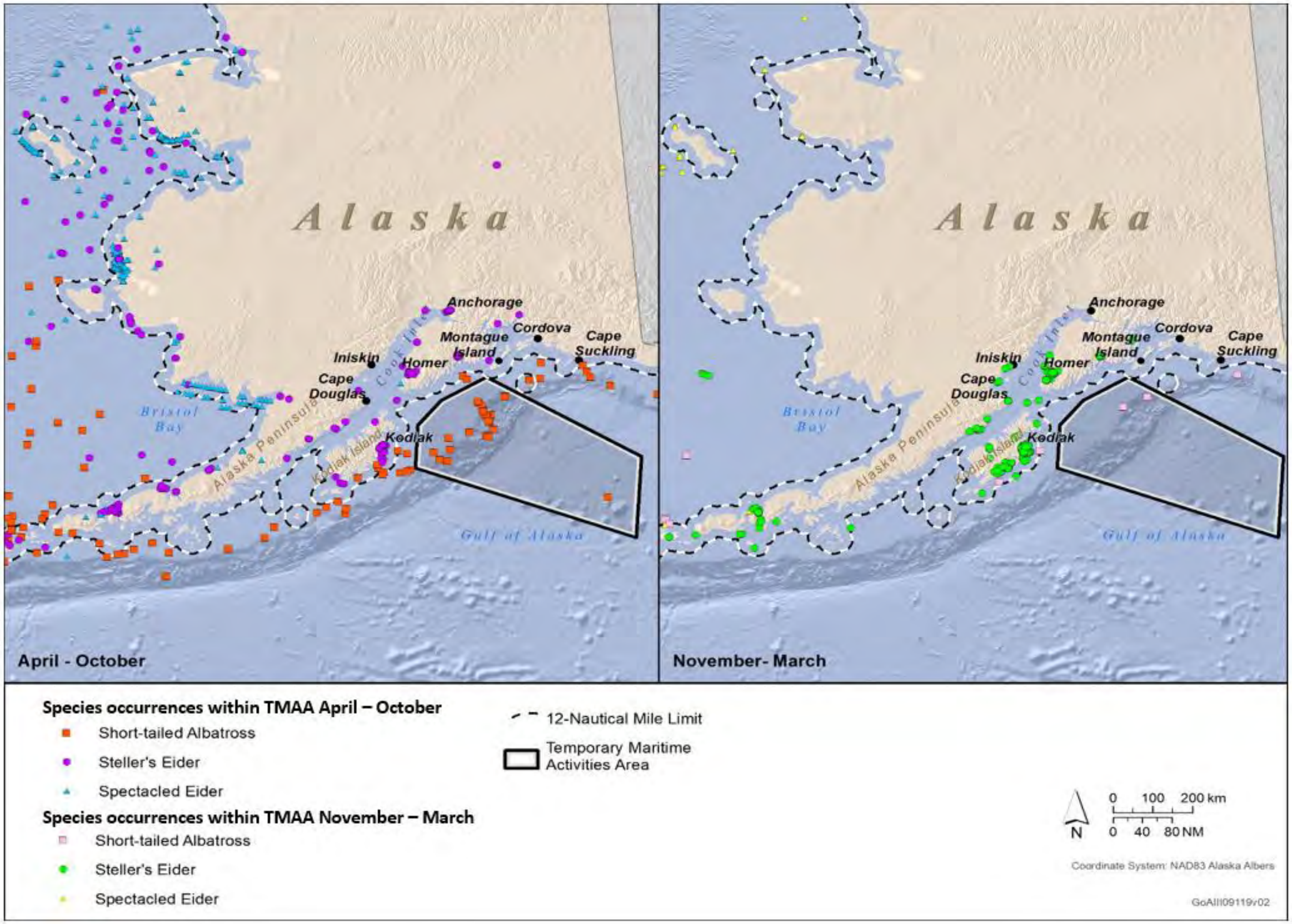
Pelagic ranges, as a function of distance from shore, can range widely for different species. Much of the recent research regarding abundance and distribution as a function of distance from shore for marine birds was conducted to better understand potential impacts on marine birds from offshore energy development.

3.9.2.1.3 Flight Altitudes

While foraging birds will be present near the water surface, migrating birds may fly at various altitudes. Flight altitudes for birds have traditionally been estimated from on the ground (or boat) observations, or from planes; however, flight altitude information increasingly relies on radar studies and telemetry techniques, where the bird's measured altitude is subtracted from the ground elevation (Poessel et al., 2018). Jongbloed (2016) completed a literature review to determine flight height of marine birds to assess potential risks from wind turbine collisions. This review found that most seabird species fly beneath the rotor blade altitudes of offshore wind turbines, which reduces the risk for collision. Some species such as sea ducks and loons may be commonly seen flying just above the water's surface, but the same species can also be spotted flying high enough (5,800 feet [ft.]) that they are barely visible through binoculars (Lincoln et al., 1998). While there is considerable variation, the favored altitude for most small birds appears to be between 500 ft. (152 meters [m]) and 1,000 ft. (305 m). Radar studies have demonstrated that 95 percent of the migratory movements occur at less than 10,000 ft. (3,050 m), with the bulk of the movements occurring under 3,000 ft. (914 m) (Lincoln et al., 1998). Weather factors may also influence flight heights. Tarroux et al. (2016) examined the flying tactics of Antarctic petrels, *Thalassoica antarctica*, in Antarctica revealing the flexibility of flight strategies. Birds tend to fly higher with favorable wind conditions and fly near ground level during strong winds. Birds were found to adjust their speed and heading during stronger winds to limit drift, however, they were able to tolerate a limited amount of drift (Tarroux et al., 2016). In summary, most marine birds can be expected to fly relatively close to the surface, but may range upwards in altitude depending on a number of factors such as wind speed and direction, precipitation avoidance, time of day or night, foraging behaviors, migration, and distance to coast.

3.9.2.1.4 Diving Information

Since the publication of the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, the Navy conducted a literature search for new information on dive behavior that may change the analysis of potential impacts on birds. No new information is available on dive behavior that would alter the analysis from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. As such, the additional description regarding dive behavior presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remains valid. A summary of diving information for bird groups and specific species is included below.



Sources: North Pacific Pelagic Seabird Database (Drew & Piatt, 2015) and eBird (2020)

Figure 3.9-1: ESA-listed Bird Species Seasonal Distributions

There are four general feeding strategies for seabirds—surface feeding, pursuit diving, and plunge diving. Many of the seabird species found in the TMAA will dive, skim, or grasp prey at the water's surface or within the upper portion (1–2 m) of the water column (Cook et al., 2011; Jiménez et al., 2012; Sibley, 2014). Surface feeding is exhibited by some tern species within the TMAA, while specialized bills in albatrosses and petrels allow for snatching prey from the surface. Birds able to pursuit dive use their wings and feet for propulsion through the water, exhibited by shearwaters, some petrels, murrelets, and cormorants that occur within the TMAA. Using this strategy, pursuit divers usually float on the water and dive under to pursue fish and other prey (Burger et al., 2004). The short-tailed shearwater, the most frequently reported bird species in the North Pacific Pelagic Database (Drew & Piatt, 2015), is known to dive to depths greater than 70 m (Onley & Scofield, 2007). Plunge diving, as used by some terns within the TMAA, is a foraging strategy in which the bird hovers over the surface and dives into the water to pursue prey (Hansen et al., 2017). Dive durations are correlated with depth and range from a few seconds in shallow divers to several minutes in alcids (Ponganis, 2015). The short-tailed albatross is a surface feeder and scavenger, and predominately takes prey by surface-seizing, not diving (U.S. Fish and Wildlife Service, 2008b).

3.9.2.1.5 Hearing and Vocalization

The Navy conducted a literature search for new information since the publication of the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS on bird hearing and vocalizations. New information regarding hearing sensitivities of waterbirds, including various duck species and lesser scaups, is summarized below, along with recent publications that show differences in hearing sensitivities between freshwater divers and pelagic birds. This information is summarized below with an overview of the most current best available science regarding bird hearing and vocalization.

3.9.2.1.5.1 Airborne Hearing and Vocalization in Seabirds

Although hearing range and sensitivity has been measured for many land birds, little is known of seabird hearing. The majority of published literature on bird hearing focuses on terrestrial birds and their ability to hear in air. A review of 32 terrestrial and marine species indicates that birds generally have greatest hearing sensitivity between 1 and 4 kilohertz (kHz) (Beason, 2004). Very few birds can hear below 20 Hertz, most have an upper frequency hearing limit of 10 kHz, and none exhibit hearing at frequencies higher than 15 kHz (Dooling & Popper, 2000). Since 2011, new scientific literature has been published on the hearing abilities of birds. Hearing capabilities have been studied for only a few seabirds (Beason, 2004; Beuter et al., 1986; Crowell et al., 2015; Johansen et al., 2016; Maxwell et al., 2017; Mooney et al., 2019; Thiessen, 1958; Wever et al., 1969); these studies show that seabird hearing ranges and sensitivity in air are consistent with what is known about bird hearing in general.

In-air auditory abilities have been measured in 10 diving bird species using electrophysiological techniques (Crowell et al., 2015; Maxwell et al., 2017). All species tested had the best in-air hearing sensitivity from 1 to 3 kHz. The red-throated loon (*Gavia stellata*) and northern gannet (*Morus bassanus*) (both non-duck species) had the highest thresholds, while the lesser scaup (*Aythya affinis*) and ruddy duck (*Oxyura jamaicensis*) (both duck species) had the lowest thresholds (Crowell et al., 2015). Auditory sensitivity varied amongst the species tested, spanning over 30 decibels (dB) in the frequency range of best hearing. While electrophysiological techniques provide insight into hearing abilities, auditory sensitivity is more accurately obtained using behavioral techniques. Crowell et al. (2016) used behavioral methods to obtain an in-air audiogram of the lesser scaup. Hearing frequency range in air was similar to other birds, with best sensitivity at 2.86 kHz with a threshold of 14 dB referenced to 20 micropascals (dB re 20 µPa). Maxwell et al. (2017) obtained the behavioral in-air audiogram of a great cormorant (*Phalacrocorax carbo*), and the most sensitive hearing was 18 dB re 20 µPa at 2 kHz.

Crowell et al. (2015) also compared the vocalizations of the same 10 diving bird species to the region of highest sensitivity of in-air hearing. Of the birds studied, vocalizations of only eight species were obtained due to the relatively silent nature of two species. The peak frequency of the vocalizations of seven of the eight species fell within the range of highest sensitivity of in-air hearing. Crowell et al. (2015) suggested that the colonial nesters tested had relatively reduced hearing sensitivity because they relied on individually distinctive vocalizations over short ranges. Additionally, they observed that the species with more sensitive hearing were those associated with freshwater habitats, which are relatively quieter compared to marine habitats with wind and wave noise.

Maxwell et al. (2017) obtained the behavioral in-air audiogram of a great cormorant (*Phalacrocorax carbo*), and the most sensitive hearing was 18 dB re 20 µPa at 2 kHz. Mooney et al. (2019) measured auditory brainstem responses from one anesthetized, wild-caught Atlantic puffin (*Fratercula arctica*) and found a hearing range of 0.5–6 kHz, with the best sensitivity in the 1-2 kHz range. That study also measured auditory brainstem responses from one common murre (*Uria aalge*), and found a hearing range of 1–4 kHz, with the best sensitivity at 1 kHz. However, Mooney et al. (2019) were unable to measure auditory brainstem responses at 3 kHz for the common murre. Recently, Mooney et al. (2020) used auditory-evoked potentials (AEPs) to measure in-air hearing for 9 wild Atlantic puffins (*Fratercula arctica*) and found especially sensitive hearing from 0.5 to 2.5 kHz. The authors suggest that adept hearing at these low frequencies may benefit this species by aiding in detecting predators from their underground burrows.

Data on short-tailed albatross hearing or vocalization does not exist. Vocalizations recorded from the Laysan albatross (*Phoebastria immutabilis*) and black-footed albatross (*Phoebastria nigripes*) contain frequencies in the range of 85 Hertz (Hz)–28 kHz (Sparling, 1977). The fundamental frequency present in these vocalizations ranged from 85 Hz to 3.48 kHz.

No audiogram data exists for any species of albatross, including the short-tailed albatross. It is likely that the range of best sensitivity in albatross is approximately 1–4 kHz, similar to other birds of the same size. Albatross species make relatively shallow dives while foraging. Due to plunge diving behavior, it is not clear that underwater hearing plays a dominant role in foraging or that albatross species would be exposed to underwater sounds except for brief periods. Accordingly, it is assumed that albatross likely do not specialize in underwater hearing and, for purposes of this analysis, could have underwater hearing capabilities similar to other diving birds, with best hearing capability from 1 to 4 kHz.

3.9.2.1.5.2 Underwater Hearing in Seabirds

Little is known about the hearing abilities of birds underwater (Dooling & Therrien, 2012). In air, the size of the bird is usually correlated with the sensitivity to sound (Johansen et al., 2016); for example, songbirds tend to be more sensitive to higher frequencies and larger non-songbirds tend to be more sensitive to lower frequencies (Dooling & Popper, 2000). Two studies have tested the ability of a single individual diving bird, a great cormorant (*Phalacrocorax carbo sinensis*), to respond to underwater sounds (Hansen et al., 2017; Johansen et al., 2016). These studies suggest that the cormorant's hearing in air is less sensitive than birds of similar size; however, the hearing capabilities in water are better than what would be expected for a purely in-air adapted ear (Johansen et al., 2016). The frequency range of best hearing underwater was observed to be narrower than the frequency range of best hearing in air, with greatest sensitivity underwater observed around 2 kHz (about 71 dB re 1 µPa), based on behavioral responses. Although results were not sufficient to be used to generate an audiogram, Therrien (2014) also examined underwater hearing sensitivity of long-tailed ducks (*Clangula hyemalis*) by measuring behavioral responses. The research showed that auditory thresholds at frequencies within the expected range of best sensitivity (1, 2, and 2.86 kHz) are expected to be between 77 and 127 dB re 1 µPa.

Recently, Larsen et al. (2020) measured auditory evoked potentials and eardrum movement in anesthetized, wild-caught, fledgling great cormorants both in air and underwater. The best average sensitivity was at 1 kHz in both media, where the thresholds were 53 dB re 20 µPa (air) and 84 dB re 1 µPa (water). Statistical analysis showed no difference between sound pressure thresholds in air and underwater, as well as no frequency-medium interaction. The authors suggest that cormorants have anatomical adaptations for underwater hearing, however, the average underwater audiogram obtained in this study does not necessarily support well-developed aquatic hearing. Furthermore, a behavioral audiogram of a single adult great cormorant (Hansen et al., 2017) suggests that absolute thresholds are lower than found by Larsen and colleagues, and shows a best frequency of 2 kHz. The differences in audiogram methodology (behavioral vs. auditory evoked potential), life stage (adult vs. fledgling), and arousal state (anesthetized vs. awake), obscure the source of discrepancy between these two studies. The authors suggest additional behavioral (psychophysical) measurements in more individuals.

Diving birds may not hear as well underwater, compared to non-avian species, based on adaptations to protect their ears from pressure changes (Dooling & Therrien, 2012). Because reproduction and communication with conspecifics occurs in air, adaptations for diving may have evolved to protect in-air hearing ability and may contribute to reduced sensitivity underwater (Hetherington, 2008). There are many anatomical adaptations in diving birds that may reduce sensitivity both in air and underwater. Anatomical ear adaptations are not well investigated, but include cavernous tissue in the meatus and middle ear that may fill with blood during dives to compensate for increased pressure on the tympanum, active muscular control of the meatus to prevent water entering the ear, and interlocking feathers to create a waterproof outer covering (Crowell et al., 2015; Rijke, 1970; Sade et al., 2008). The northern gannet, a plunge diver, has unique adaptations to hitting the water at high speeds, including additional air spaces in the head and neck to cushion the impact and a thicker tympanic membrane than similar-sized birds (Crowell et al., 2015). All of these adaptions could explain the measured higher hearing thresholds of diving birds.

Although important to seabirds in air, it is unknown if seabirds use hearing or vocalizations underwater for foraging, communication, predator avoidance, or navigation (Crowell, 2016; Dooling & Therrien, 2012). Some scientists suggest that birds must rely on vision rather than hearing while underwater (Hetherington, 2008), while others suggest birds must rely on an alternative sense in order to coordinate cooperative foraging and foraging in low light conditions (e.g., night, depth) (Dooling & Therrien, 2012).

The Navy's Living Marine Resources Program is sponsoring an ongoing study on hearing and estimated acoustic impacts in three species of auk, which will help the Navy refine its assessment of potential impacts from its activities on seabirds.

The additional published scientific information since 2011 supplements and reinforces the information presented for birds in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, and there is no new information or circumstances that would alter the analysis of those documents. As such, the description regarding bird hearing capabilities presented in the 2016 GOA Final SEIS/OEIS remain valid.

3.9.2.1.6 General Threats

Climate Change

Since the publication of the Navy's 2016 GOA Final SEIS/OEIS, new information is available describing the ecosystem, climate, productivity, and oceanographic conditions within the TMAA. Recent literature is available that improves understanding of climate change and potential impacts in the GOA and surrounding areas. In particular, these updates relate to anticipated climate change impacts that are projected to result in lengthened growing seasons in Alaska and northwestern Canada, with further warming continuing the trend of northward movement of some Arctic, cold-adapted organisms, with replacement by other sub-Arctic, warmer-water organisms (Smith et al., 2019; Tingley & Huybers, 2013). Much of this information is derived from nearly four decades of marine bird monitoring in Alaska and recently available climate models that overlap with the TMAA. These sources are summarized below and are considered in the Navy's analysis of potential impacts on birds from the Proposed Action described in Section 3.9.3 (Environmental Consequences).

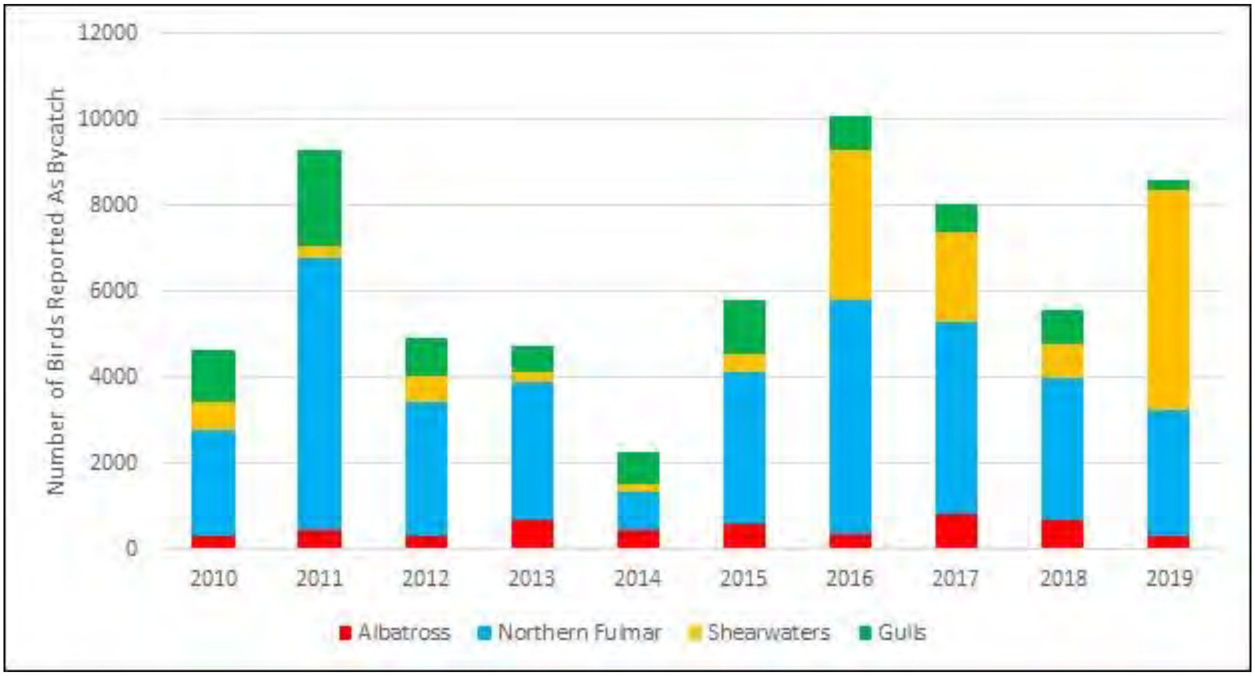
Goyert et al. (2018) analyzed the population dynamics of five species of marine birds (black-legged kittiwake [*Rissa tridactyla*], red-legged kittiwake [*Rissa brevirostris*], common murre [*Uria aalge*], thick-billed murre [*Uria lomvia*], and tufted puffin [*Fratercula cirrhata*]), and found that some species may be more sensitive to environmental changes. For example, kittiwake species showed the greatest sensitivity to decreases in zooplankton (e.g., krill) and changes in sea surface temperature, while murre species appear to be more resilient, with carrying capacity increasing in waters surrounding Alaska in response to sea surface temperature increases.

Smith et al. (2019) used recently made available climate models for the Bering Sea and Aleutian Arc to assess vulnerability of marine birds to changing climate variables considered in their analysis. Analyzing seasonal and annual spatial projections from three climate models for two physical climate variables (seawater temperature and sea ice) and three forage variables (large copepods, euphausiids, and benthic infauna), and comparing projected conditions from a recent time period (2003–2012) to a future time period (2030–2039), Smith et al. (2019) focused on core areas within areas designated as Important Bird Areas. Based on their analysis, fulmars, gulls, and auklets were affected by zooplankton declines, with the model predicting steeper declines, especially along the outer shelf and Aleutian Islands. Benthic biomass declines affected eiders along the inner shelf, and large copepod decline was significant for storm-petrels and auklets in the western Aleutians.

Recently reported bird die-offs are also notable for the description of the existing conditions in the TMAA and surrounding regions. For example, seabird mortality events in the Bering Sea and Gulf of Alaska appear to be due to starvation (Jones et al., 2019; Walsh et al., 2018). Thompson et al. (2019) analyzed size and condition of forage fish and determined that size and condition were negatively correlated to increasing sea surface temperatures and periodic Pacific Decadal Oscillation. Establishing that the condition of capelin and sand lance was among the lowest of their sample size, coinciding with fish die-offs in 2015–2016, the authors speculated that poor forage fish condition and the relatively small size of forage fish were responsible for marine bird die-offs.

Commercial Industries

The most significant commercial activity impacting seabirds within the TMAA and Gulf of Alaska region are commercial fisheries. Bycatch is defined by the National Marine Fisheries Service as discarded catch of any living marine resource plus unobserved mortality due to a direct encounter with fishing gear. Impacts from bycatch and bycatch mortality vary across fisheries and may have adverse biological, economic, and social consequences (Benaka et al., 2019). Off Alaska, most seabird bycatch has historically occurred in fisheries using demersal longline (i.e., hook-and-line) gear. Total estimated seabird bycatch in the Alaska federal groundfish and halibut fisheries for all gear types and management plans for 2010–2019 for species of albatross, shearwaters, gulls, and the northern fulmar (a seabird species reported at the highest frequency in Alaska waters) are shown in Figure 3.9-2. The annual average bycatch for seabirds in Alaska waters from 2010–2019 is 6,378 birds, with the lowest numbers reported in 2014 (2,240 total birds) and the highest in 2016 (8,040 birds). Total annual bycatch in 2019 amounted to 8,585 birds.



Source: Krieger and Eich (2020)

Figure 3.9-2: Estimated Annual Bycatch of Albatross, Shearwaters, Gulls, and Northern Fulmar from 2010 Through 2019

Albatross. In 2019, 309 albatross (243 black-footed albatross, 52 Laysan albatross, 14 unidentified albatross) were estimated to have been caught in the fisheries off Alaska; a decrease of 39 percent compared to the 2010 through 2018 average (510 birds per year). For specific species of albatross, Laysan albatross bycatch in 2019 was one-sixth the bycatch estimated for this species in 2018 (289 birds), and was 70 percent lower than the 2010 through 2018 average (173 birds). Laysan albatross bycatch has ranged from less than 1 percent to 5 percent of total estimated seabird bycatch since 2010. Black-footed albatross bycatch was 30 percent lower in 2019 (243 birds) compared to 2018 (352 birds). The estimated bycatch of black-footed albatross in 2019 was 24 percent less than the 2010 through 2018 average (319 birds per year). There has been no reported short-tailed albatross bycatch in Alaska fisheries since 2014 (11 short-tailed albatross reported as bycatch in 2014).

Shearwaters. In 2019, shearwaters accounted for the majority (58 percent) of all bycatch in waters off of Alaska. Estimated shearwater bycatch (5,103 birds) is more than 5 times greater than the 2010 through 2018 average (957 birds per year). The 2019 increase in shearwater bycatch estimates likely corresponds to the shearwater mortality event observed throughout Alaska discussed above and reported by (Jones et al., 2019; Thompson et al., 2019; Walsh et al., 2018).

Gulls. Gulls also account for high numbers in bycatch estimates, and were the third most frequently occurring species group reported as bycatch. However, 2019 estimates are the lowest from the reporting period (2010–2019).

Northern Fulmar. Fulmar bycatch has ranged from an estimated 33 percent to 65 percent of the total seabird bycatch from 2010 through 2019, and has been the most commonly reported species in bycatch every year. In 2019, this species accounted for 33 percent of total seabird bycatch.

Marine Debris and Pollution

Plastic debris is abundant and pervasive in the world oceans and, because of its durability, is continuing to increase. The ingestion of plastics by seabirds such as albatrosses and shearwaters occurs with high frequency and is of particular concern. Potential impacts to birds and other wildlife from ingesting plastic and other debris include reduced food consumption due to lower available stomach volume and therefore poorer fat deposition and body condition, physical damage to the digestive tract, and obstruction of the digestive tract which may result in starvation. Additional risks of anthropogenic debris ingestion include the transfer of pollutants and bioaccumulation of plastic-derived chemicals in body tissues, toxicity via uptake of persistent organic pollutants absorbed by plastic particles, and the translocation of microscopic plastics to other organ systems (Roman et al., 2016). The rates of plastic ingestion by seabirds are closely related to the concentrations of plastics in different areas of the ocean due to waste discharges and ocean currents and are increasing (Kain et al., 2016; Wilcox et al., 2015).

The impacts from entanglement of marine species in marine debris are clearly profound and, in many cases, entanglements appear to be increasing despite efforts over four decades to reduce the threat. Many coastal states have undertaken certain efforts to reduce entanglement rates through marine debris clean-up measures and installed fishing line recycle centers at boat landings, in part due to entanglement of seabirds and other marine species. Fishing-related gear, balloons, and plastic bags were estimated to pose the greatest entanglement risk to marine fauna. In contrast, experts identified a broader suite of items of concern for ingestion, with plastic bags and plastic utensils ranked as the greatest threats. Entanglement and ingestion affected a similar range of taxa, although entanglement was rated as slightly worse because it is more likely to be lethal. Contamination was scored the lowest in terms of impact, affecting a smaller portion of the taxa and being rated as having solely non-lethal impacts (Wilcox et al., 2016).

3.9.2.2 Short-Tailed Albatross

3.9.2.2.1 Status and Management

As presented in the 2011 GOA Final EIS/OEIS, the short-tailed albatross (*Phoebastria albatrus*) was listed as endangered throughout its range under the ESA in 2000 (65 FR 46643). There is no designated critical habitat under ESA for the short-tailed albatross.

The human-induced threats to the short-tailed albatross are described in the 2011 GOA Final EIS/OEIS and referenced in the 2016 GOA Final SEIS/OEIS. In 2016, the Navy completed a literature review to update the description and understanding of threats within the TMAA for the short-tailed albatross. These threats (hooking and drowning on commercial long-line gear, entanglement in derelict fishing gear, ingestion of plastic debris, contamination from oil spills, and potential predation by introduced mammals on breeding islands) have remained persistent since the publication of the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. There have been improvements in reducing bycatch for albatrosses and other species in Alaska's longline fisheries (Melvin et al., 2019), which has likely contributed to increasing population trends for this species.

3.9.2.2.2 Abundance

Since the publication of the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, the status of the short-tailed albatross has not changed under ESA. However, the current population estimate is approximately 3,000 birds (as compared to the 1,200 birds reported in the 2011 GOA Final EIS/OEIS) and is increasing at a rate of 5–8 percent per year (Suryan & Kuletz, 2018; U.S. Fish and Wildlife Service, 2014).

3.9.2.2.3 Distribution

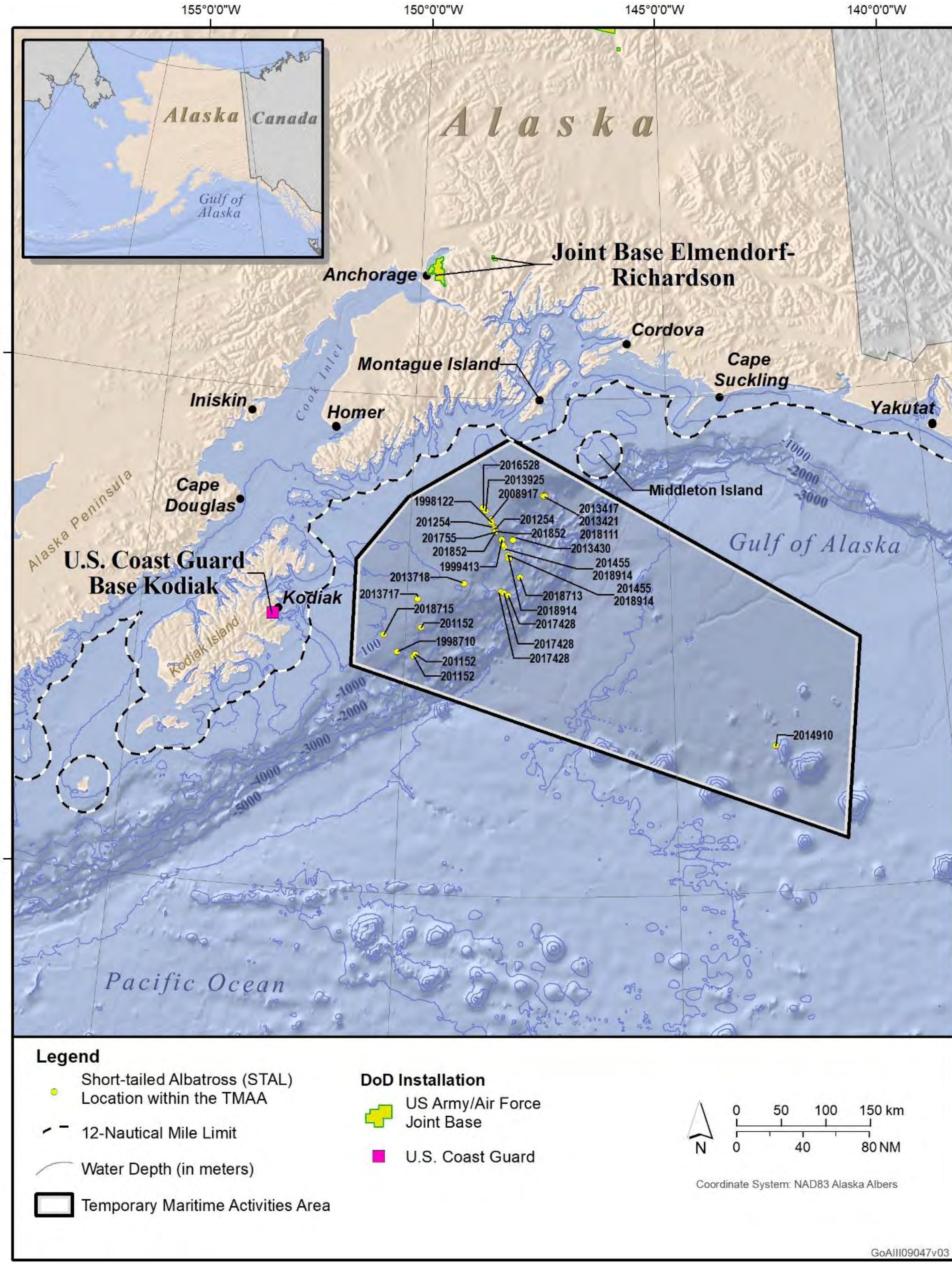
New information is available pertaining to the life history of short-tailed albatrosses (lifespan, nesting, foraging, distribution, and presence in the TMAA) since the publication of the Navy's 2016 GOA Final SEIS/OEIS. As part of the literature search supporting this SEIS/OEIS, the Navy has found additional information on juvenile foraging and distributions. Orben et al. (2018)suggest that juveniles show strong seasonal changes in distributions, traveling more in winter and occupying regions not typically used by adults. While adult short-tailed albatrosses forage over both oceanic and neritic habitats across the North Pacific, concentrating along biologically productive shelf-break areas, juveniles appear to use shelf-based habitats more, especially in the Sea of Okhotsk, Bering Sea, and along the U.S. West Coast (Orben et al., 2018). During their initial flight years, juvenile short-tailed albatrosses use a large portion of the North Pacific from tropical to arctic waters, including the transition zone, California Current system, sub-arctic gyres, and the marginal seas: the Bering Sea and Sea of Okhotsk (Orben et al., 2018). As juvenile albatrosses age, habitat use switches away from pelagic regions to shelf break and slope habitats, becoming more similar to adult distributions.

In support of this SEIS/OEIS, the Navy examined records of the USGS Alaska Science Center to determine which pelagic species overlap with the TMAA (see description of the NPPSD in Section 3.9.2.1, General Background). Based on this review of records, 30 short-tailed albatross observations were reported between 1998 and 2018 within the TMAA. Most of these observations were reported in spring and summer months (65 percent of observations within the TMAA for all short-tailed albatrosses occurred between April and May, and 95 percent occurring between April and September) (Figure 3.9-3).

3.9.2.2.4 Group Size

The Navy conducted a literature search for new information since the publication of the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS on group size that may change the analysis of potential impacts on birds. No new information is available on group size that would alter the analysis from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. A summary of group size information for bird groups and specific species is included below. A variety of group sizes and diversity may be encountered throughout the TMAA, ranging from migration of an individual bird to large concentrations of mixed-species flocks. Depending on season, location, and time of day, the number of birds observed (group size) will vary and will likely fluctuate from year to year. During spring and fall periods, diurnal and nocturnal migrants would likely occur in large groups as they migrate over open water.

Most seabird species nest in groups (colonies) on the ground of coastal areas or oceanic islands, where breeding colonies number from a few individuals to thousands (U.S. Geological Survey, 2016). Outside of the breeding season, most seabirds within the Order Procelliiformes are solitary, though they may join mixed-species flocks while foraging and can be associated with whales and dolphins (Onley & Scofield, 2007) or areas where prey density is high (U.S. Fish and Wildlife Service, 2005a, 2005b). During the



Source: North Pacific Pelagic Seabird Database (Drew & Piatt, 2015) and eBird (2020)

Figure 3.9-3: Observations of Short-Tailed Albatrosses Within the TMAA

breeding season, these seabirds usually form large nesting colonies. Similarly, birds within the Order Pelecaniformes are typically colonial. Foraging occurs either singly or in small groups. For example, foraging can range from singles or pairs (murrelets) (Lorenz et al., 2016; U.S. Fish and Wildlife Service, 2017) and can extend upward into larger groups (terns) in which juveniles accompany adults to post breeding foraging areas, where the water is calm and the food supply is good.

3.9.3 Environmental Consequences

The Navy conducted a review of existing federal and state regulations and standards, as well as a review of new literature (e.g., publications) pertaining to birds. Although additional information relating to existing environmental conditions was found, the new information does not indicate an appreciable change to the existing environmental conditions as described in the 2011 GOA Final EIS/OEIS or from updates provided in the 2016 GOA Final SEIS/OEIS. As presented in Section 1.3 (Proposed Action), the Proposed Action in this SEIS/OEIS is consistent with the Proposed Action from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. This SEIS/OEIS analyzes the impacts on birds under the No Action Alternative and Alternative 1 (the Proposed Action).

Based on the information provided in Section 3.9.2 (Affected Environment), only the short-tailed albatross is carried forward for a species-specific analysis because new information is available that improves the understanding of short-tailed albatross occurrences within the TMAA. The stressors analyzed for potential impacts on seabirds within the TMAA include the following:

- Acoustic (sonar and other transducers, vessel noise, aircraft noise, weapon noise)
- Explosives (explosive shock wave and sound, explosive fragments)

In addition to acoustic and explosive stressors, the Navy also reviewed the proposed action's potential impacts on seabird species from other stressors analyzed in the 2011 GOA Final EIS/OEIS. These stressors include entanglement and ingestion from the release of military expended materials during training activities, along with vessel and aircraft noise, and the potential for vessel and aircraft strike on seabirds. The analysis of potential impacts of stressors on seabirds within the TMAA includes consideration of the standard operating procedures and mitigation measures that the Navy will implement under Alternative 1 of the Proposed Action. Standard operating procedures are designed to provide for safety and mission success, and many also benefit birds. As described in Section 5.1.3 (Aircraft Safety) of the 2016 GOA Final SEIS/OEIS, bird strikes present an aviation safety risk for aircrews and aircraft. Pilots of Navy aircraft make every attempt to avoid large flocks of birds in order to reduce the safety risk involved with a potential bird strike. As described in Section 2.3.2.2 (Target Deployment and Retrieval Safety) of this SEIS/OEIS, standard operating procedures for target deployment and retrieval safety include conducting applicable weapons firing activities in daylight hours in Beaufort Sea state number 4 conditions or better to ensure safe operating conditions. This benefits birds by increasing the effectiveness of visual observations for mitigation, thereby reducing the potential for interactions with the weapons firing activities associated with the use of applicable deployed targets. During activities that involve recoverable targets (e.g., aerial drones), the military recovers the target and any associated decelerators/parachutes to the maximum extent practicable consistent with personnel and equipment safety. Recovery of these items helps minimize the amount of materials that remain on the surface or on the seafloor, which could potentially alert enemy forces to the presence of military assets during military missions and combat operations. This standard operating procedure benefits birds by reducing the potential for physical disturbance and strike, entanglement, or ingestion of applicable targets and any associated decelerators/parachutes. In addition to standard operating procedures, the Navy developed mitigation measures for the purpose of avoiding or reducing potential impacts from weapons firing noise, explosive medium-caliber gunnery exercises, and small- and medium-caliber non-explosive gunnery exercises on ESA-listed short-tailed albatross in the TMAA. Additional information about mitigation for birds is presented in Chapter 5 (Mitigation) of this SEIS/OEIS.

The Navy has determined that the wide distribution of seabirds within the TMAA and the dispersed occurrence of Navy training activities does not present new risks to seabird species than what was analyzed previously. Accordingly, this SEIS/OEIS will analyze in detail acoustic stressors (sonar and other transducers, vessel noise, aircraft noise, weapon noise) and explosive stressors (explosive shock wave and sound, explosive fragments). Consistent with previous consultations and analyses of potential impacts on the short-tailed albatross within the TMAA, the Navy does not anticipate adverse effects on this species resulting from non-acoustic and non-explosive stressors.

3.9.3.1 Acoustic Stressors

The analysis of effects to birds follows the concepts outlined in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). This section begins with a summary of relevant data regarding acoustic impacts on birds in Section 3.9.3.1.1 (Background). This is followed by an analysis of estimated impacts on birds due to sonar and other transducers. The Navy will rely on the previous 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS analysis of vessel noise, aircraft noise, and weapons noise, as there has been no substantive or otherwise meaningful change in the action, although new applicable and emergent science in regard to these sub-stressors is presented in the sections that follow. Based on established criteria and thresholds for auditory injury and new impact modeling methods, the analysis provided in Section 3.9.3.1.2 (Impacts from Sonar and Other Transducers) of this SEIS/OEIS supplants the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS for birds. Additional explanations of the acoustic terms and sound energy concepts used in this section are found in Appendix B (Acoustic and Explosive Concepts).

3.9.3.1.1 Background

The sections below include a survey and synthesis of best-available science published in peer-reviewed journals, technical reports, and other scientific sources pertinent to impacts on birds potentially resulting from sound-producing Navy training activities. Impacts on birds depend on the sound source and context of exposure. Possible impacts include auditory or non-auditory trauma; hearing loss resulting in temporary or permanent hearing threshold shift (TTS or PTS, respectively); auditory masking; physiological stress; or changes in behavior, including changing habitat use and activity patterns, increasing stress response, decreasing immune response, reducing reproductive success, increasing predation risk, and degrading communication (Larkin et al., 1996). Numerous studies have documented that birds and other wild animals respond to human-made noise (Bowles et al., 1994; Larkin et al., 1996; National Park Service, 1994). The manner in which birds respond to noise could depend on species' physiology life stage, characteristics of the noise source, loudness, onset rate, distance from the noise source, presence/absence of associated visual stimuli, and previous exposure. Noise may cause physiological or behavioral responses that reduce the animals' fitness or ability to grow, survive, and reproduce successfully.

The types of birds exposed to sound-producing activities depend on where military readiness activities occur. Birds in the TMAA can be divided into three groups based on breeding and foraging habitat: (1) those species such as albatrosses, petrels, frigatebirds, alcids, jaegers, and some terns that forage over the ocean and nest on coastlines and oceanic islands; (2) species such as pelicans, cormorants, gulls, and some terns that nest along the coast and forage in nearshore areas; and (3) those species such as jaegers, some gull and tern species, grebes, scoters, and ducks and loons that nest and forage along the coast and inland habitats and come to the coastal areas during non-breeding season. In addition, birds that are typically found inland, such as songbirds, may be present flying in large numbers over open ocean areas during annual spring and fall migration periods.

Birds could be exposed to sounds from a variety of sources. While above the water surface, birds may be exposed to airborne sources such as weapons noise and aircraft noise. While foraging and diving, birds may be exposed to underwater sources such as sonar and vessel noise. Exposures of birds that forage below the surface may be reduced by destructive interference of reflected sound waves near the water surface (see Appendix B, Acoustic and Explosive Concepts), although as previously stated, little is known about seabird hearing ability underwater. Birds that forage near the surface would be exposed to underwater sound for shorter periods of time than those that forage below the surface. Birds that plunge-dive or surface-dip are typically submerged for short durations, and any exposure to underwater sound would be very brief. Albatrosses exhibit shallow plunge-diving or surface-dipping behavior at or near the water surface to capture prey (see Section 3.9.2.1.4, Diving Information).

3.9.3.1.1.1 Injury

Both non-auditory and auditory injuries can occur as a result of intense sound exposure. Moderate- to low-level noise from vessels, aircraft, and weapons described in Section 3.9.3.1 (Acoustic Stressors) lacks the amplitude and energy to cause any direct injury. Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on injury and the framework used to analyze this potential impact.

Auditory structures can be susceptible to direct mechanical injury due to high levels of impulsive sound. This could include tympanic membrane rupture, disarticulation of the middle ear ossicles, and trauma to the inner ear structures such as hair cells within the organ of Corti. Auditory trauma differs from auditory fatigue in that the latter involves the overstimulation (fatiguing) of the auditory system, rather than direct mechanical damage, which may result in hearing loss (see Section 3.9.3.1.1.2, Hearing Loss). There are no data on damage to the middle ear structures of birds due to acoustic exposures. Because birds are known to regenerate auditory hair cells, studies have been conducted to purposely expose birds to very high sound exposure levels (SELs) in order to induce hair cell damage in the inner ear. The effects of sound exposures on hair cells are discussed below in Section 3.9.3.1.1.2 (Hearing Loss).

Because there are no data on non-auditory injury to birds from intense non-explosive sound sources, it may be useful to consider information for other similar-sized vertebrates. The rapid large pressure changes near non-explosive impulsive underwater sound sources, such as some large air guns and pile driving, are thought to be potentially injurious to other small animals (fishes and sea turtles). Potential for injury is generally attributed to compression and expansion of body gas cavities, either due to rapid onset of pressure changes or resonance (enhanced oscillation of a cavity at its natural frequency). Because water is considered incompressible and animal tissue is generally of similar density as water, animals would be more susceptible to injury from a high-amplitude sound source in water than in air, since waves would pass directly through the body rather than being reflected. Proximal exposures to high-amplitude non-impulsive sounds underwater could be limited by a bird's surfacing response.

In air, the risk of barotrauma would be associated with high-amplitude impulses, such as from explosives (discussed in Section 3.9.3.2, Explosive Stressors). Unlike in water, most acoustic energy will reflect off the surface of an animal's body in air. Additionally, air is compressible whereas water is not, allowing energy to dissipate more rapidly. For these reasons, in-air non-explosive sound sources in this analysis are considered to pose little risk of non-auditory injury.

3.9.3.1.1.2 Hearing Loss

Exposure to intense sound may result in hearing loss that persists after cessation of the noise exposure. Hearing loss may be temporary or permanent, depending on factors such as the exposure frequency, received sound pressure level (SPL), temporal pattern, and duration. Hearing loss could impair a bird's ability to hear biologically important sounds within the affected frequency range. Biologically important sounds come from social groups, potential mates, offspring, or parents; environmental sounds; prey; or predators.

Because in-air measures of hearing loss and recovery in birds due to an acoustic exposure are limited (e.g., quail, budgerigars, canaries, and zebra finches (Ryals et al., 1999); budgerigar (Hashino et al., 1988); parakeet (Saunders & Dooling, 1974); quail (Niemiec et al., 1994)), and no studies exist of bird hearing loss due to underwater sound exposures, auditory threshold shift in birds is considered to be consistent with general knowledge about noise-induced hearing loss described in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). The frequencies affected by hearing loss would vary depending on the exposure frequency. The limited data on hearing loss in birds shows that the frequency of exposure is the hearing frequency most likely to be affected (Saunders & Dooling, 1974).

Hearing loss can be due to biochemical (fatiguing) processes or tissue damage. Tissue damage can include damage to the auditory hair cells and their underlying support cells. Hair cell damage has been observed in birds exposed to long-duration sounds that resulted in initial threshold shifts greater than 40 dB (Niemiec et al., 1994; Ryals et al., 1999). Unlike many other animals, birds have the ability to regenerate hair cells in the ear, usually resulting in considerable anatomical, physiological, and behavioral recovery within several weeks (Rubel et al., 2013; Ryals et al., 1999). Still, intense exposures are not always fully recoverable, even over periods up to a year after exposure, and damage and subsequent recovery vary significantly by species (Ryals et al., 1999). Birds may be able to protect themselves against damage from sustained sound exposures by reducing middle ear pressure, an ability that may protect ears while in flight (Ryals et al., 1999) and from injury due to pressure changes during diving (Dooling & Therrien, 2012).

Hearing loss is typically quantified in terms of threshold shift, which is the amount (in dB) that hearing thresholds at one or more specified frequencies are elevated, compared to their pre-exposure values, at some specific time after the noise exposure. The amount of threshold shift measured usually decreases with increasing recovery time, which is the amount of time that has elapsed since a noise exposure. If the threshold shift eventually returns to zero (i.e., the hearing threshold returns to the pre-exposure value), the threshold shift is called a temporary threshold shift (TTS). If the threshold shift does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining threshold shift is called a permanent threshold shift (PTS). By definition, TTS is a function of the recovery time; therefore, comparing the severity of noise exposures based on the amount of induced TTS can only be done if the recovery times are also considered. For example, a 20 dB TTS measured 24 hours post-exposure indicates a more hazardous exposure than one producing 20 dB of TTS measured only two minutes after exposure. If the TTS is 20 dB after 24 hours, the TTS measured after two minutes would be much higher. Conversely, if 20 dB of TTS is measured after two minutes, the TTS measured after 24 hours would likely be much smaller. Studies in mammals have revealed that noise exposures resulting in high levels of TTS (greater than 40 dB) may also result in neural injury without any permanent hearing loss (Kujawa & Liberman, 2009; Lin et al., 2011). It is unknown if a similar effect would be observed in birds.

Hearing Loss due to Non-Impulsive Sound Sources

Behavioral studies of threshold shift in birds within their frequencies of best hearing (between 2 and 4 kHz) due to long duration (30 minutes to 72 hours) continuous, non-impulsive, high-level sound exposures in air have shown that susceptibility to hearing loss varies substantially by species, even in species with similar auditory sensitivities, hearing ranges, and body size (Niemiec et al., 1994; Ryals et al., 1999; Saunders & Dooling, 1974). For example, Ryals et al. (1999) conducted the same exposure experiment on quail and budgerigars, which have very similar audiograms. A 12-hour exposure to a 2.86 kHz tone at 112 dB re 20 µPa SPL (cumulative SEL of 158 dB referenced to 20 micropascals squared seconds [dB re 20 $µPa^2s$]) resulted in a 70 dB threshold shift measured after 24 hours in quail; and a PTS of approximately 20 dB persisted after one year. This same exposure in budgerigars produced a substantially lower TTS of 40 dB measured after 12 hours, which fully recovered after one month (Ryals et al., 1999). Although not directly comparable, this SPL would be perceived as extremely loud but just under the threshold of pain for humans per the American Speech-Language-Hearing Association. Whereas the 158 dB re 20 $µPa^2s$ SEL tonal exposure to quail discussed above caused 20 dB of PTS (Ryals et al., 1999), a shorter (four-hour) tonal exposure to quail with similar SEL (157 dB re 20 $µPa^2s$) caused 65 dB of TTS that fully recovered within two weeks (Niemiec et al., 1994).

Data on threshold shift in birds due to relatively short-duration sound exposures that could be used to estimate the onset of threshold shift is limited. Saunders and Dooling (1974) provide the only threshold shift growth data measured for birds. Saunders and Dooling (1974) exposed young budgerigars to four levels of continuous 1/3-octave band noise (76, 86, 96, and 106 dB re 20 µPa) centered at 2.0 kHz and measured the threshold shift at various time intervals during the 72-hour exposure. The earliest measurement found 7 dB of threshold shift after approximately 20 minutes of exposure to the 96 dB re 20 µPa SPL noise (127 dB re 20 $µPa^2s$ SEL). Generally, onset of TTS in other species has been considered 6 dB above measured threshold (Finneran, 2015), which accounts for natural variability in auditory thresholds. The Saunders and Dooling (1974) budgerigar data are the only bird data showing low levels of threshold shift. Because of the observed variability of threshold shift susceptibility between bird species and the relatively long duration of sound exposure in Saunders and Dooling (1974), the observed onset level cannot be assumed to represent the SEL that would cause onset of TTS for other bird species or for shorter duration exposures (i.e., a higher SEL may be required to induce threshold shift for shorter duration exposures).

Since the goal of most bird hearing studies has been to induce hair cell damage to study regeneration and recovery, exposure durations were purposely long. Studies with other non-avian species have shown that long-duration exposures tend to produce more threshold shift than short-duration exposures with the same SEL (e.g., see Finneran (2015)). The SELs that induced TTS and PTS in these studies likely over-estimate the potential for hearing loss due to any short-duration sound of comparable SEL that a bird could encounter outside of a controlled laboratory setting. In addition, these studies were not designed to determine the exposure levels associated with the onset of any threshold shift or to determine the lowest SEL that may result in PTS.

With insufficient data to determine PTS onset for birds due to a non-impulsive exposure, data from other taxa are considered. Studies of terrestrial mammals suggest that 40 dB of threshold shift is a reasonable estimate of where PTS onset may begin (Southall et al., 2007). Similar amounts of threshold shift have been observed in some bird studies with no subsequent PTS. Of the birds studied, the budgerigars showed intermediate susceptibility to threshold shift; they exhibited shifts in the range of 40 dB–50 dB after 12-hour exposures to 112 dB and 118 dB re 20 µPa SPL tones at 2.86 kHz (158–164 dB re 20 $\mu Pa^2 s$ SEL), which recovered to within 10 dB of baseline after three days and fully recovered after one month (Ryals et al., 1999). These experimental SELs are a conservative estimate of the SEL above which PTS may be considered possible for birds.

All of the above studies were conducted in air. There are no studies of hearing loss in diving birds due to underwater sound exposures.

Hearing Loss due to Impulsive Sound Sources

The only measure of hearing loss in a bird due to an impulsive noise exposure was conducted by Hashino et al. (1988), in which budgerigars were exposed to the firing of a pistol with a received level of 169 dB re 20 µPa peak SPL (two gunshots per each ear); SELs were not provided. While the gunshot frequency power spectrum had its peak at 2.8 kHz, threshold shift was most extensive below 1 kHz. TTS recovered at frequencies above 1 kHz, while a 24 dB PTS was sustained at frequencies below 1 kHz. Studies of hearing loss in diving birds exposed to impulsive sounds underwater do not exist.

Because there is only one study of hearing loss in birds due to an impulsive exposure, the few studies of hearing loss in birds due to exposures to non-impulsive sound (discussed above) are the only other avian data upon which to assess bird susceptibility to hearing loss from an impulsive sound source. Data from other taxa (U.S. Department of the Navy, 2017a) indicate that, for the same SEL, impulsive exposures are more likely to result in hearing loss than non-impulsive exposures. This is due to the high peak pressures and rapid pressure rise times associated with impulsive exposures.

3.9.3.1.1.3 Masking

Masking occurs when one sound, distinguished as the "noise," interferes with the detection or recognition of another sound. The quantitative definition of masking is the amount in decibels an auditory detection or discrimination threshold is raised in the presence of a masker (Erbe et al., 2016). As discussed in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), masking can effectively limit the distance over which an animal can communicate and detect biologically relevant sounds. Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise.

Critical ratios are the lowest ratio of signal-to-noise at which a signal can be detected. When expressed in decibels, critical ratios can easily be calculated by subtracting the noise level (in dB re 1 μPa^2 per hertz) from the signal level (in dB re 1 µPa) at detection threshold. A signal must be received above the critical ratio at a given frequency to be detectable by an animal. Critical ratios have been determined for a variety of bird species (e.g., Dooling (1980), Noirot et al. (2011), Dooling and Popper (2000), and Crowell (2016)), and inter-species variability is evident. Some birds exhibit low critical ratios at certain vocal frequencies, perhaps indicating that hearing evolved to detect signals in noisy environments or over long distances (Dooling & Popper, 2000).

The effect of masking is to limit the distance over which a signal can be perceived. An animal may attempt to compensate in several ways, such as by increasing the source level of vocalizations (the Lombard effect), changing the frequency of vocalizations, or changing behavior (e.g., moving to another location, increasing visual display). Birds have been shown to shift song frequencies in the presence of a tone at a similar frequency (Goodwin & Podos, 2013), and in continuously noisy urban habitats, populations have been shown to have altered song duration and shifted to higher frequencies

(Slabbekoorn & den Boer-Visser, 2006). Changes in vocalization may incur energetic costs and hinder communication with conspecifics, which, for example, could result in reduced mating opportunities. These effects are of long-term concern in constant noisy urban environments (Patricelli & Blickley, 2006) where masking conditions are prevalent.

3.9.3.1.1.4 Physiological Stress

Animals in the marine environment naturally experience stressors within their environment and as part of their life histories. Contributors to stress include changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, nesting, and interactions with predators. Anthropogenic sound-producing activities have the potential to provide additional stressors beyond those that naturally occur, as described in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

Chronic stress due to disturbance may compromise the general health and reproductive success of birds (Kight et al., 2012), but a physiological stress response is not necessarily indicative of negative consequences to individual birds or to populations (Larkin et al., 1996; National Park Service, 1994). The reported behavioral and physiological responses of birds to noise exposure can fall within the range of normal adaptive responses to external stimuli, such as predation, that birds face on a regular basis. These responses can include activation of the neural and endocrine systems, which can cause changes such as increased blood pressure, available glucose, and blood levels of corticosteroids (Manci et al., 1988). It is possible that individuals would return to normal almost immediately after short-term or transient exposure, and the individual's metabolism and energy budget would not be affected in the long term. Studies have also shown that birds can habituate to noise following frequent exposure and cease to respond behaviorally to the noise (Larkin et al., 1996; National Park Service, 1994; Plumpton, 2006). However, the likelihood of habituation is dependent upon a number of factors, including species of bird (Bowles et al., 1991) and frequency of and proximity to exposure. Although Andersen et al. (1990) did not evaluate noise specifically, they found evidence that anthropogenic disturbance is related to changes in home ranges; for example, raptors have been shown to shift their terrestrial home range when concentrated military training activity was introduced to the area. On the other hand, cardinals nesting in areas with high levels of military training activity (including gunfire, artillery, and explosives) were observed to have similar reproductive success and stress hormone levels as cardinals in areas of low activity (Barron et al., 2012).

While physiological responses such as increased heart rate or startle response can be difficult to measure in the field, they often accompany more easily measured reactions like behavioral responses. A startle is a reflex characterized by rapid increase in heart rate, shutdown of nonessential functions, and mobilization of glucose reserves. Habituation keeps animals from expending energy and attention on harmless stimuli, but the physiological component might not habituate completely (Bowles, 1995).

A strong and consistent behavioral or physiological response is not necessarily indicative of negative consequences to individuals or to populations (Bowles, 1995; Larkin et al., 1996; National Park Service, 1994). For example, many of the reported behavioral and physiological responses to noise are within the range of normal adaptive responses to external stimuli, such as predation, that wild animals face on a regular basis. In many cases, individuals would return to homeostasis or a stable equilibrium almost immediately after exposure. The individual's overall metabolism and energy budgets would not be affected if it had time to recover before being exposed again. If the individual does not recover before being exposed again, physiological responses could be cumulative and lead to reduced fitness. However, it is also possible that an individual would have an avoidance reaction (i.e., move away from the noise source) to repeated exposure or habituate to the noise when repeatedly exposed.

Due to the limited information about acoustically induced stress responses, the Navy conservatively assumes in its effects analysis that any physiological response (e.g., hearing loss or injury) or significant behavioral response is also associated with a stress response.

3.9.3.1.1.5 Behavioral Reactions

Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on behavioral reactions and the framework used to analyze this potential impact. Numerous studies have documented that birds respond to human-made noise, including aircraft overflights, weapons firing, and explosions (Larkin et al., 1996; National Park Service, 1994; Plumpton, 2006). The manner in which an animal responds to noise could depend on several factors, including life history characteristics of the species, characteristics of the noise source, sound source intensity, onset rate, distance from the noise source, presence or absence of associated visual stimuli, food and habitat availability, and previous exposure (see Section 3.0.4.3, Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). Researchers have documented a range of bird behavioral responses to noise, including no response, head turn, alert behavior, startle response, flying or swimming away, diving into the water, and increased vocalizations (Brown et al., 1999; Larkin et al., 1996; National Park Service, 1994; Plumpton, 2006; Pytte et al., 2003; Stalmaster & Kaiser, 1997). Some behavioral responses may be accompanied by physiological responses, such as increased heart rate or short-term changes in stress hormone levels (Partecke et al., 2006).

Behavioral responses may depend on the characteristics of the noise and whether the noise is similar to biologically relevant sounds such as alarm calls by other birds and predator sounds. For example, European starlings (*Sturnus vulgaris*) took significantly longer to habituate to repeated bird distress calls than white noise or pure tones (Johnson et al., 1985). Starlings may have been more likely to continue to respond to the distress calls because they are more biologically meaningful. Starlings were also more likely to habituate in winter than summer, possibly meaning that food scarcity or seasonal physiological conditions may affect intensity of behavioral response (Johnson et al., 1985).

Behavioral Reactions to Impulsive Sound Sources

It is assumed that most species would react similarly to impulsive sources such as weapons noise and explosions. However, it is important to note that most data on behavioral reactions to impulsive sources is collected from studies using air guns and impact pile driving, sources that do not occur in the TMAA. Studies regarding behavioral responses by non-nesting birds to impulsive sound sources are limited. Seismic surveys had no noticeable impacts on the movements or diving behavior of long-tailed ducks undergoing wing molt, a period in which flight is limited and food requirements are high (Lacroix et al., 2003). The birds may have tolerated the seismic survey noise to stay in preferred feeding areas.

Responses to aircraft sonic booms are informative of responses to single impulsive sounds. Responses to sonic booms are discussed below in Behavioral Reactions to Aircraft.

Behavioral Reactions to Sonar and Other Active Acoustic Sources

One study has measured bird responses to sonar. Hansen et al. (2020) exposed two common murres to broadband sound bursts and mid-frequency active sonar playback during an underwater foraging task and found that both birds exhibited behavioral reactions to both stimuli as compared to no reactions in control trials. One subject exhibited stronger behavioral reactions to the noise bursts, and the other to the sonar. The authors found this effect for received levels between 110 and 137 dB re 1 µPa root mean squared and noted that the birds tended to turn or swim away from the sound source. This research suggests that anthropogenic noise within the birds' hearing range may cause behavioral disturbance while foraging underwater.

The effect of fishing net pingers on bird bycatch has also been examined. Fewer common murres (*Uria aalge*) were entangled in gillnets when the gillnets were outfitted with 1.5 kHz pingers with a source level of 120 dB re 1 µPa; however, there was no significant reduction in rhinoceros auklet (*Cerorhinca monocerata*) bycatch in the same nets (Melvin et al., 2011; Melvin et al., 1999). It was unknown whether the pingers elicited a behavioral response by the birds.

<u>Behavioral Reactions to Aircraft</u>

There are multiple possible factors involved in behavioral responses to aircraft overflights, including the noise stimulus as well as the visual stimulus. Observations of tern colonies responses to balloon overflights suggest that visual stimulus is likely to be an important component of disturbance from overflights (Brown, 1990). Although it was assumed nesting colonial waterbirds would be more likely to flush or exhibit a mob response when disturbed, observations of nesting black skimmers and nesting least, gull-billed, and common terns showed they did not modify nesting behavior in response to military fixed-wing aircraft engaged in low-altitude tactical flights and rotary-wing overflights (Hillman et al., 2015). Maximum behavioral responses by crested tern (*Sterna bergii*) to aircraft noise were observed at sound level exposures greater than 85 A-weighted decibels (dBA) re 20 µPa. However, herring gulls (*Larus argentatus*) significantly increased their aggressive interactions within the colony and their flights over the colony during overflights with received SPLs of 101–116 dBA re 20 µPa (Burger, 1981).

Raptors and wading birds have responded minimally to jet (110 dBA re 20 µPa) and propeller plane (92 dBA re 20 µPa) overflights, respectively (Ellis, 1981). Jet flights greater than 1,640 ft. (500 m) distance from raptors were observed to elicit no response (Ellis, 1981). The impacts of low-altitude military training flights on wading bird colonies in Florida were estimated using colony distributions and turnover rates. There were no demonstrated impacts of military activity on wading bird colony establishment or size (Black et al., 1984). Fixed-wing jet aircraft disturbance did not seem to adversely affect waterfowl observed during a study in coastal North Carolina (Conomy et al., 1998); however, harlequin ducks (*Histrionicus histrionicus*) were observed to show increased agonistic behavior and reduced courtship behavior up to one to two hours after low-altitude military jet overflights (Goudie & Jones, 2004).

It is possible that birds could habituate and no longer exhibit behavioral responses to aircraft noise, as has been documented for some impulsive noise sources (Ellis, 1981; Russel et al., 1996) and aircraft noise (Conomy et al., 1998). Ellis (1981), found that raptors would typically exhibit a minor short-term startle response to simulated sonic booms, and there was no long-term effect to productivity.

3.9.3.1.1.6 Long-Term Consequences

Long-term consequences to birds due to acoustic exposures are considered following the Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities (see Section 3.0.4.3).

Long-term consequences due to individual behavioral reactions and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposures to multiple stressors over significant periods of time. Conversely, some birds may habituate to or become tolerant of repeated acoustic exposures over time, learning to ignore a stimulus that in the past did not accompany any overt threat. Most research on long-term consequences to birds due to acoustic exposures has focused on breeding colonies or shore habitats, and does not address the brief exposures that may be encountered during migration or foraging at sea. More research is needed to better understand the long-term consequences of human-made noise on birds, although intermittent exposures are assumed to be less likely than prolonged exposures to have lasting consequences.

3.9.3.1.2 Impacts from Sonar and Other Transducers

Sonar and other transducers could be used throughout the TMAA under the Proposed Action. Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of these systems are described in Section 3.0.4.1 (Acoustic Sources).

Information regarding the impacts of sonar on birds is limited, and little is known about the ability of birds to hear underwater. The limited information available (Crowell, 2016; Crowell et al., 2015; Crowell et al., 2016; Johansen et al., 2016; Maxwell et al., 2017) suggest the range of best hearing may shift to lower frequencies in water (Dooling & Therrien, 2012; Therrien, 2014) (see Section 3.9.2.1.5, Hearing and Vocalization). Because few birds can hear above 10 kHz in air, it is likely that the only sonar sources they may be able to detect are low and mid-frequency sources.

The possibility of an ESA-listed bird species being exposed to sonar and other transducers depends on whether it submerges during foraging, and if so, whether it is a pursuit-diver or plunge-diver. Other than pursuit-diving species, birds' exposure to these sounds is likely negligible because they spend only a very short time underwater (plunge-diving or surface-dipping) or forage only at the water surface. Possible exposure also depends on whether it forages in areas where these sound sources may be used.

In addition to diving behavior, the likelihood of a bird being exposed to underwater sound depends on factors such as source duty cycle (defined as the percentage of the time during which a sound is generated over a total operational period), whether the source is moving or stationary, and other activities that might be occurring in the area. For moving sources, such as most hull-mounted sonar use, the likelihood of an individual bird being repeatedly exposed to an intense sound source over a short period of time is low because the training activities are transient and both sonar use and bird diving are intermittent. The potential for birds to be exposed to intense sound associated with stationary sonar sources would likely be limited for some activities because other activities occurring in conjunction may cause them to leave the immediate area. For example, birds would likely react to helicopter noise during dipping sonar exercises by flushing from the immediate area and would therefore not be exposed to underwater sonar. Any exposure would be limited to a bird's dive duration, and a bird may reduce its exposure if its dive is disrupted or the bird re-locates to another foraging area.

Injury due to acoustic resonance of air space in the lungs from sonar and other transducers is unlikely in birds. Unlike mammals, birds have compact, rigid lungs with strong pulmonary capillaries that do not change much in diameter when exposed to extreme pressure changes (Baerwald et al., 2008), leading to resonant frequencies lower than the frequencies used for Navy sources. Furthermore, potential direct injuries (e.g., barotrauma, hemorrhage, or rupture of organs or tissue) from non-impulsive sound sources such as sonar are unlikely because of slow rise times, lack of a strong shock wave such as that associated with an explosive, and relatively low peak pressures.

A physiological impact, such as hearing loss, could only occur if a seabird were close to an intense sound source. An underwater sound exposure would have to be intense and of a sufficient duration to cause hearing loss (see Section 3.9.3.1.1.2, Hearing Loss). Avoiding the sound by returning to the surface would limit extended or multiple sound exposures underwater. Additionally, some diving birds may avoid interactions with large moving vessels upon which the most powerful sonars are operated (Schwemmer et al., 2011). In general, birds are less susceptible to both TTS and PTS than mammals (Saunders & Dooling, 1974). Diving birds have adaptations to protect the middle ear and tympanum from pressure changes during diving that may affect hearing (Dooling & Therrien, 2012). While some adaptions may exist to aid in underwater hearing, other adaptations to protect in-air hearing may limit aspects of underwater hearing (Hetherington, 2008). Because of these reasons, the likelihood of a diving bird experiencing an underwater exposure to sonar or other transducer that could result in an impact on hearing is considered low. Similarly, the masking of important acoustic signals underwater by sonar or other transducers is unlikely given the low probability of spatial, temporal, and spectral (e.g. sound frequency) overlap.

Given the information and adaptations discussed above, diving seabirds are not expected to detect high-frequency sources underwater and are only expected to detect mid- and low-frequency sources when in close proximity. A diving bird may not respond to an underwater source, or it may respond by altering its dive behavior, perhaps by reducing or ceasing a foraging bout. It is expected that any behavioral interruption would be temporary as the source or the bird changes location.

Some birds commonly follow vessels, including certain species of gulls, storm petrels, and albatrosses, as there is increased potential of foraging success as the prop wake brings prey to the surface (Hamilton, 1958; Hyrenbach, 2001, 2006; Melvin et al., 2001). Birds that approach vessels while foraging will be exposed to vessel noise and are the most likely to be exposed to underwater active acoustic sources, but only if the ship is engaged in anti-submarine warfare with active acoustic sources. However, hull mounted sonar does not project sound aft of ships (behind the ship, opposite the direction of travel), so most birds diving in ship wakes would not be exposed to sonar. In addition, based on what is known about bird hearing capabilities in air, it is expected that diving birds may have limited or no ability to perceive high-frequency sounds, so they would likely not be impacted by high-frequency sources.

3.9.3.1.2.1 Methods for Analyzing Impacts from Sonar and Other Transducers

The Navy performed a quantitative analysis to estimate the range to auditory injury for short-tailed albatross exposed to sonar and other transducers used during Navy training activities. Inputs to the quantitative analysis included sound propagation modeling in the Navy Acoustic Effects Model to the sound exposure criteria and thresholds presented below to predict ranges to effects.

There are no published studies specific to sonar and its effects on short-tailed albatross. In order to set a threshold for auditory injury, a multi-disciplinary Hydroacoustic Science Panel (Science Applications International Corporation, 2011) used data from in-air sound that caused threshold shift in birds (Ryals et al., 1999) to conclude that 40 dB of threshold shift was required to produce auditory injury in birds for tonal sound sources in air. Thresholds for hearing loss are typically reported in cumulative SEL to account for the duration of the exposure. The boundary for onset of auditory injury (40 dB threshold shift) corresponds to an SEL of 158 dB re 20 μPa^2s in air. To translate this criterion into a threshold to auditory injury underwater, correction factors were applied: 36 dB were added for impedance and 26 dB were added for the difference in air-to-water reference pressure to the level at which threshold shift occurred. The impedance adjustment accounts for the suspected hearing capabilities of birds underwater, which is estimated using the limited data on bird hearing underwater discussed in Section

3.9.2.1.5 (Hearing and Vocalization) and by considering the hearing capabilities of other amphibious animals [i.e., otariids (U.S. Department of the Navy, 2017a)]. The results of the analysis determined a cumulative SEL threshold to auditory injury of 220 dB re 1 µPa^{2}s. After reviewing the best available science since 2016 (Crowell, 2016; Crowell et al., 2015; Crowell et al., 2016; Hansen et al., 2017; Johansen et al., 2016; Maxwell et al., 2017), the Navy has re-affirmed this criterion.

3.9.3.1.2.2 Impact Ranges for Sonar and Other Transducers

The Navy performed a quantitative analysis to estimate the range to auditory injury (PTS) for birds exposed to sonar and other transducers used during Navy training using the Navy Acoustic Effects Model, described in Section 3.0.1.2.3 (The Navy Acoustic Effects Model). This is a change in methodology from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Table 3.9-2 provides sonar ranges to auditory injury for the short-tailed albatross.

Based on the sound source level, source depth, angle of the vertical beam pattern, and dive depth, the short-tailed albatross would not receive SELs from sonar that meet or exceed the threshold for onset of auditory injury. The received sound exposure levels calculated at the short-tailed albatross' maximum dive depth from each of the modelled sources all fall below the PTS and TTS threshold levels. This results in range-to-effects values of zero meters.

Table 3.9-2: Ranges to Auditory Injury from Three Representative Sonar Bins

Acoustic Bin	*Range to Auditory Injury (in meters)*[1]				
	Exposure Duration of 1 sec	*Exposure Duration of 30 sec*	*Exposure Duration of 60 sec*	*Exposure Duration of 120 sec*	*Exposure Duration of 300 sec*
MF1	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
MF4	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
MF5	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)

[1]Bins shown are those approved for public release. Ranges were modeled for the typical duty cycle of each bin.

3.9.3.1.2.3 Impacts from Sonar and Other Transducers Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the GOA Study Area, referred to as the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.9.3.1.2.4 Impacts from Sonar and Other Transducers Under Alternative 1

The Navy's Proposed Action is consistent with the Proposed Action presented in the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011a), *Record of Decision for Final Environmental Impact Statement/Overseas Environmental Impact Statement for the Gulf of Alaska Navy Training Activities* (U.S. Department of the Navy, 2011b), the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016), and *Record of Decision for the Gulf of Alaska Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy, 2017b). The Proposed Action, described in detail in Chapter 2 (Description of Proposed Action and Alternatives), entails the military continuing training activities previously conducted and as described in the 2016 GOA Final SEIS/OEIS, for which a Record of Decision was issued. Though the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been minor changes in the platforms and systems used as part of those activities.

Sonar and other transducers proposed for use are typically transient and temporary because activities that involve sonar and other transducers take place at different locations and many platforms are generally moving throughout the TMAA. In addition, the Proposed Action would occur over a maximum time period of up to 21 consecutive days during the months of April–October, further limiting the total potential time when sonar and other transducers may impact birds within the TMAA. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training under Alternative 1 are described in Section 3.0.4.1 (Acoustic Sources). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). The proposed use of sonar for training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Although the existing conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, a re-analysis of the Alternative 1 with respect to birds (the short-tailed albatross) is provided here to supplant previous analyses based on available new literature, adjusted sound exposure criteria, and new acoustic effects modeling.

The short-tailed albatross may be exposed to sonar and other transducers within the TMAA during the proposed training activities. Short-tailed albatross forage in offshore, open ocean waters and are present within the TMAA. There have been 19 recorded instances of short-tailed albatross occurrence in the TMAA in 20 years (see Section 3.9.2.2.3, Distribution). However, given increasing populations of this species, and considering juvenile short-tailed albatross presence in the TMAA, training activities conducted within the TMAA present a chance that direct or indirect impacts could occur to this species because of training activities that use sonars and other transducers.

Direct, non-auditory injury (e.g., barotrauma) to birds is unlikely because sonar and other non-impulsive sources lack the characteristics that can cause these injuries, and birds have rigid lungs that are relatively unaffected by extreme pressure changes (see Section 3.9.3.1.2, Impacts from Sonar and Other Transducers). The shallow dive depths and short dive durations used by this species combined with their limited range of hearing greatly reduce the potential for auditory injury after exposure to sonar and other transducers.

Mid-frequency sources are within the hearing range of birds (Dooling & Popper, 2000, 2007; Dooling & Therrien, 2012)(see Section 3.9.2.1.5, Hearing and Vocalization). Therefore, mid-frequency sonar sources (1 kHz to 10 kHz) are considered in this analysis. See Section 3.0.4.1.1 (Sonar and other Transducers) for a complete description of sonar and other transducers used for the Proposed Action.

The spatial and temporal variability of both the occurrence of a short-tailed albatross and the training activities conducted within the TMAA presents a negligible chance that a direct or indirect impact would occur to this species from sonar or other transducers. Due to the transient nature of most sonar operations, impacts, if any, would be localized and infrequent, only lasting a few seconds or minutes. The Navy used established criteria for auditory injury in birds and the Navy's Acoustic Effects Model (described in Section 3.0.1.2.3, The Navy Acoustic Effects Model) to generate ranges to auditory injury for representative sonar sources proposed for Navy training activities in the TMAA, and calculated a range to effect of zero meters for all sources and exposure durations (see Section 3.9.3.1.2.2, Impact Ranges for Sonar and Other Transducers, and Table 3.9-2). This analysis concludes that the short-tailed albatross would not receive SELs from sonar that meet or exceed the threshold for onset of auditory injury.

Since mid-frequency sources are audible to birds, sonar and other transducers have the potential to mask important biological sounds (see Section 3.9.3.1.1.3, Masking). However, since the short-tailed albatross is not a pursuit-diver and only briefly dives under the water surface to capture prey, sonar and other transducers are extremely unlikely to create any masking effect. Sonar and other transducers have the potential to cause behavioral reactions and physiological stress. Although individuals may be impacted, long-term consequences for populations would not be expected.

As described above, there is new information that applies to the analysis of impacts of sonar and other transducers on birds. Though the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. However, this new information does not substantively change the affected environment, which forms the environmental baseline of the analysis in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Additionally, no new Navy training activities are being proposed in this SEIS/OEIS that would affect birds in the TMAA. Therefore, conclusions for birds made for Alternative 1 that were analyzed in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS remain unchanged in this SEIS/OEIS. For a summary of effects of the action alternative on birds under both NEPA and Executive Order 12114, please refer to Table 3.6-11 in the 2011 GOA Final EIS/OEIS.

The underlying conclusions reached in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS remain unchanged—exposures to sonar and other transducers are unlikely to impact the short-tailed albatross.

Pursuant to the ESA, noise produced by sonar and other transducers during training activities as described under Alternative 1 may affect the ESA-listed short-tailed albatross. The Navy will consult with USFWS as required by section 7(a)(2) of the ESA.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from sonar and other transducers during training activities described under Alternative 1 would not result in a significant adverse effect on populations of seabirds, shorebirds, and other birds protected under the MBTA.

3.9.3.1.3 Impacts from Vessel Noise

The different types of vessels and the noise they generate are discussed in Section 3.0.4.1.2 (Vessel Noise). Background information on responses of birds to aircraft and other acoustic stressors is provided in Section 3.9.3.1.1.5 (Behavioral Reactions). Naval combat vessels are designed to be quiet to avoid detection; therefore, disturbance to birds is expected to be due to visual, rather than acoustic, stressors. Other training support vessels, such as rigid hull inflatable boats, use outboard engines that can produce substantially more noise even though they are much smaller than warships. Noise due to watercraft with outboard engines, or noise produced by larger vessels operating at high speeds, may briefly disturb birds while foraging or resting at the water surface. However, the responses due to both acoustic and visual exposures are likely related and difficult to distinguish.

3.9.3.1.3.1 Impacts from Vessel Noise Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the GOA Study Area, referred to as the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.9.3.1.3.2 Impacts from Vessel Noise Under Alternative 1

Birds may be exposed to noise from vessel movements. A detailed description of the acoustic characteristics and typical sound levels of vessel noise are in Section 3.0.4.1 (Acoustic Sources). Many proposed training activities within the TMAA involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels). Though the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. Increases and decreases shown in Table 2.6-1 for proposed activities under Alternative 1 do not appreciably change the impact conclusions presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS.

Since the 2016 GOA Final SEIS/OEIS, no new information was identified during the Navy's literature review that would substantially alter the assessment of potential impacts on marine birds, including the short-tailed albatross, from vessel noise. Although loud, sudden noises can startle and flush birds, Navy vessels are not expected to result in major acoustic disturbance of seabirds in the TMAA. Noise from Navy vessels is similar to or less than those of the general maritime environment. The potential is very low for noise generated by Navy vessels to impact individual seabirds, and such noise would not result in impacts on seabird populations. The 2016 GOA Final SEIS/OEIS concluded that, although sound levels originating from Navy vessels and aircraft are likely detectable by birds, they would not be exposed for long enough durations to cause auditory injury. Therefore, the previous conclusion that effects from vessel noise are insignificant remains valid.

Pursuant to the ESA, noise produced by vessels during training activities as described under Alternative 1 may affect the ESA-listed short-tailed albatross. The Navy will consult with USFWS as required by section 7(a)(2) of the ESA.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from sonar and other transducers during training activities described under Alternative 1 and would not result in a significant adverse effect on populations of seabirds, shorebirds, and other land birds protected under the MBTA.

3.9.3.1.4 Impacts from Aircraft Noise

The different types of aircraft and the noise they generate are detailed in Section 3.0.4.1.3 (Aircraft Noise). Reactions by birds to aircraft noise are detailed in Section 3.9.3.1.1.5 (Behavioral Reactions). Potential impacts considered are masking of other biologically relevant sounds, physiological stress, and changes in behavior.

3.9.3.1.4.1 Impacts from Aircraft Noise Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the GOA Study Area, referred to as the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.9.3.1.4.2 Impacts from Aircraft Noise Under Alternative 1

Birds may be exposed to noise from aircraft overflights. A detailed description of the acoustic characteristics and typical sound levels of aircraft overflights are in Section 3.0.4 (Stressors-Based Analysis). Many proposed training activities within the TMAA involve maneuvers by various types of fixed, rotary-wing, and tilt-rotor aircraft (collectively referred to as aircraft). Most aircraft noise would be temporary and intermittent because there are no airbases or fixed ranges within the TMAA for which aircraft would be concentrated. However, some aircraft noise could concentrate in the area immediately surrounding aircraft carriers at sea during aircraft takeoffs and landings, or during helicopter-deployed dipping sonar use.

Given the proposed timing, location, and infrequent nature of training under the Proposed Action, and the small number of short-tailed albatross that are likely to occur in the TMAA at any given time, it is unlikely that individual albatross would co-occur with aircraft noise. Therefore, any adverse effects of aircraft noise on short-tailed albatross would be discountable.

Though the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. Because the existing conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to birds is not warranted. Activities may vary slightly from those previously analyzed in the 2016 GOA Final SEIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Table 2.6-1 for proposed activities under Alternative 1 do not change the impact conclusions presented in the 2016 GOA Final SEIS/OEIS.

Pursuant to the ESA, noise produced by aircraft during training activities as described under Alternative 1 may affect the ESA-listed short-tailed albatross. The Navy will consult with USFWS as required by section 7(a)(2) of the ESA.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from aircraft noise during training activities described under Alternative 1 would not result in a significant adverse effect on populations of seabirds, shorebirds, and other birds protected under the MBTA.

3.9.3.1.5 Impacts from Weapons Noise

Training activities involving weapons noise are analyzed for potential impacts to birds within the GOA Study Area, referred to as the TMAA. The effects due to potential exposures of ESA-listed birds to explosives are analyzed separately from acoustic stressors in Section 3.9.3.2 (Explosive Stressors).

3.9.3.1.5.1 Impacts from Weapons Noise Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.9.3.1.5.2 Impacts from Weapons Noise Under Alternative 1

Birds may be exposed to sounds caused by the firing of weapons, objects in flight, and impact of non-explosive munitions on the water's surface, which are described in Section 3.0.4.1 (Acoustic Sources). In general, these are impulsive sounds (such as those discussed under Section 3.0.4.2, Explosive Stressors) generated in close vicinity to or at the water surface, with the exception of items that are launched underwater. The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated in air by firing a gun (muzzle blast) and a crack sound due to a low amplitude shock wave generated by a supersonic projectile flying through the air. Most in-air sound would be reflected at the air-water interface. Non-explosive weapon noise is therefore extremely unlikely to affect birds underwater, and no acoustic impacts to birds are expected as a result of underwater weapon noise. Conversely, in-air weapon noise produced during training activities has the potential to cause behavioral reactions, physiological stress, and auditory injury due to impulsive noise exposure.

Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange. Due to the transient nature of most activities that produce weapon noise, overall effects would be localized and infrequent, only lasting a few seconds or minutes. Reactions by birds to these specific stressors have not been recorded, however birds would be expected to react to weapon noise as they would react to other transient impulsive sounds. Marine birds would be exposed to this type of noise for a very brief period of time (less than a few seconds), and weapon noise would likely cause behavioral reactions described previously for other in-air noise disturbances. Bird responses to firing, blast, and impact noise may include short-term behavioral responses such as alerting or startle, or may result in a bird avoiding the affected area. Available data on bird responses to impulsive in-air noises are summarized above in Section 3.9.3.1.1.5 (Behavioral Reactions). Initial close exposures to impulsive weapons noise may result in received levels high enough to cause auditory injury (e.g., PTS; see Section 3.9.3.1.1.2, Hearing Loss). Birds that are initially within the area of effect for auditory injury at the start of an activity could be at risk of auditory impacts. Although individuals may be impacted, long-term consequences for populations would not be expected.

In addition to standard operating procedures, the Navy developed mitigation measures for the purpose of avoiding or reducing potential impacts of large-caliber weapons firing noise on ESA-listed short-tailed albatross in the TMAA. Additional information about mitigation for birds is presented in Chapter 5 (Mitigation) of this SEIS/OEIS.

Proposed training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Though the types of activities and number of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. Because the existing conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to birds is not warranted. Therefore, conclusions based on the previous analyses remain valid.

Pursuant to the ESA, weapon noise produced during training activities as described under Alternative 1 may affect the ESA-listed short-tailed albatross. The Navy will consult with USFWS as required by section 7(a)(2) of the ESA.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from weapons noise during training activities described under Alternative 1 would not result in a significant adverse effect on populations of seabirds, shorebirds, and other birds protected under the MBTA.

3.9.3.2 Explosive Stressors

Explosions in the water or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. However, unlike other acoustic stressors, explosives release energy at a high rate producing a shock wave that can be injurious and even deadly. Therefore, explosive impacts on birds are discussed separately from other acoustic stressors, even though the analysis of explosive impacts will in part rely on data for bird impacts due to impulsive sound exposure where appropriate.

Explosives are usually described by their net explosive weight, which accounts for the weight and type of explosive material. Explosives sources used during training in the TMAA are provided in Table 3.0-8. Additional explanation of the acoustic and explosive terms and sound energy concepts used in this section is found in Appendix B (Acoustic and Explosive Concepts).

This section begins with a summary of relevant data regarding explosive impacts on birds in Section 3.9.3.2.1 (Background). The ways in which an explosive exposure could result in immediate effects or lead to long-term consequences for an animal are explained in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), and this section follows that framework.

Due to adjusted sound exposure criteria and new acoustic effects modeling, the analysis provided in this section supplants the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS for birds.

3.9.3.2.1 Background

3.9.3.2.1.1 Injury

If a bird is close to an explosive detonation, the exposure to high pressure levels and sound impulse can cause barotrauma. Barotrauma is physical injury due to a difference in pressure between an air space inside the body and the surrounding air or water. Sudden very high pressures can also cause damage at tissue interfaces due to the way pressure waves travel differently through tissues with different material properties. Damage could also occur to the structure of the ear, considered to be the body part most susceptible to pressure damage.

Detonations that occur underwater could injure, kill, or disturb diving birds, particularly pursuit divers that spend more time underwater than other foraging birds (Danil & St Leger, 2011). Studies show that birds are more susceptible to underwater explosions when they are submerged versus partially submerged on the surface. Two species of duck were exposed to explosive blasts while submerged 0.61 m and while sitting on the water surface. Onset of mortality was predicted to occur at an impulse exposure of 248 pascal seconds (Pa-s) (36 pounds per square inch per millisecond [psi-ms]) for birds underwater and 690 Pa-s (100 psi-ms) for birds at the water surface (Yelverton & Richmond, 1981). No injuries would be expected for birds underwater at blast pressures below 41 Pa-s (6 psi-ms) and for birds on the surface at blast pressures below 207 Pa-s (30 psi-ms) (Yelverton & Richmond, 1981). Tests of underwater explosive exposures to other taxa (fish, mammals) have shown that susceptibility to injury is related to animal mass, with smaller animals being more susceptible to injury (Yelverton & Richmond, 1981). It is reasonable to assume that this relationship would apply to birds as well. The range to these thresholds would be based on several factors, including charge size, depth of the detonation, and how far the bird is beneath the water surface.

Detonations in air or at the water surface could also injure birds while either in flight or at the water surface. Experiments that exposed small, medium, and large birds to blast waves in air were conducted to determine the exposure levels that would be injurious (Damon et al., 1974). Birds were assessed for internal injuries to air sacs, organs, and vasculature, as well as injury to the auditory tympanum, but internal auditory damage was not assessed. Results indicated that peak pressure exposure of 5 pounds per square inch (psi) would be expected to produce no blast injuries, 10 psi would produce slight to extensive injuries, and 20 psi would produce 50 percent mortality. These results also suggested that birds with higher mass may be less susceptible to injury. In addition to the risk of direct blast injury, exposure to an explosion in air may cause physical displacement of a bird that could be injurious if the animal impacts a surface. The same study examined displacement injuries to birds (Damon et al., 1974). Results indicated that impulse exposures below 5 psi-ms would not be expected to result in injuries.

One experiment was conducted with birds in flight, showing how birds can withstand relatively close exposures to in-air explosions (Damon et al., 1974). Flying pigeons were exposed to a 64-pound net explosive weight explosion. Birds at 44–126 ft. from the blast exhibited no signs of injury, while serious injuries were sustained at ranges less than 40 ft. The no-injury zone in this experiment was also for exposures less than 5 psi-ms impulse, similar to the results of the displacement injury study. Ranges to the no injury threshold for a range of in-air explosives are shown in Table 3.9-3.

Table 3.9-3: Range to the No Injury Threshold for Birds Exposed to In-Air Explosives

Net Explosive Weight	*Range to 5 psi*
5 lb.	21 ft.
10 lb.	26 ft.
100 lb.	57 ft.

Note: ft. = feet, lb. = pounds
Ranges calculated using the methods in (Swisdak, 1978; Swisdak & Montanaro, 1992).

Another risk of explosions in air is exposure to explosive fragmentation, in which pieces of the casing of a cased explosive are ejected at supersonic speeds from the explosion. The risk of direct strike by fragmentation would decrease exponentially with distance from the explosion, as the worst case for strike at any distance is the surface area of the casing fragments, which ultimately would decrease their outward velocity under the influence of drag. It is reasonable to assume that a direct strike in air or at the water surface would be lethal. Once in water, the drag on any fragments would quickly reduce their velocity to non-hazardous levels (Swisdak & Montanaro, 1992).

The initial detonation in a series of detonations may deter birds from subsequent exposures via an avoidance response, however, birds have been observed taking interest in surface objects related to detonation events and subsequently being killed following detonation (R. Stemp in Greene et al. (1985)).

3.9.3.2.1.2 Hearing Loss

Exposure to intense sound may result in hearing loss that persists after cessation of the noise exposure. There are no data on hearing loss in birds specifically due to explosives; therefore, the limited data on hearing loss due to impulsive sounds, described for acoustic stressors in Section 3.9.3.1.1.2 (Hearing Loss), apply to explosive exposures.

3.9.3.2.1.3 Physiological Stress

Marine animals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, nesting, and interactions with predators all contribute to stress. Exposures to explosives have the potential to provide additional stressors beyond those that naturally occur, as described in Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

There are no data on physiological stress in birds specifically due to explosives; therefore, the limited data on physiological stress due to impulsive sounds, described for acoustic stressors in Section 3.9.3.1.1.4 (Physiological Stress), apply to explosive exposures.

3.9.3.2.1.4 Masking

Masking occurs when one sound, distinguished as the "noise," interferes with the detection or recognition of another sound. Exposure to explosives may result in masking. There are no data on masking in birds specifically due to explosives; therefore, the limited data on masking due to impulsive sounds, described for acoustic stressors in Section 3.9.3.1.1.3 (Masking), apply to explosive exposures. Due to the very brief duration of an explosive sound, any masking would be brief during an explosive activity.

3.9.3.2.1.5 Behavioral Reactions

Numerous studies have documented that birds and other wild animals respond to human-made noise, including aircraft overflights, weapons firing, and explosions (Larkin et al., 1996; National Park Service, 1994; Plumpton, 2006). The limited data on behavioral reactions due to impulsive sounds, described for acoustic stressors in Section 3.9.3.1.1.5 (Behavioral Reactions), apply to explosive exposures.

Because data on behavioral responses by birds to explosions is limited, information on bird responses to other impulsive sounds may be informative. Seismic surveys had no noticeable impacts on the movements or diving behavior of long-tailed ducks undergoing wing molt, a period in which flight is limited and food requirements are high (Lacroix et al., 2003). The birds may have tolerated the seismic survey noise to stay in preferred feeding areas. The sensitivity of birds to disturbance may also vary during different stages of the nesting cycle. Similar noise levels may be more likely to cause nest abandonment during incubation of eggs than during brooding of chicks because birds have invested less time and energy and have a greater chance of re-nesting (Knight & Temple, 1986).

3.9.3.2.1.6 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. For additional information on the determination of long-term consequences, see Section 3.0.4.3 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). Physical effects from explosive sources that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and temporary hearing impairment or chronic masking, which could affect foraging, behavioral responses (e.g. avoidance), or communication. The long-term consequences due to individual behavioral reactions, masking and short-term instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for highly nomadic and unpredictable species like the short-tailed albatross. For example, a lost feeding opportunity could be a measurable cost to the individual; however, short-term costs may be recouped during the life of an otherwise healthy individual. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposures to multiple stressors over significant periods of time. Conversely, some birds may habituate to or become tolerant of repeated acoustic exposures over time, learning to ignore a stimulus that in the past did not accompany any overt threat. More research is needed to better understand the long-term consequences of anthropogenic stressors, although intermittent exposures to explosive noise are assumed to be less likely to have lasting consequences. These factors are taken into consideration when assessing risk of long-term consequences.

3.9.3.2.2 Impacts from Explosives

This section analyzes the impacts on birds due to explosives that would be used during the proposed activities and synthesizes the background information presented above. Proposed training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details), with one exception. Consistent with the previous analyses for Alternative 1, the sinking exercise activity will not be part of the proposed action for this SEIS/OEIS, and therefore the explosive use associated with that activity is no longer part of this proposed action. Due to adjusted sound exposure criteria and new acoustic effects modeling, the analysis provided in this section supplants the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS for birds.

As discussed above, sound and energy from underwater explosions are capable of causing mortality, injury, hearing loss, masking, physiological stress, or a behavioral response, depending on the level and duration of exposure (Damon et al., 1974). Background information on studies of injuries to birds, both in air and underwater, is presented above in Section 3.9.3.2.1.1 (Injury).

Exposures that result in non-auditory injuries may limit an animal's ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or affect its ability to reproduce. Auditory injury can also impair an animal's abilities, although the individual may recover quickly. Background information on studies of hearing loss in birds is presented above in Section 3.9.3.2.1.2 (Hearing Loss).

3.9.3.2.2.1 Methods for Analyzing Impacts from Explosives

The Navy performed a quantitative analysis to estimate ranges to effect for birds exposed to explosives during the proposed activities. Inputs to the quantitative analysis included underwater sound propagation modeling in the Navy's Acoustic Effects Model, described in Section 3.0.1.2.3 (The Navy Acoustic Effects Model). The ranges to effect for in-air explosions were calculated using the methods in Swisdak (1975). These are changes in methodology from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS.

Background information on studies of injuries to birds, both in air and underwater, is presented above in Section 3.9.3.2.1.1 (Injury). The established injury and mortality thresholds for in-air and underwater explosions are reported in Table 3.9-4. The injury and mortality thresholds for in-air exposures to explosions were established using the data for multiple species of birds exposed to explosions in Damon et al. (1974). The data available from that study enabled establishment of dual metric thresholds for injury and mortality using peak pressure (dB peak) and impulse (Pa-s). There was insufficient data to correct for the mass of the bird using the data in Damon et al. (1974); therefore, the lowest values associated with injury and mortality were applied.

The injury and mortality thresholds for underwater exposures to explosions were established using the data for ducks exposed to explosions in Yelverton et al. (1973). The authors of that study correlated the impulse metric (Pa-s) to injuries observed in birds. The thresholds for injury and mortality developed using the data in Yelverton et al. (1973) were adjusted to account for the relatively smaller mass of the relatively larger mass of the short-tailed albatross (4,000 grams) compared to the ducks in the study. This adjustment was based on the data in Yelverton and Richmond (1981).

Background information on studies of hearing loss in birds is presented above in Section 3.9.3.2.1.2 (Hearing Loss). Table 3.9-4 presents the auditory and non-auditory onset thresholds for birds from underwater and in-air explosions. See Section 3.9.3.2.1.2 (Hearing Loss) above for a detailed description of peak pressure (dB peak), impulse (Pa-s), and sound exposure level (dB re 1 µPa^2 s) metrics. The in-air threshold for onset of auditory injury for impulsive noise exposure is 165 dB re 20 µPa peak. Based on the hearing loss found by Hashino et al. (1988), exposure to peak pressure of 169 dB re 1 µPa peak SPL could exceed the onset of auditory injury. However, for that study, the SEL, which is another metric for determining auditory injury, was not reported and could not be reliably approximated.

The underwater threshold for auditory injury is extrapolated from the available data on bird hearing loss from in-air exposures. The Hydroacoustic Science Panel (Science Applications International Corporation, 2011), set a sound exposure threshold (unweighted) of 135 dB re 20 µPa^{2}s cumulative SEL plus a spectral correction factor of 15 dB to account for low-frequency energy in an impulsive exposure as an approximate threshold for onset of auditory injury in birds due to impulsive sources in air. To convert this threshold to an underwater auditory injury threshold, the reference pressure is changed from 20 µPa in air to 1 µPa in water (add 26 dB) and the hearing ability of birds, and correspondingly their sensitivity to auditory impacts, is estimated using the limited data on bird hearing underwater (see Section 3.9.1, Introduction) and data from other amphibious species, specifically otariids (U.S. Department of the Navy (2017a). That data suggests a 36 dB impedance value for birds underwater. The resulting in-water auditory injury threshold is 212 dB re 1 µPa^2 s SEL.

Table 3.9-4: Explosive Effects Onset Thresholds for ESA-Listed Bird Species

Species	*Underwater*			*In Air*		
	Auditory Injury[1] (dB re 1 µPa^2 s)	*Injury[2] (Pa-s)*	*Mortality[2] (Pa-s)*	*Auditory Injury (dB re 20 µPa peak)*	*Injury[3] Dual metric (dB re 20 µPa peak) (Pa-s)*	*Mortality[3] Dual metric (dB re 20 µPa peak) (Pa-s)*
Short-Tailed Albatross	212	94	361	165	185 dB re 20 µPa peak 34.5 Pa-s	191 dB re 20 µPa peak 69 Pa-s

Notes: Underwater sound exposure level = dB re 1 µPa^2 s, In-air peak pressure = dB re 20 µPa peak, Impulse = Pa-s (pascal seconds)
[1]Threshold based on methods of the Hydroacoustic Science Panel, consistent with the analysis in the 2015 BO.
[2]Underwater injury and mortality thresholds are adjusted to consider typical mass of bird species, based on the relationships between injury and mass for fish.
[3]Dual metrics from observations of in-air explosive injuries to birds in Damon et al. (1974). Data similar to that for underwater explosive injuries is not available to conduct mass-scaling of in-air injury thresholds; however, the data in Damon et al. (1974) is specific to birds and included birds of similar size as considered in this analysis.

3.9.3.2.2.2 Impact Ranges for Explosives

The Navy performed a quantitative analysis to estimate the range to auditory injury (PTS) and non-auditory injury for short-tailed albatross exposed to explosives used during Navy training using the Navy Acoustic Effects Model, described in Section 3.0.1.2.3 (The Navy Acoustic Effects Model).

Table 3.9-5 provides impulse ranges to injury for the short-tailed albatross. These ranges to effect are based on the criteria and thresholds presented in Table 3.9-4 (see Section 3.9.3.2.2.1, Methods for Analyzing Impacts from Explosives). Detonations conducted during Navy activities would occur at or near the surface, although they are modeled in the acoustic effects analysis as if they occur fully underwater, since there is currently no means to model impacts from in-air detonations. Ranges may vary depending on factors such as the cluster size (e.g., the number of rounds fired within a short duration), location, depth, and season of the event.

Table 3.9-5: Ranges to Effects from Three Representative Explosive Bins

Source Bin (lb. NEW)	*Range to Effects for Explosives: Short-tailed Albatross[1]*			
	Source Depth (meters)	*Range to Auditory Injury (meters)*	*Range to Non-Auditory Injury (meters)*	*Range to Mortality (meters)*
E5	0.1	11 (8–14)	17 (17–17)	8 (8–8)
E9	0.1	15 (15–15)	30 (30–30)	16 (16–16)
E10	0.1	17 (17–17)	35 (35–35)	18 (18–18)
E12	0.1	20 (19–20)	40 (40–40)	21 (21–21)

[1]Average distance (in meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.

3.9.3.2.2.3 Impacts from Explosives Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur within the GOA Study Area, referred to as the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.9.3.2.2.4 Impacts from Explosives Under Alternative 1

Short-tailed albatross pelagic range overlaps with areas that include detonations as part of training activities in the TMAA. If a short-tailed albatross were located in close proximity to an explosive detonation, mortality, injury, or various behavioral responses may occur. Due to the expected low numbers of short-tailed albatrosses at sea where training activities would occur, short-tailed albatrosses would have a low potential for any exposures from explosives use during training activities. Training activities under Alternative 1 would use surface or near-surface detonations and explosive ordinance. The use of explosives would occur throughout the TMAA, the same location as analyzed under the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, and are typically dispersed in space and time. The number and type (i.e., source bin) of explosives that would be used during training under Alternative 1 are described in Section 3.0.4.2 (Explosive Stressors). Activities using explosives would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions). The proposed use of explosives for training activities would be almost identical to what is currently conducted (see Table 2.6-1 for details) with one exception. Consistent with the previous analyses for Alternative 1, the sinking exercise activity will not be part of the proposed action for this SEIS/OEIS. Although the existing conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, a re-analysis of the Alternative 1 with respect to birds (the short-tailed albatross) is provided here to supplant previous analyses based on available new literature, adjusted sound exposure criteria, and new acoustic effects modeling.

The short-tailed albatross is a surface feeder and scavenger, and predominately takes prey by surface-seizing, not diving (U.S. Fish and Wildlife Service, 2008b). The probability of a short-tailed albatross being exposed to explosive stressors underwater is extremely low, and the bird would have to dive in close proximity to explosions to experience impacts (see Table 3.9-5).

In air, short-tailed albatross exposed to explosions may be subject to lethal or non-lethal injuries (see Table 3.9-3). Short-tailed albatross may survive exposure to explosions and associated stressors; however, these individuals could have reduced levels of fitness and reproductive success. For individual short-tailed albatross that are exposed to explosions but not injured or killed, responses would likely include startle responses or avoidance behaviors. In uninjured individuals, these responses would be short-term; and since short-tailed albatross are transient and geographically wide-ranging, no significant disruptions to their normal behavior would be expected that could create a likelihood of injury. The Navy developed mitigation measures for the purpose of avoiding or reducing potential impacts of explosive medium-caliber projectiles on ESA-listed short-tailed albatross in the TMAA. Additional information about mitigation for birds is presented in Chapter 5 (Mitigation) of this SEIS/OEIS. Although individuals may be impacted, long-term consequences for populations would not be expected.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect the ESA-listed short-tailed albatross. The Navy will consult with USFWS as required by section 7(a)(2) of the ESA.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from explosives stressors during training activities using explosives described under Alternative 1 would not result in a significant adverse effect on populations of seabirds, shorebirds, and other birds protected under the MBTA.

3.9.3.3 Secondary Stressors

Navy training activities could pose indirect impacts on seabirds via habitat or prey as a result of explosives by-products, metals, chemicals, and transmission of disease and parasites. Analysis of the potential impacts on sediment and water quality are discussed in Section 3.3 (Water Resources) in the 2016 GOA Final SEIS/OEIS. The relatively low solubility of most explosives and their degradation products, metals, and chemicals means that concentrations of these contaminants in the marine environment, including those associated with either high-order or low-order detonations, are relatively low and readily diluted. For example, in the TMAA the concentration of unexploded ordnance, explosion byproducts, metals, and other chemicals would never exceed that of a World War II dump site. A series of studies of a World War II dump site off Hawaii have demonstrated only minimal concentrations of degradation products were detected in the adjacent sediments and that there was no detectable uptake in sampled organisms living on or in proximity to the site (Briggs et al., 2016; Carniel et al., 2019; Edwards et al., 2016; Hawaii Undersea Military Munitions Assessment, 2010; Kelley et al., 2016; Koide et al., 2016). It has also been documented that the degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Lotufo, 2017; Rosen & Lotufo, 2010). Any remnant undetonated components from explosives such as trinitrotoluene (TNT), royal demolition explosive, and high melting explosive experience rapid biological and photochemical degradation in marine systems (Carniel et al., 2019; Cruz-Uribe et al., 2007; Juhasz & Naidu, 2007; Pavlostathis & Jackson, 2002; Singh et al., 2009; Walker et al., 2006). As another example, the Canadian Forces Maritime Experimental and Test Ranges near Nanoose, British Columbia began operating in 1965 conducting test events for both U.S. and Canadian forces, which included many of the same test events that are conducted in the TMAA. Environmental analyses of the impacts from years of testing at Nanoose were documented in 1996 and 2005 (Environmental Science Advisory Committee, 2005). These analyses concluded the Navy test activities "…had limited and perhaps negligible effects on the natural environment" (Environmental Science Advisory Committee, 2005). Therefore, based these and other similar applicable findings from multiple Navy ranges and based on the analysis in Section 3.3 (Water Resources) in the 2016 GOA Final SEIS/OEIS, indirect impacts on seabirds from the training activities in the TMAA would be negligible and would have no long-term effect on habitat.

Secondary stressors from training activities were analyzed for potential indirect impacts on seabird prey availability. Indirect impacts of explosives and unexploded ordnance on birds via water could not only cause physical impacts, but prey items (e.g., fishes) might also have behavioral reactions to underwater sound. For example, the sound from underwater explosions might induce startle reactions and temporary dispersal of schooling fishes if they are within close proximity. The abundances of fish and invertebrate prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Secondary impacts from underwater explosions would be temporary, and no lasting impact on prey availability or the pelagic food web would be expected. Indirect impacts of underwater detonations and explosive ordnance use under the Proposed Action would not result in a decrease in the quantity or quality of bird populations or habitats, or prey species and habitats, in the TMAA.

Any effects to birds are not anticipated to be harmful or severe because of (1) the temporary nature of impacts on water or air quality, (2) the distribution of temporary water or air quality impacts, (3) the wide distribution of birds in the TMAA, and (4) the dispersed spatial and temporal nature of the training activities that may have temporary water or air quality impacts. No long-term or population-level impacts are expected.

Pursuant to the ESA, secondary impacts on prey availability during training activities as described under Alternative 1 may affect the short-tailed albatross. The Navy will consult with USFWS as required by section 7(a)(2) of the ESA.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from secondary during training activities using explosives described under Alternative 1 would not result in a significant adverse effect on populations of seabirds, shorebirds, and other birds protected under the MBTA.

3.9.4 Summary of Stressor Assessment (Combined Impacts of All Stressors)

As described above, there is new information on existing environmental conditions since the analysis in the 2016 GOA Final SEIS/OEIS. However, this new information does not significantly change the affected environment, which forms the environmental baseline of the analyses in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Additionally, no new activities are being proposed in this SEIS/OEIS that would affect birds in the TMAA. Therefore, conclusions for birds made for Alternative 1 in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remain unchanged in this SEIS/OEIS. For a summary of effects of the action alternative on birds under both the NEPA and Executive Order 12114, please refer to Table 3.9-3 in the 2011 GOA Final EIS/OEIS.

Migratory Bird Treaty Act Determination

The take of an individual bird from the Proposed Action is allowed under the MBTA regulations applicable to military readiness activities (50 CFR Part 21) provided it does not result in a significant adverse effect on a population of a migratory bird species. As presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, the Proposed Action would not diminish the capacity of a population of a migratory bird species to maintain genetic diversity, to reproduce, and to function effectively in its native ecosystem, nor would it adversely affect migratory bird populations. Because the Proposed Action has not changed and there is no new information that would change the analysis conducted in support of the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, the Navy is not required to confer with the USFWS on the development and implementation of conservation measures to minimize or mitigate adverse effects to migratory birds that are not listed under the ESA.

Endangered Species Act Determinations

In accordance with Section 7 of the ESA (50 CFR Part 402), during the preparation of the 2011 GOA Final EIS/OEIS the Navy prepared a biological evaluation and submitted it to the USFWS. The Navy received a concurrence letter from USFWS (March 24, 2010), which agreed that the Navy's actions may affect, not likely to adversely affect, the short-tailed albatross. Other ESA-listed bird species discussed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS (Steller's eider and spectacled eider) were not included in this previous consultation. As provided in 50 CFR Section 402.16, re-initiation of consultation is normally required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered, or (4) a new species is listed or critical habitat designated that may be affected by the action.

Because of revised acoustic and explosives criteria and methods, the Navy has requested reinitiation of consultation with the USFWS for the short-tailed albatross pursuant to Section 7 of the ESA. The Navy has determined that the Proposed Action will have no effect on Steller's eider and the spectacled eider.

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3.11 Socioeconomic Resources and Environmental Justice

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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3.11 Socioeconomic Resources and Environmental Justice

3.11.1 Affected Environment

For purposes of this Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS), the Study Area remains the same as that identified in the March 2011 Gulf of Alaska (GOA) United States (U.S.) Department of the Navy (Navy) Training Activities Final Environmental Impact Statement (EIS)/OEIS and the July 2016 GOA Navy Training Activities Final SEIS/OEIS. The Study Area includes the Temporary Maritime Activities Area (TMAA). The TMAA is beyond 12 nautical miles (NM) from shore and outside of the U.S. Territorial Sea. The Proposed Action is to conduct an annual exercise, historically referred to as Northern Edge, over a maximum time period of up to 21 consecutive days during the months of April to October.

Executive Order (EO) 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, was issued on February 11, 1994. This EO requires each federal agency to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions. An analysis of environmental justice should also include an analysis of effects from the Proposed Action on children as described in EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*. Executive Order 13045 requires that federal agencies prioritize assessing environmental health risks and safety risks that may disproportionately impact children. The Council on Environmental Quality has emphasized the importance of incorporating environmental justice review in the analyses conducted by federal agencies under the National Environmental Policy Act (NEPA) and of developing protective measures, as appropriate for the action, that reduce or avoid disproportionate environmental effects on minority and low-income populations and the health and safety of children.

3.11.1.1 Existing Conditions

Concerns regarding socioeconomic resources (including transportation and circulation) and environmental justice remain the same as those issues previously identified in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Further, the Navy's standard operating procedures to prevent or lessen socioeconomic impacts on the local community—as described in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS—remain applicable in this SEIS/OEIS.

Socioeconomic Resources

As discussed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, military, commercial, institutional, and recreational activities take place in the TMAA; there are no continuously restricted zones in this area (U.S. Department of the Navy, 2011, 2016). However, as noted in the 2013 Special Local Notice to Mariners (NTMs), Navy operating areas are in "use on a continuing basis by Navy ships and aircraft," and because of the "frequency and variety of exercises conducted in the [operating areas] and the difficulty in scheduling them far in advance due to uncertainties of weather, it is not possible to issue individual NTMs each time an exercise is scheduled" (U.S. Coast Guard, 2013b). The U.S. Coast Guard (USCG) does utilize a broadcast NTMs system, which is used to let mariners, pilots, fishermen, and other commercial users of the area know when Navy training is scheduled or occurring.

In addition to NTMs and Notices to Airmen, the Navy has participated in public outreach and community events since 2016, such as post-Northern Edge coastal community meetings, Navy band events, Alaska Federation of Natives Convention, Alaska Marine Science Symposium, Alaska Forum on the

Environment, ComFish, and Pacific Marine Exposition in Anchorage, Cordova, Seward, and Fairbanks, Alaska; and Seattle, Washington. Advanced notice and public outreach efforts related to future training activities in the TMAA had been scheduled for fall and winter of 2020 and winter and spring of 2021 prior to the planned 2021 Northern Edge Activity. The Navy is still participating in these but, due to the COVID-19 pandemic, these efforts have become virtual events.

Following a review of recent literature, the Navy has determined that the existing conditions with respect to military, commercial, and general aviation air traffic along with military and civilian marine traffic have not changed appreciably since the release of the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. Additionally, during the early planning phases before an exercise commences, the military and the local Federal Aviation Administration officials (Anchorage Air Route Traffic Control Center) work in close coordination to schedule and mitigate any potential conflicts to the commercial and general aviation communities. As stated in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, the Navy's scheduled activities are published for access by all vessels and operators by use of NTMs issued by the USCG and Notices to Airmen issued by the Federal Aviation Administration. Additionally, to ensure the broadest dissemination of information about hazards to commercial and recreational vessels within the region, the Navy provides schedule conflicts along with other USCG concerns at U.S. Department of Homeland Security Navigation Center, Local Notice to Mariners[1].

<u>Environmental Justice</u>

As stated in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, with the exception of Cape Cleare on Montague Island, which is located over 12 NM from the northern point of the TMAA, the nearest shoreline (Kenai Peninsula) is located approximately 24 NM north of the TMAA's northern boundary (U.S. Department of the Navy, 2011, 2016). The approximate middle of the TMAA is located 140 NM offshore. The TMAA consists of open water surface and subsurface operating areas, and overlying airspace with no population centers present. Additionally, no new or additional Navy training activities in the TMAA are being proposed in this SEIS/OEIS that would disproportionately affect any minority populations or low-income populations. Though the types of activities and level of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. As such, the information and analysis regarding environmental justice presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS are still valid.

3.11.1.1.1 Commercial Shipping

As discussed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, the TMAA is traversed by large and small marine vessels, with several commercial ports occurring near the TMAA. Three of these ports were ranked in the top 150 U.S. ports by tonnage in 2018, the latest year in which summary statistics are available; Anchorage (81st), Nikishka (76th), and Valdez (21st) (U.S. Army Corps of Engineers, 2018b). Commercially used waterways are controlled by the use of directional shipping lanes for large vessels (e.g., cargo, container ships, and tankers). In 2017 there were 7,934 commercial ship transits (both inbound and outbound) from the ports and harbors of Valdez, Anchorage, Homer, Seward, Kodiak, and Cordova (U.S. Army Corps of Engineers, 2018a). Ships that travel from major ports to the lower 48 states and Hawaii, as well as marine traffic between coastal ports, enter the TMAA briefly. According to USCG District 17, Juneau, Alaska, no incidents have occurred between commercial shipping

[1] See http://www.navcen.uscg.gov/?pageName=lnmDistrict&region=17.

and Navy activities. While the Navy does not publish daily NTMs, USCG District 17, Juneau, Alaska communicates any active Navy training activity to shipping vessels through broadcast NTMs on very high frequency-FM Channel 16 (U.S. Coast Guard, 2013a).

3.11.1.1.2 Commercial and Recreational Fishing

3.11.1.1.2.1 Commercial Fishing

Commercial fishing was discussed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, and the GOA supports one of the most sustainable fisheries in the world (National Marine Fisheries Service, 2020a). This section describes some of the most important commercial and recreational fisheries to the Alaska economy, including groundfish, crab, shellfish, salmon, and Pacific herring. Throughout this section, the term "harvest weight" or "harvest" refers to the weight of fish caught.

Groundfish

The term groundfish includes 141 species in the GOA, including walleye pollock (the most commercially harvested fish in the United States), sablefish, and Pacific cod along with an aggregate of flatfish (including but not limited to Pacific halibut species) and rockfish species (Alaska Fisheries Science Center, 2019). Landings data from 2019 show that walleye pollock had the greatest harvest and highest value, with 3.26 billion pounds landed (85 percent of the total), representing a total value of $503 million (71 percent of value) (Figure 3.11-1 and Figure 3.11-2) (National Marine Fisheries Service, 2020c). Pacific cod had the second-highest harvest and value in 2019, with 463 million pounds harvested and a value of $118 million (Figure 3.11-1 and Figure 3.11-2). Combined, these two species accounted for over 98 percent of the total groundfish harvest in the Gulf of Alaska in 2019 (National Marine Fisheries Service, 2020c).

Commercial fishing regions, as defined by the Alaska Department of Fish and Game (ADFG), which are closest to or overlap the TMAA include the Cook Inlet, Kodiak, and Prince William Sound/Copper River regions. Several groundfish species' seasons are open year round, while others vary throughout the year depending on the region (Alaska Department of Fish and Game, 2020b). However, the areas of highest harvest for groundfish in the TMAA (> 19.5 million pounds harvested from 2015 to 2019) occur in less than one-quarter of the area where groundfish data were available in the TMAA (Figure 3.11-3) (Alaska Department of Fish and Game, 2020b, 2020d; National Marine Fisheries Service, 2020c).

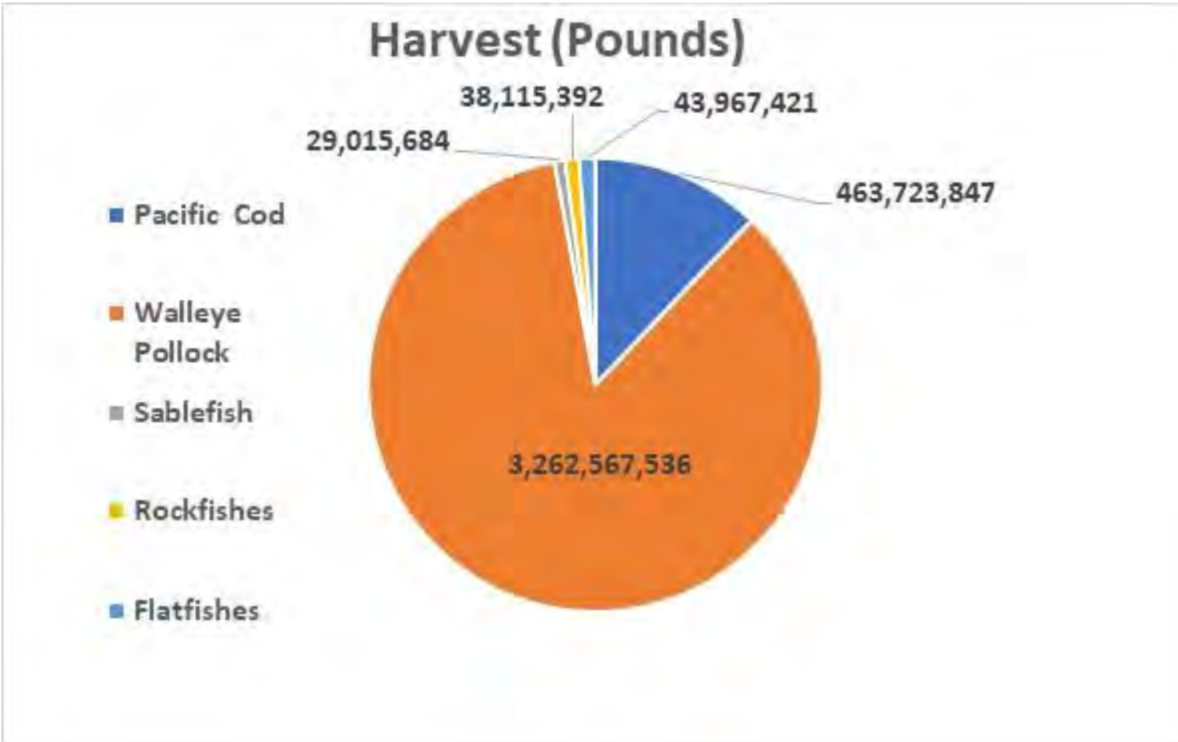

Figure 3.11-1: 2019 Commercial Groundfish Harvest by Species in Alaska State Waters

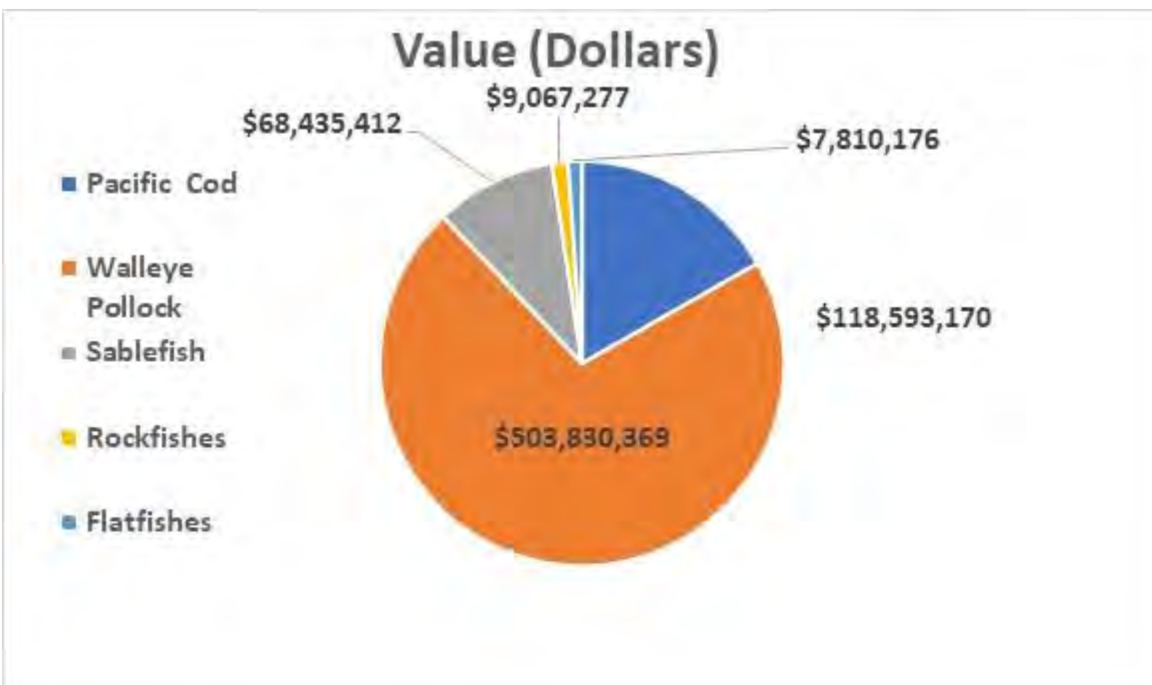

Figure 3.11-2: 2019 Commercial Groundfish Harvest Value by Species in Alaska State Waters

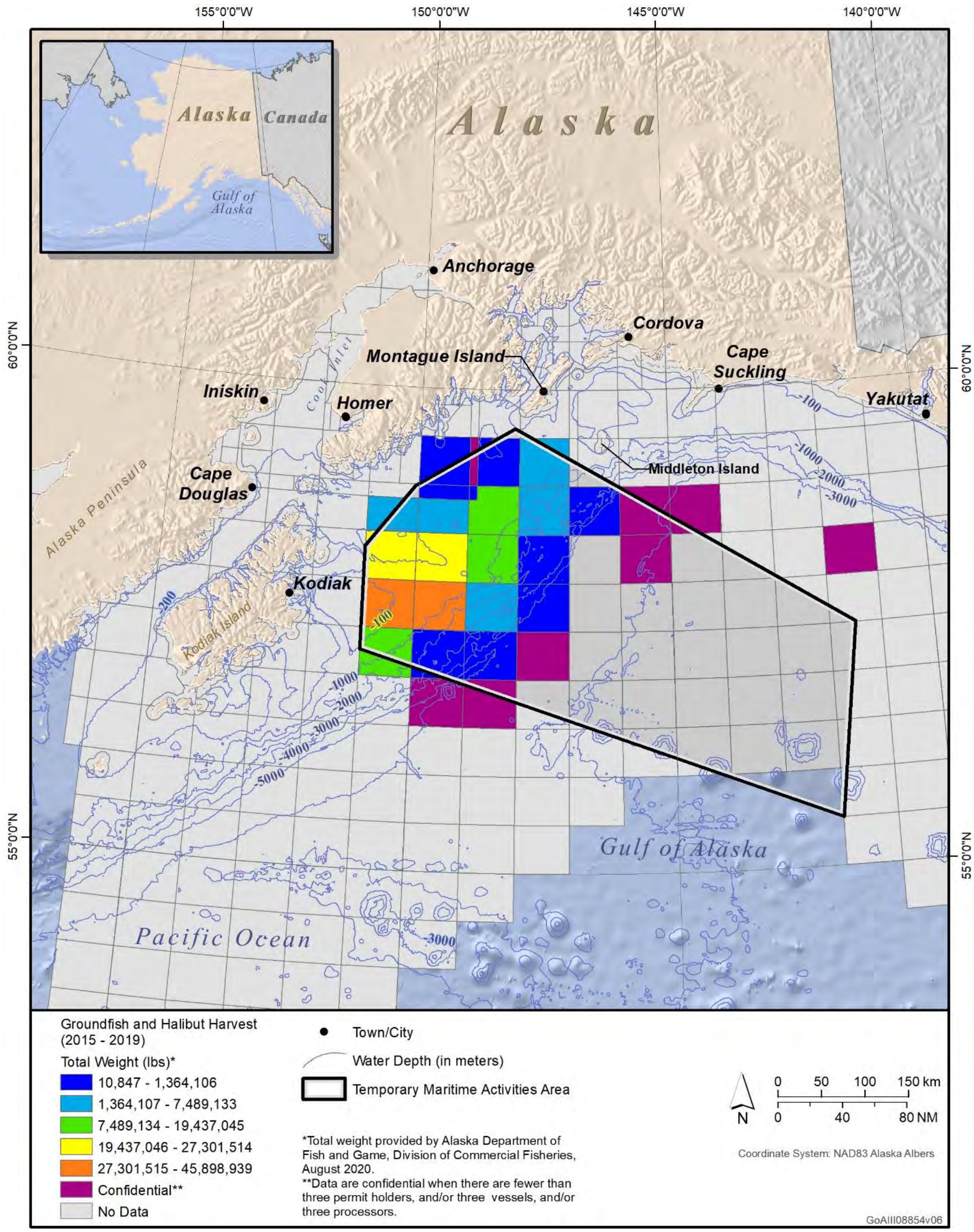

Figure 3.11-3: 2015–2019 Commercial Gulf of Alaska Groundfish and Halibut Harvest in Relation to the TMAA

Crab

Crab are defined as shellfish by the ADFG; however, for this analysis, crab are analyzed separately from all other non-crab shellfish (see subsection "Shellfish"). Seven species of crab are commercially harvested in Alaska state waters, including three species of king crab (red, blue, and golden), tanner crab, snow crab, Dungeness, and hair crab (Alaska Department of Fish and Game, 2019b; National Marine Fisheries Service, 2020b). In general, Alaskan crab harvest increased from 2001 to 2012, then decreased from 2012 to 2017 (Alaska Department of Fish and Game, 2019b; National Marine Fisheries Service, 2020b). Since 2017, overall crab harvest in Alaska has been increasing (Alaska Department of Fish and Game, 2019b; National Marine Fisheries Service, 2020b). As shown in Figure 3.11-4, snow crab is the most-harvested species in terms of weight, with king crab being the second-most harvested. Even though snow crab has had the greatest annual harvest since the release of the 2016 GOA Final SEIS/OEIS, king crab has had the highest value (Figure 3.11-5) (National Marine Fisheries Service, 2020b). Since 2017, the Dungeness crab fishery has been steadily increasing in both harvest and value (Figure 3.11-4 and Figure 3.11-5). In 2019, the Southeast region set records for its third-largest harvest weight and largest harvest value of Dungeness crab on record, showing that their crab population is healthy according to a shellfish biologist at the ADFG (Denning, 2020). Decreases in tanner and king crab harvest have been largely attributed to changing environmental conditions, including ocean acidification, overfishing, habitat disturbance from trawling, and increasing ocean temperatures (Alaska Department of Fish and Game, 2020c, 2020e; Kraegel, 2019; National Marine Fisheries Service, 2020b). Bitter crab disease, which is a parasite that tends to cause mortality one to one-and-a-half years after infection, may also contribute to the decrease in tanner crab harvest (Alaska Department of Fish and Game, 2020e).

Commercial crab harvest has very little overlap with the TMAA. The Kodiak region is the only commercial fishing region close to or overlapping the TMAA (Alaska Department of Fish and Game, 2020b). Dungeness and tanner crab are the only crab species commercially harvested within the Kodiak region. The Dungeness crab season runs from May to December (Alaska Department of Fish and Game, 2020b) and has some overlap with the May to October window when training activities could occur. In contrast, the tanner crab season typically runs from February to March (Alaska Department of Fish and Game, 2020b) and does not overlap with the proposed window for training activities (Alaska Department of Fish and Game, 2020b).

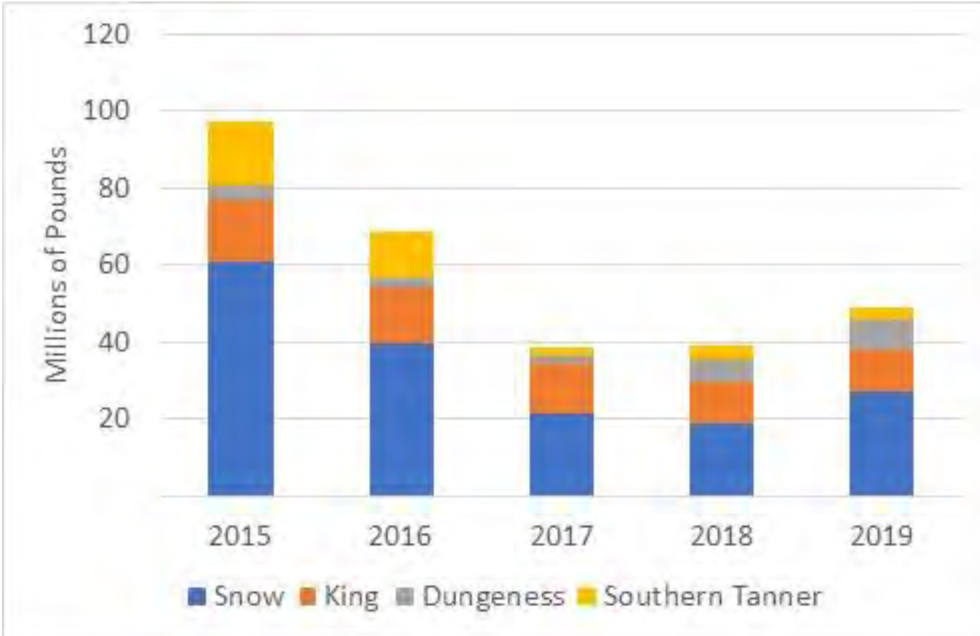

Figure 3.11-4: 2015–2019 Commercial Crab Harvest by Species in Alaska State Waters

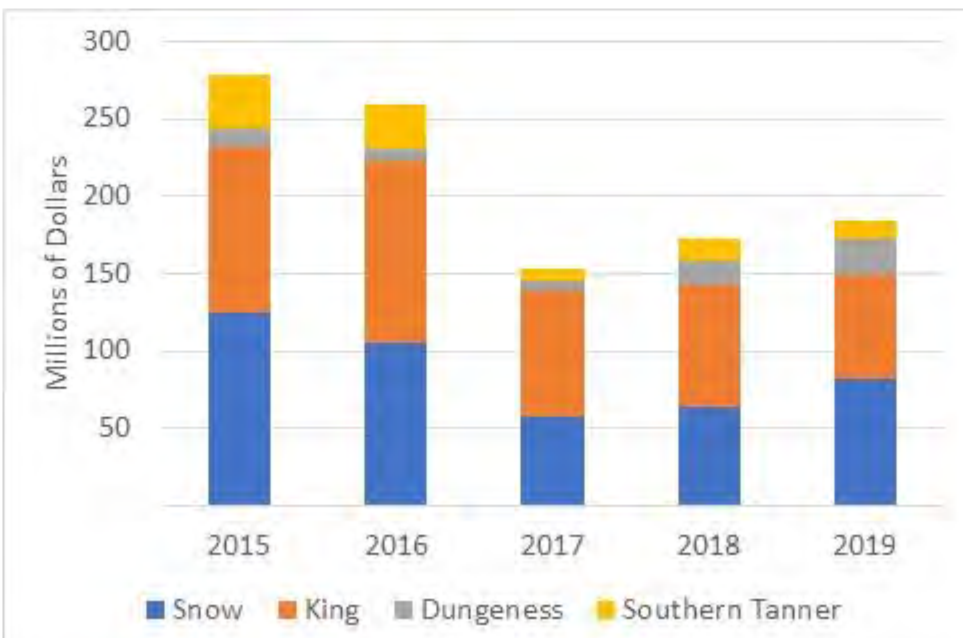

Figure 3.11-5: 2015–2019 Commercial Crab Harvest Value by Species in Alaska State Waters

Shellfish

According to the ADFG, crabs, shrimp, clams, scallops, octopuses, and squids are commercially harvested in the GOA under the term "shellfish" and "miscellaneous shellfish." However, for this analysis, with the exception of crab (see above), all other shellfish species are combined into one group, referred to as "shellfish."

Squid species in the family Loliginidae represent the largest single portion of the total shellfish harvest between 2015 and 2019, with the exception of 2019 when no data were available (Figure 3.11-6). In contrast, squids represent a very small portion of the total value of shellfish (Figure 3.11-7). Pacific geoducks represent the largest portion of the harvest value, with penaeid shrimps also making up a significant portion of the overall value (National Marine Fisheries Service, 2020e).

Weathervane scallops are the only scallop commercially harvested in the GOA. Statewide, the harvest per season has been generally decreasing since the mid-1990s, with minor peaks in 1999/2000, 2005/2006, and 2009/2010 seasons (Armstrong et al., 2019). Decreases in harvests occurred in 1995/1996, 2004/2005, and 2008/2009 seasons. Between 2016 and 2019 the fishery remained relatively stable (Armstrong et al., 2019). There is some overlap of scallop harvesting seasons with the training activities window in the TMAA. However, these seasons also run for several months outside of this time frame and are much longer than the 21-day-period training activities that would occur (Alaska Department of Fish and Game, 2020b). It should also be noted that none of the general harvest areas for weathervane scallops overlap with the TMAA, and only a small portion of exploratory scallop fishery waters in the Prince William Sound registration area would overlap the TMAA (Armstrong et al., 2019).

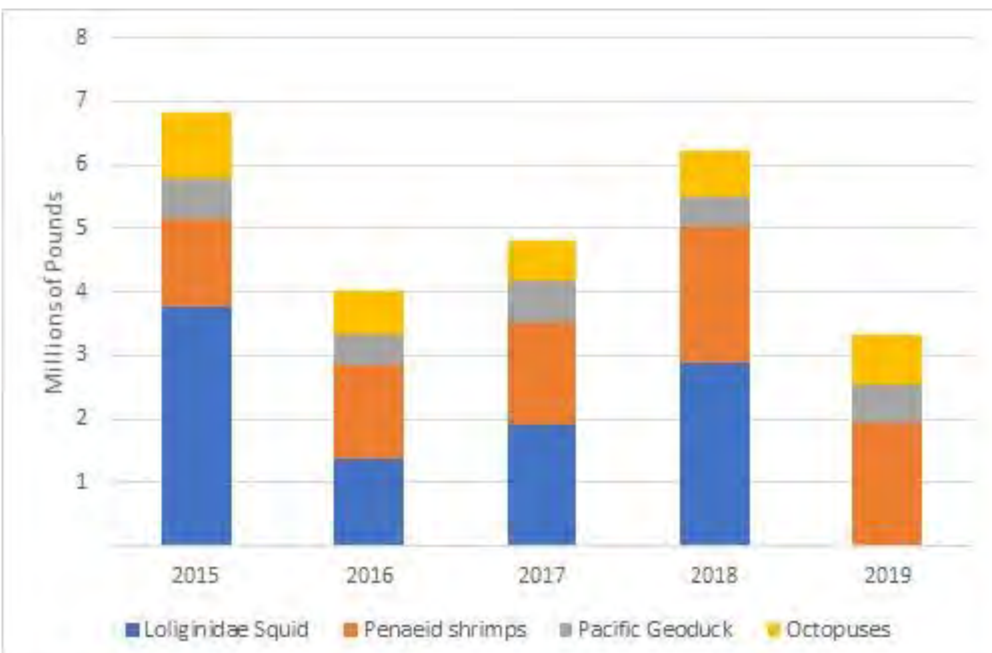

Figure 3.11-6: 2015–2019 Commercial Shellfish Harvest by Species in Alaska State Waters

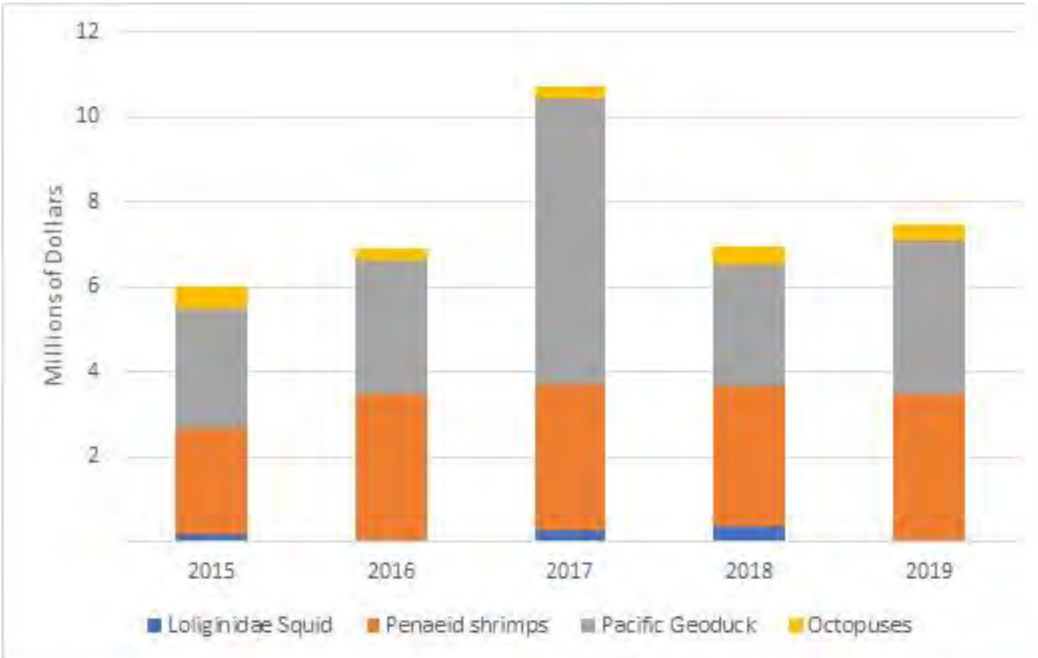

Figure 3.11-7: 2015–2019 Commercial Shellfish Harvest Value by Species in Alaska State Waters

Salmon

Across Alaska, trends in commercial harvest and the ability to meet escapement goals amongst the five native Alaskan salmon species (Chinook, coho, chum, pink, and sockeye salmon) have varied over time (Munro, 2019). For chum and coho salmon, harvest and meeting escapement goals have been stable. Sockeye salmon harvest has been variable through time, with a recent increase being driven by large runs to Bristol Bay, yet escapement goals are consistently met. Variability in the abundance of pink salmon runs between even and odd-year broodlines is increasing, as reflected in both commercial harvest and the ability to meet escapement goals. Chinook salmon runs in Alaska have declined in the last decade, leading to restrictions throughout Alaska for commercial, sport and subsistence fisheries. Despite these restrictions, meeting escapement goals has been challenging and has led to listing of several Alaskan stocks as “stocks of concern” (Munro, 2018).

Over the past five years, pink and sockeye salmon have accounted for the greatest harvest, with sockeye salmon catch being highest in 2016 and 2018, and pink salmon catch being highest in 2015, 2017, and 2019 (Figure 3.11-8). Despite pink salmon having the highest catch in 2015, 2017, and 2019, sockeye salmon consistently had the highest value (Figure 3.11-9). Coho, sockeye, and chum salmon harvests have fluctuated but have been relatively stable over the past five years, with sockeye, coho, and chum showing slightly upward trends while Chinook shows a slightly downward trend (National Marine Fisheries Service, 2020d, 2020f).

The mechanisms driving these observed patterns are not well understood. It is hypothesized that some of these changes, particularly in stocks from GOA, may be related to environmental factors (Munro, 2019). It is believed that environmental changes in habitat conditions such as increasing temperatures, above-or-below normal rainfall, and increasing melting of glaciers have strong negative effects on salmon breeding and recruitment (Jones et al., 2020), which could negatively affect annual harvests and could account for the years of low harvest. Estimates of freshwater and marine survival based on juvenile tagging studies indicate that marine survival for brood years since 2001 have declined to below average despite above-average freshwater survival. This information has helped develop management strategies that resulted in heavily restricted fishing for southeast Alaska Chinook salmon over the past two years (Munro, 2019). There is no science-based evidence that trends in salmon harvests (National Marine Fisheries Service, 2020d, 2020f) are positively or negatively correlated with bi-annual Navy training activities in the TMAA. Salmon fishing seasons occur April through October and range from one-and-a-half to four months in waters within or adjacent to the TMAA (Alaska Department of Fish and Game, 2020b). Commercial and recreational fishing of salmonids is concentrated in on-shelf environments near the coast, and only a small northwest portion of the TMAA is located in an on-shelf environment.

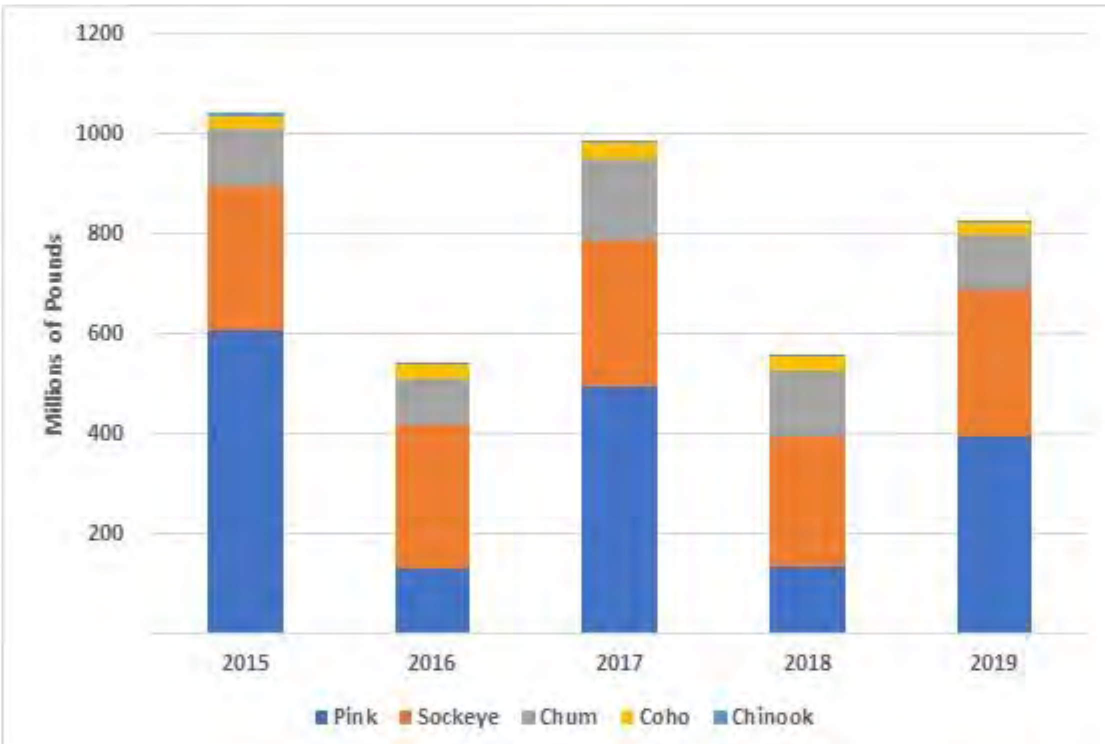

Figure 3.11-8: 2015–2019 Commercial Salmon Harvest by Species in Alaska State Waters

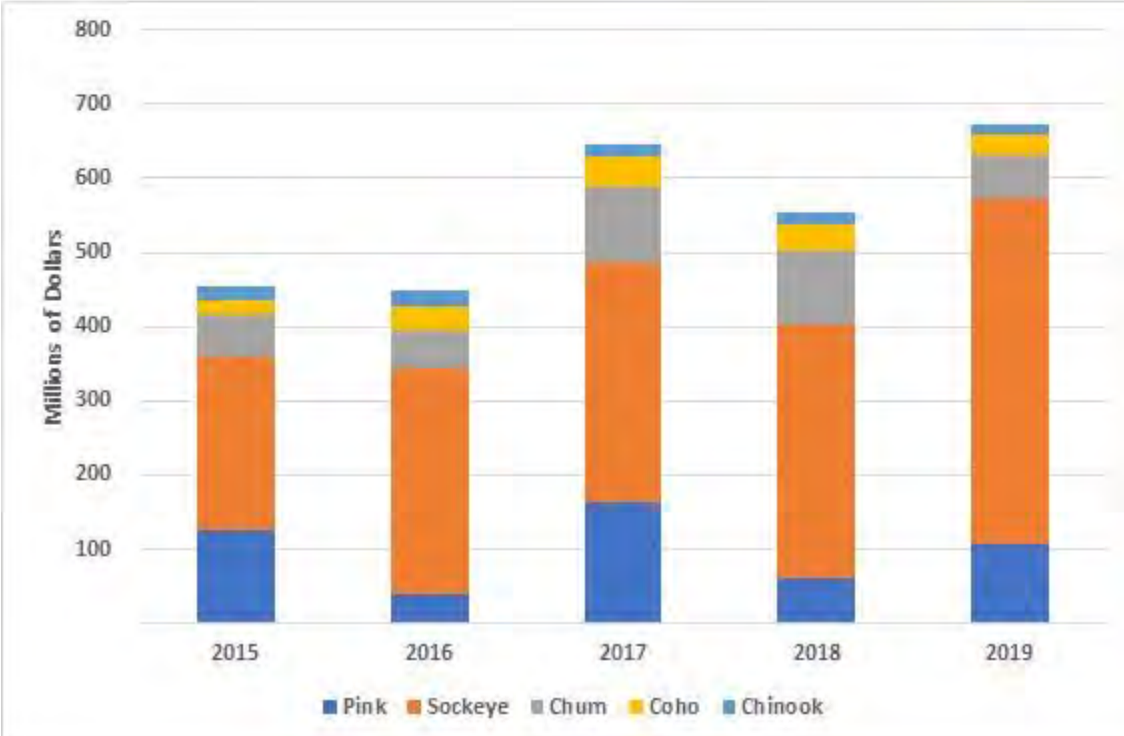

Figure 3.11-9: 2015–2019 Commercial Salmon Harvest Value by Species in Alaska State Waters

Pacific Herring

Pacific herring is the only commercially harvested forage fish species in Alaska. Forage fish are ecologically important as both consumers of zooplankton, and as prey for fish, seabirds, and marine mammals (McGowan et al., 2019). According to the ADFG, all commercial herring fishing occurs in inlets, sounds, and bays, all of which are located well within 12 NM of the coast and thus do not overlap with the TMAA (Alaska department of Fish and Game, 2016).

3.11.1.1.2.2 Recreational Fishing

The status and projected trends of socioeconomic resources described in this section represent the affected environment prior to the global coronavirus pandemic and subsequent dramatic declines in economies around the world, including in the United States. State and local governments either limited business operations or mandated the closure of certain businesses across multiple economic sectors. The travel and tourism industry, which many people in the Gulf of Alaska are dependent on for employment and income, has been particularly hard hit. The analysis in this section shows that training activities would not significantly impact tourism and related recreational activities in the Study Area. Tourism in the GOA has grown consistently in recent years, adapting to fluctuations in domestic and international travel, and in concert with ongoing training activities.

Recreational fishing is defined for the purposes of this discussion as charter fishing and fishing for purposes other than commercial benefit or subsistence. According to Alaska Department of Commerce's *Economic Impact of Alaska's Visitor Industry* (2018), the second-largest contributor of direct visitor industry revenues to the Alaska state government in 2017 was from fishing licenses and tags, valued at $25.5 million. As shown in Figure 3.11-10, there has been an overall downward trend in recreational catch since 2010, as well as a decrease in recreational value for fish species other than salmon caught recreationally (Figure 3.11-11) (Alaska Department of Fish and Game, 2020a). These decreases, primarily in Chinook salmon catches, are largely attributed to strict fishery management in many parts of Alaska as a result of low juvenile recruitment (Alaska Department of Fish and Game, 2019a). Despite the stricter fishery management and downward trend of recreational fishing catch, Alaska state income from recreational fishing has been stable since the release of the 2016 GOA Final SEIS/OEIS (Alaska Department of Commerce, 2018). In addition to this, only a small northwest portion of the TMAA is located in an on-shelf environment. Recreational and commercial fishing of salmonids is concentrated in on-shelf and river environments near the coast or inland.

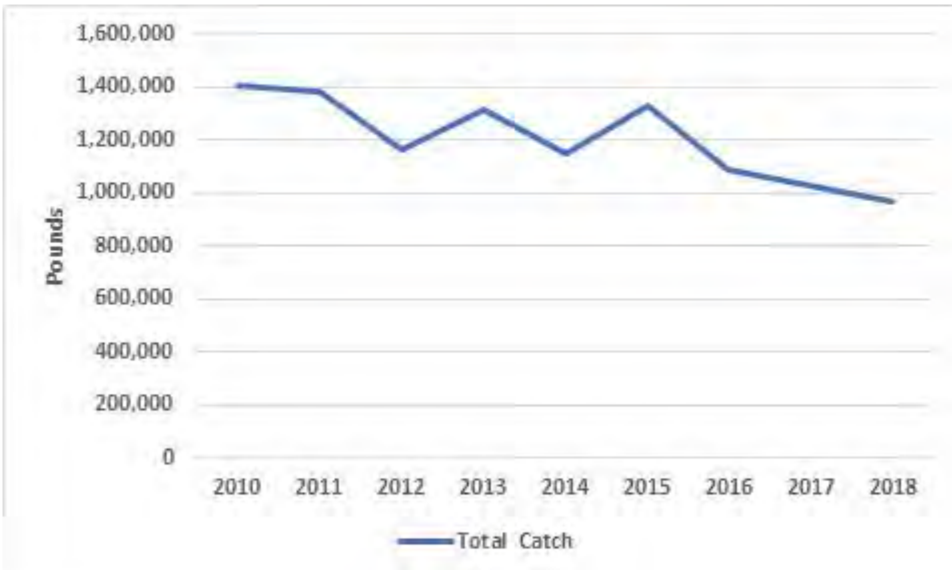

Figure 3.11-10: 2010–2018 Total Catch Estimates for Recreational Marine Fishing in Alaska State Waters

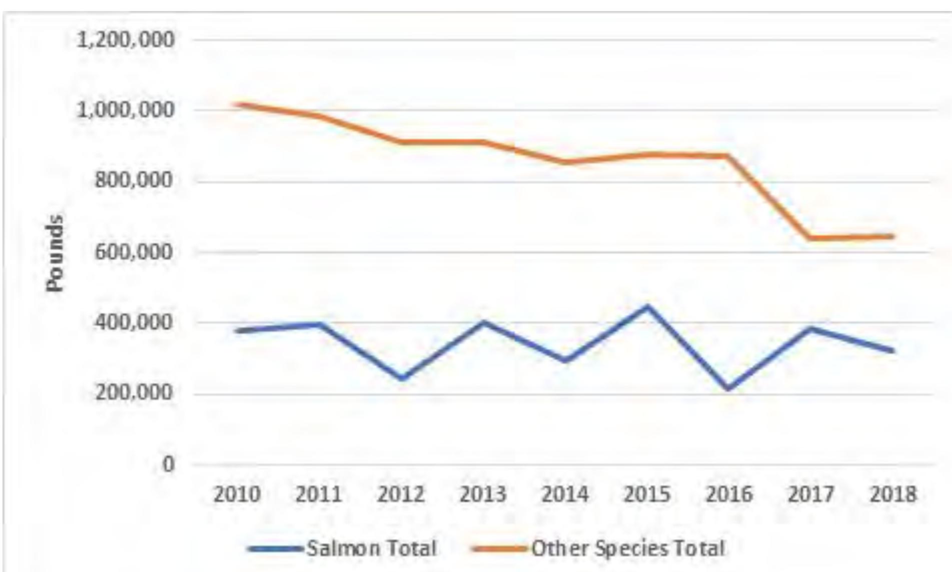

Figure 3.11-11: 2010–2018 Total Catch Estimates for Ocean Salmon and Other Fish Species in Alaska State Waters

3.11.1.1.3 Tourism and Recreation

Tourism and recreation were described and analyzed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Areas around the TMAA on the Kenai Peninsula, Kodiak Island, Prince William Sound, and Resurrection Bay are used for tourism and recreation. In 2018, over 2 million tourists visited Alaska between May and September alone. The Alaska Department of Commerce's Economic Impact of Alaska's Visitor Industry (2018) does not list Navy activities as a source of decreased tourism volume of revenue. Summer tourism rates for Alaska have increased steadily since 2010, increasing by a total of 32 percent from 2010 to 2018 (McDowell Group, 2019). Cruises account for more than half of the number of visitors to Alaska annually, making it one of the most popular tourism activities in the state (McDowell Group, 2019).

There were 68,616 recreational vessels (motorized and non-motorized) registered in the state of Alaska in 2018 (Alaska Division of Motor Vehicles, 2018). Since the release of the 2016 GOA Final SEIS/OEIS the number of registered recreational vessels decreased by 1,528 or 2.2 percent. The decreasing trend in vessel registrations, a proxy for recreational vessel use, is relatively small.

Overall, recreation and tourism in Alaska has increased steadily since the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS were released. Although tourism rates have been steadily increasing since 2010, the information and analysis presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remains valid, because the majority of tourism activities would not use waters in the TMAA, and the proposed training activities would be unlikely to occur in the same place and at the same time as recreational activities.

3.11.1.2 Standard Operating Procedures and Mitigation Measures

As described in Section 2.3.3 (Standard Operating Procedures), the Navy implements standard operating procedures for safety and mission success, many of which are recognized as providing a benefit to socioeconomic resources. For example, the Navy schedules training activities to minimize conflicts with the use of sea space and airspace throughout the TMAA to ensure safety and avoid interaction with non-military activities (e.g., commercial and recreational fishing) during training. As described in Chapter 5 (Mitigation), the Navy also implements mitigation measures to avoid or reduce potential impacts on marine resources, including fishery resources that have a high socioeconomic value in the TMAA.

3.11.2 Alternatives Analysis

The Navy conducted a review of new literature, to include laws, regulations, and publications pertaining to socioeconomic resources (including transportation and circulation) and environmental justice. Based on the information presented above, new information relating to existing environmental conditions and socioeconomic trends was found; however, the new information does not indicate an appreciable change to the existing environmental conditions as described in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Additionally, no new information was found that indicates an appreciable change to the existing environmental conditions as they relate to environmental justice as described in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. As discussed in Section 1.3 (Proposed Action), the Proposed Action in this SEIS/OEIS is consistent with the Proposed Action from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. This SEIS/OEIS analyzes the impacts on socioeconomic resources from the Proposed Action under the No Action Alternative and Alternative 1 (the Proposed Action).

3.11.2.1 No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur in the TMAA, referred to as the TMAA. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing Navy training activities.

3.11.2.2 Alternative 1

Socioeconomic Resources

Alternative 1 for this SEIS/OEIS remains consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS.

No adverse impacts on commercial/recreational fishing, fisheries research/management, civilian access, or tourism would occur as a result of the activities proposed. Furthermore, after a review of the best available science, including but not limited to the National Marine Fisheries Service landings data, there is no science-based evidence that Navy activities in the TMAA have a significant effect on socioeconomic resources in the region. Commercial fishing is not expected to be significantly impacted because while some commercial fishing seasons may overlap with the maximum 21-consecutive-day training period during April–October, commercial fishing seasons that do conflict with this timeframe are typically longer than (at least double) the 21-day training period (Alaska Department of Fish and Game, 2020b). In addition to this, the TMAA is located far enough offshore (>12 NM) that it is not expected to significantly impact commercial and recreational fishing. Reasons for this include the following: (1) the largest commercial fishery in Alaska state waters, groundfish, is largely open year round, and groundfish species' seasons in regions that overlap or are adjacent to the TMAA that are not year round are over double the length of the 21-day window training activities could occur (Alaska Department of Fish and Game, 2020b); (2) the only fishing region, as defined by the ADFG, which allows crab harvesting and overlaps with the TMAA is the Kodiak region (Alaska Department of Fish and Game, 2020b), and the only crab season that overlaps with the window training activities could occur is Dungeness, which is a relatively shallow water, on-shelf, coastal fishery and has demonstrated to be healthy (Denning, 2020); (3) general areas of effort for the scallop fishery do not overlap the TMAA, and only a small portion of the Prince William Sound exploratory scallop fishing waters overlap the northern tip of the TMAA (Armstrong et al., 2019); (4) the Pacific herring fishery has no overlap with the TMAA (Alaska department of Fish and Game, 2016); and (5) the commercial and recreational salmon fisheries are concentrated near the coasts (<12 NM).

Based on the information presented above, the existing baseline conditions have not changed appreciably in the TMAA since the release of either the 2011 GOA Final EIS/OEIS or the 2016 GOA Final SEIS/OEIS. Further, no new Navy training activities are proposed in the TMAA; therefore, as determined in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, no significant impacts are expected to occur to socioeconomic resources under Alternative 1. Thus, a detailed re-analysis of this alternative with respect to socioeconomic resources (including transportation and circulation) is not warranted.

Environmental Justice

Alternative 1 for this SEIS/OEIS remains consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. The existing baseline conditions have not changed appreciably since the release of either the 2011 GOA Final EIS/OEIS or the 2016 GOA Final SEIS/OEIS. Furthermore, no new Navy training activities are proposed in the TMAA in this SEIS/OEIS. Given the geographic location of the TMAA (>12 NM offshore with no population centers), a detailed re-analysis of this alternative with respect to environmental justice is not warranted.

3.11.3 Conclusion

Socioeconomic Resources

As described above, there is new information on existing environmental conditions since the analysis in the 2016 GOA Final SEIS/OEIS. However, this new information does not significantly change the affected environment, which forms the environmental baseline of the analysis in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Additionally, no new activities are contemplated in the foreseeable future, as reflected in this SEIS/OEIS, that would significantly impact socioeconomic resources (including transportation and circulation) in the TMAA. Therefore, conclusions for socioeconomic resources made for Alternative 1 analyzed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remain unchanged in this SEIS/OEIS. There are no significant impacts related to socioeconomic resources (including transportation and circulation) that would occur. For a summary of effects of the action alternative on socioeconomic resources under both the NEPA and EO 12114, please refer to Table 3.12-1 in the 2011 GOA Final EIS/OEIS.

Environmental Justice

As described above, there is no information on existing environmental conditions that significantly changes the affected environment, which forms the environmental baseline of the analysis in the 2011 GOA Final EIS/OEIS and 2016 GOA Final EIS/OEIS. Additionally, the geographic location of the TMAA is offshore with no population centers, and no new Navy training activities are being proposed in this SEIS/OEIS, so there would be no disproportionately high and adverse human health or environmental effects on any minority populations and low-income populations. Therefore, conclusions for environmental justice made for Alternative 1 in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remain unchanged in this SEIS/OEIS. For a summary of effects of the action alternative on environmental justice under both the NEPA and EO 12114, please refer to Table 3.13-1 in the 2011 GOA Final EIS/OEIS.

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4 Cumulative Impacts

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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4 Cumulative Impacts

This chapter (1) defines cumulative impacts; (2) describes past, present, and reasonably foreseeable future actions relevant to cumulative impacts; (3) analyzes the incremental interaction the Proposed Action may have with other actions with coincidental effects; and (4) evaluates cumulative impacts potentially resulting from these interactions of the coincidental effects on the same environmental resource. For this Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS), the approach to analysis of cumulative impacts has changed since the 2011 Gulf of Alaska (GOA) United States (U.S.) Department of the Navy (Navy) Training Activities Final Environmental Impact Statement (EIS)/OEIS and the 2016 GOA Navy Training Activities Final SEIS/OEIS. An explanation of the updated analysis is provided below.

4.1 Definition of Cumulative Impacts

The approach taken in the analysis of cumulative impacts follows the objectives outlined in the Office of the Chief of Naval Operations's *Environmental Readiness Program Manual* section 10-5.17.c. This section states that "Cumulative impacts (NEPA) result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (U.S. Department of the Navy, 2019). This analysis does not incorporate by reference the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011) nor the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016), but rather builds upon it for an updated look at cumulative impact potential.

4.2 Scope of Cumulative Analysis

The scope of the cumulative impacts analysis involves both the geographic extent of the effects and the temporal (relating to time) extent in which the coincidental effects could be expected to occur.

The geographic boundaries for the cumulative impacts analysis included the entire GOA Navy Training Activities SEIS/OEIS Temporary Maritime Activities Area (TMAA). In general, the TMAA includes those areas previously identified in Chapter 3 (Affected Environment and Environmental Consequences) and is the same TMAA as described in the 2011 GOA Final EIS/OEIS and in the 2016 GOA Final SEIS/OEIS. The geographic boundaries for cumulative impacts analysis for marine mammals were expanded to include activities outside the GOA SEIS/OEIS TMAA that might impact migratory marine mammals. Primary considerations from outside the TMAA include impacts associated with maritime traffic (e.g., vessel strikes and underwater noise) and commercial fishing (e.g., bycatch and entanglement).

The time frame for cumulative impacts centers on the timing of the Proposed Action (see Chapter 2, Description of Proposed Action and Alternatives). The Proposed Action would occur over a maximum time period of up to 21 consecutive days during the months of April–October annually. While Navy training requirements change over time in response to global events, geopolitical events, or other factors, the general types of activities addressed by this SEIS/OEIS are expected to continue into the reasonably foreseeable future, along with the associated impacts. Likewise, some non-military activities addressed in this cumulative impacts analysis (e.g., oil and gas production, maritime traffic, commercial fishing) are expected to continue into the reasonably foreseeable future. Therefore, the cumulative impacts analysis is not bounded by a specific future timeframe. For past actions, the cumulative impacts analysis only considers those actions or activities that have ongoing impacts.

Another factor influencing the scope of cumulative impacts analysis involves identifying other actions to consider. In addition to identifying the geographic scope and time frame for the previously completed and currently ongoing actions, the analysis also includes the identification of "reasonably foreseeable" actions (i.e., anticipated future actions). For the purposes of this analysis, public documents prepared by federal, state, and local government agencies form the primary sources of information regarding reasonably foreseeable actions. Documents used to identify other actions include notices of intent for EISs and Environmental Assessments, management plans, land use plans, and other planning related studies. Finally, local websites for local news outlets were searched for articles pertaining to ongoing and future actions that would need to be included in this analysis.

4.3 Past, Present, and Reasonably Foreseeable Actions

This section focuses on past, present, and reasonably foreseeable future actions that occur within or potentially impact resources analyzed in the TMAA. Using the first fundamental question included in Section 4.1 (Definition of Cumulative Impacts), in determining which projects to include in the cumulative impacts analysis, a preliminary determination was made regarding each past, present, or reasonably foreseeable action as to whether a relationship exists such that the affected resource areas of the Proposed Action (included in this SEIS/OEIS) might interact with the affected resource area of a past, present, or reasonably foreseeable action. If no such potential relationship exists, the action was not carried forward into the cumulative impacts analysis. In accordance with CEQ guidance these actions considered but excluded from further cumulative effects analysis are not catalogued here because the intent is to focus the analysis on the meaningful actions relevant to inform decision making (Council on Environmental Quality, 2005). Actions included in this cumulative impacts analysis were determined to affect resource areas that the Proposed Action would also cumulatively affect and are listed and briefly described in Table 4.3-1.

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Offshore Power Generation						
Marine Hydrokinetic Projects	Kvichak River, Alaska	The Federal Energy Regulatory Commission issues permits for marine and hydrokinetic projects. There is currently one licensed hydrokinetic project in Alaska on the Kvichak River. While this river is not a part of the GOA watershed, this project may have cumulative impacts on sediments and water quality, marine habitats, fishes, and socioeconomic resources and environmental justice (Federal Energy Regulatory Commission, 2019).		O	O	O
Yakutat Alaska Wave Energy Project	Yakutat, Alaska	This project has undergone a feasibility study and is currently being looked at by students at the University of Alaska Fairbanks. There are no confirmed plans to begin construction, but if feasible the city of Yakutat would like to proceed with this alternate power source (Grassi, 2019). This project could have cumulative effects on air quality, sediments and water quality, fishes, marine mammals, and socioeconomic resources and environmental justice.	If this project is implemented it would reduce the amount of diesel used by the city to generate electricity.		X	X

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	***Location***	***Project Description***	***Summary of Impact Minimization and Mitigation Measures***	***Project Timeframe C=Construction O=Operation X=Other***		
				Past	***Present***	***Future***
Hilcorp's Liberty Project - First Oil Production Facility in Federal Waters Offshore Alaska	Beaufort Sea	The Bureau of Ocean Management released an EIS in 2018 following the U.S. Secretary of the Interior's announcement that oil and gas production in federal waters offshore the state of Alaska would be granted. The EIS examined the potential environmental impacts of Hilcorp's proposal, and looked at a range of alternatives (U.S. Department of the Interior, 2018). The implementation of the proposed action in this EIS, including construction and operational procedures, could have cumulative effects on air quality, sediments and water quality, fishes, marine mammals, and socioeconomic resources and environmental justice.		X	X	C/O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Restoration, Research, and Conservation Projects and Programs						
Alaska Groundfish Harvest Specifications EIS	Bering Sea, Aleutian Islands, and Gulf of Alaska groundfish fisheries	This EIS provides information on the harvesting strategies of the groundfish fisheries in the GOA, which is a federally managed fishery (National Marine Fisheries Service, 2007). Operations carried out under this EIS could have cumulative effects on sediments and water quality, fishes, and socioeconomic resources and environmental justice.	This document defines where and how groundfish fisheries can be cultivated, thus reducing overfishing.	O	O	O
Alaska Groundfish Fisheries Programmatic SEIS	Bering Sea, Aleutian Islands, and Gulf of Alaska groundfish fisheries	This Programmatic SEIS assesses the past, present, and future environmental impacts of the Alaska groundfish fishery management practices (National Marine Fisheries Service, 2015). Operations carried out under this Programmatic SEIS could have cumulative effects on sediments and water quality, fishes, and socioeconomic resources and environmental justice.		O	O	O
Cook Inlet Beluga Whale Subsistence Harvest – Final SEIS	Cook Inlet, Alaska	This SEIS is intended to specify Beluga whale harvest limits “to recover the Cook Inlet beluga stock and to fulfill the Federal Government’s trust responsibility to recognize Alaska Native traditional cultural and nutritional needs for subsistence harvest” (National Marine Fisheries Service, 2015). Operations carried out under this SEIS could have cumulative effects on sediments and water quality, marine mammals, and socioeconomic resources and environmental justice.	This document defines the number of Belugas that may be harvested by local tribes, setting a limit that National Marine Fisheries Service (NMFS) determines will not pose a long-term threat to the species.	O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Final EIS for Essential Fish Habitat Identification and Conservation in Alaska	Entire TMAA	This EIS provides information about describing and identifying Essential Fish Habitat (EFH) and habitats of Particular Concern in Alaska to aid in expanding necessary closures of EFH (National Marine Fisheries Service, 2005). Operations carried out under this EIS could have cumulative effects on sediments and water quality, fishes, and socioeconomic resources and environmental justice.	This document outlines procedures for identifying EFH, which can allow for further closures and protection of EFH from fishing.	O	O	O
Gulf Watch Alaska Monitoring Plan	Prince William Sound, lower Cook Inlet, outer Kenai Peninsula coast	This project is a long-term monitoring program looking at the effects of the Exxon Valdez oil spill and the GOA, which will help the Navy detect change in the TMAA on resources affected by the oil spill (Batchelder, 2019). This project could have cumulative effects on sediments and water quality, fishes, birds, marine mammals, and public health and safety.	Knowledge of long-term effects of the Exxon Valdez oil spill will aid the Navy and other entities operating in the GOA to reduce further impacts on environmental resources.	O	O	O
Alaska Aerospace Corporation Kodiak Launch Complex	Kodiak, Alaska	The Alaska Aerospace Corporation Kodiak Launch Complex is to be issued regulations from NMFS to take species of marine mammals that may be impacted by space vehicle and missile launch. The period of regulation from NMFS is 2017–2022 and will include issuance of Letters of Authorization (82 Federal Register 14996). This may have cumulative impacts on air quality, marine mammals, birds, and socioeconomic resources and environmental justice.	The NMFS permitting process will allow for a certain amount of incidental marine mammal takes and has the ability to stop further actions taken by the Alaska Aerospace Corporation Kodiak Launch Complex should the limit be reached.	O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	***Location***	***Project Description***	***Summary of Impact Minimization and Mitigation Measures***	***Project Timeframe C=Construction O=Operation X=Other***		
				Past	***Present***	***Future***
Bureau of Safety and Environmental Enforcement, Alaska Region promotion of safety, protection of the environment, and conservation of resources through vigorous regulatory oversight and enforcement	Arctic Ocean, Bering Sea, and the northern Pacific Ocean	The Bureau of Safety and Environmental Enforcement, Alaska Region, has regulatory oversite and enforcement responsibility for more than one billion acres on the Outer Continental Shelf and more than 6,000 miles of the Alaskan coastline. Currently there is an active lease in the Beaufort Sea. This may have cumulative effects on sediments and water quality, marine habitats, marine vegetation, marine invertebrates, fishes, marine mammals, and birds.		O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	***Location***	***Project Description***	***Summary of Impact Minimization and Mitigation Measures***	***Project Timeframe C=Construction O=Operation X=Other***		
				Past	***Present***	***Future***
Oceanographic Research	All of TMAA and open ocean areas	There are currently scientific research permits and General Authorizations for research issued by NMFS for cetacean work in the North Pacific. Scientific research permits allow for tagging, biopsy, vessel and aerial surveys, and photo-identification; General Authorizations allow commercial photography of non-listed marine mammals. As of November 2019, the Bureau of Ocean Energy Management has no active survey permits in the Alaskan region. Their last permit was completed on October 31, 2019 and was for a 3D Marine Seismic Survey (Bureau of Ocean Energy Management, 2013). This research could have cumulative impacts on sediments and water quality, marine habitats, marine vegetation, marine invertebrates, fishes, and marine mammals.	Given the analysis and scrutiny given to permit applications, it is assumed that any adverse effects are largely transitory. Data to assess population-level effects from research are not currently available, and it is uncertain that research effects could be separately identified from other adverse effects on populations in the TMAA.	O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Academic Research	All of the TMAA and open ocean areas	The University of Alaska Anchorage devotes sponsored programs and research to special concerns and opportunities associated with northern populations. Research areas include public decision making, ecosystem studies and conservation biology, earth and climate processes, human ecology and coupled human-environment interactions, health research, behavioral and physical health, biomedical programs, and rural health issues. The continuation of academic research in the Gulf of Alaska, open oceans, and on land could have cumulative effects on marine vegetation, marine invertebrates, fishes, marine mammals, and birds.	Given the analysis and scrutiny given to permit applications, it is assumed that any adverse effects are largely transitory. Data to assess population-level effects from research are not currently available, and it is uncertain that research effects could be separately identified from other adverse effects on populations in the TMAA.	O	O	O
Exon Valdez Oil Spill Trustee Council	Gulf of Alaska	The Trustee Council was formed to oversee restoration of the injured ecosystem through the use of the $900 million civil settlement (Exxon Valdez Oil Spill Trustee Council, n.d.). Actions of the Exxon Valdez Oil Spill Trustee Council could have cumulative effects on sediments and water quality, marine habitats, marine vegetation, marine invertebrates, fishes, marine mammals, birds, and public health and safety.	In fiscal year (FY) 2019 alone there were 27 active monitoring, research, general restoration, and public information, science management, and administration projects dedicated to aiding in gathering information and remedying long-term effects of the Exxon Valdez oil spill (Exxon Valdez Oil Spill Trustee Council, 2019).	O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Alaska Marine Conservation Council	North East Pacific	This council has 8 active conservation projects dedicated to maintaining Alaska's fisheries. The projects enacted by this council could have cumulative effects on sediments and water quality, fishes, and socioeconomic resources and environmental justice (Alaska Marine Council, n.d.).	The projects enacted by this council help to collect data, pass litigation, and promote healthy fishing practices in the Northeast Pacific.	O	O	O
Ocean Acidification Program (OAP) – Gulf of Alaska	Gulf of Alaska and Bering Sea	National Oceanic and Atmospheric Administration's (NOAA's) OAP projects in the GOA and Bering Sea focus on the effects of ocean acidification and its effects on marine life. There are currently 6 active projects (National Ocean and Atmospheric Administration, 2018). The active projects enacted by the OAP could have cumulative effects on sediments and water quality, marine habitats, marine vegetation, marine invertebrates, fishes, and marine mammals.		O	O	O
North Pacific Research Board	Gulf of Alaska	The North Pacific Research Board has four research and monitoring programs centered around producing peer-reviewed research on the Gulf of Alaska, Bering Sea/Aleutian Islands, and the Arctic Ocean ecosystems. The projects enacted by the North Pacific Research Board could have cumulative effects on sediments and water quality, marine habitats, marine vegetation, marine invertebrates, fishes, and marine mammals.	Research from the North Pacific Research Board has been used to help guide fishery management, ultimately aiding in sustaining fisheries.	O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	***Location***	***Project Description***	***Summary of Impact Minimization and Mitigation Measures***	***Project Timeframe C=Construction O=Operation X=Other***		
				Past	***Present***	***Future***
Other Military Activities						
Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar Draft SEIS/OEIS	Western and Central North Pacific and Eastern Indian Oceans	The Navy released a Draft SEIS/OEIS for SURTASS LFA Sonar in 2018 to continue to train with low-frequency sonar with its four surveillance ships. The training occurs outside of the TMAA (U.S. Department of the Navy, 2018). This project could have cumulative effects on fishes and marine mammals.	Under the Navy's preferred alternative, the number of hours the Navy could train SURTASS LFA would decrease from 1,020 to 496 hours per year. However, for the foreseeable future the Navy would increase training by approximately 100 hours every 5 years.	O	O	O
EIS for the Modernization and Enhancement of Ranges, Airspace, and Training Areas in the Joint Pacific Alaska Range Complex (JPARC) in Alaska	JPARC	This EIS proposed to modernize and enhance the JPARC to enable realistic joint training for the Army, Navy, Marine Corps, and Air Force. The proposed modernization could have cumulative effects on all resource categories.		O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Naval Special Warfare Maritime Training Activities – 2014 Programmatic Environmental Assessment (EA)	Kodiak Island	A thorough description of Naval Special Warfare Maritime Training Activities can be found in the 2011 GOA Final EIS/OEIS. The 2014 Programmatic EA was finalized with a Finding of No Significant Impact (FONSI) in 2015 (U.S. Department of Homeland Security & United States Coast Guard, 2014). Based on the analysis in this document and the FONSI, it is unlikely any significant effects would arise from the actions of the Naval Special Warfare Maritime Training. However, the actions described in this programmatic EA could contribute to cumulative effects on public health and safety.		O	O	O
United States Coast Guard						
North Pacific Regional Fisheries Training Center	Kodiak, Alaska	The United States Coast Guard (USCG) training center located in Kodiak, Alaska, instructs 13 different courses to 750–1,000 students per year. Instruction includes fisheries-related topics, both international and domestic. This training center's operation could have cumulative effects on fishes and socioeconomic resources and environmental justice.		O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Draft Programmatic EA Arctic Operations and Training Exercises Alaska	Above the Arctic Circle – Proposed Forward Operating Locations are Barrow, Nome, Kotzebue, and Port Clarence, Alaska	The Proposed Action is to conduct increased operations and training exercises in the Arctic to meet USCG mission responsibilities due to the increase of national and international activities in the area. This would provide a shore, air, and sea Coast Guard presence to meet the seasonal surge mission requirements, typically mid-March through mid-November. The Preferred Alternative consists of five main elements, including shore operations, air operations, sea operations, training operations, and building partnerships (U.S. Department of Homeland Security & United States Coast Guard, 2014). The actions taken by the USCG could have cumulative effects on public health and safety.		O	O	O
Environmental Regulations and Planning						
A Climate Science Regional Action Plan for the Gulf of Alaska	Gulf of Alaska	This NOAA Technical Memorandum aims to meet the demand for scientific information to prepare for and respond to climate impacts on the Nation's living marine resources and resource-dependent communities (Dorn et al., 2018). The contents of this document could have cumulative effects on all environmental resources analyzed in this SEIS/SOEIS except for cultural resources.	This document addresses some of the biggest factors contributing to and dangers of climate change. The purpose of this document is to aid federal and non-federal entities to take actions to reduce their contribution to climate change.	X	X	X

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Other Environmental Considerations						
Commercial and Recreational Fishing	All of the TMAA and open ocean areas	Commercial and recreational fishing constitutes an important and widespread use of the ocean resources throughout the TMAA. Potential impacts of fishing include overfishing of targeted species, bycatch, entanglement, and habitat destruction, all of which negatively affect fish stocks and other marine resources. Fisheries bycatch has been identified as a primary driver of population declines in several marine species, including sharks, mammals, seabirds, and sea turtles (Simkins, 2019). The continuation of commercial and recreational fishing throughout the TMAA and open ocean could have cumulative effects on sediments and water quality, marine invertebrates, fishes, marine mammals, birds, and socioeconomic resources and environmental justice.		O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Maritime Traffic	All of the TMAA and open ocean areas	In 2020, cruise ship passengers are expected to follow an upward trend of the past 5 years and grow by an additional 6% (The Associated Press, 2019). Ferries, passenger vessels with overnight accommodations, and cruise ships comprise 68% of the vessel activity, although cruise ships only operate during a 5-month period from May through September. Dry freight cargo barges, tank barges, and freight ships comprise the other 32% of the vessel activity (Alaska Department of Environmental Conservation, 2012). The Alaska Marine Highway is a ferry service operated by the State of Alaska, headquartered in Ketchikan, Alaska. Primary concerns for this cumulative impact analysis include vessel strikes on marine mammals, introduction of non-native species through hull fouling and ballast water, and underwater sound from ships and other vessels. The continued maritime traffic in and around the GOA could result in cumulative effects on air quality, sediments and water quality, fishes, marine mammals, and socioeconomic resources and environmental justice.		O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Knik Arm Crossing	Cook Inlet Knik Army	This project is currently dormant, with many opposing it. The project was scheduled to originally begin in 2013 but was postponed indefinitely due to funding issues. If this project resumes it could have a cumulative effect on fishes, marine mammals, and public health and safety during construction, along with a cumulative effect on socioeconomic resources and environmental justice after its completion and during its operation (KnikBridgeFacts.org, 2019).				C/X
Port MacKenzie Development	Cook Inlet along the Knik Arm	According to the 2016 update of the 2011 Port MacKenzie Master Plan, the mission of the port's owner, Matanuska-Susitna Borough, is to "develop a premier deep-water port capable of safely and efficiently transporting bulk commodities and project cargoes into and out of Southcentral Alaska" (Matanuska-Susitna Borough, 2016). This project could potentially have cumulative effects on sediments and water quality, fishes, marine mammals, socioeconomic resources and environmental justice, and public health and safety.		C/O	C/O	C/O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	***Location***	***Project Description***	***Summary of Impact Minimization and Mitigation Measures***	***Project Timeframe C=Construction O=Operation X=Other***		
				Past	***Present***	***Future***
Port of Alaska (formerly the Port of Anchorage) Expansion	Port of Alaska	The Port of Alaska is currently looking to begin infrastructure improvements again after a failed first attempt ended in 2010. The project is estimated to cost $2 Billion (Brehmer, 2019). This project could potentially have cumulative effects on sediments and water quality, fishes, marine mammals, socioeconomic resources and environmental justice, and public health and safety.				X
Shoreline Development	Northern coastline of Gulf of Alaska	Shoreline development adjacent to the TMAA is prompted for commercial, industrial, transportation and circulation, and residential purposes. The TMAA also includes coastal tourism development and the infrastructure supporting coastal development; however, the TMAA is greater than 12 nautical miles off the coast of Alaska. Shoreline development could have a cumulative impact on air quality, sediments and water quality, birds, socioeconomic resources and environmental justice, and public health and safety.		C/O	C/O	C/O
ShoreZone – NOAA's 5-Year Plan for the Alaska Shore Zone Program	Beaufort Sea, Chukchi Sea	This document is used to guide ShoreZone's strategic planning for FY 2017-2021 including, but not limited to, expansion of ShoreZone data (ShoreZone, 2019). The actions taken by ShoreZone could have cumulative effects on birds and socioeconomic resources and environmental justice.	Expansion of ShoreZone data will help aid federal and non-federal entities in reducing impacts on environmental resources from actions carried out in Alaska's marine and nearshore environment.	O	O	O

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Ocean Noise	All of TMAA and open ocean areas	Anthropogenic sources of noise that are most likely to contribute to increases in ocean noise are vessel noise from commercial shipping and general vessel traffic, oceanographic research, oil and gas exploration, underwater construction, and naval and other use of sound navigation and ranging (sonar). Appendix B (Acoustic and Explosive Concepts) provides additional information about sources of anthropogenic sound in the ocean and other background information about underwater noise. Ocean noise from non-Navy anthropogenic sources could have an effect on fishes, marine mammals, and birds.	Navy vessels during a Carrier Strike Group exercise are a small, infrequent, and short duration component of overall vessel noise in Gulf of Alaska. In addition, Navy combatant vessels have been designed to generate minimal noise and use ship quieting technology to elude detection by enemy passive acoustic devices (Mintz & Filadelfo, 2011; Southall et al., 2005).	X	X	X

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	***Location***	***Project Description***	***Summary of Impact Minimization and Mitigation Measures***	***Project Timeframe C=Construction O=Operation X=Other***		
				Past	***Present***	***Future***
Ocean Pollution, Tsunami Debris, and Other Marine Debris in Alaska	All of the TMAA and open ocean areas	Ocean pollution has and will continue to have serious impacts on marine ecosystems. The government of Japan estimates that 5 million tons of debris was swept into the Pacific Ocean after the March 2011 earthquake and tsunami that struck Japan. Some of this debris has reached the Alaskan coast. Plastic marine debris is a major concern because it degrades slowly, is consumed by fish, and many plastics float, allowing the debris to be transported by currents throughout the oceans. Sunken debris contributes to marine habitat degradation and are also a concern for ingestion and entanglement. This issue could have cumulative effects on sediments and water quality, marine habitats, marine vegetation, marine invertebrates, fishes, marine mammals, birds, and public health and safety.	The National Oceanic and Atmospheric Administration works closely with state agencies and local authorities to systematically survey Alaska's coast. NOAA models predict an increase in debris in the next several years; however, very little is anticipated to be hazardous.	X	X	X

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	***Location***	***Project Description***	***Summary of Impact Minimization and Mitigation Measures***	***Project Timeframe C=Construction O=Operation X=Other***		
				Past	***Present***	***Future***
Non-Point Sources, Point Sources, and Atmospheric Deposition	All of the TMAA and open ocean areas	Storm water runoff, wastewater, and nonpoint source pollution, are considered major causes of impairment of ocean waters. Hypoxia (low dissolved oxygen concentration) occurs when waters become overloaded with nutrients. Too many nutrients can ultimately cause dissolved oxygen in the water to decline to the point where marine life that depends on oxygen can no longer survive (Boesch et al., 1997). According to *Our Nation's Air*, published by the U.S. Environmental Protection Agency (2019), criteria air pollutants (refer to Section 3.1, Air Quality, of the 2011 GOA Final EIS/OEIS for a list of criteria air pollutants) have been steadily decreasing since 1990. Non-Point Sources, Point Sources, and Atmospheric Deposition could have a cumulative effect on air quality, sediments and water quality, marine habitats, marine vegetation, marine invertebrates, fishes, marine mammals, birds, and public health and safety.	The trend in decreasing criteria pollutant emissions is predicted to continue with the help of the Environmental Protection Agency's regulations.	X	X	X

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	*Location*	*Project Description*	*Summary of Impact Minimization and Mitigation Measures*	*Project Timeframe C=Construction O=Operation X=Other*		
				Past	*Present*	*Future*
Marine Tourism	All of the TMAA and open ocean areas	The coast and some major rivers are the center of Alaska's tourism. The Alaska Railroad Corporation, fish and game licenses/tags, and commercial passenger vessels (cruise ships) made up the 3 largest sources of state revenue in Alaska, according to the Alaska Department of Commerce (Alaska Department of Commerce, 2018). From 2008 to 2017 there was an increase of 20%, 32%, and 32% to the amount of jobs, labor income, and economic output of Alaska's visitor industry, respectively (Alaska Department of Commerce, 2018). Marine tourism is essential to Alaska's growing economy and could have cumulative effects on sediments and water quality, marine habitats, marine vegetation, marine invertebrates, fishes, marine mammals, birds, cultural resources, and socioeconomic resources and environmental justice.		O/X	O/X	O/X
Port on Nome Modification	Bering Sea	In May 2019 a Draft Integrated Feasibility Report and EA and Draft FONSI was released that presented several alternatives to facilitate the modification of the Port of Nome to better handle commerce, national security, and recreational usage (U.S. Army Corps of Engineers, 2019). Modification of the Port of Nome could have cumulative impacts on air quality, sediments and water quality, fishes, marine mammals, socioeconomic resources and environmental justice, and public health and safety.		X	X	C

Table 4.3-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis (continued)

Project	***Location***	***Project Description***	***Summary of Impact Minimization and Mitigation Measures***	***Project Timeframe C=Construction O=Operation X=Other***		
				Past	***Present***	***Future***
Alaska Deep-Draft Arctic Port System Study	Bering Sea and Gulf of Alaska	This project looks at optimizing several ports in Northern Alaska to prepare for more resource extraction and shipping in the Arctic as the open sea season expands. As of 2015 there has been a Draft Integrated Feasibility Report, Draft EA, and Draft FONSI released by the U.S. Army Corps of Engineers, with a final soon to be released (Battelle, 2015). If this project moves forward it could have a cumulative effect on air quality, sediments and water quality, fishes, marine mammals, socioeconomic resources and environmental justice, and public health and safety.		X	X	C/X
The Pebble Project	Iliamna, Iliamna Lake, and Cook Inlet	The U.S. Army Corps of Engineers released a Draft EIS in 2019 regarding Pebble Limited Partnership's proposal to develop the Pebble copper-gold-molybdenum porphyry deposit (Pebble Deposit) as an open-pit mine, with associated infrastructure, in southwest Alaska. The proposed action would include ferrying resources extracted from the mine through Iliamna lake and the Cook Inlet (The Pebble Partnership, 2018). This project could have cumulative effects on air quality, sediments and water quality, and socioeconomic resources and environmental justice.		X	X	C/O

Notes: EIS = Environmental Impact Statement, OEIS = Overseas Environmental Impact Statement, SEIS = Supplemental Environmental Impact Statement, GOA = Gulf of Alaska, U.S. = United States, Navy = U.S. Department of the Navy, TMAA = Temporary Maritime Activities Area.

4.4 Resource-Specific Cumulative Impacts

In accordance with CEQ Guidance (Council on Environmental Quality, 1997), the following cumulative impacts analysis focuses on impacts that are "truly meaningful." The level of analysis for each resource is commensurate with the intensity of the impacts identified in Chapter 3 (Affected Environment and Environmental Consequences) and the level to which impacts from the Proposed Action are expected to mingle with similar impacts from existing activities. A full analysis of potential cumulative impacts is provided for marine mammals. Rationale is also provided for an abbreviated analysis of the following resources: fishes, sea turtles, birds, and socioeconomic resources and environmental justice.

For air quality, sediments and water quality, marine habitats, marine vegetation, marine invertebrates, cultural resources, and public health and safety, the Navy determined that changes to the project and new research, literature, laws, and regulatory guidance addressed in this SEIS/OEIS resulted in little or no change to the findings of the impact analyses in the 2016 GOA Final SEIS/OEIS. There have been changes in some platforms and systems used as part of the proposed activities, but those changes would not affect the conclusions reached in the 2016 GOA Final SEIS/OEIS. Because the existing baseline conditions have not changed appreciably, and no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, the cumulative impact assessments from the 2016 GOA Final SEIS/OEIS in Chapter 4 (Cumulative Impacts) remain valid and are not described further in this SEIS/OEIS.

4.4.1 Fishes

The analysis presented in Section 3.6 (Fish) of the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS detailed the potential for impacts on fish from the various stressors related to Navy training activities. As discussed in Section 3.6 (Fishes) of this SEIS/OEIS, there have been no substantial changes to the activities analyzed in the previous 2011 GOA Final EIS/OEIS or 2016 GOA Final SEIS/OEIS that would change the conclusions reached regarding ESA-listed fish species, groundfish species, or Essential Fish Habitat in the TMAA. Analysis of cumulative impacts on fishes was specifically addressed in the 2011 GOA Final SEIS/OEIS (Section 4.2.6) with additional information provided in the 2016 GOA Final SEIS/OEIS (Chapter 4). However, new information since the 2016 GOA Final SEIS/OEIS suggests that additional ESA-listed salmonids and green sturgeon may occur in the TMAA. As such, it is important to re-evaluate cumulative effects to fishes and their habitat that may occur in relation to the Proposed Action.

Marine fishes and their habitat in the TMAA will continue to be threatened by commercial fishing, pollution, shipping, underwater noise, oil and gas development, disease, and climate change (Bureau of Ocean Energy Management, 2017; Melnychuk et al., 2013; Wisniewska et al., 2018). Many of these issues currently present threats but are expected to increase in the future (U.S. Fish and Wildlife Service, 2016). Further, as scientists increasingly link the ingestion of plastic chemicals with harmful health impacts, plastic debris potentially threatens ESA-listed fish which make up a portion of the commercial fisheries (Senate Hearing 114-390, 2016;Wilson, 2019). While it is not proven whether long-term climate change is driving the emergence of the Blob and other forms of climate variability in the GOA (such as El Niño and warm Pacific Decadal Oscillation phases), there is concern that eventually the long-term prevailing conditions will come to approximate effects on fisheries productivity (Johnson, 2016).

Many of the cumulative stressors identified in Section 4.4.9 (Birds) for birds also apply to fish. The aggregate impacts of past, present, and reasonably foreseeable future actions, including those summarized in Table 4.3-1, may have a significant effect on fish. The Proposed Action could also result in injury, mortality, or behavioral impacts to some individual fish from explosive ordnances. However, the percentage of any ESA-listed Evolutionarily Significant Unit or Distinct Population Segment that is expected to be injured or killed from these activities is expected to be very low and similar to that described in the 2017 National Marine Fisheries Service (NMFS) Biological Opinion. Injury and mortality that might occur under the Proposed Action would be additive to injury and mortality associated with other actions. However, there is no evidence indicating that the combined noise of other anthropogenic noise-generating activities would result in harmful additive impacts on fish. Further, there are no data indicating that a fish affected by ocean pollution would be more susceptible to stressors associated with the Proposed Action.

In summary, based upon the analysis in Section 3.6 (Fishes), and the reasons summarized above, the incremental contribution of the Proposed Action to cumulative impacts on fish populations and their habitat would be low. Therefore, further analysis of cumulative impacts on fish is not warranted. Continued fisheries harvest management and habitat protection are crucial to ensure that fish resources are effectively managed in the GOA and TMAA.

4.4.2 Sea Turtles

No new Navy training activities are being proposed in this SEIS/OEIS. The Navy Acoustic Effects Model was used to quantitatively estimate potential impacts on leatherback sea turtles in the TMAA. No impacts on leatherback sea turtles were predicted. No other sea turtle species are expected to occur in the TMAA. Furthermore, conclusions for impacts on sea turtles, made for the alternatives analyzed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, remain unchanged in this SEIS/OEIS. Other projects proposed to occur within or near the TMAA may add to stressors on sea turtles in the TMAA; however, the Proposed Action would not contribute significantly to the cumulative impacts on sea turtles in the TMAA, as discussed in Section 3.7 (Sea Turtles). Therefore, as stated in the 2016 GOA Final SEIS/OEIS, detailed analysis of cumulative impacts on sea turtles is not necessary as the incremental contribution of the Proposed Action to cumulative impacts would be low and was assessed in the 2011 GOA Final EIS/OEIS.

4.4.3 Marine Mammals

The analysis presented in the 2016 GOA Final SEIS/OEIS detailed the potential for impacts on marine mammals from the various stressors related to Navy training and testing activities, and an updated analysis has been completed in this current SEIS/OEIS. As discussed in Section 3.8.3 (Environmental Consequences), in general there have been no substantial changes to the activities analyzed in the 2016 GOA Final SEIS/OEIS that would change the overall conclusions reached regarding populations of marine mammals in the TMAA. The current analysis has incorporated all applicable new marine mammal science, thresholds and criteria, and methods of determining potential effects that have emerged since 2016. Analysis of cumulative impacts on marine mammals was specifically addressed in the 2016 GOA Final SEIS/OEIS Section 4.4.3.4 (Cumulative Impacts on Marine Mammals) and is also presented in the current SEIS/OEIS in Section 3.8.4 (Summary of Stressor Assessment [Combined Impacts of All Stressors] on Marine Mammals) with reference to new emergent applicable science available since the 2016 GOA Final SEIS/OEIS.

In association with the 2016 GOA Final EIS/OEIS, NMFS determined that within the TMAA, only acoustic stressors and explosive stressors could potentially result in harassment or the incidental taking of marine mammals from Navy training and testing activities (National Marine Fisheries Service, 2017b) and that none of the other stressors would result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Marine Fisheries Service, 2017a). In addition, NMFS determined that the vast majority of impacts expected from sonar exposure and underwater detonations are behavioral in nature, temporary and comparatively short in duration, relatively infrequent, and specifically not of the type or severity that would be expected to be additive for the small portion of the stocks and species likely to be exposed, and therefore would not contribute to cumulative impacts.

The National Marine Fisheries Service specifically incorporated the impacts from other past and ongoing anthropogenic activities (see Section 3.8.2.1.5, General Threats) into their negligible impact analyses pursuant to the Marine Mammal Protection Act (MMPA) and ESA (National Marine Fisheries Service, 2017b). The NMFS Biological Opinion included an explanation of how the results of NMFS' baseline and effects analyses in Biological Opinions relate to those contained in the cumulative impact section of the 2016 GOA Final SEIS/OEIS (National Marine Fisheries Service, 2017a). The National Marine Fisheries Service found that Navy training and testing activities are not likely to jeopardize the continued existence of threatened or endangered species in the TMAA during any single year or as a result of the cumulative impacts of the five-year authorization under the MMPA (ending in 2022). There has been no emergent science that would necessitate changes to conclusions reached by Navy or NMFS (as a cooperating agency) in association with the 2016 GOA Final SEIS/OEIS with regard to marine mammals. It has long been understood that the cumulative effects of stressors on marine organisms in general and marine mammal populations in particular is extremely difficult to predict (National Academies of Sciences Engineering and Medicine, 2017). Recognizing the difficulties with measuring trends in marine mammal populations, the focus has been on indicators for adverse impacts, including health and other population metrics (Bradford et al., 2014; Murray et al., 2020; National Academies of Sciences Engineering and Medicine, 2017; Ward et al., 2009). This recommended use of population indicators is the approach Navy has presented in the previous environmental analyses of Navy training and testing activities; see in particular the 2016 GOA Final SEIS/OEIS Section 3.8.4 (Summary of Monitoring and Observations During Navy Activities), and the update to that information in this SEIS/OEIS (Section 3.8.6.1, Summary of Science in the Temporary Maritime Activities Area by the Navy Related to Potential Effects on Marine Mammals Since 2006). Since the 2016 analyses, neither the present nor the reasonably foreseeable actions change the previous assessment that the Navy's contribution to any cumulative impacts on marine mammal populations would be negligible.

Based on the analysis presented in Section 3.8 (Marine Mammals) of this SEIS/OEIS, the findings from NMFS regarding cumulative impacts on marine mammals in the TMAA (National Marine Fisheries Service, 2017a, 2017b), and the reasons summarized above relating to the 2016 GOA Final SEIS/OEIS, the incremental contribution of the Proposed Action to cumulative impacts would be negligible. Therefore, further analysis of cumulative impacts on marine mammals is not warranted.

4.4.4 Birds

The analysis presented in Section 3.9 (Birds) of both the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS detailed the potential for impacts on birds from the various stressors related to Navy training and testing activities. As discussed in Section 3.9 (Birds) of this SEIS/OEIS, there have been no changes to the activities analyzed in the 2011 GOA Final EIS/OEIS nor the 2016 GOA Final SEIS/OEIS that would change the conclusions reached regarding populations of birds in the TMAA. Analysis of cumulative impacts on birds was specifically addressed in the 2011 GOA Final EIS/OEIS Section 4.2.9 (Seabirds).

Marine birds in the TMAA are threatened by continued overfishing, pollution, shipping, and oil and gas development (Bureau of Ocean Energy Management, 2017; Melnychuk et al., 2013; Wisniewska et al., 2018). Many of these actions are currently present but are expected to increase in the future (U.S. Fish and Wildlife Service, 2016). Approximately 90 percent of the world's fisheries are already overfished threatening the ocean life and habitat. The shipping industry is expected to increase as global trade grows, particularly trans-Pacific and trans-Arctic container ship trade. Increasing the size of ships carrying containers and cargo goods increase oil spills, dumping of trash, ballast water, and oily waste. Therefore, the aggregate impacts of past, present, and reasonably foreseeable future actions may have a significant effect on birds. The Proposed Action could also result in injury and mortality to individual birds from underwater explosions, sonar, and strikes. Injury and mortality that might occur under the Proposed Action would be additive to injury and mortality associated with other actions. Section 3.9 (Birds) also analyzed potential cumulative impacts on the short-tailed albatross (*Phoebastria albatrus*), an ESA-listed species known to occur within the TMAA during the same general timeframe when military activities would be scheduled within the TMAA.

It is likely that distant shipping and aircraft noise (which is more pervasive and continuous) and sound associated with underwater explosions and sonar would overlap in time and space. However, there is no evidence indicating that the combined noise of shipping activities and aircraft noise, and sounds associated with underwater explosions and sonar use, would result in harmful additive impacts on birds.

The potential also exists for the impacts of ocean pollution and acoustic stressors associated with the Proposed Action to be additive or synergistic. It is possible that the response of a previously stressed animal would be more severe than the response of an unstressed animal. However, there are no data indicating that a seabird affected by ocean pollution would be more susceptible to stressors associated with the Proposed Action.

In summary, based upon the analysis in Section 3.9 (Birds), and the reasons summarized above, the incremental contribution of the Proposed Action to cumulative impacts on bird populations would be low. Therefore, further analysis of cumulative impacts on birds is not warranted.

4.4.5 Socioeconomic Resources and Environmental Justice

As stated in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, the Proposed Action could contribute to impacts on accessibility to nearshore areas popular for commercial and recreational fishing and some tourism activities that access the marine environment. However, limits on accessibility to these areas are not expected to significantly impact these resources, because restrictions would be temporary and of short duration (hours). To ensure public safety, access to waters within exclusion areas would be limited during military training activities. The same limitations on accessing portions of the TMAA designated as restricted areas, and warning areas as described in the 2011 GOA Final EIS/OEIS. In addition, the U.S. Coast Guard (USCG) has published a final rule establishing protection zones extending 500 yards around all Navy vessels in navigable waters of the United States and within the boundaries of Coast Guard Pacific Area (32 CFR Part 761). All vessels must proceed at a no-wake speed when within a protection zone. Non-military vessels are not permitted to enter within 100 yards of a U.S. naval vessel, whether underway or moored, unless authorized by an official patrol.

When training activities are scheduled that require specific areas to be free of non-participating vessels and aircraft, the military requests that the USCG issues a Notice to Mariners and that the Federal Aviation Administration issues a Notice to Airmen, as applicable for the activity. These measures are intended to alert the public of pending training activities and to ensure the safety of the public and military personnel. Providing advance notice of scheduled activities should allow members of the public to avoid unexpected delays or interruptions to their planned activities due to restrictions on accessing areas used for military activities.

The Port of Alaska (formerly the Port of Anchorage) was the nation's 38th-highest ranked port (out of 63) by value of international trade (imports + exports) in 2017. The volume of international trade at the Port of Alaska peaked in 2011 at just over 430 thousand metric tons, declining to just over 11 thousand metric tons in 2014. While recent trends show a decline that peaked in 2014, the volume of goods since has been increasing steadily (U.S. Maritime Administration, 2019).

Overall, harvest and catch from the commercial fisheries off Alaska have been consistent except for some minor exceptions. These trends suggest that the volume and value of fisheries off of Alaska will likely remain consistent in coming years (Fissel et al., 2019).

Waterways in the TMAA are heavily traveled by commercial, recreational, and other vessels, including military and USCG vessels. Several commercial ports are located in or near the TMAA, including the ports of Alaska and Kodiak. Commercial vessel traffic has the potential to limit access by the public to waterways, which would also include access by tourism related activities and businesses (e.g., whale watching vessels).

Several commercial airways cross over the Gulf of Alaska, mainly connecting Ted Stevens Anchorage International Airport to other airports in the continental United States. There are also numerous smaller commercial and general aviation airports along Alaska's southern coast. Airborne noise generated by commercial and private aircraft using airways traversing the Pacific Northwest and Southern Alaskan Coast may disturb, or otherwise impact the enjoyment of, tourist activities in the Gulf of Alaska.

Cumulative impacts from intermittent and short-term impacts on accessibility to areas within the TMAA, physical disturbances and interactions, airborne acoustics that disturb people on the ground, and secondary impacts (e.g., to tourism) resulting from effects on marine species populations are not anticipated. No cumulative impacts on commercial transportation and shipping are anticipated, because major shipping routes and airways are well defined, and training activities would avoid those areas. The Navy would continue to reduce or avoid impacts on commercial and recreational fishing and tourism and recreation by continuing to notify the public of upcoming activities that may limit accessibility to certain areas of the TMAA popular to participants in these activities. Broader socioeconomic metrics generally indicate that the state of Alaska's maritime economy has been on a downward trend since 2012. For example, data reported by the National Ocean Economics Program show that the Gross Domestic Product for the state of Alaska's ocean related activities and industries has decreased by over half since 2012 (National Ocean Economics Program, 2019). Short duration limits on accessibility, potentially impacting recreational and tourism related activities, are expected to be intermittent and have no long-term, cumulative impacts. Airborne acoustics from aircraft overflights in the GOA, potentially impacting recreational and tourism activities in the GOA and regions surrounding it, are expected to be brief (seconds) and discrete and are not expected to have long-term negative impacts on the enjoyment of the region.

In addition to this, no new Navy training activities are being proposed in this SEIS/OEIS. The analysis presented in Section 3.13 (Environmental Justice and Protection of Children) of the 2011 GOA Final EIS/OEIS, 2016 GOA Final SEIS/OEIS, and in Section 3.11 (Socioeconomic Resources and Environmental Justice) of this SEIS/OEIS demonstrates that the Proposed Action would not contribute incrementally to impacts on environmental justice. Under this SEIS/OEIS, the Proposed Action is not expected to contribute significantly to disproportionate impacts on environmental justice populations or children. Other projects proposed to occur within or near the TMAA may add to cumulative impacts on environmental justice in the TMAA; however, the Proposed Action would not contribute significantly to the cumulative impacts on environmental justice in the TMAA. Therefore, further analysis of cumulative impacts on environmental justice is not warranted.

4.5 Summary of Cumulative Impacts

The analyses presented in this chapter and Chapter 3 (Affected Environment and Environmental Consequences) indicate that the incremental contribution of the Proposed Action to cumulative impacts on fishes, sea turtles, birds, and socioeconomic resources and environmental justice would not rise to a level of significance. Marine mammals are the primary resources of concern for this cumulative impacts analysis for the following reasons:

- Past human activities have impacted these resources to the extent that several marine mammal species occurring in the TMAA are ESA-listed.
- These resources would be impacted by multiple ongoing and future actions.
- Acoustic and explosive stressors under the Proposed Action could result in injuries or disturbance to marine mammals.

In summary, based on the analysis presented in Section 3.8 (Marine Mammals), the current aggregate impacts of past, present, and other reasonably foreseeable future actions are not significantly different than the assessment in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. No new information or circumstances are significant enough to warrant further cumulative impact review.

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5 Mitigation

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5 MITIGATION

5.1 Introduction

This chapter describes the mitigation measures that the United States (U.S.) Department of the Navy (Navy) will implement to avoid or reduce potential impacts within the Temporary Maritime Activities Area (TMAA) from the Gulf of Alaska (GOA) Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS) Proposed Action. This chapter has been updated in its entirety since Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016).

The Navy will also implement standard operating procedures specific to training activities conducted under the Proposed Action. In many cases, standard operating procedures provide a benefit to biological resources, some of which have high socioeconomic value in the TMAA. Standard operating procedures differ from mitigation measures because standard operating procedures are designed to provide for safety and mission success, whereas mitigation measures are designed specifically to avoid or reduce potential environmental impacts. An example of a standard operating procedure is that ships operated by or for the Navy have personnel assigned to stand watch at all times when underway. Watch personnel monitor their assigned sectors for any indication of danger to the ship and the personnel on board, such as a floating or partially submerged object or piece of debris, periscope, surfaced submarine, wisp of smoke, flash of light, or surface disturbance. The Navy also avoids known navigation hazards that appear on navigational charts, such as submerged wrecks and obstructions. As a standard collision avoidance procedure, watch personnel also monitor for marine mammals that have the potential to be in the direct path of the ship. The standard operating procedures to avoid collision hazards are designed for safety of the ship and the personnel on board. This is different from mitigation measures for vessel movement, which require vessels to maneuver to avoid marine mammals by specified distances to avoid or reduce the potential for physical disturbance and strike of marine mammals, as described in Section 5.3.4.1 (Vessel Movement). In this example, the benefit of the mitigation measure for vessel movement is additive to the benefit of the standard operating procedure for vessel safety. Standard operating procedures that apply to the Proposed Action and are generally consistent with those included in the 2016 GOA Final SEIS/OEIS are described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of that document. Standard operating procedures that apply to the Proposed Action and were not included in, or require a clarification from, the 2016 GOA Final SEIS/OEIS are discussed in Section 2.3.2 (Standard Operating Procedures) of this SEIS/OEIS.

5.1.1 Benefits of Mitigation

The Chapter 3 (Affected Environment and Environmental Consequences) environmental analyses indicate that certain acoustic, explosive, and physical disturbance and strike stressors have the potential to impact certain biological or cultural resources. The Navy developed mitigation measures that would be implemented under Alternative 1 for those stressors and considered the benefits of that mitigation in the environmental analyses in this SEIS/OEIS. In addition to analyzing mitigation measures pursuant to the National Environmental Policy Act (NEPA), the Navy designed its mitigation to achieve one or more benefits, such as the following:

- Effect the least practicable adverse impact on marine mammal species or stocks and their habitat, and have a negligible impact on marine mammal species and stocks (as required under the Marine Mammal Protection Act [MMPA]);

- Ensure that the Proposed Action does not jeopardize the continued existence of endangered or threatened species, or result in destruction or adverse modification of critical habitat (as required under the Endangered Species Act [ESA]);
- Avoid or minimize adverse effects on Essential Fish Habitat (as required under the Magnuson-Stevens Fishery Conservation and Management Act).

In addition to the benefits listed above, certain mitigation measures would also benefit other species in the TMAA, such as seabirds listed under the Migratory Bird Treaty Act.

5.1.2 Compliance Initiatives

To disseminate its mitigation requirements to the appropriate personnel and meet other compliance requirements for the MMPA and ESA, the Navy will continue using the Protective Measures Assessment Protocol and its ongoing monitoring and reporting initiatives, as described in the sections below.

5.1.2.1 Protective Measures Assessment Protocol

To disseminate requirements to the personnel who are required to implement mitigation during training activities, the Navy will continue inputting its mitigation measures into the Protective Measures Assessment Protocol and appropriate governing instructions. The Protective Measures Assessment Protocol is a software tool that serves as the Navy's comprehensive data source for at-sea mitigation. The software tool provides personnel with notification of the required mitigation measures and a visual display of the planned training activity location overlaid with relevant environmental data (e.g., mapped locations of live hard bottom). Navy policy requires applicable personnel to access the Protective Measures Assessment Protocol during the event planning process. This helps ensure that personnel receive mitigation instructions prior to the start of training activities and that mitigation is implemented appropriately.

5.1.2.2 Monitoring, Research, and Reporting Initiatives

Many of the Navy's monitoring programs, research programs, and reporting initiatives have been ongoing for more than a decade and will continue as a compliance requirement for the MMPA or ESA, or both. The Navy and National Marine Fisheries Service (NMFS) use the information contained within monitoring, research, activity, and incident reports when evaluating the effectiveness and practicality of mitigation and determining if adaptive adjustments to mitigation may be appropriate. These reports also facilitate better understanding of the biological resources that inhabit the TMAA and the potential impacts of the Proposed Action on those resources.

5.1.2.2.1 Marine Species Research and Monitoring Programs

Through its marine species research and monitoring programs, the Navy is one of the nation's largest sponsors of scientific research on and monitoring of marine species. Navy research programs focus on investments in basic and applied research that increase fundamental knowledge and advance naval technological capabilities. Navy monitoring programs focus on the potential impacts of military readiness activities on biological resources. For example, the Navy Living Marine Resources Program is sponsoring an ongoing study on hearing and estimated acoustic impacts in three species of auk, which will help the Navy refine its assessment of potential impacts from its activities on seabirds.

Other projects, such as those sponsored by the U.S. Navy's Marine Species Monitoring Program, primarily focus on marine mammals and sea turtles. Monitoring reports are available to the public on the U.S. Navy's Marine Species Monitoring webpage (https://www.navymarinespeciesmonitoring.us/). The Navy will post future reports online as they become available. Specific details regarding the content of the reports will be coordinated with the appropriate agencies through the consultation and permitting processes. Additional information about the U.S. Navy's Marine Species Monitoring Program, including its adaptive management and strategic planning components, is provided in the sections below.

5.1.2.2.1.1 Adaptive Management

Adaptive management is an iterative process of decision-making that accounts for changes in the environment and scientific understanding over time through a system of monitoring and feedback. Within the natural resource management community, adaptive management involves ongoing, real-time learning and knowledge creation, both in a substantive sense and in terms of the adaptive process itself (Williams et al., 2009). Adaptive management focuses on learning and adapting, through partnerships of natural resource managers, scientists, and other stakeholders. Adaptive management helps managers maintain flexibility in their decisions and provides them the latitude to change direction to improve understanding of ecological systems and achieve management objectives. Taking action to improve progress toward desired outcomes is another function of adaptive management.

The Navy's adaptive management review process and reporting requirements serve as the basis for evaluating performance and compliance. The process involves technical review meetings and ongoing discussions between the Navy, NMFS, the Marine Mammal Commission, and other experts in the scientific community. An example of a revision to the compliance monitoring structure as a result of adaptive management is the development of the Strategic Planning Process, which is a planning tool for the selection and management of monitoring investments (U.S. Department of the Navy, 2013). Through adaptive management, the Strategic Planning Process has been incorporated into the Integrated Comprehensive Monitoring Program, which is described below.

5.1.2.2.1.2 Integrated Comprehensive Monitoring Program

The Navy developed an Integrated Comprehensive Monitoring Program to serve as the overarching framework for coordinating its marine species monitoring efforts and as a planning tool to focus its monitoring priorities pursuant to ESA and MMPA requirements (U.S. Department of the Navy, 2010). The purpose of the Integrated Comprehensive Monitoring Program is to coordinate monitoring efforts across 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. The Integrated Comprehensive Monitoring Program does not identify specific field work or individual projects. It is designed to provide a flexible, scalable, and adaptable framework using adaptive management and the Strategic Planning Process to periodically assess progress and reevaluate objectives.

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

The Strategic Planning Process serves to guide the investment of resources to most efficiently address Integrated Comprehensive Monitoring Program objectives and intermediate scientific objectives. Navy-funded monitoring projects relating to the impact of Navy activities on protected marine species are designed to accomplish one or more of the following top-level goals, as described in the Integrated Comprehensive Monitoring Program charter:

- Increase the understanding of the likely occurrence of marine mammals and ESA-listed marine species in the vicinity of the action (e.g., presence, abundance, distribution, density).
- Increase the understanding of the nature, scope, or context of the likely exposure of marine mammals and ESA-listed marine species to any of the potential stressors associated with the action (e.g., acoustics, explosives, physical disturbance and strike of military expended materials) through a better understanding of one or more of the following: (1) the nature of the action and its surrounding environment (e.g., sound-source characterization, propagation, ambient noise levels), (2) the affected species (e.g., life history, dive patterns), (3) the likely co-occurrence of marine mammals and ESA-listed marine species with the action (in whole or part), and (4) the likely biological or behavioral context of exposure to the stressor for the marine mammal and ESA-listed marine species (e.g., age class of exposed animals or known pupping, calving, or feeding areas).
- Increase the understanding of how individual marine mammals or ESA-listed marine species respond behaviorally or physiologically to the specific stressors associated with the action and in what context (e.g., at what distance or received level).
- Increase the understanding of how anticipated individual responses to individual stressors or anticipated combinations of stressors may impact either (1) the long-term fitness and survival of an individual; or (2) the population, species, or stock (e.g., through impacts on annual rates of recruitment or survival).
- Increase the understanding of the effectiveness of mitigation and monitoring.
- Improve the understanding and record of the manner in which the Navy complies with its Incidental Take Authorizations and Incidental Take Statements.
- Increase the probability of detecting marine mammals through improved technology or methods within mitigation zones to improve mitigation effectiveness and better achieve monitoring goals.

The Navy established a Scientific Advisory Group in 2011 with the initial task of evaluating current Navy monitoring approaches under the Integrated Comprehensive Monitoring Plan and existing MMPA Regulations and Letters of Authorization. The Scientific Advisory Group was also tasked with developing objective scientific recommendations that would form the basis for the Strategic Plan. While recommendations were fairly broad and not specifically prescriptive, the Scientific Advisory Group did provide specific programmatic recommendations that serve as guiding principles for the continued evolution of the Integrated Comprehensive Monitoring Program. Key recommendations included

- working within a conceptual framework of knowledge, from basic information on the occurrence of species within each range complex, to more specific matters of exposure, response, and consequences;
- facilitating collaboration among researchers in each region, with the intent to develop a coherent and synergistic regional monitoring and research effort;

- striving to move away from effort-based compliance metrics (e.g., completing a pre-determined amount of survey hours or days), with the intent to design and conduct monitoring projects according to scientific objectives rather than effort expended; and
- approaching the monitoring program holistically and selecting projects that offer the best opportunity to advance understanding of the issues, as opposed to establishing range-specific requirements.

5.1.2.2.1.3 Strategic Planning Process

The U.S. Navy's Marine Species Monitoring Program has evolved and improved as a result of adaptive management review and the Strategic Planning Process through changes that include

- recognizing the limitations of effort-based compliance metrics;
- developing a strategic approach to monitoring based on recommendations from the Scientific Advisory Group;
- shifting focus to projects based on scientific objectives that facilitate generation of statistically meaningful results upon which natural resources management decisions may be based;
- focusing on priority species or areas of interest as well as best opportunities to address specific monitoring objectives to maximize return on investment; and
- increasing transparency of the program and management standards, improving collaboration among participating researchers, and improving accessibility to monitoring data and results.

As a result of the changes outlined above due to the implementation of the Strategic Planning Process, the U.S. Navy's Marine Species Monitoring Program has undergone a transition. Intermediate scientific objectives now serve as the basis for developing and executing new monitoring projects across Navy training and testing areas in the Atlantic and Pacific Oceans. Implementation of the Strategic Planning Process involves coordination among fleets, system commands, Chief of Naval Operations Energy and Environmental Readiness Division, NMFS, and the Marine Mammal Commission with five primary steps:

1. **Identify overarching intermediate scientific objectives.** Through the adaptive management process, the Navy coordinates with NMFS and the Marine Mammal Commission to review and revise the list of intermediate scientific objectives that guide development of individual monitoring projects. Examples include addressing information gaps in species occurrence and density, evaluating behavioral responses of marine mammals to Navy activities, and developing tools and techniques for passive acoustic monitoring.
2. **Develop individual monitoring project concepts.** This step generally takes the form of soliciting input from the scientific community in terms of potential monitoring projects that address one or more of the intermediate scientific objectives. This can be accomplished through a variety of forums, including professional societies, regional scientific advisory groups, and contractor support.
3. **Evaluate, prioritize, and select monitoring projects.** Navy technical experts and program managers review and evaluate monitoring project concepts and develop a prioritized ranking. The goal of this step is to establish a suite of monitoring projects that address a cross-section of intermediate scientific objectives spread over a variety of range complexes.
4. **Execute and manage selected monitoring projects.** Individual projects are initiated through appropriate funding mechanisms and include clearly defined objectives and deliverables, such as data, reports, or publications.

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

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

- Integrated Comprehensive Monitoring Program top-level goals,
- Scientific Advisory Group recommendations,
- integration of regional scientific expert input,
- ongoing adaptive management review dialog between NMFS and the Navy,
- lessons learned from past and future monitoring of Navy military readiness activities, and
- leveraging of research and lessons learned from other Navy-funded science programs.

The Strategic Planning Process will continue to shape the future of the U.S. Navy's Marine Species Monitoring Program and serve as the primary decision-making tool for guiding investments. Information on monitoring projects currently underway in the Atlantic and Pacific oceans, as well as results, reports, and publications, can be accessed through the U.S. Navy's Marine Species Monitoring Program webpage.

5.1.2.2.2 Training Activity Reports

The Navy developed a classified data repository known as the Sonar Positional Reporting System to maintain an internal record of underwater sound sources (e.g., active sonar) used during training. The Sonar Positional Reporting System facilitates reporting pursuant to the Navy's MMPA Regulations and Letters of Authorization. Using data from the Sonar Positional Reporting System and other relevant sources, the Navy will continue to provide the NMFS Office of Protected Resources with classified or unclassified (depending on the data) annual reports on the training activities that use underwater sound sources under the Proposed Action. In its annual training activity reports, the Navy will describe the level of training conducted during the reporting period. Unclassified annual training activity reports that have been submitted to NMFS can be found on the NMFS Office of Protected Resources and U.S. Navy's Marine Species Monitoring Program webpages.

5.1.2.2.3 Incident Reports

The Navy's mitigation measures and many of its standard operating procedures are designed to prevent incidents involving biological resources, such as aircraft strikes and vessel strikes. The Navy has been collecting data on such incidents (if they have occurred) for more than a decade and will continue doing so under the Proposed Action. To provide information on incidents involving biological and cultural resources, the Navy will submit reports to the appropriate management authorities as described below:

- **Bird Aircraft Strikes:** As described in Section 5.1.3 (Aircraft Safety) of the 2016 GOA Final SEIS/OEIS, bird strikes present an aviation safety risk for aircrews and aircraft. The Navy will report all aircraft strikes of birds per standard operating procedures.
- **Incidents Involving Marine Mammals, Sea Turtles, ESA-Listed Birds, and ESA-Listed Fish:** The Navy will notify the appropriate regulatory agency (e.g., NMFS, U.S. Fish and Wildlife Service [USFWS]) immediately or as soon as operational security considerations allow if it observes the following that is (or may be) attributable to Navy activities: (1) a vessel strike of a marine mammal or sea turtle during training; (2) a stranded, injured, or dead marine mammal or sea turtle during training; or (3) an injured or dead marine mammal, sea turtle, or ESA-listed bird or fish species during post-explosive event monitoring. The Navy will provide relevant information pertaining to the incident (e.g., vessel speed). Additional details on these incident reporting requirements will be included in the Notification and Reporting Plan, which will be publicly available on the NMFS Office of Protected Resources webpage. The Navy will continue to provide the appropriate personnel with training on marine species incidents and their associated reporting requirements to aid the data collection and reporting processes (see Section 5.3.1, Environmental Awareness and Education). Information on marine mammal strandings is included in the *Marine Mammal Strandings Associated with U.S. Navy Sonar Activities* technical report (U.S. Department of the Navy, 2017c).
- **Cultural Resources:** As described in Section 3.10 (Cultural Resources) of the 2016 GOA Final SEIS/OEIS, precise locations of submerged historic properties (e.g., historic shipwrecks, historic sunken aircraft) within the TMAA are not known. Should the Navy impact a newly discovered historic property, the Navy will commence consultation with the appropriate State Historic Preservation Officer or Tribal Historic Preservation Officer in accordance with 36 Code of Federal Regulations section 800.13(b)(3).

5.2 Mitigation Development Process

The Navy, in coordination with the appropriate regulatory agencies, developed its initial suite of mitigation measures for Phase I of environmental planning (2011–2016) and subsequently revised those mitigation measures for the 2016 GOA Final SEIS/OEIS in Phase II (2017–2022). For this SEIS/OEIS (which represents Phase III of environmental planning), the Navy is working collaboratively with the appropriate regulatory agencies, such as NMFS, to develop and refine its mitigation, which will be finalized through the consultation and permitting processes. The mitigation development process involves reanalyzing existing mitigation measures implemented under the 2016 GOA Final SEIS/OEIS and analyzing new potential mitigation options (e.g., mitigation recommendations received from Navy and NMFS scientists, other governmental agencies, the public, and non-governmental organizations during NEPA scoping, the Draft SEIS/OEIS public review, and the consultation and permitting processes). The Navy is conducting a detailed review and assessment of each potential mitigation measure individually and then all potential mitigation measures collectively to determine if, as a whole, mitigation will effectively avoid or reduce potential impacts from the Proposed Action and will be practical to implement. The Navy operational community (i.e., leadership from the aviation, surface, subsurface, and special warfare communities and training experts), environmental planners, and scientific experts provide input on the effectiveness and practicality of mitigation implementation. Navy Senior Leadership reviewed and approved all mitigation measures included in this SEIS/OEIS.

The Navy Record of Decision will document all mitigation measures the Navy will implement under the Proposed Action. The NMFS Record of Decision, MMPA Regulations and Letter of Authorization, ESA Biological Opinion, and other applicable consultation documents will include the mitigation measures applicable to the resources for which the Navy has consulted. The suite of mitigation measures that will be included in the Final SEIS/OEIS will represent the maximum level of mitigation that is practical for the Navy to implement when balanced against impacts on safety, sustainability, and the ability to continue meeting mission requirements. Should the Navy require a change in how it implements mitigation based on national security concerns, evolving readiness requirements, or other factors (e.g., significant changes in the best available science), the Navy will engage the appropriate agencies and reevaluate its mitigation through adaptive management or the appropriate consultations. The Navy's adaptive management approach is discussed in Section 5.1.2.2.1.1 (Adaptive Management). This approach has been coordinated with NMFS and will be included in the MMPA Regulations and Letter of Authorization.

Mitigation measures that the Navy will implement under the Proposed Action are organized into two categories: procedural mitigation measures and mitigation areas. The sections below provide definitions of mitigation terminology, background information pertinent to the mitigation development process, and information about the mitigation effectiveness and practicality criteria. Section 5.5 (Mitigation Measures Considered but Eliminated) contains information on measures that did not meet the appropriate balance between being both effective as well as practical to implement, and therefore will not be implemented under the Proposed Action.

5.2.1 Procedural Mitigation Development

Procedural mitigation is mitigation that the Navy will implement whenever and wherever training activities involving applicable acoustic, explosive, and physical disturbance and strike stressors take place within the TMAA. Procedural mitigation generally involves (1) the use of one or more trained Lookouts to observe for specific biological resources within a mitigation zone, (2) requirements for Lookouts to immediately communicate sightings of specific biological resources to the appropriate watch station for information dissemination, and (3) requirements for the watch station to implement mitigation until a pre-activity commencement or during-activity recommencement condition has been met.

Procedural mitigation primarily involves Lookouts observing for marine mammals and sea turtles. For some activities, Lookouts may also be required to observe for additional biological resources, such as ESA-listed seabirds or floating vegetation. For example, the Navy implements procedural mitigation for several activities that have the potential to overlap the range of ESA-listed short-tailed albatross. In this chapter, the term "floating vegetation" refers specifically to floating concentrations of detached kelp paddies. Floating vegetation can be an indicator of potential marine mammal or sea turtle presence because marine mammals and sea turtles have been known to seek shelter in, feed on, or feed among them. The Navy observes for these additional biological resources prior to the initial start or during the conduct of certain activities to offer an additional layer of protection for marine mammals and sea turtles. While on watch, Lookouts employ visual search techniques, including a combination of naked-eye scanning and the use of hand-held binoculars or high-powered binoculars mounted on a ship deck, depending on the observation platform. After sunset and prior to sunrise, Lookouts and other Navy watch personnel employ night visual search techniques, which could include the use of night vision devices.

To consider the benefits of procedural mitigation to marine mammals and sea turtles within the MMPA and ESA impact estimates, the Navy conservatively factored mitigation effectiveness into its quantitative analysis process, as described in the technical report titled *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing*

(U.S. Department of the Navy, 2018). The Navy's quantitative analysis assumes that Lookouts will not be 100 percent effective at detecting all individual marine mammals and sea turtles within the mitigation zones for each activity. This is due to the inherent limitations of observing marine species and because the likelihood of sighting individual animals is largely dependent on observation conditions (e.g., time of day, sea state, mitigation zone size, observation platform) and animal behavior (e.g., the amount of time an animal spends at the surface of the water). This is particularly true for sea turtles, small marine mammals, and marine mammals that display cryptic behaviors (e.g., surfacing to breathe with only a small portion of their body visible from the surface). Throughout Section 5.3 (Procedural Mitigation to be Implemented), discussions about the likelihood that a Lookout would observe a marine mammal or sea turtle pertain specifically to animals that are available to be observed (i.e., on, above, or just below the water's surface). The benefits of procedural mitigation measures for species that were not included in the quantitative analysis process (e.g., birds) are discussed qualitatively.

Data inputs for assessing and developing procedural mitigation included operational data described in Section 5.2.3 (Practicality of Implementation), the best available science discussed in Chapter 3 (Affected Environment and Environmental Consequences), published literature, data on marine mammal and sea turtle impact ranges obtained through acoustic modeling, data on bird hearing, marine species monitoring and density data, and the most recent guidance from NMFS and the USFWS. Background information on the data that were used to develop the ranges to effect is provided in Section 3.7 (Sea Turtles), Section 3.8 (Marine Mammals), and Section 3.9 (Birds). Additional activity or stressor-specific details, such as the level of effect to which a procedural mitigation measure is expected to mitigate and if a measure has been modified from the 2016 GOA Final SEIS/OEIS, is provided throughout Section 5.3 (Procedural Mitigation to be Implemented).

5.2.1.1 Lookouts

Lookouts perform similar duties as the standard watch personnel described in Section 5.1.2 (Vessel Safety) of the 2016 GOA Final SEIS/OEIS, such as personnel on the bridge watch team and personnel stationed for man-overboard precautions. Lookouts are designated the responsibility of helping meet the Navy's mitigation requirements by visually observing mitigation zones. The number of Lookouts designated for each training activity is dependent upon the number of personnel involved in the activity (i.e., manning restrictions) and the number and type of assets available (i.e., equipment and space restrictions).

Depending on the activity, a Lookout may be positioned on a ship (i.e., surface ships and surfaced submarines), on a small boat (e.g., a rigid-hull inflatable boat), or in an aircraft. Certain platforms, such as aircraft and small boats, have manning or space restrictions; therefore, the Lookout on these platforms is typically an existing member of the aircraft or boat crew who is responsible for other essential tasks (e.g., a pilot or Naval Flight Officer who is also responsible for navigation). Some platforms are minimally manned and are therefore either physically unable to accommodate more than one Lookout or divert personnel from mission-essential tasks, including safe and secure operation of propulsion, weapons, and damage control systems that ensure safety of the ship and the personnel on board. The number of Lookouts specified for each activity in Section 5.3 (Procedural Mitigation to be Implemented) represents the maximum number of Lookouts that can be designated for those activities without requiring additional personnel or reassigning duties. The "maximum" number of Lookouts is equivalent to the required number of Lookouts; therefore, the Navy would not use fewer Lookouts than what is specified in each mitigation table. The Navy is unable to position Lookouts on unmanned surface vehicles, unmanned aerial systems, unmanned underwater vehicles, and submerged submarines, or have Lookouts observe during activities that use systems deployed from or towed by unmanned platforms, except in limited circumstances when escort vehicles are already participating in the activity.

When Lookouts are positioned in a fixed-wing aircraft or rotary-wing aircraft (i.e., helicopter), mission requirements determine the flight parameters (altitude, flight path, and speed) for that aircraft. For example, most fixed-wing aircraft sorties occur above 3,000 feet (ft.). Similarly, when Lookouts are positioned on a vessel, mission requirements determine the operational parameters (course and speed) for that vessel.

The Navy's passive acoustic devices (e.g., remote acoustic sensors, expendable sonobuoys, passive acoustic sensors on submarines) can complement visual observations for marine mammals when passive acoustic assets are already participating in an activity. The passive acoustic devices can detect vocalizing marine mammals within the frequency bands already being monitored by Navy personnel. Marine mammal detections from passive acoustic devices can alert Lookouts to possible marine mammal presence in the vicinity. Lookouts can use the information from passive acoustic detections to assist their visual observations of the mitigation zone. Based on the number and type of passive acoustic devices that are typically used, passive acoustic detections do not provide range or bearing to a detected animal in order to determine its location or confirm its presence in a mitigation zone. Therefore, it is not practical for the Navy to implement mitigation in response to passive acoustic detections alone (i.e., without a visual sighting of an animal within the mitigation zone). Additional information about passive acoustic devices is provided in Section 5.5.3 (Active and Passive Acoustic Monitoring Devices).

5.2.1.2 Mitigation Zones

Mitigation zones are areas at the surface of the water within which applicable training activities will be ceased, powered down, or modified to protect specific biological resources from an auditory injury (permanent threshold shift [PTS]), non-auditory injury (from impulsive sources), or direct strike (e.g., vessel strike) to the maximum extent practicable. Mitigation zones are measured as the radius from a stressor. Implementation of procedural mitigation is most effective when mitigation zones are appropriately sized to be realistically observed during typical training activity conditions.

The Navy customized its mitigation zone sizes and mitigation requirements for each applicable training activity category or stressor. The Navy developed each mitigation zone to be the largest area that (1) Lookouts can reasonably be expected to observe during typical activity conditions (i.e., most environmentally protective); and (2) the Navy can commit to implementing mitigation without impacting safety, sustainability, or the ability to meet mission requirements. The Navy designed the mitigation zones for most acoustic and explosive stressors according to its source bins. As described in Section 3.0.4.1 (Acoustic Sources), sonars and other transducers are grouped into classes that share an attribute, such as frequency range or purpose of use. Classes are further sorted by bins based on the frequency or bandwidth, source level, and when warranted, the application in which the source would be used. As described in Section 3.0.4.2 (Explosive Stressors), explosives are binned by net explosive weight. Mitigation does not pertain to stressors that do not have the potential to impact biological resources (e.g., *de minimis* acoustic and explosive sources that do not have the potential to impact marine mammals).

Discussions throughout Section 5.3 (Procedural Mitigation to be Implemented) about the level of effect that will likely be mitigated for marine mammals and sea turtles are based on a comparison of the mitigation zone size to the predicted impact ranges for the applicable source bins with the longest average ranges to PTS. These conservative discussions represent the worst-case scenario for each activity category or stressor. The mitigation zones will oftentimes cover all or a larger portion of the predicted average ranges to PTS for other comparatively smaller sources with shorter impact ranges (e.g., sonar sources used at a lower source level, explosives in a smaller bin). The discussions are primarily focused on how the mitigation zone sizes compare to the ranges to PTS; however, depending on the activity category or stressor, the mitigation zones are oftentimes large enough to also mitigate within a portion of the ranges to temporary threshold shift (TTS). Temporary Threshold Shift is a threshold shift that is recoverable. Background information on PTS, TTS, and marine mammal and sea turtle hearing groups is presented in the U.S. Department of the Navy (2017a) technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)*.

5.2.1.3 Procedural Mitigation Implementation

The Navy takes several courses of action in response to a sighting of an applicable biological resource in a mitigation zone. First, a Lookout will communicate the sighting to the appropriate watch station. Next, the watch station will implement the prescribed mitigation, such as delaying the initial start of an activity, powering down sonar, ceasing an explosive detonation, or maneuvering a vessel. If floating vegetation is observed in the mitigation zone prior to the initial start of an activity, the activity will either be relocated to an area where floating vegetation is not observed in concentrations, or the initial start of the activity will be delayed until the mitigation zone is clear of floating vegetation concentrations. There are no requirements to cease activities if vegetation floats into the mitigation zone after activities commence. For sightings of marine mammals, sea turtles, and seabirds within a mitigation zone prior to the initial start of or during applicable activities, the Navy will continue mitigating until one of the five conditions listed below has been met. The conditions are designed to allow a sighted animal to leave the mitigation zone before the initial start of an activity or before an activity resumes.

- The animal is observed exiting the mitigation zone;
- The animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the stressor source;
- The mitigation zone has been clear from any additional sightings for a specific wait period;
- For mobile activities, the stressor source has transited or has been relocated a distance equal to double that of the mitigation zone size beyond the location of the last sighting; or
- For activities using hull-mounted sonar, the ship concludes that dolphins are deliberately closing in on the ship to ride the ship’s bow wave and are therefore out of the main transmission axis of the sonar (and there are no other marine mammal sightings within the mitigation zone).

To supplement the implementation of procedural mitigation, the Navy has agreed to undertake reporting initiatives for certain activities or resources based on previous consultations with NMFS and the USFWS, as summarized in Section 5.1.2.2 (Monitoring, Research, and Reporting Initiatives) and detailed where applicable in Section 5.3 (Procedural Mitigation to be Implemented).

5.2.2 Mitigation Area Development

Mitigation areas are geographic locations within the TMAA where the Navy will implement additional mitigation measures (i.e., geographic mitigation, in addition to procedural mitigation). The Navy completed an assessment of the TMAA to develop mitigation areas for the Proposed Action. The Navy reanalyzed existing mitigation areas implemented under the 2016 GOA Final SEIS/OEIS and assessed habitats suggested through comments received during NEPA scoping or identified internally by the Navy. The Navy will also assess mitigation recommendations received through public comments on this

SEIS/OEIS, and mitigation identified by regulatory agencies during the consultation and permitting processes. The Navy's initial biological effectiveness and operational assessments of mitigation areas developed for this SEIS/OEIS are presented in Section 5.4 (Geographic Mitigation to be Implemented).

Mitigation areas are designed to help avoid or reduce potential impacts in key areas of importance. Therefore, the mitigation benefit is discussed qualitatively in terms of the context of impact avoidance or reduction. The Navy considered a mitigation area to be effective if it meets the following criteria:

- **The mitigation area is a key area of biological or ecological importance:** The best available science suggests that the mitigation area is particularly important to one or more species or resources for a biologically important life process (e.g., foraging, migration, reproduction) or ecological function; and
- **The mitigation will result in an avoidance or reduction of impacts:** Implementing the mitigation will likely avoid or reduce potential impacts on (1) species, stocks, or populations of marine mammals based on data regarding their seasonality, density, and behavior; or (2) other biological resources based on their distribution and physical properties. Furthermore, implementing the mitigation will not shift or transfer adverse effects from one species to another (e.g., to a more vulnerable or sensitive species).

5.2.3 Practicality of Implementation

Mitigation measures are expected to have some degree of impact on the training activities that implement them (e.g., modifying where and when activities occur, ceasing an activity in response to a sighting). The Navy is able to accept a certain level of impact on its military readiness activities because of the benefit that mitigation measures provide for avoiding or reducing potential impacts on biological resources. The Navy's focus during mitigation assessment and development is that mitigation measures must meet the appropriate balance between being both effective as well as practical to implement. To evaluate practicality, the Navy operational community conducted an extensive and comprehensive assessment to determine how and to what degree potential mitigation measures would be compatible with planning, scheduling, and conducting training activities under the Proposed Action in order to meet the Navy's Title 10 requirements.

5.2.3.1 Assessment Criteria

The purpose and need of the Proposed Action is to ensure that the Navy meets its mission to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. The Navy is statutorily mandated to protect U.S. national security by being ready, at all times, to effectively prosecute war and defend the nation by conducting operations at sea, as outlined in Title 10 section 8062 of the United States Code. The Navy's mission is achieved in part by conducting training within the TMAA in accordance with established military readiness requirements. Training requirements have been developed through many years of iteration and adaptation and are designed to ensure that Sailors achieve the levels of readiness needed to properly respond to the multitude of contingencies they may face during military missions and combat operations. Activities are planned and scheduled in accordance with the Optimized Fleet Response Plan, which details instructions on manning distribution, range scheduling, operational requirements, maintenance and modernization plans, quality of work and life for personnel, achieving training capabilities, and meeting strategic readiness objectives.

To achieve the highest skill proficiency possible, the Navy conducts activities in a variety of realistic tactical oceanographic and environmental conditions. Such conditions include variations in bathymetry, topography, surface fronts, and sea surface temperatures. Training activities must be as realistic as possible to provide the experiences and stressors necessary to successfully execute all required military missions and combat operations. Degraded training would result in units being unqualified to conduct the range of military operations required by operational Commanders. The inability of such Commanders to meet national security objectives would result in not only the increased risk to life, but also the degradation of national security.

As described in Chapter 2 (Description of Proposed Action and Alternatives), the Navy requires access to sea space and airspace throughout the TMAA, including large-scale open ocean areas of the high seas. Each area plays a critical role in the Navy's ability to plan, schedule, and effectively execute military readiness activities. The locations where training occur must be situated in a way that allows the Navy to complete its activities without physical or logistical obstructions. The Navy requires extensive sea space so that individual training activities can occur at sufficient distances so they do not interfere with one another. Some training activities require continuous access to large and unobstructed areas, consisting potentially of tens or thousands of square miles. This provides personnel the ability to develop competence and confidence in their capabilities across multiple types of weapons and sensors, and the ability to train to communicate and operate in a coordinated fashion as required during military missions and combat operations. For example, some training exercises may require large areas of the open ocean for realistic and safe anti-submarine warfare training. The Navy also requires large areas of sea space because it trains in a manner to avoid observation by potential adversaries. Modern sensing technologies make training on a large scale without observation more difficult. A foreign military's continual observation of U.S. Navy training in predictable geographic areas and timeframes would enable foreign nations to gather intelligence and subsequently develop techniques, tactics, and procedures to potentially and effectively counter U.S. naval operations. Other activities may be conducted on a smaller and more localized scale, with training at discrete locations that are critical to certain aspects of military readiness.

The locations for training activities are selected to maximize efficiency while supporting specific mission and safety requirements, deconflict sea space and airspace, and minimize the time personnel must spend away from home. Training locations are typically selected based on their proximity to homeports, home bases, associated training ranges, air squadrons, and existing infrastructure to reduce travel time and associated costs. Activities involving the use of rotary-wing aircraft typically occur in proximity to shore or refueling stations due to fuel restrictions and safety requirements.

During its assessment to determine how and to what degree the implementation of mitigation would be compatible with meeting the purpose and need of the Proposed Action, the Navy considered a mitigation measure to be practical to implement if it met all criteria discussed below:

- **Implementing the mitigation is safe:** Mitigation measures must not increase safety risks to Navy personnel and equipment, or to the public. When assessing whether implementing a mitigation measure would be safe, the Navy factored in the potential for increased pilot fatigue; accelerated fatigue-life of aircraft; typical fuel restrictions of participating aircraft; locations of refueling stations; proximity to aircraft emergency landing fields, critical medical facilities, and search and rescue resources; space restrictions of the observation platforms; the ability to de-conflict platforms and activities to ensure that training activities do not impact each other; and the ability to avoid interaction with non-Navy sea space and airspace uses, such as established commercial air traffic routes, commercial vessel shipping lanes, and areas used for energy exploration or alternative energy development. Other safety considerations included identifying if mitigation measures would reasonably allow Lookouts to safely and effectively maintain situational awareness while observing the mitigation zones during typical activity conditions, or if the mitigation would increase the safety risk for personnel. For example, the safety risk would increase if Lookouts were required to direct their attention away from essential mission requirements.

- **Implementing the mitigation is sustainable:** One of the primary factors that the Navy incorporates into the planning and scheduling of its training activities is the amount and type of available resources, such as funding, personnel, and equipment. Mitigation measures must be sustainable over the life of the Proposed Action, meaning that they will not require the use of resources in excess of what is available. When assessing whether implementing a mitigation measure would be sustainable, the Navy considered if the measure would require excessive time on station or time away from homeport for Navy personnel, require the use of additional personnel (i.e., manpower) or equipment (e.g., adding a small boat to serve as an additional observation platform), or result in additional operational costs (e.g., increased fuel consumption, equipment maintenance, or acquisition of new equipment).
- **Implementing the mitigation allows the Navy to continue meeting its mission requirements:** The Navy considered if each individual measure and the iterative and cumulative impact of all potential measures would be within the Navy's legal authority to implement. The Navy also considered if mitigation would modify training activities in a way that would prevent individual activities from meeting their mission objectives and if mitigation would prevent the Navy from meeting its national security requirements or statutorily-mandated Title 10 requirements, such as by
  - impacting training realism or preventing ready access to ranges or training areas (which would reduce realism and present sea space and airspace conflicts);
  - impacting the ability for Sailors to train and become proficient in using sensors and weapon systems as would be required in areas analogous to where the military operates or causing an erosion of capabilities or reduction in perishable skills (which would result in a significant risk to personnel or equipment safety during military missions and combat operations);
  - impacting the ability for units to meet their individual training and certification requirements (which would impact the ability to deploy with the required level of readiness necessary to accomplish any tasking by Combatant Commanders);
  - impacting the ability to certify forces to deploy to meet national security tasking (which would limit the flexibility of Combatant Commanders and warfighters to project power, engage in multi-national operations, and conduct the full range of naval warfighting capabilities in support of national security interests);
  - requiring the Navy to provide advance notification of specific times and locations of Navy platforms, such as platforms using active sonar (which would present national security concerns); and
  - reducing the Navy's ability to be ready, maintain deployment schedules, or respond to national emergencies or emerging national security challenges (which would present national security concerns).

5.2.3.2 Factors Affecting Practicality

Two of the factors that influenced whether procedural mitigation measures met the practicality criteria were the number of times mitigation measures would likely be implemented and the duration over which the activity would likely be ceased due to mitigation implementation. The number of times mitigation would likely be implemented is largely dependent on the size of the mitigation zone. As a mitigation zone size increases, the area of observation increases by an order of magnitude. This is because mitigation zones are measured as the radius (r) from a stressor but apply to circular area (A) around that stressor ($A = \pi * r^2$, where π is a constant that is approximately equal to 3.14). For example, a 100-yard (yd.) mitigation zone is equivalent to an area of 31,416 square yd. A 200 yd. mitigation zone is equivalent to an area of 125,664 square yd. Therefore, increasing a mitigation zone from 100 yd. to 200 yd. (i.e., doubling the mitigation zone radius) would quadruple the mitigation zone area (the area over which mitigation must be implemented). Similarly, increasing a mitigation zone from 1,000 yd. to 4,000 yd. (i.e., quadrupling the mitigation zone radius) would increase the mitigation zone area by a factor of 16. Increasing the area over which mitigation must be implemented consequently increases the number of times mitigation would likely be implemented during that activity.

The duration over which mitigation is implemented can differ considerably depending on the mitigation zone size, number of animal sightings, behavioral state of animals sighted (e.g., travelling at a fast pace on course to exit the mitigation zone, milling slowly in the center of the mitigation zone), and which pre-activity commencement or during-activity recommencement condition is met before the activity can commence or resume after each sighting. The duration of mitigation implementation typically equates to the amount of time the training activity will be extended. The impact that extending the length of an activity has on safety, sustainability, and the Navy's ability to accomplish the activity's intended objectives varies by activity. This is one reason why the Navy tailors its mitigation zone sizes and mitigation requirements by activity category or stressor and the platforms involved.

As described in Section 5.2.1 (Procedural Mitigation Development), the Navy will mitigate for each applicable sighting and will continue mitigating until one of five conditions has been met. In some instances, such as if an animal dives underwater after a sighting, it may not be possible for a Lookout to visually verify if the animal has exited the mitigation zone. The Navy cannot delay or cease activities indefinitely for the purpose of mitigation due to impacts on safety, sustainability, and the Navy's ability to continue meeting its mission requirements. To account for this, one of the pre-activity commencement and during-activity recommencement conditions is an established post-sighting wait period of 30 minutes or 10 minutes, based on the platforms involved. Wait periods are designed to allow animals the maximum amount of time practical to resurface (i.e., become available to be observed by a Lookout) before activities resume. When developing the length of its wait periods, the Navy factored in the assumption that mitigation may need to be implemented more than once. For example, an activity may need to be delayed or ceased for more than one 30-minute or 10-minute period.

The Navy assigns a 30-minute wait period to activities conducted from vessels and that involve aircraft that are not typically fuel constrained (e.g., maritime patrol aircraft). A 30-minute period covers the average dive times of most marine mammals and a portion of the dive times of sea turtles and deep-diving marine mammals (i.e., sperm whales, dwarf and pygmy sperm whales [Kogia whales], and beaked whales) (U.S. Department of the Navy, 2017b). The Navy determined that a 30-minute wait period is the maximum wait time that is practical to implement during activities involving vessels and aircraft that are not typically fuel constrained to allow the activities to continue meeting their intended objectives. Implementing a longer wait period (such as 45 minutes or 60 minutes to cover the average dive times of sea turtles and additional marine mammal species) would be impractical to implement. Activities are scheduled to occur at specific locations within specific timeframes based on range scheduling and for sea space deconfliction. Increasing the wait period, and consequently the amount of time activities would need to be delayed or extended in order to accomplish their intended objectives, would impact activity realism or cause sea space conflicts in a way that could impact the Navy's ability to continue meeting its mission requirements. For example, delaying an explosive activity for multiple wait periods could result in personnel not being able to detonate an explosive before the participating platforms are required to depart the range due to range scheduling; therefore, the activity would not accomplish its intended objectives.

The Navy assigns a 10-minute wait period to activities involving aircraft that are typically fuel constrained (e.g., rotary-wing aircraft, fighter aircraft). A 10-minute period covers a portion, but not the average, dive times of marine mammals and sea turtles (U.S. Department of the Navy, 2017b). The Navy determined that a 10-minute wait period is the maximum wait time that is practical to implement during activities involving aircraft that are typically fuel constrained. Increasing the wait period, and consequently the amount of time the training activity would need to be extended in order to accomplish its intended objective, would require aircraft to depart the activity area to refuel in order to safely complete the event. If the wait period was implemented multiple times, the aircraft would be required to depart the activity area to refuel multiple times. Refueling events would vary in duration, depending on the activity location and proximity to the nearest refueling station. Multiple refueling events would generally be expected to extend the length of the activity by two to five times or more. This would impact activity realism, could cause air space or sea space conflicts in a way that could impact the Navy's ability to continue meeting its mission requirements, would decrease the ability for Lookouts to safely and effectively maintain situational awareness of the activity area, and would increase safety risks due to increased pilot fatigue and accelerated fatigue-life of aircraft. For example, delaying an Anti-Submarine Warfare Tracking Exercise – Helicopter activity for multiple wait periods could result in personnel not being able to effectively search for, detect, classify, localize, and track a simulated threat submarine before the rotary-wing aircraft is required to depart the range due to range scheduling; therefore, the activity would not accomplish its intended objectives.

Factors that influenced whether a mitigation area measure met the practicality criteria included the historical use and projected future use of geographic locations for training activities under the Proposed Action, and the relative importance of each location. The frequency that an area is used for training does not necessarily equate to that area's level of importance for meeting an individual activity objective, or collectively, the Navy's mission requirements. While frequently used areas can be essential to one or more types of military readiness activities, some infrequently used areas are critical for a particular training exercise.

5.3 Procedural Mitigation to be Implemented

The first procedural mitigation measure (Section 5.3.1, Environmental Awareness and Education) is designed to aid Lookouts and other personnel with observation, environmental compliance, and reporting responsibilities. The remaining procedural mitigation measures are organized by stressor type and training activity category.

5.3.1 Environmental Awareness and Education

The Navy will continue to implement procedural mitigation to provide environmental awareness and education to the appropriate personnel to aid visual observation, environmental compliance, and reporting responsibilities, as outlined in Table 5.3-1.

The Navy requires Lookouts and other personnel to complete their assigned environmental compliance responsibilities (e.g., mitigation, reporting requirements) before, during, and after training activities.

Marine Species Awareness Training was first developed in 2007 and has since undergone numerous updates to ensure that the content remains current, with the most recent product approved by NMFS and released by the Navy in 2014. In 2014, the Navy developed a series of educational training modules, known as the Afloat Environmental Compliance Training program, to ensure Navywide compliance with environmental requirements. The Afloat Environmental Compliance Training program, including the updated Marine Species Awareness Training, helps Navy personnel from the most junior Sailors to Commanding Officers gain a better understanding of their personal environmental compliance roles and responsibilities. Additional information on the Protective Measures Assessment Protocol is provided in Section 5.1.2.1 (Protective Measures Assessment Protocol), and additional information on training activity and incident reports is provided in Section 5.1.2.2 (Monitoring, Research, and Reporting Initiatives).

Table 5.3-1: Environmental Awareness and Education

Procedural Mitigation Description
Stressor or Activity • All training activities, as applicable
Resource Protection Focus • Marine mammals • Sea turtles • Birds
Mitigation Requirements • Appropriate personnel (including civilian personnel) involved in mitigation and training activity reporting under the Proposed Action will complete one or more modules of the U.S. Navy Afloat Environmental Compliance Training Series, as identified in their career path training plan. Modules include – **Introduction to the U.S. Navy Afloat Environmental Compliance Training Series.** The introductory module provides information on environmental laws (e.g., Endangered Species Act, Marine Mammal Protection Act) and the corresponding responsibilities that are relevant to Navy training activities. The material explains why environmental compliance is important in supporting the Navy's commitment to environmental stewardship. – **Marine Species Awareness Training.** All bridge watch personnel, Commanding Officers, Executive Officers, maritime patrol aircraft aircrews, anti-submarine warfare aircrews, Lookouts, and equivalent civilian personnel must successfully complete the Marine Species Awareness Training prior to standing watch or serving as a Lookout. The Marine Species Awareness Training provides information on sighting cues, visual observation tools and techniques, and sighting notification procedures. Navy biologists developed Marine Species Awareness Training to improve the effectiveness of visual observations for biological resources, focusing on marine mammals and sea turtles, and including floating vegetation, jellyfish aggregations, and flocks of seabirds. – **U.S. Navy Protective Measures Assessment Protocol.** This module provides the necessary instruction for accessing mitigation requirements during the event planning phase using the Protective Measures Assessment Protocol software tool. – **U.S. Navy Sonar Positional Reporting System and Marine Mammal Incident Reporting.** This module provides instruction on the procedures and activity reporting requirements for the Sonar Positional Reporting System and marine mammal incident reporting.

From an operational perspective, the interactive web-based format of the U.S. Navy Afloat Environmental Compliance Training Series is ideal for providing engaging and educational content that is cost effective and convenient to access by personnel who oftentimes face rotating job assignments. The U.S. Navy Afloat Environmental Compliance Training Series has resulted in an improvement in the quality and accuracy of training activity reports, incident reports, and Sonar Positional Reporting System reports submitted by Navy operators. Improved reporting quality indicates that the U.S. Navy Afloat Environmental Compliance Training Series is helping to facilitate Navywide environmental compliance as intended.

Lookouts and members of the operational community have demonstrated enhanced knowledge and understanding of the Navy's environmental compliance responsibilities since the development of the U.S. Navy Afloat Environmental Compliance Training Series. For example, it is likely that the implementation of the Marine Species Awareness Training starting in 2007, and the additional U.S. Navy Afloat Environmental Compliance Training Series modules starting in 2014, potentially helped contribute to a Navywide reduction in vessel strikes of marine mammals in areas where the Navy trains. This indicates that the environmental awareness and education program is helping to improve the effectiveness of mitigation implementation.

5.3.2 Acoustic Stressors

The Navy will implement procedural mitigation to avoid or reduce potential impacts on biological resources from the acoustic stressors discussed in the sections below. In addition to procedural mitigation, the Navy will implement mitigation for acoustic stressors within mitigation areas, as described in Section 5.4 (Geographic Mitigation to be Implemented).

5.3.2.1 Active Sonar

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from active sonar, as outlined in Table 5.3-2. In the 2016 GOA Final SEIS/OEIS, the Navy's active sonar mitigation zones were based on associated average ranges to PTS for marine mammals. When developing this SEIS/OEIS, the Navy analyzed the potential for increasing the sizes of these mitigation zones. The Navy determined that the current mitigation zones for active sonar are the largest areas within which it is practical to implement mitigation; therefore, it will continue implementing these same mitigation zones under the Proposed Action. The Navy is clarifying in the table that it will require observation of the mitigation zone prior to the initial start of the activity to ensure the area is clear of applicable biological resources. The Navy has always verified that the mitigation zone is visually clear prior to conducting active sonar activities and is more clearly capturing this current practice in the mitigation measures for this activity. The Navy will follow the incident reporting procedures outlined in Section 5.1.2.2.3 (Incident Reports) if an incident is detected at any time during the event.

The mitigation zone sizes and proximity to the observation platforms will result in a high likelihood that Lookouts will be able to detect marine mammals and sea turtles throughout the mitigation zones. Observing for floating vegetation will further help avoid or reduce potential impacts on marine mammals and sea turtles within the mitigation zones.

Table 5.3-2: Procedural Mitigation for Active Sonar

Procedural Mitigation Description
Stressor or Activity • Mid-frequency active sonar and high-frequency active sonar – For vessel-based active sonar activities, mitigation applies only to sources that are positively controlled and deployed from manned surface vessels (e.g., sonar sources towed from manned surface platforms). – For aircraft-based active sonar activities, mitigation applies only to sources that are positively controlled and deployed from manned aircraft that do not operate at high altitudes (e.g., rotary-wing aircraft). Mitigation does not apply to active sonar sources deployed from unmanned aerial systems or aircraft operating at high altitudes (e.g., maritime patrol aircraft).
Resource Protection Focus • Marine mammals • Sea turtles (only for sources <2 kHz)
Number of Lookouts and Observation Platform • Hull-mounted sources: – 1 Lookout: Platforms with space or manning restrictions while underway (at the forward part of a small boat or ship) and platforms using active sonar while moored or at anchor – 2 Lookouts: Platforms without space or manning restrictions while underway (at the forward part of the ship) • Sources that are not hull-mounted: – 1 Lookout on the ship or aircraft conducting the activity
Mitigation Requirements • Mitigation zones: – 1,000 yd. power down, 500 yd. power down, and 200 yd. shut down for hull-mounted mid-frequency active sonar – 200 yd. shut down for mid-frequency active sonar sources that are not hull-mounted and high-frequency active sonar • Prior to the initial start of the activity (e.g., when maneuvering on station): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of active sonar transmission. • During the activity: – Hull-mounted mid-frequency active sonar: Observe the mitigation zone for marine mammals and sea turtles (for sources <2 kHz); power down active sonar transmission by 6 dB if a marine mammal or sea turtle is observed within 1,000 yd. of the sonar source; power down an additional 4 dB (10 dB total) if a marine mammal or sea turtle is observed within 500 yd.; cease transmission if a marine mammal or sea turtle is observed within 200 yd. – Mid-frequency active sonar sources that are not hull-mounted and high-frequency active sonar: Observe the mitigation zone for marine mammals and sea turtles (for sources <2 kHz); cease transmission if a marine mammal or sea turtle is observed within 200 yd. of the sonar source. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: – The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing or powering up active sonar transmission) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the sonar source; (3) the mitigation zone has been clear from any additional sightings for 10 minutes for aircraft-deployed sonar sources or 30 minutes for vessel-deployed sonar sources; (4) for mobile activities, the active sonar source has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting; or (5) for activities using hull-mounted sonar, the Lookout concludes that dolphins are deliberately closing in on the ship to ride the ship's bow wave, and are therefore out of the main transmission axis of the sonar (and there are no other marine mammal sightings within the mitigation zone).

Section 3.8.3.1.2 (Impacts from Sonar and Other Transducers) of this SEIS/OEIS provides a full analysis of the potential impacts of sonar on marine mammals and includes the impact ranges for various source bins. For all active sonar sources used under the Proposed Action, bin MF1 has the longest predicted ranges to PTS. For the highest source level in bin MF1, the 1,000 yd. and 500 yd. power down mitigation zones and 200 yd. shut down mitigation zone extend beyond the average ranges to PTS for marine mammals. The ranges to PTS for the 200 yd. shut down mitigation zone were calculated based on full power transmissions and do not consider that the impact ranges would be reduced if the 1,000 yd. and 500 yd. power down mitigation measures are implemented in response to a marine mammal sighting in those mitigation zones. If an animal is first sighted in the 1,000 yd. or 500 yd. power down mitigation zone, the source level reduction would shorten the ranges to PTS, and the 200 yd. shut down mitigation would then extend even further beyond the average ranges to PTS for all marine mammal hearing groups. The active sonar mitigation zones also extend beyond the average ranges to TTS for Otariids and into a portion of the average ranges to TTS for all other marine mammal hearing groups; therefore, mitigation will help avoid or reduce the potential for some exposure to higher levels of TTS. Active sonar sources that fall within lower source bins or are used at lower source levels have shorter impact ranges than those discussed above; therefore, the mitigation zones will extend further beyond or into the average ranges to PTS and TTS for these sources. The 30-minute wait period for vessel-deployed sources will cover the average dive times of most marine mammal species that occur in the TMAA, and a portion of the dive times of deep-diving species (e.g., sperm whales). The 10-minute wait period for aircraft-deployed sources will cover a portion, but not the average, of the dive times of marine mammals.

Due to sea turtle hearing capabilities, the mitigation only applies to sea turtles during the use of sources below 2 kilohertz. The range to auditory effects for most active sonar sources in sea turtle hearing range is zero meters. Impact ranges are longer (i.e., up to tens of meters) for active sonars with higher source levels. The mitigation zones for active sonar extend beyond the ranges to PTS and TTS for sea turtles; therefore, mitigation will help avoid or reduce the potential for exposure to these effects for sea turtles.

The Navy currently uses, and will continue to use, computer simulation to augment training whenever possible. Simulators and synthetic training are critical elements that provide early skill repetition and enhance teamwork; however, they cannot replicate the complexity and stresses faced by Sailors during military missions and combat operations to which the Navy trains under the Proposed Action (e.g., anti-submarine warfare training using hull-mounted mid-frequency active sonar). Training with active sonar is essential to national security. Active sonar is the only reliable technology for detecting and tracking potential enemy diesel-electric submarines. The ability to effectively operate active sonar is a highly perishable skill that must be repeatedly practiced during realistic training. Naval forces must train in the same mode and manner in which they conduct military missions and combat operations. Anti-submarine warfare training typically involves the periodic use of active sonar to develop the "tactical picture," or an understanding of the battle space (e.g., area searched or unsearched, identifying false contacts, and understanding the water conditions). This can take from several hours to multiple days and typically occurs over vast areas with varying physical and oceanographic conditions (e.g., bathymetry, topography, surface fronts, and variations in sea surface temperature). Sonar operators train to avoid or reduce interference and sound-reducing clutter from varying ocean floor topographies and environmental conditions, practice coordinating their efforts with other sonar operators in a strike group, develop skill proficiency in detecting and tracking submarines and other threats, and practice the focused endurance vital to effectively working as a team in shifts around the clock until the conclusion of the event.

As described previously, the mitigation zones developed for this SEIS/OEIS are based on the largest areas within which it is practical for the Navy to implement mitigation during training within the TMAA. Increasing the mitigation zone sizes would result in a larger area over which active sonar would need to be powered down or shut down in response to a sighting, and therefore would likely increase the number of times that these mitigation measures would be implemented. This would extend the length of the activity, significantly diminish event realism, and prevent activities from meeting their intended objectives. It would also create fundamental differences between how active sonar would be used in training and how active sonar should be used during military missions and combat operations. For example, additional active sonar power downs or shut downs would prevent sonar operators from developing and maintaining awareness of the tactical picture during training events. Without realistic training in conditions analogous to military missions and combat operations, sonar operators cannot become proficient in effectively operating active sonar. Sonar operators, vessel crews, and aircrews would be expected to operate active sonar during military missions and combat operations in a manner inconsistent with how they were trained.

During integrated training, multiple vessels and aircraft may participate in an exercise using different warfare components simultaneously. Degrading the value of one training element results in a degradation of the training value of the other training elements. Degrading the value of training would cause a reduction in perishable skills and diminished operational capability, which would significantly impact military readiness. Each of these factors would ultimately impact the ability for units to meet their individual training and certification requirements and the Navy's ability to certify forces to safely deploy to meet national security tasking. Diminishing proficiency or eroding active sonar capabilities would present a significant risk to personnel safety during military missions and combat operations and would impact the ability to deploy with the required level of readiness necessary to accomplish any tasking by Combatant Commanders.

For activities that involve aircraft (e.g., activities involving rotary-wing aircraft that use dipping sonar or sonobuoys to locate submarines or submarine targets), extending the length of the activity would require aircraft to depart the area to refuel. If multiple refueling events were required, the length of the activity would be extended by two to five times or more, which would decrease the ability for Lookouts to safely and effectively maintain situational awareness of the activity area and increase safety risks due to increased pilot fatigue and accelerated fatigue-life of aircraft. Extending the length of the activity would also result in additional operational costs due to increased fuel consumption. Increasing the mitigation zone sizes would not result in a substantial reduction of injurious impacts because, as described above, the mitigation zones extend beyond the average ranges to PTS for sea turtles and marine mammals.

In summary, the operational community determined that implementing procedural mitigation for active sonar beyond what is detailed in Table 5.3-2 would be incompatible with the practicality assessment criteria for safety, sustainability, and mission requirements.

5.3.2.2 Weapon Firing Noise

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts from weapon firing noise, as outlined in Table 5.3-3.

Table 5.3-3: Procedural Mitigation for Weapon Firing Noise

Procedural Mitigation Description
Stressor or Activity • Weapon firing noise associated with large-caliber gunnery activities
Resource Protection Focus • Marine mammals • Sea turtles • Seabirds (short-tailed albatross)
Number of Lookouts and Observation Platform • 1 Lookout positioned on the ship conducting the firing – Depending on the activity, the Lookout could be the same one described in Section 5.3.3.1 (Explosive Large-Caliber Projectiles) or Section 5.3.4.3 (Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions)
Mitigation Requirements • Mitigation zone: – 30° on either side of the firing line out to 70 yd. from the muzzle of the weapon being fired • Prior to the initial start of the activity: – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals, sea turtles, and seabirds; if observed, relocate or delay the start of weapon firing. • During the activity: – Observe the mitigation zone for marine mammals, sea turtles, and seabirds; if observed, cease weapon firing. • Commencement/recommencement conditions after a marine mammal, sea turtle, or seabird sighting before or during the activity: – The Navy will allow a sighted marine mammal, sea turtle, or seabird to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing weapon firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the firing ship; (3) the mitigation zone has been clear from any additional sightings for 30 minutes; or (4) for mobile activities, the firing ship has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

In the 2016 GOA Final SEIS/OEIS, the weapon firing noise mitigation zone for marine mammals and sea turtles was based on the associated average ranges to PTS. When developing this SEIS/OEIS, the Navy analyzed the potential for increasing mitigation for this stressor. The Navy determined that the current mitigation zone is the largest area within which it is practical to implement mitigation for this activity; therefore, it will continue implementing the same mitigation zone size under the Proposed Action. The Navy identified an opportunity to develop new weapon firing noise mitigation for seabirds in the TMAA. The Navy will implement a weapon firing noise mitigation zone for seabirds consistent with the mitigation zone used for similar activities in the Northwest Training and Testing SEIS/OEIS to enhance protection of the ESA-listed short-albatross under the Proposed Action.

The Navy is clarifying in the table that it will require observation of the mitigation zone prior to the initial start of the activity to ensure the area is clear of applicable biological resources. The Navy has always verified that the mitigation zone is visually clear prior to conducting weapon firing activities and is more clearly capturing this current practice in the mitigation measures for this activity. The Navy will follow the incident reporting procedures outlined in Section 5.1.2.2.3 (Incident Reports) if an incident is detected at any time during the event.

The small mitigation zone size and proximity to the observation platform will result in a high likelihood that Lookouts will be able to detect marine mammals, sea turtles, and seabirds throughout the mitigation zone. Section 3.9.3.1.5 (Impacts from Weapon Noise) provides a full analysis of the potential impacts of weapon noise on birds. Due to the difficulty of differentiating bird species, the Navy will implement mitigation for all seabird species for weapon noise during large-caliber weapon firing. Although there is a low likelihood that short-tailed albatross will occur in locations where the Navy conducts large-caliber gunnery activities, the mitigation will help the Navy further avoid or reduce potential impacts (e.g., startle response) on ESA-listed birds and other seabird species that occur in the TMAA.

Section 3.8.3.1.5 (Impacts from Weapon Noise) of this SEIS/OEIS and Section 3.7.2.2 (Approach to Analysis) of the 2011 GOA Final SEIS/OEIS provide an analysis of the potential impacts of weapon noise on marine mammals and sea turtles, respectively. Underwater sounds from large-caliber weapon firing activities would be strongest just below the surface and directly under the firing point. Any sound that enters the water only does so within a narrow cone below the firing point or path of the projectile. The mitigation zone extends beyond the distance to which marine mammals and sea turtles would likely experience PTS or TTS from weapon firing noise; therefore, mitigation will help avoid or reduce the potential for exposure to these impacts. Observing for floating vegetation will further help avoid or reduce potential impacts on marine mammals and sea turtles within the mitigation zone.

As described previously, the mitigation zone developed for this SEIS/OEIS is based on the largest area within which it is practical for the Navy to implement mitigation for this activity. Increasing the mitigation zone would result in a larger area over which weapon firing would need to be ceased in response to a sighting, and therefore would likely increase the number of times weapon firing would be ceased. However, increasing the mitigation zone size would not result in a substantial reduction of injurious impacts because the mitigation zone extends beyond the average ranges to PTS for sea turtles and marine mammals.

Large-caliber gunnery training activities may involve a single ship firing or may be conducted as part of a larger exercise involving multiple ships. Surface ship crews learn to track targets (e.g., with radar), engage targets, practice defensive marksmanship, and coordinate their efforts within the context of larger activities. Increasing the number of times that the Navy must cease weapon firing during training would decrease realism and impact the ability for Navy Sailors to train and become proficient in using large-caliber guns as required during military missions and combat operations. For example, additional ceasing of the activity would reduce the crew's ability to react to changes in the tactical situation or respond to an incoming threat, which could result in a delay to the ship's training schedule. When training is undertaken in the context of a coordinated exercise involving multiple ships, degrading the value of one of the training elements results in a degradation of the training value of the other training elements. These factors would ultimately impact the ability for units to meet their individual training and certification requirements, and the Navy's ability to certify forces to deploy to meet national security tasking.

In summary, the operational community determined that implementing procedural mitigation for weapon firing noise beyond what is detailed in Table 5.3-3 would be incompatible with the practicality assessment criteria for safety and mission requirements.

5.3.3 Explosive Stressors

The Navy will implement procedural mitigation to avoid or reduce potential impacts on biological resources from the explosives discussed in the sections below. Section 3.8.3.2 (Explosive Stressors) of this SEIS/OEIS, Section 3.7.2.2 (Explosive Stressors) of the 2011 GOA Final SEIS/OEIS, and Section 3.9.3.2

(Explosive Stressors) provide a full analysis of the potential impacts of explosives on marine mammals, sea turtles, and seabirds, respectively, including predicted impact ranges. In addition to procedural mitigation, the Navy will implement mitigation for explosives within mitigation areas, as described in Section 5.4 (Geographic Mitigation to be Implemented).

5.3.3.1 Explosive Medium-Caliber and Large-Caliber Projectiles

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts from explosive gunnery activities, as outlined in Table 5.3-4. In the 2016 GOA Final SEIS/OEIS, explosive gunnery activity mitigation zones for marine mammals and sea turtles were based on net explosive weight and the associate average ranges to PTS. When developing this SEIS/OEIS, the Navy analyzed the potential for increasing the size of these mitigation zones. The Navy identified an opportunity to increase the marine mammal and sea turtle mitigation zone sizes by 400 yd. for surface-to-surface activities to enhance protections to the maximum extent practicable. These increases are reflected in Table 5.3-4. The marine mammal and sea turtle mitigation zones for explosive medium-caliber and large-caliber projectiles are now based on the largest areas within which it is practical to implement mitigation.

The Navy also identified an opportunity to develop new mitigation for seabirds during explosive medium-caliber gunnery activities. The Navy will implement a 200 yd. mitigation zone for seabirds, consistent with the mitigation zone developed with USFWS guidance for similar activities in the Northwest Training and Testing SEIS/OEIS to enhance protection of the ESA-listed short-albatross under the Proposed Action. Due to the difficulty of differentiating bird species, the Navy will implement mitigation for all seabird species during explosive medium-caliber weapon firing. Although there is a low likelihood that short-tailed albatross will be exposed to explosive medium-caliber gunnery activities in the TMAA, the mitigation will help the Navy further avoid or reduce potential impacts on this ESA-listed bird species, as well as other seabird species that occur in the TMAA. The Navy will not implement mitigation for seabirds during explosive large-caliber gunnery events because Lookouts would not be effective at detecting seabirds from the distant firing location, even with the use of high-powered binoculars.

The Navy is clarifying in the table that it will require observation of the mitigation zone prior to the initial start of the activity to ensure the area is clear of applicable biological resources. The Navy has always verified that the mitigation zone is visually clear prior to conducting explosive activities and is more clearly capturing this current practice in the mitigation measures for this activity. The Navy developed a new mitigation measure requiring the Lookout to observe the mitigation zone after completion of the activity. In accordance with the 2016 GOA Final SEIS/OEIS consultation requirements, the Navy currently conducts post-activity observations for some, but not all explosive activities. When developing this SEIS/OEIS, the Navy determined that it could expand this requirement to other explosive activities for enhanced consistency and to help determine if any resources were injured during explosive events, when practical. The Navy is also adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources. The Navy will follow the incident reporting procedures outlined in Section 5.1.2.2.3 (Incident Reports) if an incident is detected at any time during the event, including during the post-activity observations.

Table 5.3-4: Procedural Mitigation for Explosive Medium-Caliber and Large-Caliber Projectiles

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using explosive medium-caliber and large-caliber projectiles   – Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles • Seabirds (short-tailed albatross)
Number of Lookouts and Observation Platform • 1 Lookout on the vessel or aircraft conducting the activity   – For activities using explosive large-caliber projectiles, depending on the activity, the Lookout could be the same as the one described in Section 5.3.2.2 (Weapon Firing Noise) • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.

Mitigation Requirements
• Mitigation zones:
   – 200 yd. (for seabirds, marine mammals, and sea turtles) around the intended impact location for air-to-surface activities using explosive medium-caliber projectiles
   – 200 yd. (for seabirds) and 600 yd. (for marine mammals and sea turtles) around the intended impact location for surface-to-surface activities using explosive medium-caliber projectiles
   – 1,000 yd. (for marine mammals and sea turtles) around the intended impact location for surface-to-surface activities using explosive large-caliber projectiles
• Prior to the initial start of the activity (e.g., when maneuvering on station):
   – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear.
   – Observe the mitigation zone for marine mammals, sea turtles, and seabirds (as applicable); if observed, relocate or delay the start of firing.
• During the activity:
   – Observe the mitigation zone for marine mammals, sea turtles, and seabirds (as applicable); if observed, cease firing.
• Commencement/recommencement conditions after a marine mammal, sea turtle, or seabird sighting (as applicable) before or during the activity:
   – The Navy will allow a sighted marine mammal, sea turtle, or seabird to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; (3) the mitigation zone has been clear from any additional sightings for 10 min. for aircraft-based firing or 30 minutes for vessel-based firing; or (4) for activities using mobile targets, the intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.
• After completion of the activity (e.g., prior to maneuvering off station):
   – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead marine mammals or Endangered Species Act-listed species are observed, follow established incident reporting procedures.
   – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

Large-caliber gunnery activities involve vessels firing projectiles at targets located up to 6 nautical miles (NM) down range. Medium-caliber gunnery activities involve vessels or aircraft firing projectiles at targets located up to 4,000 yd. down range, although typically much closer. As described in Section 5.2.1 (Procedural Mitigation Development), certain platforms, such as the small boats and aircraft used during explosive medium-caliber gunnery exercises, have manning or space restrictions; therefore, the Lookout for these activities is typically an existing member of the aircraft or boat crew who is responsible for other essential tasks (e.g., navigation). Due to their relatively lower vantage point, Lookouts on vessels (during medium-caliber or large-caliber gunnery exercises) will be more likely to detect large visual cues (e.g., whale blows, breaching whales) than individual marine mammals, cryptic marine mammal species, and sea turtles when observing around targets located at the furthest firing distances. The Navy will implement larger mitigation zones for large-caliber gunnery activities than for medium-caliber gunnery activities due to the nature of how the activities are conducted. For example, large-caliber gunnery activities are conducted from surface combatants, so Lookouts can observe a larger mitigation zone because they typically have access to high-powered binoculars mounted on the ship deck. This will enable observation of the distant mitigation zone in combination with hand-held binoculars and naked-eye scanning. Lookouts in aircraft (during medium-caliber gunnery exercises), have a relatively higher vantage point for observing the mitigation zones but will still be more likely to detect individual marine mammals and sea turtles when observing mitigation zones located close to the firing platform than at the furthest firing distances.

The mitigation applies only to activities using surface targets. Most airborne targets are recoverable aerial drones that are not intended to be hit by ordnance. Given the speed of the projectiles and mobile target, and the long ranges that projectiles typically travel, it is not possible to definitively predict or to effectively observe where the projectile fragments will fall. For gunnery activities using explosive medium-caliber and large-caliber projectiles, the potential military expended material fall zone can only be predicted within thousands of yards, which can be up to 6 NM from the firing location. These areas are too large to be effectively observed for marine species with the number of personnel and platforms available for this activity. The potential risk to marine mammals and sea turtles during events using airborne targets is limited to the animal being directly struck by falling military expended materials. There is no potential for direct impact from the explosives because the detonations occur in air. Based on the extremely low potential for projectile fragments to co-occur in space and time with a marine mammal or sea turtle at or near the surface of the water, the potential for a direct strike is negligible; therefore, mitigation for gunnery activities using airborne targets would not be effective at avoiding or reducing potential impacts on marine mammals and sea turtles.

Bin E5 (e.g., 5 in. large-caliber projectiles) has the longest predicted impact ranges for explosive projectiles used in the TMAA. The 1,000 yd. and 600 yd. mitigation zones extend beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals for bin E5. The mitigation zones extend into a portion of the average ranges to PTS for high-frequency cetaceans and beyond the average ranges to PTS for sea turtles and other marine mammal hearing groups for bin E5. The mitigation zones also extend beyond or into a portion of the average ranges to TTS for sea turtles and marine mammals. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest explosives in bin E5. Explosives in smaller source bins (e.g., 40-millimeter medium-caliber projectiles in Bin E2) have shorter predicted impact ranges; therefore, the mitigation zones will extend further beyond or cover a greater portion of the impact ranges for these explosives.

As described previously, the mitigation zones developed for this SEIS/OEIS are based on the largest areas within which it is practical for the Navy to implement mitigation for marine mammals and sea turtles. It is not practical to increase these mitigation zones because observations within the margin of increase would be unsafe and ineffective. One of the mission-essential safety protocols for explosive gunnery activities is a requirement for event participants (including the Lookout) to maintain focus on the activity area to ensure safety of Navy personnel and equipment, and the public. For example, when air-to-surface medium-caliber gunnery exercises involve fighter aircraft descending on a target, or rotary-wing aircraft flying a racetrack pattern and descending on a target using a forward-tilted firing angle, maintaining attention on the activity area is paramount to aircraft safety. The typical activity areas for medium-caliber and large-caliber gunnery activities coincide with the applicable mitigation zones; therefore, the Lookout can safely and effectively observe the mitigation zones for biological resources while simultaneously maintaining focus on the activity area. However, if the mitigation zone sizes increased, the Lookout would need to redirect attention to observe beyond the activity area. This would not meet the safety criteria since personnel would be required to direct attention away from mission requirements. Alternatively, the Navy would need to add personnel to serve as additional Lookouts on the existing observation platforms or allocate additional platforms to the activity to observe for biological resources. These actions would not be safe or sustainable due to an exceedance of manpower, resource, and space restrictions for these activities. Similarly, positioning platforms closer to the intended impact location would increase safety risks related to proximity to the detonation location and path of the explosive projectile.

Increasing the mitigation zone sizes would result in larger areas over which detonations would need to be ceased in response to a sighting, and therefore would likely increase the number of times firing would be ceased and would extend the length of the activity. These impacts would significantly diminish event realism in a way that would prevent activities from meeting their intended objectives. For example, the Navy must train its gun crews to coordinate with other participating platforms (e.g., small boats launching a target, other firing platforms), locate and engage surface targets (e.g., high speed maneuverable surface targets), and practice precise defensive marksmanship to disable threats.

Depending on the type of target being used, additional stopping of the activity could result in the target needing to be recovered and relaunched, which would cause a significant loss of training time. For activities that involve aircraft, extending the length of the activity would require aircraft to depart the area to refuel. If multiple refueling events were required, the length of the activity would be extended by two to five times or more, which would decrease the ability for Lookouts to safely and effectively maintain situational awareness of the activity area and increase safety risks due to increased pilot fatigue and accelerated fatigue-life of aircraft. These types of impacts would reduce the number of opportunities that gun crews have to fire on the target and cause significant delays to the training schedule. Therefore, an increase in mitigation would impede the ability for gun crews to train and become proficient in using their weapons as required during military missions and combat operations and would prevent units from meeting their individual training and certification requirements (which would prevent them from deploying with the required level of readiness necessary to accomplish their missions). Extending the length of the activity would also result in additional operational costs due to increased fuel consumption.

In summary, the operational community determined that implementing procedural mitigation for explosive medium-caliber and large-caliber projectiles beyond what is detailed in Table 5.3-4 would be incompatible with the practicality assessment criteria for safety, sustainability, and mission requirements.

5.3.3.2 Explosive Bombs

The Navy will continue to implement procedural mitigation to avoid or reduce potential impacts on marine mammals and sea turtles from explosive bombs, as outlined in Table 5.3-5.

Table 5.3-5: Procedural Mitigation for Explosive Bombs

Procedural Mitigation Description
Stressor or Activity • Explosive bombs
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in the aircraft conducting the activity • If additional platforms are participating in the activity, personnel positioned in those assets (e.g., safety observers, evaluators) will support observing the mitigation zone for applicable biological resources while performing their regular duties.
Mitigation Requirements • Mitigation zone: – 2,500 yd. around the intended target • Prior to the initial start of the activity (e.g., when arriving on station): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of bomb deployment. • During the activity (e.g., during target approach): – Observe the mitigation zone for marine mammals and sea turtles; if observed, cease bomb deployment. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting before or during the activity: – The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing bomb deployment) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target; (3) the mitigation zone has been clear from any additional sightings for 10 minutes; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting. • After completion of the activity (e.g., prior to maneuvering off station): – When practical (e.g., when platforms are not constrained by fuel restrictions or mission-essential follow-on commitments), observe the vicinity of where detonations occurred; if any injured or dead marine mammals or ESA-listed species are observed, follow established incident reporting procedures. – If additional platforms are supporting this activity (e.g., providing range clearance), these assets will assist in the visual observation of the area where detonations occurred.

In the 2016 GOA Final SEIS/OEIS, the explosive bombing mitigation zone was based on net explosive weight and the associated average ranges to PTS for marine mammals. When developing this SEIS/OEIS, the Navy analyzed the potential for increasing the size of this mitigation zone. The Navy determined that the current mitigation zone for explosive bombs is the largest area within which it is practical to implement mitigation for this activity; therefore, it will continue implementing this same mitigation zone under the Proposed Action.

The Navy is clarifying in the table that it will require observation of the mitigation zone prior to the initial start of the activity to ensure the area is clear of applicable biological resources. The Navy has always verified that the mitigation zone is visually clear prior to conducting explosive activities and is more clearly capturing this current practice in the mitigation measures for this activity. The Navy developed a new mitigation measure requiring the Lookout to observe the mitigation zone after completion of this activity. In accordance with the 2016 GOA Final SEIS/OEIS consultation requirements, the Navy currently conducts post-activity observations for some, but not all explosive activities. When developing this SEIS/OEIS, the Navy determined that it could expand this requirement to other explosive activities for enhanced consistency and to help determine if any resources were injured during explosive events, when practical. The Navy is also adding a requirement that additional platforms already participating in the activity will support observing the mitigation zone before, during, and after the activity while performing their regular duties. Typically, when aircraft are firing explosive munitions there are additional observation aircraft, multiple aircraft firing munitions, or other safety aircraft in the vicinity. When available, having additional personnel support observations of the mitigation zone will help increase the likelihood of detecting biological resources. The Navy will follow the incident reporting procedures outlined in Section 5.1.2.2.3 (Incident Reports) if an incident is detected at any time during the event, including during the post-activity observations.

Bombing exercises involve an aircraft deploying munitions at a surface target located beneath the firing platform. During target approach, aircraft maintain a relatively steady altitude of approximately 1,500 ft. Lookouts, by necessity for safety and mission success, primarily focus their attention on the water surface surrounding the intended detonation location (i.e., the mitigation zone). Being positioned in an aircraft gives the Lookout a good vantage point for observing marine mammals and sea turtles throughout the mitigation zone. Observing for floating vegetation will further help avoid or reduce potential impacts on marine mammals and sea turtles within the mitigation zone.

Bin E12 (e.g., 2,000-pound bomb) has the longest predicted impact ranges for explosive bombs used in the TMAA. The 2,500 yd. mitigation zone extends beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals. The mitigation zone extends into a portion of the average range to PTS for high-frequency cetaceans and beyond the average ranges to PTS for other marine mammal hearing groups and sea turtles. The mitigation zone also extends beyond or into a portion of the average ranges to TTS for marine mammals and sea turtles. Therefore, depending on the species, mitigation will help avoid or reduce all or a portion of the potential for exposure to mortality, non-auditory injury, PTS, and higher levels of TTS for the largest bombs in bin E12. Smaller bombs in bin E12 have shorter predicted impact ranges; therefore, the mitigation zone will extend further beyond or cover a greater portion of the impact ranges for these explosives.

As described previously, the mitigation zone developed for this SEIS/OEIS is based on the largest area within which it is practical for the Navy to implement mitigation. It is not practical to increase this mitigation zone because observations within the margin of increase would be unsafe and ineffective unless the Navy allocated additional platforms to the activity to observe for biological resources. The use of additional personnel and aircraft would be unsustainable due to increased operational costs and an exceedance of the available manpower and resources for this activity. Adding aircraft to observe the mitigation zone could result in airspace conflicts with the event participants. This would either require the aircraft participating in the activity to modify their flight plans (which would reduce activity realism) or force the observing aircraft to position itself a safe distance away from the activity area (which would decrease observation effectiveness). Adding vessels to observe the mitigation zone would increase safety risks due to the presence of observation vessels within the vicinity of the intended explosive bomb detonation location.

Increasing the mitigation zone would result in a larger area over which explosive bomb deployment would need to be ceased in response to a sighting, and therefore would likely increase the number of times explosive bombing activities would be ceased and would extend the length of the activity. These impacts would significantly diminish event realism in a way that would prevent the activity from meeting its intended objectives. For example, critical components of a Bombing Exercise Air-to-Surface training activity are the assembly, loading, delivery, and assessment of an explosive bomb. The activity requires focused situational awareness of the activity area and continuous coordination between multiple training components. The training exercise starts with ground personnel, who must practice the building and loading of explosive munitions. Training includes the safe handling of explosive material, configuring munitions to precise specifications, and loading munitions onto aircraft. Aircrew must then identify a target and safely deliver fused munitions, discern if the bomb was assembled correctly, and determine bomb damage assessments based on how and where the explosive detonated. Extending the length of the activity would require aircraft to depart the area to refuel. If the firing aircraft departed the activity area to refuel, aircrew would lose the ability to maintain situational awareness of the activity area, effectively coordinate with other participating platforms, and complete all training components as required during military missions and combat operations. If multiple refueling events were required, the activity length would be extended by two to five times or more, which would cause a significant loss of training time and would increase safety risks due to increased pilot fatigue and accelerated fatigue-life of aircraft. This would reduce the number of opportunities that aircrews have to approach targets and deploy bombs, which would cause a significant delay to the training schedule. Therefore, an increase in mitigation would impede the ability for aircrews to train and become proficient in using their weapons. This would prevent units from meeting their individual training and certification requirements and deploying with the required level of readiness necessary to accomplish their missions. Extending the length of the activity would also result in additional operational costs due to increased fuel consumption.

In summary, the operational community determined that implementing procedural mitigation for explosive bombs beyond what is detailed in Table 5.3-5 would be incompatible with the practicality assessment criteria for safety, sustainability, and mission requirements.

5.3.4 Physical Disturbance and Strike Stressors

The Navy will implement procedural mitigation to avoid or reduce potential impacts on biological resources from the physical disturbance and strike stressors or activities discussed in the sections below. Section 3.8.2.2 (Approach to Analysis), Section 3.7.2.2 (Approach to Analysis), and Section 3.9.2.3 (Approach to Analysis) of the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011) provide analyses of the potential impacts of physical disturbance and strikes on marine mammals, sea turtles, and seabirds, respectively.

5.3.4.1 Vessel Movement

The Navy will continue to implement procedural mitigation to avoid or reduce the potential for vessel strikes of marine mammals and sea turtles, as outlined in Table 5.3-6.

Table 5.3-6: Procedural Mitigation for Vessel Movement

Procedural Mitigation Description
Stressor or Activity • Vessel movement – The mitigation will not be applied if (1) the vessel's safety is threatened, (2) the vessel is restricted in its ability to maneuver (e.g., during launching and recovery of aircraft or landing craft, during towing activities, when mooring), (3) the vessel is submerged or operated autonomously, or (4) when impractical based on mission requirements (e.g., during Vessel Visit, Board, Search, and Seizure activities as military personnel from ships or aircraft board suspect vessels).
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout on the vessel that is underway
Mitigation Requirements • Mitigation zones: – 500 yd. around whales – 200 yd. around other marine mammals (except bow-riding dolphins) – Within the vicinity of sea turtles • During the activity: – When underway, observe the mitigation zone for marine mammals and sea turtles; if observed, maneuver to maintain distance. • Additional requirements: – If a marine mammal or sea turtle vessel strike occurs, the Navy will follow established incident reporting procedures.

The procedural mitigation measures for vessel movement are a continuation from the 2016 GOA Final SEIS/OEIS for marine mammals based on the largest area within which it is practical for the Navy to implement mitigation and guidance from NMFS for vessel strike avoidance. The Navy has always avoided vessel strikes of sea turtles, but is newly capturing that mitigation in this SEIS/OEIS. Although the Navy is unable to position Lookouts on unmanned vessels, as a standard operating procedure, some vessels that operate autonomously have embedded sensors that aid in avoidance of large objects. The embedded sensors may help those unmanned vessels avoid vessel strikes of marine mammals.
A mitigation zone size is not specified for sea turtles to allow flexibility based on vessel type and mission requirements. The small mitigation zone sizes and proximity to the observation platform will result in a high likelihood that Lookouts will be able to detect marine mammals and sea turtles throughout the mitigation zones while vessels are underway.

As discussed in Section 5.3.1 (Environmental Awareness and Education), it is likely that the implementation of the Marine Species Awareness Training starting in 2007, and the additional U.S. Navy Afloat Environmental Compliance Training Series modules starting in 2014, potentially helped contributed to a Navy wide reduction of vessel strikes of marine mammals across areas where the Navy conducts military readiness activities. The Navy is able to detect if a whale is struck due to the diligence of standard watch personnel and Lookouts stationed specifically to observe for marine mammals while a vessel is underway. In the unlikely event that a vessel strike of a marine mammal occurs, the Navy will notify the appropriate regulatory agency immediately or as soon as operational security considerations allow per the established incident reporting procedures described in Section 5.1.2.2.3 (Incident Reports). The Navy's incident reports include relevant information pertaining to the incident, including but not limited to vessel speed.

As described in Section 5.1.2 (Vessel Safety) of the 2016 GOA Final SEIS/OEIS, Navy vessels are required to operate in accordance with applicable navigation rules. Applicable rules include the Inland Navigation Rules (33 Code of Federal Regulations 83) and International Regulations for Preventing Collisions at Sea (72 COLREGS), which were formalized in the Convention on the International Regulations for Preventing Collisions at Sea, 1972. These rules require that vessels proceed at a safe speed so proper and effective action can be taken to avoid collision and so vessels can be stopped within a distance appropriate to the prevailing circumstances and conditions. In addition to complying with navigation requirements, Navy ships transit at speeds that are optimal for fuel conservation, to maintain ship schedules, and to meet mission requirements. Vessel captains use the totality of the circumstances to ensure the vessel is traveling at appropriate speeds in accordance with navigation rules. Depending on the circumstances, this may involve adjusting speeds during periods of reduced visibility or in certain locations.

Navy vessel operators need to train to proficiently operate vessels as they would during military missions and combat operations, including being able to react to changing tactical situations and evaluate system capabilities. For example, during training activities involving flight operations from an aircraft carrier, the vessel must maintain a certain wind speed over the deck to launch or recover aircraft. Depending on wind conditions, the aircraft carrier itself must travel at a certain speed to generate the wind required to launch or recover aircraft. Implementing vessel speed restrictions would increase safety risks for Navy personnel and equipment and the public during the training event and would reduce skill proficiency in a way that would increase safety risks during military missions and combat operations. Furthermore, vessel speed restrictions would not allow the Navy to continue meeting its training requirements due to diminished realism of training exercises.

In summary, the operational community determined that implementing procedural mitigation for vessel movements beyond what is detailed in Table 5.3-6 would be incompatible with the practicality assessment criteria for safety, sustainability, and mission requirements.

5.3.4.2 Towed In-Water Devices

The Navy will continue to implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from towed in-water devices, as outlined in Table 5.3-7. Vessels involved in towing in-water devices will implement the mitigation described in Section 5.3.4.1 (Vessel Movement), in addition to the mitigation outlined in Table 5.3-7.

The mitigation zones for towed in-water devices are a continuation from the 2016 GOA Final SEIS/OEIS based on the largest area within which it is practical for the Navy to implement mitigation. The Navy has always avoided sea turtles when towing in-water devices, but is newly capturing that mitigation in this SEIS/OEIS. A mitigation zone size is not specified for sea turtles to allow flexibility based on towing platform type and mission requirements. The small mitigation zone sizes and proximity to the observation platform will result in a high likelihood that Lookouts will be able to detect marine mammals and sea turtles throughout the mitigation zones.

Table 5.3-7: Procedural Mitigation for Towed In-Water Devices

Procedural Mitigation Description
Stressor or Activity • Towed in-water devices – Mitigation applies to devices towed from a manned surface platform or manned aircraft, or when a manned support craft is already participating in an activity involving in-water devices being towed by unmanned platforms – The mitigation will not be applied if the safety of the towing platform or in-water device is threatened
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned on the towing platform or support craft
Mitigation Requirements • Mitigation zones: – 250 yd. around marine mammals – Within the vicinity of sea turtles • During the activity (i.e., when towing an in-water device) – Observe the mitigation zone for marine mammals and sea turtles; if observed, maneuver to maintain distance.

Mission and safety requirements determine the operational parameters (e.g., course) for in-water device towing platforms. Towed-in water devices must be towed at certain speeds and water depths for stability, which are controlled in part by the towing platform's speed and directional movements. Because these devices are towed and not self-propelled, they generally have limited maneuverability and are not able to make immediate course corrections. For example, a high degree of pilot skill is required when rotary-wing aircraft are deploying in-water devices, safely towing them at relatively low speeds and altitudes, and recovering them. The aircraft can safely alter course to shift the route of the towed device in response to a sighted marine mammal or sea turtle up to a certain extent (i.e., up to the size of the mitigation zone) while still maintaining the parameters needed for stable towing. However, the aircraft would be unable to further alter its course to more drastically course-correct the towed device without decreasing towing stability, which would have implications for safety of personnel and equipment.

In summary, the operational community determined that implementing procedural mitigation for towed in-water devices beyond what is detailed in Table 5.3-7 would be incompatible with the practicality assessment criteria for safety.

5.3.4.3 Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions

The Navy will continue to implement procedural mitigation to avoid or reduce the potential for strike from small-, medium-, and large-caliber non-explosive practice munitions, as outlined in Table 5.3-8. The mitigation is a continuation from the 2016 GOA Final SEIS/OEIS for marine mammals and sea turtles. The mitigation zone is conservatively designed to be several times larger than the impact footprint for large-caliber non-explosive practice munitions, which are the largest projectiles used for these activities. Small-caliber and medium-caliber non-explosive practice munitions have smaller impact footprints than large-caliber non-explosive practice munitions; therefore, the mitigation zone will extend even further beyond the impact footprints for these smaller projectiles.

Table 5.3-8: Procedural Mitigation for Small-, Medium-, and Large-Caliber Non-Explosive Practice Munitions

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using small-, medium-, and large-caliber non-explosive practice munitions – Mitigation applies to activities using a surface target
Resource Protection Focus • Marine mammals • Sea turtles • Seabirds (short-tailed albatross)
Number of Lookouts and Observation Platform • 1 Lookout positioned on the platform conducting the activity – Depending on the activity, the Lookout could be the same as the one described in Section 5.3.2.2 (Weapon Firing Noise)
Mitigation Requirements • Mitigation zone: – 200 yd. around the intended impact location • Prior to the initial start of the activity (e.g., when maneuvering on station): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals and sea turtles (small-, medium-, and large-caliber activities) and seabirds (small- and medium-caliber activities); if observed, relocate or delay the start of firing. • During the activity: – Observe the mitigation zone for marine mammals and sea turtles (small-, medium-, and large-caliber activities) and seabirds (small- and medium-caliber activities); if observed, cease firing. • Commencement/recommencement conditions after a marine mammal, sea turtle, or seabird sighting before or during the activity: – The Navy will allow a sighted marine mammal, sea turtle, or seabird to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing firing) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended impact location; (3) the mitigation zone has been clear from any additional sightings for 10 minutes for aircraft-based firing or 30 minutes for vessel-based firing; or (4) for activities using a mobile target, the intended impact location has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

When developing this SEIS/OEIS, the Navy identified an opportunity to develop new mitigation for seabirds during non-explosive small- and medium-caliber gunnery activities. This new mitigation for seabirds is consistent with mitigation zone developed with USFWS guidance for similar activities in the Northwest Training and Testing SEIS/OEIS to enhance protection of the ESA-listed short-albatross under the Proposed Action. Due to the difficulty of differentiating bird species, the Navy will implement mitigation for all seabird species during small- and medium-caliber non-explosive gunnery activities. Although there is a low likelihood that short-tailed albatross will be exposed to these activities in the TMAA, the mitigation will help the Navy further avoid or reduce potential impacts on this ESA-listed bird species, as well as other seabird species that occur in the TMAA. The Navy will not implement mitigation for seabirds during non-explosive large-caliber gunnery events because Lookouts would not be effective at detecting seabirds from the distant firing location, even with the use of high-powered binoculars.

Large-caliber gunnery activities involve vessels firing projectiles at a target located up to 6 NM down range. Small- and medium-caliber gunnery activities involve vessels or aircraft firing projectiles at targets located up to 4,000 yd. down range, although typically much closer. Lookouts will have a better likelihood of detecting marine mammals and sea turtles when observing mitigation zones around targets located close to the firing platform. When observing activities that use a target located far from the firing platform, Lookouts will be more likely to detect large visual cues (e.g., whale blows or large pods of dolphins) than individual marine mammals, cryptic marine mammal species, and sea turtles. Observing for floating vegetation will further help avoid or reduce potential impacts on marine mammals and sea turtles within the mitigation zone. Positioning additional observers closer to the targets would increase safety risks because these platforms would be located in the vicinity of an intended impact location or in the path of a projectile.

5.3.4.4 Non-Explosive Bombs

The Navy will continue to implement procedural mitigation to avoid or reduce the potential for strike of marine mammals and sea turtles from non-explosive bombs, as outlined in Table 5.3-9.

Table 5.3-9: Procedural Mitigation for Non-Explosive Bombs

Procedural Mitigation Description
Stressor or Activity • Non-explosive bombs
Resource Protection Focus • Marine mammals • Sea turtles
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft
Mitigation Requirements • Mitigation zone: – 1,000 yd. around the intended target • Prior to the initial start of the activity (e.g., when arriving on station): – Observe the mitigation zone for floating vegetation; if observed, relocate or delay the start until the mitigation zone is clear. – Observe the mitigation zone for marine mammals and sea turtles; if observed, relocate or delay the start of bomb deployment. • During the activity (e.g., during approach of the target or intended minefield location): – Observe the mitigation zone for marine mammals and sea turtles; if observed, cease bomb deployment. • Commencement/recommencement conditions after a marine mammal or sea turtle sighting prior to or during the activity: – The Navy will allow a sighted marine mammal or sea turtle to leave the mitigation zone prior to the initial start of the activity (by delaying the start) or during the activity (by not recommencing bomb deployment) until one of the following conditions has been met: (1) the animal is observed exiting the mitigation zone; (2) the animal is thought to have exited the mitigation zone based on a determination of its course, speed, and movement relative to the intended target or minefield location; (3) the mitigation zone has been clear from any additional sightings for 10 minutes; or (4) for activities using mobile targets, the intended target has transited a distance equal to double that of the mitigation zone size beyond the location of the last sighting.

The mitigation zone for non-explosive bombs is conservatively designed to be several times larger than the impact footprint for the largest non-explosive bomb used for these activities. Smaller non-explosive bombs have smaller impact footprints than the largest non-explosive bomb used for these activities; therefore, the mitigation zone will extend even further beyond the impact footprints for these smaller military expended materials. Activities involving non-explosive bombing involve aircraft deploying munitions from a relatively steady altitude of approximately 1,500 ft. at a surface target or in an intended minefield located beneath the aircraft. Due to the mitigation zone size, proximity to the observation platform, and the good vantage point from an aircraft, Lookouts will be able to observe the entire mitigation zone during approach of the target or intended minefield location. Observing for floating vegetation will further help avoid or reduce potential impacts on marine mammals and sea turtles within the mitigation zone.

5.4 Geographic Mitigation to be Implemented

As described in Table 5.4-1 and shown in Figure 5.4-1, the Navy developed mitigation areas in the TMAA to avoid or reduce potential impacts on marine mammals and fishery resources from active sonar, explosives, and physical disturbance and strike stressors in particularly important habitat areas. Consistent with the definition provided in Section 3.0.4.2 (Explosive Stressors), within this section, the term "in-water explosives" refers specifically to detonations occurring in air at a height of 33 ft. (10 meters [m]) or less above the water surface, and detonations occurring directly on the water surface, both of which were modeled to detonate at a depth of 0.3 ft. (0.1 m) below the water surface.

Table 5.4-1: Mitigation Areas

Mitigation Area Description
Stressor or Activity • Sonar • Explosives • Physical disturbance and strikes
Resource Protection Focus • Marine mammals • Fishery resources
Mitigation Requirements[1] • **North Pacific Right Whale Mitigation Area** – From June 1 to September 30 within the North Pacific Right Whale Mitigation Area, the Navy will not use surface ship hull-mounted MF1 mid-frequency active sonar or in-water explosives during training. • **Portlock Bank Mitigation Area** – The Navy will not use in-water explosives in the Portlock Bank Mitigation Area during training. • **Temporary Maritime Activities Area** – The Temporary Maritime Activities Area boundaries will continue to be located outside of the 1993 NMFS-designated Steller sea lion critical habitat. – The Navy will issue annual seasonal awareness notification messages to alert ships and aircraft operating within the TMAA to the possible presence of increased concentrations of gray whales in their migration habitat from April 1 to August 31 and humpback whales on the continental shelf from June 1 to September 30. To maintain safety of navigation and to avoid interactions with gray whales and humpback whales, the Navy will instruct vessels to remain vigilant to the presence of large whales that may be vulnerable to vessel strikes or potential impacts from training activities. Platforms will use the information from the awareness notification messages to assist their visual observation of applicable mitigation zones during training activities and to aid in the implementation of procedural mitigation.

[1] Should national security present a requirement to conduct training prohibited by the mitigation requirements specified in this table, naval units will obtain permission from the appropriate designated Command authority prior to commencement of the activity. The Navy will provide NMFS with advance notification and include relevant information about the event (e.g., sonar hours, in-water explosives use) in its annual activity reports to NMFS.

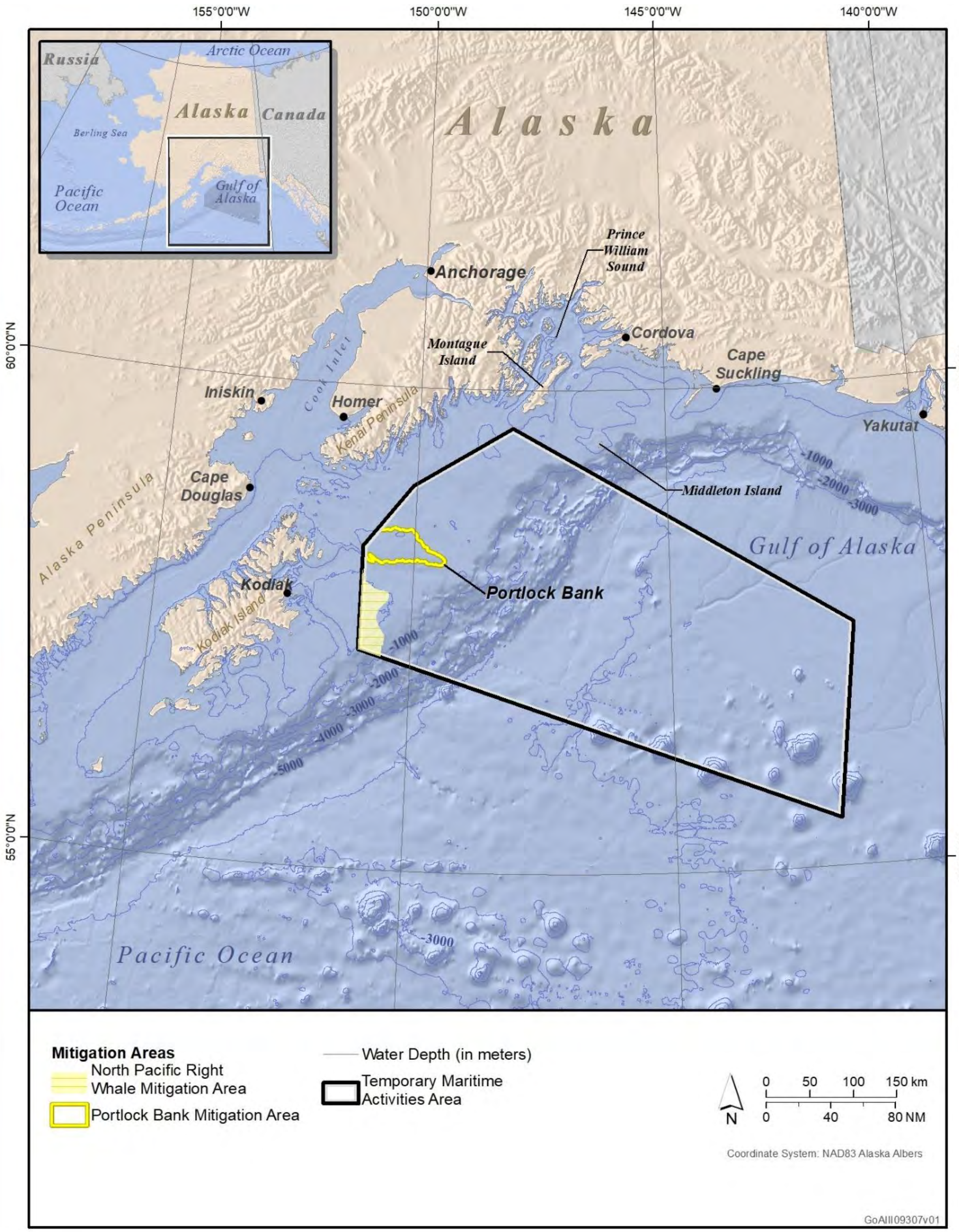

Figure 5.4-1: Mitigation Areas

5.4.1 Resource Descriptions for the Habitats Considered

Key marine species habitat areas identified within the TMAA that were considered for mitigation include biologically important areas identified by Ferguson et al. (2015) for North Pacific right whale feeding and gray whale migration, NMFS-proposed critical habitat for humpback whales, and a fishery area important for Native Alaska tribes. Discussion of one key habitat located adjacent to the TMAA, NMFS-designated critical habitat for Steller sea lions, is also included in this section because as described in Section 5.4.1.4 (Steller Sea Lions), the critical habitat would have been located within the TMAA absent mitigation to modify the TMAA boundaries. These habitat areas are described in the sections below and shown in Figure 5.4-2. The purpose of developing mitigation areas is to avoid or reduce potential impacts on key areas of biological or ecological importance; therefore, not all marine species or areas with known marine species occurrence are discussed in the sections below. For example, although blue whales have been detected seasonally in the GOA, the best available science does not indicate that any particular area within the TMAA serves as a key area of biological importance for this species.

5.4.1.1 North Pacific Right Whales

North Pacific right whales, which are listed under the ESA as endangered, are one of the world's rarest marine mammals (Wade et al., 2011). The species is distributed in the North Pacific Ocean from subpolar to temperate waters. Any individual in the TMAA would be from the Eastern North Pacific stock. The range of the Eastern North Pacific stock includes the Gulf of Alaska and Bering Sea, which are used for feeding in the summer months. North Pacific right whales primarily feed on zooplankton, including copepods and euphausiids. The location of winter breeding and calving areas is unknown (Muto et al., 2019).

One area that overlaps the southwest corner of the TMAA was identified by Ferguson et al. (2015) as biologically important North Pacific right whale feeding habitat from June to September. The feeding area was substantiated through vessel and aerial surveys, passive acoustic monitoring, fecal samples, historic whaling records, and expert judgment. Sightings and acoustic detections of North Pacific right whales in the Gulf of Alaska since the cessation of whaling have been extremely rare (Muto et al., 2019). Observations of this species have typically been made around the Barnabus Trough area (which is located just south of the TMAA) in association with dense concentrations of zooplankton (Wade et al., 2011). The U.S. Navy's Marine Species Monitoring Program sponsored a visual line-transect and passive acoustic monitoring survey of the TMAA and surrounding waters in summer 2013, known as the Gulf of Alaska Line-Transect Survey, or GOALS-II (Rone et al., 2014). Rone et al. (2014) acoustically detected North Pacific right whales outside of the TMAA in Barnabus Trough and did not visually observe the species within or outside of the TMAA. Similarly, during a 2015 Navy-sponsored survey in a portion of the TMAA and other waters in the Gulf of Alaska, NMFS and its scientific collaborators acoustically detected North Pacific right whales in Barnabus Trough, but did not make any visual observations (Rone et al., 2017). No North Pacific right whale detections were made during the most recent passive acoustic monitoring survey of the TMAA from 2015 to 2017 (Rice et al., 2018).

In summary, North Pacific right whale observations are rare within the TMAA. Historical records indicate that feeding within the TMAA could potentially occur within the biologically important area identified by Ferguson et al. (2015). Due to the species' extremely low population numbers and endangered status, the identified habitat area can be considered particularly important to North Pacific right whales relative to other locations in the TMAA, even though the occurrence of detections is rare. For additional information about North Pacific right whales and their habitat use and geographic range, see Section 3.8.2.2 (North Pacific Right Whale [*Eubalaena japonica*]) of this SEIS/OEIS.

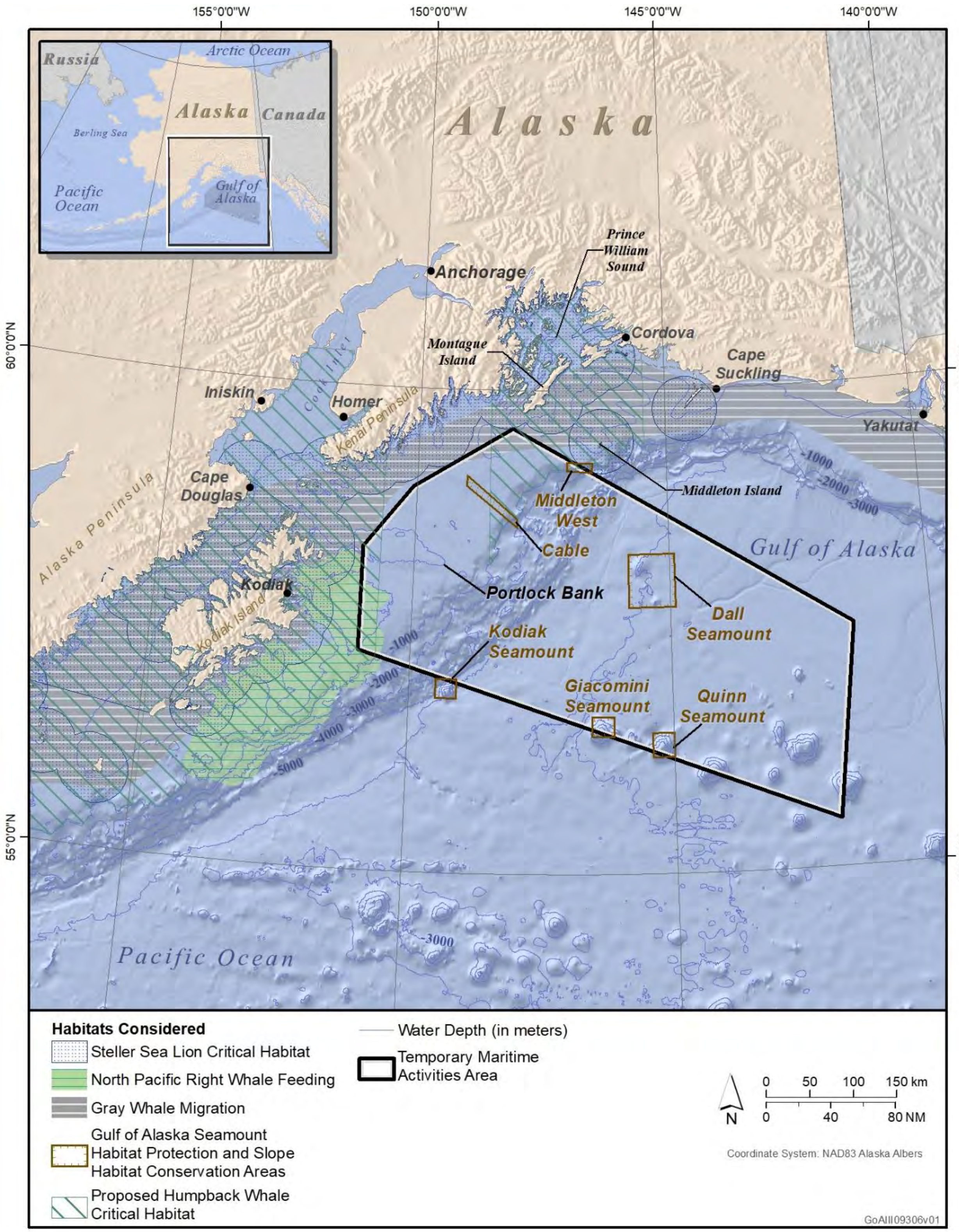

Figure 5.4-2: Habitats Considered

5.4.1.2 Humpback Whales

Humpback whales are distributed worldwide in all major oceans and most seas. They are most abundant in high-latitude feeding grounds during the summer, and in tropical and subtropical breeding habitats during the winter (Barlow et al., 2011; Bettridge et al., 2015; Calambokidis et al., 2017a; Calambokidis et al., 2010; Keen et al., 2018; Wade et al., 2016). Humpback whales are typically most abundant in shelf and slope waters less than 2,000 m deep, are often associated with areas of high productivity (Becker et al., 2010; Becker et al., 2012; Forney et al., 2012). As described in 84 Federal Register (FR) 54354, feeding areas primarily occur in cooler waters along the continental shelf and shelf break at shallow (i.e., less than 10 m) to moderate water depths (i.e., 50–200 m), and along the continental slope (Green et al., 1992). Humpback whale feeding areas are associated with productive oceanographic features (e.g., upwelling) and bathymetric features (e.g., canyons) that concentrate prey species (84 FR 54354). Individual humpback whales display high levels of site fidelity to their foraging locations.

As described in Section 3.8.2.3.1 (Status and Management), in 2019, NMFS proposed critical habitat for the Western North Pacific Distinct Population Segment and Mexico Distinct Population Segment of humpback whales in feeding areas that overlap the TMAA (84 FR 54354). Prey species for humpback whales in Alaska includes euphausiids, capelin, Pacific herring, Atka mackerel, juvenile walleye pollock, Pacific cod, mysids, amphipods, shrimp, and various other species of fish. The boundary of the proposed critical habitat was drawn to include areas where humpback whale aggregations have been documented feeding with a high degree of site fidelity further offshore Kodiak Island and Prince Willian Sound (Witteveen & Wynne, 2017). Passive acoustic monitoring studies (Debich et al., 2013; Debich et al., 2014a; Rice et al., 2015; Rice et al., 2018) have documented the presence of humpback whales year round in the TMAA, with a primary occurrence in the summer in locations (i.e., June through September) where prey species concentrate on the shelf (Burrows et al., 2016; Matta & Baker, 2020; McGowan et al., 2019; Moran et al., 2015; Straley et al., 2017).

The proposed critical habitat overlaps waters in and around Portlock Bank, an area known to have high productivity that may be particularly important for feeding. For example, in 2003, a humpback whale calf and its mother were observed feeding in Portlock Bank for at least 30 days (84 FR 54354). The proposed critical habitat also overlaps areas identified by Ferguson et al. (2015) as biologically important humpback whale feeding habitat located entirely outside of the TMAA off Kodiak Island and in Prince William Sound. The Kodiak Island biologically important area was identified for July through September, and the Prince William Sound area was identified for September through December. The biologically important area boundaries were based on vessel or aerial survey data, prey consumption studies, and photo-identification (Ferguson et al., 2015).

In summary, humpback whales feed in habitats in the North Pacific, both within and outside of the TMAA. Within the TMAA, the best available science indicates that foraging occurs primarily within the critical habitat proposed by NMFS in 2019; therefore, that habitat can be considered particularly important to humpback whales in the summer (i.e., June through September) relative to other locations in the TMAA (during the applicable months when the Proposed Action would occur). For additional information about humpback whales and their habitat use and geographic range, see Section 3.8.2.3 (Humpback Whale [*Megaptera novaeangliae*]) of this SEIS/OEIS.

5.4.1.3 Gray Whales

Gray whales from the Western North Pacific population, which is listed under the ESA as endangered, have been known to transit through offshore waters of the Gulf of Alaska (Carretta et al., 2017); however, their migration paths are not well defined (Ferguson et al., 2015; Muto et al., 2019).

As described in Section 3.8.2.8.1 (Status and Management), there are a few hundred gray whales that feed along the Pacific coast, known as the Pacific Coast Feeding Group (Calambokidis et al., 2002; Calambokidis et al., 2017b; Carretta et al., 2017; Mate et al., 2013; Weller et al., 2013). The Pacific Coast Feeding Group is a subpopulation of the Eastern North Pacific gray whale population. The majority of the Eastern North Pacific population of gray whales, which is not ESA-listed, migrates annually through the nearshore waters off western North America between winter breeding grounds off Mexico and summer feeding grounds from California to the Arctic (Calambokidis et al., 2015), including feeding areas off Kodiak Island (Gosho et al., 2011). Prey species for gray whales in these areas include amphipods, worms, bivalves, euphausiids, and crustaceans (Coyle et al., 2007; Moore et al., 2007).

As described in Section 3.8.2.8.3 (Distribution), gray whale occurrence in the TMAA is expected to be seasonal, with their highest likelihood of occurring being between June and August. Gray whale call detections are most common on the continental shelf (Rice et al., 2015; Rice et al., 2018; Wiggins et al., 2017). Because Eastern North Pacific population of gray whales has been studied so extensively, their migration patterns are relatively well-defined. One area identified by Ferguson et al. (2015) as biologically important gray whale migration habitat overlaps the TMAA at its northernmost corner and southwestern edge. The migration area was substantiated through vessel and aerial surveys, passive acoustic monitoring, genetic sampling, and expert judgment. In the Gulf of Alaska, southbound migration occurs from November to January (outside of the Proposed Action timeframe), while northbound migration occurs from March to May (partially overlapping the Proposed Action timeframe). There is little geographical overlap of the migration habitat with the TMAA boundaries, as shown in Figure 5.4-2. Overlap of migration timing with the potential timing of the Proposed Action would occur in April and May. Recent passive acoustic monitoring studies infrequently detected migrating gray whales in the TMAA along the continental slope and at Quinn Seamount (Rice et al., 2018).

In summary, Eastern North Pacific gray whales migrate through habitats throughout the Arctic and western coast of North America, both within and outside of the TMAA. Within the TMAA, the best available science indicates that migration occurs primarily within the biologically important area identified by Ferguson et al. (2015) in April and May, and that gray whales could be seasonally concentrated on the continental shelf between June and August; therefore, these habitats can be considered particularly important to gray whales from April through August relative to other locations or seasons in the TMAA. For additional information about gray whales and their habitat use and geographic range, see Section 3.8.2.8 (Gray Whale [*Eschrichtius robustus*]) of this SEIS/OEIS.

5.4.1.4 Steller Sea Lions

Steller sea lions live in cold temperate to subarctic waters along the North Pacific Rim from northern Japan to California (Loughlin et al., 1984). Individuals from the Western Distinct Population Segment, which is listed as endangered under the ESA, and Eastern Distinct Population Segment, which was delisted under the ESA in 2013, may occur in the TMAA. Steller sea lions display high site fidelity during the breeding season from May to July. Outside of the breeding season, individuals disperse widely in search of prey, which consists primarily of fish (Muto et al., 2018).

National Marine Fisheries Service-designated critical habitat for the Western Distinct Population Segment (which was designated in 1993) is situated along the Aleutian Islands and Western Alaska (58 FR 45269). The critical habitat encompasses terrestrial habitats and the surrounding nearshore waters that Steller sea lions use for foraging, haul-out sites, and rookeries for reproduction (pupping and mating). The critical habitat is located adjacent to the TMAA, but would have otherwise overlapped a portion of the training area, absent mitigation to modify the TMAA boundaries as described in Table 5.4-1 and Section 5.4.2.4 (Temporary Maritime Activities Area). In the Gulf of Alaska, foraging habitat is primarily inshore of the TMAA in shallower, more nearshore continental shelf waters (ranging from approximately 4.3 to 13 NM offshore). Additionally, there is a secondary occurrence inshore of the 1,000 m isobath, and a rare occurrence seaward of the 1,000 m isobath (Lander et al., 2011).

In summary, Steller sea lions use terrestrial and nearshore habitats along the North Pacific Rim for reproduction and foraging. Individuals from the Western Distinct Population Segment and Eastern Distinct Population of Steller sea lions could be present within the TMAA; however, the best available science indicates that reproduction and foraging occur primarily within the critical habitat areas designated by NMFS and located outside of the TMAA. For additional information about Stellar sea lions and their habitat use and geographic range, see Section 3.8.2.17 (Steller Sea Lion [*Eumetopias jubatus*]) of this SEIS/OEIS.

5.4.1.5 Fisheries Habitats

As described in Section 3.6 (Fish) of the 2016 GOA Final SEIS/OEIS, Habitat Areas of Particular Concern are a subset of Essential Fish Habitat. These Marine Protected Areas are known to provide particularly important ecological functions for fish and other important fishery resources. The North Pacific Fishery Management Council is the regional fishery management council responsible for managing groundfish fisheries (i.e., cod, flatfish, mackerel, Pollock, sablefish, and rockfish) in federal waters (i.e., 3–200 NM offshore) of the Bering Sea and Gulf of Alaska. The North Pacific Fishery Management Council established several Habitat Areas of Particular Concern that are within or partially overlapping the TMAA, including the following Gulf of Alaska Seamount Habitat Protection Areas and Gulf of Alaska Slope Habitat Conservation Areas: (1) Dall Seamount, (2) Giacomini Seamount, (3) Quinn Seamount, (4) Kodiak Seamount, (5) Cable, and (6) Middleton Island West. These areas support high biomass of groundfishes due to their high productivity, variable currents, clear waters, and unique seafloor topography (Rogers, 1994). These areas also provide important habitat for deep-sea coral communities, benthic fauna, and a wide variety of invertebrates. Fishery resources in the Gulf of Alaska are of particular importance to Alaska Native tribes and the economies of Alaska and the rest of the United States.

The waters off Kodiak Island (including Portlock Bank), are also known for having high productivity that supports important fishery resources for Alaska Native tribes. As described in the 2011 GOA Final EIS/OEIS, the benthos of the TMAA-portion of Portlock Bank was surveyed in water depths from 50 to 750 m. The seafloor is generally flat and covered with small boulders, cobble, and gravel. The most common epifauna were crinoids, small nonburrowing sea anemones, glass sponges, stylasterid corals, and brittlestars. The ecosystem in this area supports a strong trophic system from plankton, invertebrates, and small fish to higher-level predators, such as large fish, birds, and marine mammals. Portlock bank is associated with high densities of zooplankton in the summer, likely due to the oceanographic currents and the presence of deep gullies that help move water masses onto the shelf (Wang, 2007). Waters off Kodiak Island also support summer aggregations of fish species, such as arrowtooth flounder, capelin, and pollock (Knoth & Foy, 2008; Ormseth et al., 2017). Fishery resources in Portlock Bank are important to Native Alaska tribes, including the Native Village of Afognak and the Sun'aq Tribe of Kodiak.

Due to their high rates of productivity, some oceanographic features (e.g., seamounts) have also been associated with the presence of marine mammal species. For example, blue whales, fin whales, minke whales, killer whales, Baird's beaked whales, Cuvier's beaked whales, and Stejneger's beaked whales were detected near Quinn Canyon during a 2013–2014 passive acoustic monitoring study in the TMAA (Debich et al., 2014b). As described in Section 5.4.1.3 (Gray Whales), recent passive acoustic monitoring studies infrequently detected migrating gray whales in the TMAA along the continental slope and at Quinn Seamount (Rice et al., 2018). Although marine mammals have been detected near some seamounts in the TMAA, the best available science does not indicate that seamounts in the TMAA are particularly important to any marine mammal species for foraging, migration, or reproduction. For example, during a summer 2013 visual and passive acoustic survey of the entire TMAA, beaked whale passive acoustic detections were just as frequent over deep water abyssal plain areas of the TMAA as compared to slopes and seamounts (Rone et al., 2014).

In summary, the best available science indicates that Habitat Areas of Particular Concern and Portlock Bank constitute particularly important habitats and fishery resources for Alaska Native tribes and commercial fisheries within the TMAA. For additional information about fisheries, socioeconomic resources, and cultural resources, see Section 3.6 (Fishes) of this SEIS/OEIS, and Section 3.10 (Cultural Resources) and Section 3.12 (Socioeconomics) of the 2016 GOA SEIS/OEIS. For additional information on Marine Protected Areas within the TMAA, such as areas designed to restrict commercial or recreational fishing, see Section 6.1.1 (Marine Protected Areas).

5.4.2 Biological Effectiveness Assessment

Mitigation areas in the TMAA will help the Navy avoid or reduce potential impacts on one or more marine species in key areas of biological or ecological importance, as discussed in the sections below.

5.4.2.1 North Pacific Right Whale Mitigation Area

Mitigation within the North Pacific Right Whale Mitigation Area is a continuation from the 2016 GOA Final SEIS/OEIS. The Navy developed the mitigation area to encompass the portion of the biologically important habitat identified by Ferguson et al. (2015) for North Pacific right whale feeding that overlaps the TMAA. The potential occurrence of North Pacific right whales in the TMAA is expected to be rare due to the species' extremely low population numbers; however, mitigation requirements to not use surface ship hull-mounted MF1 mid-frequency active sonar or in-water explosives in the mitigation area seasonally will help the Navy further avoid or reduce the already low potential for impacts to occur within this endangered species' feeding habitat. The Navy will implement the mitigation from June 1 to September 30, which fully corresponds with the North Pacific right whale feeding period in this area.

The mitigation will also help avoid or reduce potential impacts on fishery resources that inhabit the mitigation area. As described in Section 5.4.1.5 (Fisheries Habitats), the productive waters off Kodiak Island support a strong trophic system from plankton, invertebrates, and small fish to higher-level predators, such as large fish, birds, and marine mammals.

5.4.2.2 Portlock Bank Mitigation Area

Mitigation within the Portlock Bank Mitigation Area is a continuation from the 2016 GOA Final SEIS/OEIS. The Navy developed the mitigation area to encompass the portion of Portlock Bank that overlaps the TMAA. Mitigation requirements to not use in-water explosives in the mitigation area will help the Navy avoid or reduce potential impacts on fishery resources for Native Alaska tribes. The mitigation will also help avoid or reduce potential impacts on marine mammals that forage in the highly productive waters of Portlock Bank, including humpback whales (84 FR 54354).

5.4.2.3 Temporary Maritime Activities Area

Mitigation to conduct the Proposed Action outside of Steller sea lion critical habitat is a continuation from the 2016 GOA Final SEIS/OEIS. To accomplish this mitigation, the Navy adjusted the boundaries of the TMAA so it is situated outside of the Steller sea lion critical habitat designated by NMFS in 1993 (58 FR 45269). This will help the Navy avoid the potential for Steller sea lions from the Western Distinct Population Segment to be exposed to active sonar and explosives within their critical habitat for reproduction and foraging.

The Navy developed new mitigation that is included in this SEIS/OEIS to issue seasonal awareness notification messages to alert ships and aircraft operating within the TMAA to the possible presence of increased concentrations of gray whales in their migration habitat from April 1 to August 31 and humpback whales on the continental shelf from June 1 to September 30. This mitigation will further help avoid or reduce potential impacts from vessel strikes and training activities on gray whales and humpback whales within the TMAA, which overlaps the biologically important gray whale migration habitat identified by Ferguson et al. (2015) and the NMFS-proposed critical habitat for humpback whale feeding.

5.4.3 Operational Assessment

The Navy conducts training activities in the TMAA because it provides valuable access to sea space and airspace conditions analogous to areas where the Navy operates or may need to operate in the future. The unique and complex bathymetric and oceanographic environment in the TMAA presents a challenging anti-submarine warfare training opportunity. The complexity of the sea bottom, the input of freshwater into the sea, and the areas of upwelling and ocean currents combine in the TMAA like in no other training area in the Pacific Ocean. The location of the TMAA affords aircraft from Navy carrier strike groups supporting joint exercises with the Air Force ability to reach inland established Air Force and Army instrumented land ranges where they conduct air-to-air ground training. The location of the TMAA also allows appropriate distance limitations to support Air Force aircraft reaching the TMAA without needing to refuel to conduct training at sea with the carrier strike group. Therefore, the TMAA as currently sited is dependent on these location-specific factors to satisfy criteria for safety, practicality, and mission requirements.

Navy training schedules are based on national tasking, the number and duration of training cycles identified in the Optimized Fleet Response Plan and various training plans. Navy vessels and aviation squadrons have a limited amount of time available for training. The Navy must factor in variables such as maintenance and weather when scheduling event locations and timing. Training in the TMAA is largely scheduled to accommodate weather conditions for safety of personnel and to achieve optimum operational parameters. Storms and high sea states in the Gulf of Alaska can create challenges for surface ship training between November and March. In part as a result of these conditions, annual joint training activities are scheduled during the summer months from April to October. When scheduling activities between April through October, the Navy considers the need to minimize sea space and airspace conflicts throughout the TMAA. For example, the Navy schedules training to minimize conflicts between its own activities and with consideration for public safety (e.g., safe distances from recreational boating activities). Restrictions on the level and number of training activities and associated sound source or ordnance use (e.g., annual sonar hours or explosives use) would be impractical because such limitations would not allow the Navy to continue meeting its mission requirements.

The Navy selects training locations in the TMAA to allow for the realistic tactical development of the myriad training scenarios Navy units are required to complete to be mission effective. Certain activities require large areas of open ocean for realistic and safe training. As described in Section 5.2.3 (Practicality of Implementation), the Navy requires extensive sea space so that individual training activities can occur at sufficient distances so they do not interfere with one another, and so that Navy units can train to communicate and operate in a coordinated fashion over tens or hundreds of square miles, as required during military missions and combat operations. Other activities may be conducted on a smaller and more localized scale, with training at discrete locations that are critical to certain aspects of military readiness. For example, the northwest and southwest corners of the TMAA are important for several events, including Maritime Interdiction Training. During Maritime Interdiction Training, the Navy interacts with participating contracted commercial vessels homeported in GOA ports (e.g., Kodiak, Homer); therefore, conducting these activities in proximity to existing ports and facilities is essential for safety and mission success. Requiring this activity to be conducted in other locations, such as further offshore, would increase safety risks for the types of vessels involved. Increasing transit distances would result in additional fuel consumption and expenditures, which could serve as a limiting factor for Navy surface units whose available underway times are constrained by fuel expenses. It would also reduce training opportunities during a platform’s limited available timeframes (i.e., increased time spent transiting to more distant training areas results in decreased time available for training).

Activities using mid-frequency active sonar and explosives typically take place a certain distance away from operating area boundaries to allow for sea space deconfliction and training realism. For example, The Navy does not typically conduct anti-submarine warfare training along the TMAA boundaries because doing so would limit the ability for naval units to tactically consider the adjacent sea space and airspace outside of the TMAA. The southwest portion of the TMAA experiences relatively high levels of commercial and recreational vessel and aircraft traffic, which presents sea space and airspace conflicts. For these reasons, it is practical for the Navy to not conduct surface ship hull-mounted MF1 mid-frequency active sonar or use in-water explosives in the North Pacific Right Whale Mitigation Area, and to not use explosives in the Portlock Bank Mitigation Area, both of which are located in the southwest portion of the TMAA.

Restrictions beyond what is identified in Table 5.4-1 regarding the locations of training near seamounts or within Marine Protected Areas (e.g., Habitat Areas of Particular Concern) would be impractical to implement for the types of activities conducted under the Proposed Action. Such mitigation would encroach upon the Navy’s primary training waterspace, which would preclude ready access to training areas and the necessary environmental and oceanographic conditions that replicate military mission and combat conditions. This would have a significant impact on the ability for units to meet their individual training and certification requirements (impacting the ability to deploy with the required level of readiness necessary to accomplish their missions), to certify forces to deploy to meet national security tasking (limiting the flexibility of Combatant Commanders and warfighters to project power, engage in multi-national operations, and conduct the full range of naval warfighting capability in support of national security interests). Furthermore, as described in Section 5.4.1.5 (Fisheries Habitats), although marine mammals have been detected near some seamounts in the TMAA, the best available science does not indicate that the seamounts or Marine Protected Areas within the TMAA are particularly important to any marine mammal species for foraging, migration, or reproduction; therefore, avoiding explosives or active sonar within these areas would likely not effectively avoid potential impacts on marine mammal species or stocks in the TMAA. Additional information about why such mitigation would not be effective at avoiding or reducing potential impacts on marine species is provided in Section 5.5.2 (Explosives).

As described in Section 5.3.2.1 (Active Sonar) and Section 5.5.1 (Active Sonar), the Navy needs to maintain access to sea space with the unique, challenging, and diverse environmental and oceanographic features (e.g., bathymetry, topography, surface fronts, and variations in sea surface temperature) analogous to military mission and combat conditions to achieve the highest skill proficiency possible. Training with active sonar in varying ocean floor topographies, such as near seamounts, is essential to national security. Active sonar is the only reliable technology for detecting and tracking potential enemy diesel-electric submarines. Daily fluctuations in training schedules and objectives could mean that, on any given day, vessels or aircraft may depend on discrete locations of the TMAA for discrete purposes. The Navy requires flexibility in the timing of its use of active sonar and explosives in order to meet individual training schedules. In June and July, there are approximately 19 hours of daylight per day in the TMAA; therefore, there are naturally fewer hours of available nighttime to be used for sonar training. Due to the already limited timeframe of when the Proposed Action can occur in the TMAA based on weather conditions (April through October), time-of-day restrictions or further seasonal restrictions on the use of active sonar or explosives based on marine species occurrence, fishery seasons, or other factors (e.g., avoiding all activities during the spring months, requiring training activities to be conducted in the winter) would significantly restrict logistical flexibility for planning and carrying out the Proposed Action. Such mitigation would prevent the Navy from being able to successfully complete its mission requirements within the necessary timeframes.

5.5 Mitigation Measures Considered but Eliminated

As described in Section 5.2 (Mitigation Development Process), the Navy conducted a detailed review and assessment of each potential mitigation measure individually and then all potential mitigation measures collectively to determine if, as a whole, the mitigation will be effective at avoiding or reducing potential impacts and practical to implement. The operational community determined that implementing mitigation beyond what is detailed in Section 5.3 (Procedural Mitigation to be Implemented) and Section 5.4 (Geographic Mitigation to be Implemented) would be incompatible with the practicality assessment criteria for safety, sustainability, and mission requirements. Information about why implementing additional mitigation measures for active sonar, explosives, active and passive acoustic monitoring devices, thermal detection systems, third-party observers, foreign navy mitigation, and reporting requirements would be impractical is provided in the sections below and in Section 5.4 (Geographic Mitigation to be Implemented).

When analyzing all potential mitigation measures collectively, the operational community determined that adopting certain mitigation measures would result in the unacceptable limitation of the Navy's utilization of sea space and airspace required to effectively support training of naval forces in the TMAA. Certain measures would restrict or prohibit Navy training throughout most of the TMAA except in very narrow circumstances. For example, blanket limitations or restrictions on the level, number, or timing (seasonal or time of day) of training activities within certain discrete or broad-scale areas of water would prevent the Navy from accessing the locations necessary to meet the purpose and need of the Proposed Action. As described in Section 5.2.3 (Practicality of Implementation), the Navy requires extensive sea space so that individual training activities can occur at sufficient distances such that these activities do not interfere with one another, and so that Navy units can train to communicate and operate in a coordinated fashion over tens or hundreds of square miles, as required during military missions and combat operations. The Navy also needs to maintain access to sea space with the unique, challenging, and diverse environmental and oceanographic features (e.g., bathymetry, topography, surface fronts, and variations in sea surface temperature) analogous to military mission and combat conditions to achieve the highest skill proficiency possible. The iterative and cumulative impact of all potential mitigation measures the Navy assessed would deny national command authorities the flexibility to respond to national security challenges and effectively accomplish the training necessary for deployment. For example, additional limitations on the use of active sonar would require the Navy to shift its training activities to alternative locations, which would preclude ready access to the necessary environmental and oceanographic conditions that replicate military mission and combat conditions. This would have significant impacts on safety, sustainability, and the ability to meet mission requirements within limited available timeframes.

Threats to national security are constantly evolving. The Navy requires the ability to adapt training to meet these emerging threats. Restricting access to broad-scale areas of water would impact the ability for Navy training to evolve as threats evolve. Eliminating opportunities for the Navy to train in a myriad of at-sea conditions would put U.S. forces at a tactical disadvantage during military missions and combat operations. This would also present a risk to national security if potential adversaries were to be alerted to the environmental conditions within which the U.S. Navy is prohibited from training. Restricting large areas of ocean or other smaller areas that are critical to Navy training would make training and concealment much more difficult and would adversely impact the Navy's ability to perform its statutory mission.

5.5.1 Active Sonar

When assessing and developing mitigation, the Navy considered reducing active sonar training hours, modifying active sonar sound sources, implementing time-of-day restrictions and restrictions during surface ducting conditions, replacing active sonar training with synthetic activities (e.g., computer simulated training), and implementing active sonar ramp-up procedures. The Navy determined that it would be practical to implement certain restrictions on the use of active sonar in the TMAA, as detailed in Section 5.3.2.1 (Active Sonar) and Section 5.4 (Geographic Mitigation to be Implemented). As discussed in Chapter 2 (Description of Proposed Action and Alternatives), Section 5.2.3 (Practicality of Implementation), Section 5.4 (Geographic Mitigation to be Implemented), and Appendix A (Navy Activities Descriptions), training activities are planned and scheduled based on numerous factors and data inputs, such as compliance with the Optimized Fleet Response Plan. Information on why training with active sonar is essential to national security is presented in Section 5.3.2.1 (Active Sonar). The Navy uses active sonar during military readiness activities only when it is essential to training missions since active sonar has the potential to alert opposing forces to the operating platform's presence. Passive sonar and other available sensors are used in concert with active sonar to the maximum extent practicable.

The Navy currently uses, and will continue to use, computer simulation to augment training whenever possible. As discussed in Section 1.4.1 (Why the Navy Trains), simulators and synthetic training are critical elements that provide early skill repetition and enhance teamwork; however, they cannot replicate the complexity and stresses faced by Sailors during military missions and combat operations to which the Navy trains under the Proposed Action (e.g., anti-submarine warfare training using hull-mounted mid-frequency active sonar). Just as a pilot would not be ready to fly solo after simulator training, operational Commanders cannot allow military personnel to engage in military missions and combat operations based merely on simulator training. Sonar operators must train to effectively handle bottom bounce and sound passing through changing currents, eddies, and across changes in ocean temperature, pressure, salinity, depth, and in surface ducting conditions.

Although the majority of sonar use occurs during the day, the Navy has a nighttime training requirement for some active sonar systems, Training in both good visibility (e.g., daylight, favorable weather conditions) and low visibility (e.g., nighttime, inclement weather conditions) is vital because environmental differences between day and night and varying weather conditions affect sound propagation and the detection capabilities of sonar. Temperature layers that move up and down in the water column and ambient noise levels can vary significantly between night and day. This affects sound propagation and could affect how sonar systems function and are operated.

Submarines may hide in the higher ambient noise levels of surface ducts. Surface ducting occurs when water conditions, such as temperature layers and lack of wave action, result in little sound energy penetrating beyond a narrow layer near the surface of the water. Avoiding surface ducting conditions would be impractical because ocean conditions contributing to surface ducting change frequently, and surface ducts can be of varying duration. Surface ducting can also lack uniformity and may or may not extend over a large geographic area, making it difficult to determine where to reduce power and for what periods. Submarines have long been known to take advantage of the phenomena associated with surface ducting to avoid being detected by sonar. When surface ducting occurs, active sonar becomes more useful near the surface but less useful at greater depths. As noted by the U.S. Supreme Court in *Winter v. Natural Resources Defense Council Inc.*, 555 U.S. 7 (2008), because surface ducting conditions occur relatively rarely and are unpredictable, it is especially important for the Navy to be able to train under these conditions when they occur. Training with active sonar in these conditions is a critical component of military readiness because sonar operators need to learn how sonar transmissions are altered due to surface ducting, how submarines may take advantage of them, and how to operate sonar effectively under these conditions. Reducing power, shutting down active sonar based on environmental conditions, or implementing other sonar modification techniques (e.g., sound shielding) as a mitigation would affect a Commander’s ability to develop the tactical picture. It would also prevent sonar operators from training in conditions analogous to those faced during military missions and combat operations, such as during periods of low visibility.

Active sonar signals are designed explicitly to provide optimum performance at detecting underwater objects (e.g., submarines) in a variety of acoustic environments. The Navy assessed the potential for implementing active sonar signal modification as mitigation. At this time, the science on the differences in potential impacts of up or down sweeps of the sonar signal (e.g., different behavioral reactions) is extremely limited and requires further development. If future studies indicate that modifying active sonar signals (i.e., up or down sweeps) could be an effective mitigation approach, then the Navy will investigate if and how the mitigation would affect the sonar's performance.

Active sonar equipment power levels are set consistent with mission requirements. Active sonar ramp-up procedures are used during seismic surveys and some foreign navy sonar activities. Ramping up involves slowly increasing sound levels over a certain length of time until the optimal source level is reached. The intent of ramping up a sound source is to alert marine mammals with a low sound level to deter them from the area and avoid higher levels of sound exposure. The best available science does not suggest that ramp-up would be an effective mitigation tool for U.S. Navy active sonar training activities under the Proposed Action. Wensveen et al. (2017) found that active sonar ramp-up was not an effective method for reducing impacts on humpback whales because most whales did not display strong behavioral avoidance to the sonar signals. The study suggested that sonar ramp-up could potentially be more effective for other more behaviorally responsive species but would likely also depend on the context of exposure. For example, ramp-up would be less effective if animals have a strong motivation not to move away from their current location, such as when foraging. Dunlop et al. (2016) and von Benda-Beckmann et al. (2014) found that implementing ramp-up as a mitigation may be effective for some activities in some situations. Additionally, von Benda-Beckmann et al. (2014) found that the main factors limiting ramp-up effectiveness for a typical anti-submarine warfare activity are a high source level, a moving sonar source, and long silences between consecutive sonar transmissions. Based on the source levels, vessel speeds, and sonar transmission intervals that will be used during typical active sonar activities under the Proposed Action, the Navy has determined that ramp-up would be an ineffective mitigation measure for the active sonar activities analyzed in this SEIS/OEIS.

Implementing active sonar ramp-up procedures during training under the Proposed Action would not be representative of military mission and combat conditions and would significantly impact training realism. For example, during an anti-submarine warfare exercise using active sonar, ramp-ups have the potential to alert opponents (e.g., target submarines) to the transmitting vessel's presence. This would defeat the purpose of the training by allowing the target submarine to detect the searching unit and take evasive measures, thereby denying the sonar operator the opportunity to learn how to locate the submarine. Reducing realism in training impedes the ability for Navy Sailors to train and become proficient in using active sonar, erodes capabilities, and reduces perishable skills. These impacts would result in a significant risk to personnel safety during military missions and combat operations and would prevent units from meeting their individual training and certification requirements. Therefore, implementing additional mitigation that would reduce training realism would ultimately prevent units from deploying with the required level of readiness necessary to accomplish their missions and impede the Navy's ability to certify forces to deploy to meet national security tasking.

5.5.2 Explosives

When assessing and developing mitigation for the Proposed Action, which no longer includes a Sinking Exercise or other underwater detonations, the Navy considered reducing the number and size of explosives and limiting the locations and time of day of explosive training in the TMAA. The Navy determined that it would be practical to implement certain restrictions on the use of explosives, as detailed in Section 5.3.3 (Explosive Stressors) and Section 5.4 (Geographic Mitigation to be Implemented). As discussed in Chapter 2 (Description of Proposed Action and Alternatives), Section 5.2.3 (Practicality of Implementation), Section 5.4 (Geographic Mitigation to be Implemented), and Appendix A (Navy Activities Descriptions), the locations and timing of the training activities that use explosives vary throughout the TMAA based on range scheduling, mission requirements, and standard operating procedures for safety and mission success.

Activities that involve explosive ordnance are inherently different from those that involve non-explosive practice munitions. For example, critical components of an explosive Bombing Exercise Air-to-Surface include the assembly, loading, delivery, and assessment of the explosive bomb. The explosive bombing training exercise starts with ground personnel, who must practice the building and loading of explosive munitions. Training includes the safe handling of explosive material, configuring munitions to precise specifications, and the loading of munitions onto aircraft. Aircrew must then identify a target and safely deliver fused munitions, discern if the bomb was assembled correctly, and determine bomb damage assessments based on how and where the explosive detonated. An air-to-surface bombing exercise using non-explosive practice munitions can train aircrews on valuable skills to locate and accurately deliver munitions on a target; however, it cannot effectively replicate the critical components of an explosive activity in terms of assembly, loading, delivery, and assessment of an explosive bomb. Reducing the number and size of explosives or diminishing activity realism by implementing time of day or geographic restrictions for additional explosive training activities would impede the ability for Navy Sailors to train and become proficient in using explosive weapons systems (which would result in a significant risk to personnel safety during military missions and combat operations), and would ultimately prevent units from meeting their individual training and certification requirements (which would prevent them from deploying with the required level of readiness necessary to accomplish their missions) and impede the Navy's ability to certify forces to deploy to meet national security tasking.

The 2016 GOA Final SEIS/OEIS included mitigation to not conduct Sinking Exercises within Habitat Areas of Particular Concern within the TMAA, including the GOA Seamount Habitat Protection Areas and GOA Slope Habitat Conservation Areas. Because Sinking Exercises will not be conducted under the Proposed Action of this SEIS/OEIS, mitigation for that activity within Habitat Areas of Particular Concern is no longer needed and has not been included in this chapter. As described in Section 5.4.1.5 (Fisheries Habitats), the North Pacific Fishery Management Council established several Habitat Areas of Particular Concern that support high biomass of groundfishes within the TMAA. Certain types of fishing activities are prohibited or restricted within the Habitat Areas of Particular Concern, including fishing with bottom-contact gear such as longlines, trawls, and pots. The protected areas were designated to support sustainable fisheries management by preventing impacts from groundfish fishery practices that are known to directly result in degradation of seafloor habitats. The 2016 GOA Final SEIS/OEIS Sinking Exercise mitigation requirements had been designed to help the Navy avoid physical disturbance and strike impacts on fishery resources associated with important seafloor habitats, consistent with the intent of the fishery management regulations (i.e., to avoid degradation of seafloor habitats from activities designed to deliberately make contact with the seafloor). During a Sinking Exercise, ship, aircraft, and submarine crews attack with coordinated tactics and deliver a variety of explosive ordnance to deliberately sink a seaborne target. The target is typically a decommissioned ship that has been made environmentally safe for sinking according to U.S. Environmental Protection Agency standards. Because the event involves firing a variety of munitions from multiple weapons systems at a stationary target, Sinking Exercises would result in a higher concentration of expended projectiles relative to other training activities that are smaller in scale and more transient or dispersed in nature. Additionally, Sinking Exercises result in a large target (a ship hulk) deliberately sinking to the seafloor, which differs from other types of training activities that use comparatively small targets or recoverable targets. Requiring other training activities (e.g., explosive bombing exercises) to implement the mitigation developed specific to Sinking Exercises would not effectively avoid or reduce potential impacts on seafloor habitats and their associated fishery resources due to the already low potential for impacts to occur from those activities.

5.5.3 Active and Passive Acoustic Monitoring Devices

When assessing and developing mitigation, the Navy considered using active and passive acoustic monitoring devices as procedural mitigation. During Surveillance Towed Array Sensor System low-frequency active sonar (which is not part of the Proposed Action), the Navy uses a specially-designed adjunct high-frequency marine mammal monitoring active sonar known as "HF/M3" to mitigate potential impacts. HF/M3 can only be towed at slow speeds and operates like a fish finder used by commercial and recreational fishermen. Installing the HF/M3 adjunct system on the tactical sonar ships used under the Proposed Action would have implications for safety and mission requirements due to impacts on speed and maneuverability. Furthermore, installing the system would significantly increase costs associated with designing, building, installing, maintaining, and manning the equipment. The Navy will not install the HF/M3 system or other adjunct marine mammal monitoring devices as mitigation under the Proposed Action. However, Navy assets with passive acoustic monitoring capabilities that are already participating in an activity will continue to monitor for marine mammals, as described in Section 5.2.1 (Procedural Mitigation Development) and Section 5.3 (Procedural Mitigation to be Implemented). Significant manpower and logistical constraints make constructing and maintaining additional passive acoustic monitoring systems for each training activity under the Proposed Action impractical. For example, the Navy does not have available manpower or resources to allocate additional aircraft for the purpose of deploying, monitoring, and retrieving passive acoustic monitoring equipment during a bombing exercise. All platforms participating in explosive bombing exercises (e.g., firing aircraft, safety aircraft) must focus on situational awareness of the activity area and continuous coordination between multiple training components for safety and mission success. Diverting platforms with passive acoustic monitoring capabilities to monitor training events would impact their ability to meet their mission requirements and would reduce the service life of those systems.

The Navy is continuing to improve its capabilities to use range instrumentation to aid in the passive acoustic detection of marine mammals. For example, at the Southern California Offshore Range, the Pacific Missile Range Facility off Kauai, Hawaii, and the Atlantic Undersea Test and Evaluation Center in the Bahamas, the Navy can monitor instrumented ranges in real-time or through data recorded by hydrophones. The Navy has sponsored numerous studies that have produced meaningful results on marine mammal occurrence, distribution, and behavior on these ranges through the U.S. Navy's Marine Species Monitoring Program. For information on the U.S. Navy's Marine Species Monitoring Program, see Section 5.1.2.2.1 (Marine Species Research and Monitoring Programs).

Although the Navy's instrumented ranges are helping to facilitate a better understanding of the species that are present in those areas, instrumented ranges were not developed for the purpose of mitigation, and therefore do not have the capabilities to be used effectively for mitigation. To develop an estimated position for an individual marine mammal, the animal's vocalizations must be detected on at least three hydrophones. The vocalizations must be loud enough to provide the required signal to noise ratio on those hydrophones. The hydrophones must have the required bandwidth and dynamic range to capture that signal. Detection capabilities are generally degraded under noisy conditions (such as high sea state) that affect signal to noise ratio. The ability to detect and develop an estimated position for marine mammals on the Navy's instrumented ranges depends of numerous factors, such as behavioral state (e.g., only vocalizing animals can be detected), species (e.g., species vocalize at varying rates, call types, and source levels), animal location relative to the passive acoustic receivers (hydrophones), and location on the range. The Navy's hydrophones cannot track the real-time locations of individual animals with dispersed and directional vocalizations with the level of precision needed for effective mitigation. Even marine mammals that have been vocalizing for extended periods of time have been known to stop vocalizing for hours at a time, which would prevent the Navy from obtaining or maintaining an accurate estimate of that animal's location. In addition, the Navy does not currently have the capability to perform data processing for large baleen whales in real-time. Determining if an animal is located within a mitigation zone within the timeframes required for mitigation would be prohibited by the amount of time it takes to process the data.

If a vocalizing animal is detected on only one or two hydrophones, estimating its location is not possible, and the location of the animal would be assigned generally within the detection radius around each hydrophone. The detection radius of a hydrophone is typically much larger than the mitigation zone for the activities conducted on instrumented ranges. The Navy does not have a way to verify if that vocalizing animal is located within the mitigation zone or at a location down range. Mitigating for passive acoustic detections based on unknown animal locations would essentially increase the mitigation zone sizes for each activity to that of the hydrophone detection radius. Increasing the mitigation zone sizes beyond what is described for each activity is impractical for the reasons described throughout Section 5.3 (Procedural Mitigation to be Implemented).

In summary, although the Navy is continuing to improve its capabilities to use range instrumentation to aid in the passive acoustic detection of marine mammals, at this time it would not be effective or practical for the Navy to monitor instrumented ranges for real-time mitigation or to construct additional instrumented ranges as a tool to aid in the implementation of mitigation.

5.5.4 Thermal Detection Systems and Unmanned Aerial Vehicles

When assessing and developing mitigation, the Navy considered using thermal detection systems and other technologies (e.g., autonomous platforms such as unmanned aerial vehicles, X-band radar) as procedural mitigation. The use of X-band radar instruments for marine mammal monitoring is a new field of study. A preliminary pilot experiment in the Mediterranean Sea indicated that X-band radar instruments, which allow for continuous observation of the sea surface within a certain range from the radar antenna, were able to detect bottlenose dolphins during optimal weather and sea state conditions (Mingozzi et al., 2020). Detections by radar were generally limited by conditions such as waves, which did not allow for the correct identification of small targets, and rain, which masked the radar signal reflection and reduced the ability to detect targets. The pilot experiment used a manual approach to observe for and validate radar detections; however, future technological developments could potentially allow for automated marine mammal observation using X-band radar (Mingozzi et al., 2020).

Thermal detection technology is designed to allow observers to detect the difference in temperature between a surfaced marine mammal (i.e., the body or blow of a whale) and the environment (i.e., the water and air). Thermal detection systems can be effective at detecting some types of marine mammals in a limited range of marine environmental conditions. Technologies are advancing but continue to be limited by their: (1) reduced performance in certain environmental conditions, (2) ability to detect certain animal characteristics and behaviors, (3) low sensor resolution and narrow fields of view, and (4) high cost and low lifecycle (Boebel, 2017; Zitterbart et al., 2013). Current thermal detection systems have proven more effective at perceiving thermal anomalies as distance to the observer decreases (Zitterbart et al., 2020), and at detecting large whale blows than the bodies of small animals, particularly at a distance (Zitterbart et al., 2013). Zitterbart et al. (2020) found that certain cues, such as those caused by the displacement of relatively large amounts of water (e.g., whale breaches) were less affected by distance than other cues (e.g., whale blows) that showed a linear decay related to the effects of wind on thermal perceptibility. The study also found that the maximum thermal perceptibility distance ranged from <1–10 kilometers, depending on factors such as cue type, species, and observation location.

The effectiveness of current technologies has not been demonstrated for small marine mammals. Thermal detection systems exhibit varying degrees of false positive detections (i.e., incorrect notifications) due in part to their low sensor resolution and reduced performance in certain environmental conditions. False positive detections may incorrectly identify other features (e.g., birds, waves, boats) as marine mammals. Zitterbart et al. (2013) reported a false positive rate approaching one incorrect notification per four minutes of observation. Zitterbart et al. (2020) reported maximum false positive rates of > 50 or 30 per hour, depending on observation location.

Thermal detection systems are generally thought to be most effective in detecting large, short-diving marine mammals in cold environments where there is a large temperature differential between an animal's temperature and the environment (Verfuss et al., 2018). Two studies that examined the effectiveness of thermal detection systems for marine mammal observations are Zitterbart et al. (2013), which tested a thermal detection system and automatic algorithm in polar waters between 34 and 50 degrees Fahrenheit, and a Navy-funded study in subtropical and tropical waters. Zitterbart et al. (2013) found that current technologies have limitations regarding temperature and survey conditions (e.g., rain, fog, sea state, glare, ambient brightness), for which further effectiveness studies are required. The Office of Naval Research Marine Mammals and Biology program funded a project (2013–2018) to test the thermal limits of infrared-based automatic whale detection technology. That project focused on capturing whale spouts at two different locations featuring subtropical and tropical water temperatures, optimizing detector/classifier performance on the collected data, and testing system performance by comparing system detections with concurrent visual observations. Results indicated that thermal detection systems in subtropical and tropical waters can be a valuable addition to marine mammal surveys within a certain distance from the observation platform (e.g., during seismic surveys, vessel movements), but they have challenges associated with false positive detections of waves and birds (Boebel, 2017).

The Navy has also been investigating the use of thermal detection systems with automated marine mammal detection algorithms for future mitigation during training and testing, including on autonomous platforms. For example, the Defense Advanced Research Projects Agency funded six initial studies to test and evaluate infrared-based thermal detection technologies and algorithms to automatically detect marine mammals on an unmanned surface vehicle. Based on the outcome of these initial studies, the Navy is pursuing additional follow-on research efforts.

Thermal detection systems are currently used by some specialized U.S. Air Force aircraft for marine mammal mitigation. These systems are specifically designed for and integrated into Air Force aircraft and cannot be added to Navy aircraft. Only certain Navy aircraft have specialized infrared capabilities, and these capabilities are only for fine-scale targeting within a narrow field of view. The only thermal imagery sensors aboard Navy surface ships are associated with specific weapons systems, and these sensors are not available on all vessels. These sensors are typically used only in select training events, have a limited lifespan before requiring expensive replacement, and are not optimized for marine mammal observations within the Navy's mitigation zones. For example, as described in Section 5.3.3.1 (Explosive Medium-Caliber and Large-Caliber Projectiles), Lookouts are required to observe a 1,000 yd. mitigation zone around the intended impact location during explosive large-caliber gunnery activities. In addition to observing for marine mammals, one of the activity's mission-essential requirements is for event participants, including Lookouts, to maintain focus on the mitigation zone to ensure the safety of Navy personnel and equipment and the public. Lookouts would not be able to observe the 1,000 yd. mitigation zone using the Navy's thermal imagery sensors due to their narrow fields of view and technological design specific to fine-scale targeting. Such observations would be ineffective for marine mammals and would prevent Lookouts from effectively maintaining focus on the activity area and implementing mission-essential safety protocols.

The effectiveness of even the most advanced commercially available thermal detection systems with technological designs specific to marine mammal observations is highly dependent on environmental conditions, animal characteristics, and animal behaviors (Zitterbart et al., 2013). High false positive rates of thermal detection systems could result in the Navy implementing mitigation for features incorrectly identified as marine mammals. Increasing the instances of mitigation implementation based on incorrectly identified features would have significant impacts on the ability for military readiness activities to accomplish their intended objectives, without providing any mitigation benefit to the species. In addition, thermal detection systems are designed to detect marine mammals and do not have the capability to detect other resources for which the Navy is required to implement mitigation. Requiring Lookouts to use thermal detection systems could potentially prevent them from detecting and mitigating for sea turtles.

Verfuss et al. (2018) determined that based on the science of current thermal detection system technologies, the combined performance of two or more observation methods would improve detection probability for real-time monitoring of marine mammals. Similarly, during a study conducted offshore Atlantic Canada, Smith et al. (2020) found that overall marine mammal detection rates increased when complementary methods (marine mammal observers, infrared cameras, and passive acoustic monitoring) were used. A combination of techniques balances the benefits and limitations of each method, particularly in conditions such as high sea state and low-visibility. As discussed in Section 5.3 (Procedural Mitigation to be Implemented), the Navy's procedural mitigation measures include the maximum number of Lookouts the Navy can assign to each activity based on available manpower and resources, combined with the use of passive acoustic monitoring when those assets are already participating in an activity. It would be impractical to add personnel to serve as additional Lookouts for the sole purpose of thermal detection system use under the Proposed Action because the Navy does not have available manpower to add Lookouts to use thermal detection systems in tandem with existing Lookouts who are using traditional observation techniques.

In summary, thermal detection systems have not been sufficiently studied both in terms of their effectiveness and compatibility with Navy military readiness activities. The Navy plans to continue researching thermal detection systems to determine their effectiveness and compatibility with Navy applications. If the technology matures to the state where thermal detection is determined to be an effective mitigation tool during military readiness activities, the Navy will assess the practicality of using the technology during applicable events and retrofitting its observation platforms with thermal detection devices. The assessment will include an evaluation of the budget and acquisition process (including costs associated with designing, building, installing, maintaining, and manning equipment that is expensive and has a relatively short lifecycle before key system components need replacing); logistical and physical considerations for device installment, repair, and replacement (e.g., conducting engineering studies to ensure there is no electronic or power interference with existing shipboard systems); manpower and resource considerations for training personnel to effectively operate the equipment; and considerations of potential security and classification issues. New system integration on Navy assets can entail up to 5–10 years of effort to account for acquisition, engineering studies, and development and execution of systems training. The Navy will provide information to NMFS about the status and findings of Navy-funded thermal detection studies and any associated practicality assessments at the annual adaptive management meetings. Information about the Navy's adaptive management program is included in Section 5.1.2.2.1.1 (Adaptive Management).

5.5.5 Third-Party Observers

When assessing and developing mitigation, the Navy considered using third-party observers during training to aid in the implementation of procedural mitigation. The use of third-party observers to conduct pre- or post-activity biological resource observations would be an ineffective mitigation because marine mammals would likely move into or out of the activity area, and mitigation must be implemented at the time the activity is taking place.

There are significant manpower and logistical constraints that make using third-party observers for every training activity under the Proposed Action impractical. Training activities often occur simultaneously and in various locations in the TMAA, some of which last for days or weeks at a time. Having third-party observers embark on Navy vessels or aircraft would result in safety and security clearance issues. Training event planning includes careful consideration of capacity limitations when placing personnel on participating aircraft and vessels. The Navy is unable to add third-party observers on a ship or substitute a Navy Lookout with a third-party observer without causing a berthing shortage or exceedance of other space limitations, or impacting the ability for Lookouts to complete their other mission-essential duties. The use of third-party observers also presents national security concerns due to the requirement to provide advance notification of specific times and locations of Navy platform movements and activities (e.g., vessels using active sonar).

Reliance on the availability of third-party personnel for mitigation would be impractical because training activity timetables oftentimes cannot be precisely fixed and are instead based on the free-flow development of tactical situations. Waiting for third-party aircraft or vessels to complete surveys, refuel, or transit on station would extend the length of the activity in a way that would diminish realism and delay training schedules. Hiring third-party civilian vessels or aircraft to observe Navy training activities would also be unsustainable due to the significant associated costs. Because many training activities take place offshore, the amount of time observers would spend on station would be limited due to aircraft fuel restrictions. Fuel restrictions and distance from shore would increase safety risks should mechanical problems arise. The presence of civilian aircraft or vessels in the vicinity of training activities would present increased safety risks due to airspace conflicts and proximity to explosives.

5.5.6 Foreign Navy Mitigation

When assessing and developing mitigation, the Navy considered adopting the mitigation measures implemented by foreign navies. Mitigation measures are carefully developed for and assessed by each individual navy based on the potential impacts of their activities on the biological resources that live in their study areas, and the practicality of mitigation implementation based on their training mission requirements and the resources available for mitigation. The U.S. Navy's readiness considerations differ from those of foreign navies based on each navy's strategic reach, global mission, country-specific legal requirements, and geographic considerations. Most non-U.S. navies do not possess an integrated strike group and do not have integrated training requirements. The U.S. Navy's training is built around the integrated warfare concept and is based on the U.S. Navy's capabilities, the threats faced, the operating environment, and the overall mission. For this reason, not all measures developed for foreign navies would be effective at reducing impacts of U.S. Navy training, or practical to implement by the U.S. Navy (and vice versa). For example, some navies implement active sonar ramp-up as mitigation for marine mammals; however, as described in Section 5.5.1 (Active Sonar), the U.S. Navy determined that active sonar ramp-up would be an ineffective mitigation measure for training activities under the Proposed Action and would be impractical to implement because it would significantly impact training realism.

The U.S. Navy will implement mitigation measures that have been determined to be effective at avoiding or reducing impacts from the Proposed Action and practical to implement by the U.S. Navy. Many of these measures are the same as, or comparable to, those implemented by foreign navies. For example, most navies implement some form of procedural mitigation to cease certain activities if a marine mammal is observed in a mitigation zone (Dolman et al., 2009). Some navies also implement geographic mitigation to restrict activities within particularly important marine mammal breeding, feeding, or migration habitats. The U.S. Navy will implement several mitigation measures and environmental compliance initiatives that are not implemented by foreign navies. For example, as discussed in Section 5.1.2.2 (Monitoring, Research, and Reporting Initiatives), the U.S. Navy will continue to sponsor scientific monitoring and research and comply with stringent reporting requirements.

5.5.7 Reporting Requirements

When assessing and developing mitigation, the Navy considered increasing its reporting requirements, such as additional reporting of vessel speeds and marine species observations. As discussed in Section 5.1.2.2 (Monitoring, Research, and Reporting Initiatives), the Navy developed its reporting requirements in conjunction with NMFS to be consistent with mission requirements and balance the usefulness of the information to be collected with the practicality of collecting it. The Navy's training activity reports and incident reports are designed to verify implementation of mitigation; comply with current permits, authorizations, and consultation requirements; and improve future environmental analyses. In the unlikely event that a vessel strike of a marine mammal should occur, the Navy would provide NMFS with relevant information pertaining to the incident, including but not limited to vessel speed.

Additional reporting would be ineffective as mitigation because it would not result in modifications to training activities or further avoidance or reductions of potential impacts. For example, additional reporting of vessel speed data would not result in modifications to vessel speeds (e.g., speed restrictions) or reduce the already low potential for vessel strikes of marine mammals for the reasons described in Section 5.3.4.1 (Vessel Movement). Lookouts are not trained to make species-specific identification and would not be able to provide detailed scientific data if more detailed marine species observation reports were to be required. Furthermore, the Navy does not currently maintain a record management system to collect, archive, analyze, and report every marine species observation or all vessel speed data for every training activity and all vessel movements. For example, the speed of Navy vessels can fluctuate an unlimited number of times during training events. Developing and implementing a record management system of this magnitude would be unduly cost prohibitive and place a significant administrative burden on vessel operators and activity participants. Burdening operational Commanders, vessel operators, and event participations with requirements to complete additional administrative reporting would distract them from preparing a ready force and focusing on mission-essential tasks. Additional reporting requirements would draw event participants' attention away from the complex tactical tasks they are primarily obligated to perform, such as driving a warship or engaging in a gunnery event, which would adversely impact personnel safety, public health and safety, and the effectiveness of training.

5.6 Mitigation Summary

Table 5.6-1 provides a general summary of mitigation measures the Navy will implement under Alternative 1 of the Proposed Action. For detailed requirements, see Section 5.3 (Procedural Mitigation to be Implemented) and Section 5.4 (Geographic Mitigation to be Implemented). The mitigation zones in the table apply to marine mammals and sea turtles unless specified otherwise.

Table 5.6-1: Summary of Mitigation Requirements in the Temporary Maritime Activities Area

Stressor, Activity, or Mitigation Category	Summary of Procedural Mitigation Requirements Wherever Activities Occur		Mitigation Areas and Summary of Geographic Mitigation Requirements			Species Protection Focus				Summary of New Mitigation Added Since the 2016 GOA Final SEIS/OEIS
	Number of Lookouts	Mitigation Zone Size or Other Requirement	North Pacific Right Whale Mitigation Area	Portlock Bank Mitigation Area	Temporary Maritime Activities Area	Marine Mammals	Sea Turtles	Seabirds	Fishery Resources	
Other	—	—	—	—	• Remain out of Steller sea lion CH	X	—	—	—	—
Environmental Awareness and Education	—	• Applicable personnel take assigned Afloat Environmental Compliance Training modules	—	—	• Seasonal awareness messages	X	X	X	—	• Seasonal awareness messages
Active Sonar	1 or 2, source dependent	• 1,000 yd. and 500 yd. power downs, and 200 yd. shut down for HM MFAS • 200 yd. shut down for MFAS, non-HM and HFAS	• No HM MF1	—	—	X	X	—	—	—
Weapon Firing Noise	1	• 30° on sides of firing line out to 70 yd. from the weapon muzzle	—	—	—	X	X	X	—	• Seabird mitigation
Explosive Med-Cal and Lg-Cal Projectiles	1	• 200 yd. (A-S med-cal: seabirds, marine mammals, sea turtles) • 200 yd. (S-S med-cal: seabirds) and 600 yd. (marine mammals, sea turtles) • 1,000 yd. (S-S lg-cal: marine mammals, sea turtles)	• No in-water explosives	• No in-water explosives	—	X	X	X	X	• Seabird mitigation • Increased marine mammal and sea turtle mitigation zones • Post-event observations • Additional participants support Lookout observations
Explosive Bombs	1	• 2,500 yd.	• No in-water explosives	• No in-water explosives	—	X	X	—	X	• Post-event observations • Additional participants support Lookout observations
Vessel Movement	1	• 500 yd. (whales) • 200 yd. (other marine mammals) • Vicinity (sea turtles)	—	—	—	X	X	—	—	• Sea turtle mitigation
Towed In-Water Devices	1	• 250 yd. (marine mammals) • Vicinity (sea turtles)	—	—	—	X	X	—	—	• Sea turtle mitigation
Sm-, Med-, Lg-Cal Non-Explosive Practice Munitions	1	• 200 yd. for sm-, med-, and lg-cal (marine mammals, sea turtles) and for sm- and med-cal (seabirds)	—	—	—	X	X	X	—	• Seabird mitigation
Non-Explosive Bombs	1	• 1,000 yd.	—	—	—	X	X	—	—	—

Notes: — = No mitigation or mitigation is not applicable, X = Mitigation is applicable, CH = critical habitat, GOA = Gulf of Alaska, HFAS = high-frequency active sonar, HM = hull-mounted, Lg-cal = large-caliber, Med-cal = medium-caliber, MFAS = mid-frequency active sonar, NEW = net explosive weight, NM = nautical miles, OEIS = Overseas Environmental Impact Statement, Sm-cal = small-caliber, SEIS = Supplemental Environmental Impact Statement, yd. = yard

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6 Additional Regulatory Considerations

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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6 ADDITIONAL REGULATORY CONSIDERATIONS

In accordance with the Council on Environmental Quality regulations for implementing the National Environmental Policy Act (NEPA), federal agencies shall, to the fullest extent possible, integrate the requirements of NEPA with other planning and environmental review procedures required by law or by agency practice so that all such procedures run concurrently rather than consecutively. This chapter summarizes environmental compliance for the Proposed Action; consistency with other federal, state, and local plans, policies, and regulations not considered in Chapter 3 (Affected Environment and Environmental Consequences); the relationship between short-term impacts and the maintenance and enhancement of long-term productivity in the affected environment; irreversible or irretrievable commitments of resources; and energy conservation.

6.1 Consistency with Other Applicable Federal, State, and Local Plans, Policies, and Regulations

Implementation of the Proposed Action addressed in the Gulf of Alaska (GOA) Navy Training Activities Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS) would comply with applicable federal, state, and local laws, regulations, and executive orders (EOs). The United States (U.S.) Department of the Navy (Navy) is consulting with and will continue to consult with regulatory agencies, as appropriate, during the NEPA process and prior to implementation of the Proposed Action.

Table 6.1-1 summarizes environmental compliance requirements that were considered in preparing this SEIS/OEIS (including those that may be secondary considerations in the resource evaluations). Many of the federal statutes, regulations, executive orders, and international standards described in the 2016 GOA Final SEIS/OEIS (Table 6.1-1) remain unchanged since the publishing of the 2016 GOA Final SEIS/OEIS. Since the Proposed Action is also unchanged, the Navy's compliance regarding those statutes, regulations, executive orders, and international standards remains the same and will not be repeated in this SEIS/OEIS.

Section 3.0.2 (Regulatory Framework) in the 2016 GOA Final SEIS/OEIS provides brief excerpts of the primary federal statutes, EOs, international standards, and guidance that form the regulatory framework for the resource evaluations. Documentation of consultation and coordination with regulatory agencies is provided in Appendix E (Agency Correspondence). Consultations with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act will begin following the release of the Draft SEIS/OEIS. However, the Navy has been coordinating with regulatory offices prior to initiating consultation. Likewise, the Navy submitted applications to the National Marine Fisheries Service (NMFS) for Marine Mammal Protection Act authorizations supported by this SEIS/OEIS. Consultation with NMFS is currently underway. Therefore, not all consultation documentation is included in Appendix E (Agency Correspondence) or on the website (www.goaeis.com) at this time.

Table 6.1-1: Summary of Environmental Compliance for the Proposed Action

Statutes, Regulations, Executive Orders, International Standards, and Guidance	Status of Compliance
Statutes and Regulations	
Endangered Species Act (ESA) (16 United States Code [U.S.C.] sections 1531 et seq.)	This SEIS/OEIS analyzes potential effects to species listed under the ESA and is administered by both the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). In accordance with Section 7 of the ESA (50 Code of Federal Regulations [CFR] section 402), during the preparation of the 2011 GOA Final EIS/OEIS, the Navy prepared a biological evaluation and submitted it to USFWS. The Navy received a concurrence letter from the USFWS (March 2010), which remains valid (consultation # 2010-0075 and 2010-0075-R001). On July 23, 2014, the USFWS sent an email to the Navy stating that reinitiation of consultation for the 2016 GOA Final SEIS/OEIS was not necessary as there were no changes to the actual activities, geographic parameters, or levels of activities occurring in the areas previously subject to consultation with the USFWS. There were also no new listed or proposed species in the Study Area. In accordance with 50 CFR section 402, the Navy is developing a biological assessment to reinitiate the informal consultation because of Trigger (b), new information reveals effects of the Navy's proposed activities (the action) that may affect listed species (ESA-listed short-tailed albatross) or critical habitat in a manner or to an extent not previously considered in the 2016 GOA Final SEIS/OEIS. Additionally, during the preparation of the 2016 GOA Final EIS/OEIS, the Navy formally consulted with NMFS. The Navy received a Biological Opinion (BO) (April 2017) that indicated that the Navy's actions were not likely to jeopardize the continued existence of any ESA-listed species and would not result in the destruction or adverse modification of any critical habitat. NMFS also determined that the Navy's activities were not likely to adversely affect the following species and critical habitat: Western North Pacific Distinct Population Segment (DPS) gray whales, Mexico DPS humpback whales, Western North Pacific DPS humpback whales, critical habitat for the Steller sea lion (Western DPS), critical habitat for the North Pacific right whale; leatherback sea turtle, green sea turtle (Central North Pacific and Eastern Pacific DPSs), loggerhead sea turtle (North Pacific Ocean DPS), the olive ridley sea turtle; Chinook salmon (Puget Sound Evolutionarily Significant Unit [ESU], Upper Columbia River Spring-run ESU, Lower Columbia River ESU, Upper Willamette River ESU, Snake River Spring/Summer-run ESU, Snake River Fall-run ESU, California Coastal ESU, Central Valley Spring-run ESU, and Sacramento River Winter-run ESU), coho salmon (Southern Oregon/Northern California Coast ESU and Central California Coast ESU), sockeye salmon (Ozette Lake ESU and Snake River ESU), and steelhead trout (Northern California DPS, California Central Valley DPS, Central California Coast DPS, South Central California Coast DPS, and Southern California DPS).

Table 6.1-1: Summary of Environmental Compliance for the Proposed Action (continued)

Statutes, Regulations, Executive Orders, International Standards, and Guidance	Status of Compliance
Statutes and Regulations (continued)	
Endangered Species Act (ESA) (16 U.S.C. sections 1531 et seq.) (continued)	In accordance with 50 CFR section 402, the Navy is preparing another Biological Assessment that will be submitted to NMFS as part of the new formal consultation. A BO may be issued by NMFS, and the Navy will adhere to any BO terms and conditions listed therein. In addition, the Navy applied for a Letter of Authorization (LOA), which is expected to impose terms and conditions that, when implemented, would make ESA Section 9 prohibitions inapplicable to covered Navy activities. The Marine Mammal Protection Act (MMPA) LOA permit may be issued by NMFS prior to the issuance of the Record of Decision on this SEIS/OEIS.
Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. sections 1801–1882)	The Navy will submit a letter to NMFS in which the Navy will advise that it will not request a reinitiation of consultation. There are no changes to the type of activities or the geographic parameters; however, there are reductions to the levels of activities occurring in the areas previously subject to consultation with NMFS. Therefore, the Navy's previous analysis of impacts on essential fish habitat within the TMAA remains valid and does not raise the requirement of supplemental consultation pursuant to 50 CFR 600.920(1). The Navy will continue to implement the conservation recommendation of coordinating with other research activities within the Gulf of Alaska to avoid displacement or effects to other activities.
Marine Mammal Protection Act (16 U.S.C. sections 1431 et seq.)	This SEIS/OEIS updates the analysis and is the basis for a request for a 7-year LOA, which is a change from the 2016 GOA Final SEIS/OEIS per the 2018 National Defense Authorization Act and the MMPA, as the NMFS permitting period has been changed from 5- to 7-year permits, to cover the Navy's proposed activities for the 2022–2029 timeframe.
National Historic Preservation Act (16 U.S.C. sections 470 et seq.)	The proposed activities would occur more than 12 nautical miles from shore. The Navy will coordinate with the Alaska State Historic Preservation Officer.
National Marine Sanctuaries Act (16 U.S.C. section 1431-1445c-1)	The TMAA does not include any National Marine Sanctuaries; therefore, the National Marine Sanctuaries Act does not apply.
Submerged Lands Act of 1953 (43 U.S.C. sections 1301–1315)	In accordance with the State's regulations, the Proposed Action is consistent with regulations concerning the Submerged Lands Act.

Table 6.1-1: Summary of Environmental Compliance for the Proposed Action (continued)

Statutes, Regulations, Executive Orders, International Standards, and Guidance	Status of Compliance
Executive Orders (EOs)	
EO 13175, *Consultation and Coordination with Indian Tribal Governments*	These legal requirements have not changed since the 2016 GOA Final SEIS/OEIS. The Navy has invited federally recognized tribal governments to initiate government-to-government consultation.
EO 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*	This EO was revoked and replaced by EO 13840, *Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States*, since the 2016 GOA Final SEIS/OEIS.
EO 13693, *Planning for Federal Sustainability in the Next Decade*	This EO was revoked and replaced by EO 13834, *Efficient Federal Operations*, since the 2016 GOA Final SEIS/OEIS.
EO 13783, On Promoting Energy Independence and Economic Growth	This EO revokes EO 13653, Preparing the United States for the Impacts of Climate Change. The Proposed Action is consistent with the policy's goals for the safe, efficient development of domestic energy resources.
EO 13792*, Review of Designations Under the Antiquities Act*	On April 26, 2017, EO 13792 was issued and directed the Secretary of the Interior to review designations of national monuments made since 1996. The Proposed Action is consistent with this EO and considers all national monuments that are still designated as such.
EO 13834, *Efficient Federal Operations*	The Proposed Action is consistent with the federal government's order to prioritize actions that reduce waste, cut costs, enhance the resilience of federal infrastructure and operations, and enable more effective accomplishment of an agency's mission. This Executive Order revokes EO 13693, *Planning for Federal Sustainability in the Next Decade*.
EO 13840, *Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States*	The Proposed Action is consistent with the comprehensive national policy for the *Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States* (which replaced EO 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*).

Notes: EIS = Environmental Impact Statement, GOA = Gulf of Alaska, Navy = United States Department of the Navy, OEIS = Overseas Environmental Impact Statement, SEIS = Supplemental Environmental Impact Statement, TMAA = Temporary Maritime Activities Area.

6.1.1 Marine Protected Areas

This SEIS/OEIS has been prepared in accordance with requirements for natural or cultural resources protected under the National System of Marine Protected Areas (MPAs). While several MPAs are located within the Temporary Maritime Activities Area (TMAA), none of these MPAs are included as members in the National System of MPAs. Navy activities within these MPAs abide by the regulations of the individual MPA. Table 6.1-2 provides information on the individual MPA regulations and the Navy activities that occur in these areas.

Table 6.1-2: Marine Protected Areas Near the Gulf of Alaska Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement TMAA

Marine Protected Area	Location Within the TMAA	Protection Focus	Regulations Applicable to Navy Activities	Navy Proposed Activities and Potential Impacts
Alaska Maritime National Wildlife Refuge	Borders the Gulf of Alaska and Pacific Ocean	Natural Heritage	Commercial and recreational fishing restricted.	The Navy's proposed activities near the Refuge would not involve the taking of fish, wildlife, or shellfish.
Becharof National Wildlife Refuge	Southwestern Alaska	Ecosystem	Commercial and recreational fishing restricted.	The Navy's proposed activities near the Refuge would not involve the taking of fish, wildlife, or shellfish.
Kenai National Wildlife Refuge	Kenai Peninsula of Alaska	Ecosystem	Commercial and recreational fishing restricted.	The Navy's proposed activities near the Refuge would not involve the taking of fish, wildlife, or shellfish.
Steller Sea Lion Protection Areas (including the Atka Mackerel Closure)	Gulf of Alaska	Natural Heritage	Commercial fishing restricted; Atka Mackerel, Groundfish, Pollock, and Pacific Cod Closures	The Navy's proposed activities near the protected areas would not involve the taking of fish, wildlife, or shellfish.
Kachemak Bay National Estuarine Research Reserve	Western coast of the Kenai Peninsula in Alaska	Natural Heritage	No restrictions.	The Navy's proposed activities near the Reserve would not involve the taking of fish, wildlife, or shellfish.
Katmai National Park and Preserve	Southern Alaska	Natural Heritage	Commercial and recreational fishing restricted.	The Navy's proposed activities near the Preserve would not involve the taking of fish, wildlife, or shellfish.
Kodiak Island Wildlife Refuge	Alaska South Coast	Sustainable Production	Commercial fishing restricted.	The Navy's proposed activities near the Refuge would not involve the taking of fish, wildlife, or shellfish.
Southeast Alaska Trawl Closure	Southeastern Alaska	Sustainable Protection	Commercial fishing restricted.	The Navy's proposed activities near the protected area would not involve the taking of fish, wildlife, or shellfish.

Notes: Navy = United States Department of the Navy, TMAA = Temporary Maritime Activities Area

The 2016 GOA Final SEIS/OEIS discussed MPAs that overlapped with the TMAA. Executive Order 13792, *Review of Designations Under the Antiquities Act*, authorized a review by the Secretary of Interior of certain designated National Monuments under the Antiquities Act. No changes have been made currently to any of the National Monuments in the TMAA. Figure 6.1-1 shows MPAs near the TMAA.

6.1.2 Fishery Management Habitat Protections

The Magnuson-Stevens Fishery Conservation and Management Act established jurisdiction over marine fishery resources in the United States and was reauthorized and amended by the Sustainable Fisheries Act of 1996 (Public Law 104-297) to include the essential fish habitat mandate. The Sustainable Fisheries Act set forth a number of new directives for the National Marine Fisheries Service, regional Fishery Management Councils, and other federal agencies to identify and protect important marine, estuarine, and anadromous fish habitat. The TMAA is within the jurisdiction of the North Pacific Fishery Management Council, which is responsible for identifying Habitat Areas of Particular Concern (HAPC) for federally managed species. In order to protect HAPCs, certain habitat protection areas and habitat conservation zones have been designated. A habitat protection area is an area of special, rare habitat features where fishing activities that may adversely affect the habitat are restricted. HAPCs within the TMAA include designation of specific habitat protection areas to help maintain productivity of fishery resources, including seamount habitat and slope habitat protection areas.

Currently, there are 15 Alaska Seamount Habitat Protection Areas, 3 of which occur almost entirely within the TMAA and include Dall, Giacomini, and Quinn Seamounts (71 Federal Register 36703) (Figure 6.1-1), while the Kodiak Seamount and Middleton West Slope habitat protection areas are only partially located in the TMAA. These areas have restrictions prohibiting bottom trawling. Additionally, there are 10 GOA Slope Habitat Conservation Areas, including Middleton Island West and Cable that occur within the TMAA (71 Federal Register 36703) (Figure 6.1-1). These areas have restrictions prohibiting the use of bottom contact fishing gear and anchorages. Navy activities are not subject to the regulations based on the types of activities conducted in the TMAA.

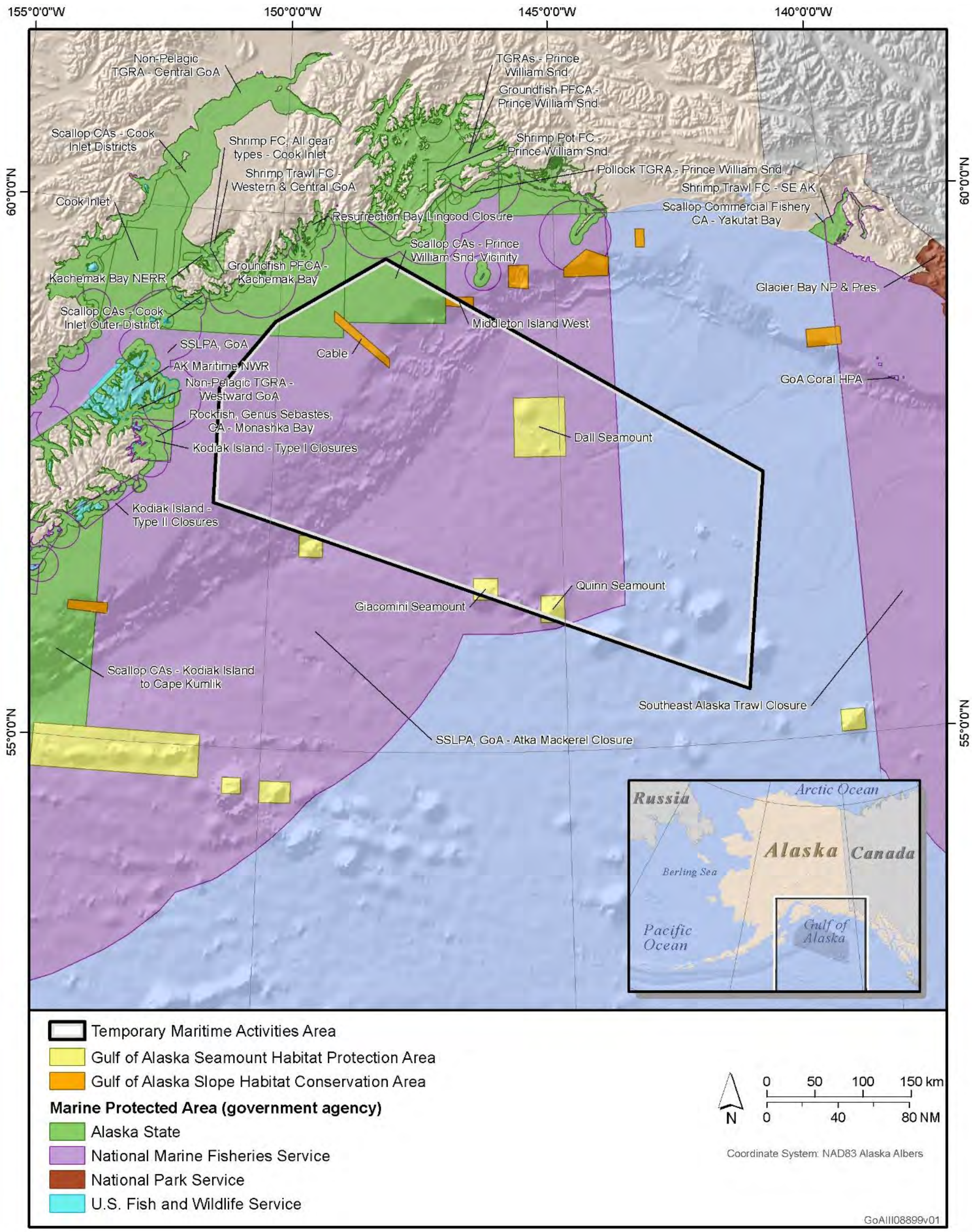

Figure 6.1-1: Map of Marine Protected Areas Near the TMAA

6.1.3 Government-to-Government Consultation with Federally Recognized Alaska Native Tribes

The Navy will continue government-to-government communications with several tribes in Alaska in accordance with Secretary of the Navy Instruction 11010.14B, *Department of the Navy Policy for Consultation with Federally Recognized Indian Tribes, Alaska Native Tribal Entities, and Native Hawaiian Organizations*; Commander, Navy Region Northwest Instruction 11010.14, *Policy for Consultation with Federally-Recognized American Indian and Alaska Native Tribes* (April 10, 2020); EO 13175, *Consultation and Coordination with Indian Tribal Governments*; EO 13007, *Indian Sacred Sites*; the Presidential Memorandum dated April 29, 1994, *Government-to-Government Relations with Native American Governments*; the National Historic Preservation Act of 1966 as amended in 2006; the American Indian Religious Freedom Act of 1978, and Navy consultation policies as needed.

In accordance with Department of Defense (DoD) and Navy policies, the Navy has invited federally recognized tribal governments to initiate government-to-government consultation because the proposed action has the potential to significantly affect tribal rights, protected resources, or Indian lands.

6.2 Relationship Between Short-Term Use of the Environment and Maintenance and Enhancement of Long-Term Productivity

In accordance with the Council on Environmental Quality regulations (Part 1502), this SEIS/OEIS analyzes the relationship between the short-term impacts on the environment and the effects those impacts may have on the maintenance and enhancement of the long-term productivity of the affected environment. This analysis has not changed since the analysis conducted in the 2016 GOA Final SEIS/OEIS. See Section 6.2 (Relationship Between Short-Term Use of the Environment and Maintenance and Enhancement of Long-Term Productivity) of the 2016 GOA Final SEIS/OEIS for more information (U.S. Department of the Navy, 2016).

6.3 Irreversible or Irretrievable Commitment of Resources

NEPA requires that environmental analysis include identification of "any irreversible and irretrievable commitments of resources which would be involved in the Proposed Action should it be implemented" (42 United States Code section 4332). This analysis has not changed since the analysis conducted in the 2016 GOA Final SEIS/OEIS. See Section 6.3 (Irreversible or Irretrievable Commitment of Resources) of the 2016 GOA Final SEIS/OEIS for more information (U.S. Department of the Navy, 2016).

6.4 Energy Requirements and Conservation Potential of the Proposed Action

Under the operational strategy report in 2011, the DoD published an implementation plan to integrate operational energy considerations and transformation into existing programs, processes, and institutions (U.S. Department of Defense, 2012). In Fiscal Year 2015, the Navy reduced its petroleum consumption by 25.1 percent compared to the Fiscal Year 2005 baseline (U.S. Department of Defense, 2016b). In 2016, the DoD published a new *Operational Energy Strategy* (U.S. Department of Defense, 2016a) to update the 2011 strategy and transform the way energy is consumed in military operations. The 2011 strategy set the overall direction for operational energy security (U.S. Department of Defense, 2011). The 2016 strategy shifts focus towards three objectives: (1) increasing future warfighting capability by including energy throughout future force development, (2) identifying and reducing logistic and operational risks from operational energy vulnerabilities, and (3) enhancing the force's mission effectiveness through updated equipment and improvements in training, exercises, and operations

(U.S. Department of Defense, 2016a). These documents guide the DoD in how to better use energy resources and transform the way we power current and future forces.

This strategy is consistent with energy conservation practices and states that the Navy values energy as a strategic resource, understands how energy security is fundamental to executing our mission afloat and ashore, and is resilient to any potential energy future. The *Fiscal Year 2019 Operational Energy Budget Certification Report* (Department of Defense, 2018) satisfies the requirements in section 2925(b) of title 10 United States Code for fiscal year 2018 and includes information on operational energy demands, progress in implementing the *Operational Energy Strategy* (2016a), alternative fuels investments, and contingency operations support. The DoD consumed approximately 85 million barrels of fuel to power ships, aircraft, combat vehicles, and contingency bases in fiscal year 2018 (Department of Defense, 2018). The Navy consumes approximately 26 percent of the total DoD share (Department of Defense, 2018).

As stated previously, the Proposed Action in this SEIS/OEIS is consistent with that which was implemented in the 2016 GOA Final SEIS/OEIS. Implementation of the Proposed Action for this SEIS/OEIS would not result in an increase in energy use. Energy requirements would be subject to any established energy conservation practices. The use of energy sources has been minimized wherever possible without compromising safety or training activities. Additionally, energy requirements would be subject to any established energy conservation practices. No additional conservation measures related to direct energy consumption by the proposed activities are identified.

Energy requirements would be subject to any established energy conservation practices. The use of energy sources has been minimized wherever possible without compromising safety, training, or testing activities. No additional conservation measures related to direct energy consumption by the proposed activities are identified. The Navy's energy vision given in the Operational Energy Strategy report (U.S. Department of Defense, 2016a) is consistent with energy conservation practices and states that the Navy values energy as a strategic resource, understands how energy security is fundamental to executing our mission afloat and ashore and is resilient to any potential energy future.

The Navy is committed to improving energy security and environmental stewardship by reducing its reliance on fossil fuels (U.S. Department of the Navy, n.d.). The Navy is actively developing and participating in energy, environmental, and climate change initiatives that will increase use of alternative energy and help conserve the world's resources for future generations. Examples of Navy-wide greenhouse gas reduction projects include energy-efficient construction, thermal and photovoltaic solar systems, geothermal power plants, and the generation of electricity with wind energy. The Navy continues to promote and install new renewable energy projects.

Two Navy programs—the Incentivized Energy Conservation Program and the Naval Sea Systems Command's Fleet Readiness, Research and Development Program—are helping the fleet conserve fuel via improved operating procedures and long-term initiatives. The Incentivized Energy Conservation Program encourages the operation of ships in the most efficient manner while conducting their mission and supporting the Secretary of the Navy's efforts to reduce total energy consumption on naval ships. The Naval Sea Systems Command's Fleet Readiness, Research and Development Program includes the High-Efficiency Heating, Ventilating, and Air Conditioning and the Hybrid Electric Drive for DDG-51 class ships, which are improvements to existing shipboard technologies that will both help with fleet readiness and decrease the ships' energy consumption and greenhouse gas emissions. These initiatives are expected to greatly reduce the consumption of fossil fuels.

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7 List of Preparers

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Appendix A Navy Activities Descriptions

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Appendix A Navy Activities Descriptions

A.1 Training Activities

The U.S. Department of the Navy's (Navy's) training activities are organized generally into five primary mission areas and a miscellaneous category (Support Operations) in this Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS) that includes those activities that do not fall within a primary mission area but are an essential part of Navy training. Since the 1990s, the Navy has participated in Exercise Northern Edge, a major joint training exercise in Alaska and off the Alaskan coast that involves the Departments of the Navy, Army, Air Force, and Coast Guard participants reporting to a unified or joint commander. The commander then coordinates the activities planned to demonstrate and evaluate the ability of the services to engage in a regional conflict and carry out plans in response to a threat to national security. The tempo and types of training activities have fluctuated within the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA) Study Area (referred to as the "TMAA") due to evolving requirements, the introduction of new technologies, the dynamic nature of international events, advances in warfighting doctrine and procedures, and force structure changes. Training conducted in the TMAA is considered a major training exercise but is broken out into the individual warfare areas that could be part of the Northern Edge Exercise, or future Commander, United States Indo-Pacific Command high-end, multi-domain exercises. The exercise itself may vary by year and has flexibility based on assigned forces involved in the exercise for a particular year. The Proposed Action would occur over a maximum time period of up to 21 consecutive days during the months of April–October.

Descriptions of sonar, ordnance/munitions, targets, and other systems were provided in the 2011 GOA Final Environmental Impact Statement (EIS)/OEIS (Chapter 2, Description of Proposed Action and Alternatives, and Appendix H, Acoustic Systems Descriptions). Though the types of activities and level of events in the Proposed Action are the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS), there have been changes in the platforms and systems used as part of those activities. Consistent with the previous analysis for Alternative 1, the sinking exercise activity will not be part of the Proposed Action for this SEIS/OEIS. The Navy has reduced the number or type of explosives used in the TMAA because unlike the analysis in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, this SEIS/OEIS does not include an "Alternative 2" that covers sinking exercise activities.

A.1.1 Air Warfare Training

Air warfare is the primary mission area that addresses combat operations by air and surface forces against hostile aircraft and missile threats. Navy ships contain an array of modern anti-aircraft weapon systems, including surface-to-air missile systems and naval guns linked to radar-directed fire-control systems. Strike/fighter aircraft carry anti-aircraft weapons, including air-to-air missiles and aircraft guns. Air warfare training encompasses events and exercises to train ship and aircraft crews in the employment of these weapons systems against simulated threat aircraft or targets. Air warfare training includes air combat maneuver, air defense exercise, gunnery exercise surface-to-air, missile exercise air-to-air, and missile exercise surface-to-air.

A.1.1.1 Air Combat Maneuver

<table>
<tr><th colspan="4">Air Warfare</th></tr>
<tr><th colspan="4">Air Combat Maneuver</th></tr>
<tr><td>Short Description</td><td colspan="2">Fixed-wing aircrews aggressively maneuver against threat aircraft to gain a tactical advantage.</td><td>Typical Duration
1–2 hours</td></tr>
<tr><td>Long Description</td><td colspan="3">Basic flight maneuvers in which fixed-wing aircrew engage in offensive and defensive maneuvering against each other. During air combat maneuver engagements, no ordnance is fired. These maneuvers typically involve two aircraft; however, based upon the training requirement, air combat maneuver exercises may involve over a dozen aircraft.</td></tr>
<tr><td>Typical Components</td><td colspan="3">Platforms: Fixed-wing aircraft
Targets: None</td></tr>
<tr><td>Standard Operating Procedures (Section 2.13)</td><td>Aircraft safety</td><td colspan="2">Typical Locations
At high altitude above the TMAA</td></tr>
<tr><td>Stressors to Biological Resources</td><td>Acoustic:
Aircraft noise

Explosive:
None</td><td>Physical Disturbance and Strike:
Aircraft

Ingestion:
None</td><td>Energy:
In-air electromagnetic devices
Entanglement:
None</td></tr>
<tr><td>Stressors to Physical Resources</td><td>Air Quality:
Criteria air pollutants
Habitats:
None</td><td colspan="2">Sediments and Water Quality:
Metals</td></tr>
<tr><td>Stressors to Human Resources</td><td>Cultural Resources:
None</td><td>Socioeconomic Resources:
Accessibility
Airborne acoustics
Physical disturbance and strike</td><td>Public Health and Safety:
None</td></tr>
<tr><td>Military Expended Material</td><td>Ingestible Material:
None

Non-Ingestible Material:
None</td><td>Military Recoverable Material</td><td>None</td></tr>
<tr><td>Sonar and Other Transducer Bins</td><td colspan="3">None</td></tr>
<tr><td>In-Water Explosive Bins</td><td colspan="3">None</td></tr>
<tr><td>Procedural Mitigation Measures</td><td colspan="3">None</td></tr>
<tr><td>Assumptions Used for Analysis</td><td colspan="3">No munitions fired. Flare and chaff may be used. All flare and chaff accounted for in Counter Targeting Chaff Exercise—Aircraft events and Electronic Warfare Exercise.</td></tr>
</table>

A.1.1.2 Air Defense Exercise

<table>
<tr><th colspan="3">Air Warfare</th></tr>
<tr><th colspan="3">Air Defense Exercise</th></tr>
<tr><td>Short Description</td><td>Aircrew and ship crews conduct defensive measures against threat aircraft or simulated missiles.</td><td>Typical Duration
1–4 hours</td></tr>
<tr><td>Long Description</td><td colspan="2">Fixed-wing aircrew and ship personnel perform measures designed to defend against attacking threat aircraft or missiles or reduce the effectiveness of such attack. This exercise involves full detection through engagement sequence. Aircraft operate at varying altitudes and speeds. During this exercise, no ordnance is fired, however, countermeasures such as chaff and flares may be used.

This exercise may include air intercept control exercises where aircraft controllers on ships, in fixed-wing aircraft, or at land-based locations use search radars to track and direct friendly aircraft to intercept the threat aircraft, and to engage exercises where personnel on ships use search radars to detect, classify, and track enemy aircraft or missiles up to the point of engagement.</td></tr>
<tr><td>Typical Components</td><td colspan="2">Platforms: Fixed-wing aircraft, surface combatant
Targets: Aircraft, Air targets</td></tr>
<tr><td>Standard Operating Procedures (Section 2.13)</td><td>Vessel safety
Aircraft safety</td><td>Typical Locations
TMAA</td></tr>
<tr><td>Stressors to Biological Resources</td><td colspan="2">Acoustic:
Aircraft noise
Vessel noise

Physical Disturbance and Strike:
Aircraft and aerial targets
Vessels and in-water devices

Energy:
In-air electromagnetic devices

Explosive:
None

Ingestion:
None

Entanglement:
None</td></tr>
<tr><td>Stressors to Physical Resources</td><td colspan="2">Air Quality:
Criteria air pollutants

Sediments and Water Quality:
None

Habitats:
None</td></tr>
<tr><td>Stressors to Human Resources</td><td colspan="2">Cultural Resources:
None

Socioeconomic Resources:
Accessibility
Airborne acoustics
Physical disturbance and strike

Public Health and Safety:
None</td></tr>
<tr><td>Military Expended Material</td><td>Ingestible Material:
None
Non-Ingestible Material:
None</td><td>Military Recoverable Material
None</td></tr>
<tr><td>Sonar and Other Transducer Bins</td><td colspan="2">None</td></tr>
<tr><td>In-Water Explosive Bins</td><td colspan="2">None</td></tr>
</table>

Air Warfare	
Air Defense Exercise	
Procedural Mitigation Measures	**Physical Disturbance and Strike:** *(Section 5.3.4)* Vessel movement
Assumptions Used for Analysis	All flare and chaff accounted for in flare exercise and chaff exercise events. No munitions are fired.

A.1.1.3 Surface-to-Air Gunnery Exercise

Air Warfare			
Surface-to-Air Gunnery Exercise			
Short Description	Surface ship crews fire large-caliber or medium-caliber guns at air targets.	**Typical Duration**	1–2 hours
Long Description	An event involves one ship and a simulated threat aircraft or missile that is detected by the ship's radar. Large-caliber or medium-caliber guns fire non-explosive projectiles to disable or destroy the threat before it reaches the ship. The target is towed by a contract air services jet.		
Typical Components	**Platforms:** Aircraft carrier, amphibious warfare ship, fixed-wing aircraft, surface combatant **Targets:** Towed Air targets		
Standard Operating Procedures *(Section 2.13)*	Vessel safety Aircraft safety Weapons firing procedures	**Typical Locations**	TMAA
Stressors to Biological Resources	**Acoustic:** Aircraft noise Vessel noise Weapons noise **Explosive:** None	**Physical Disturbance and Strike:** Aircraft and aerial targets Vessels and in-water devices Military expended materials **Ingestion:** Military expended materials – munitions	**Energy:** In-air electromagnetic devices **Entanglement:** None
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants **Habitats:** Physical disturbance and strike – military expended material	**Sediments and Water Quality:** Metals	
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** Accessibility Airborne acoustics Physical disturbance and strike	**Public Health and Safety:** Physical interactions
Military Expended Material	**Ingestible Material:** Large-caliber projectile fragments **Non-Ingestible Material:** None	**Military Recoverable Material**	None
Sonar and Other Transducer Bins	None		
In-Water Explosive Bins	None		
Procedural Mitigation Measures	**Acoustic Stressors:** *(Section 5.3.2)* Weapon firing noise	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement	
Assumptions Used for Analysis	The target is a fiberglass finned target that is towed approximately 3 nautical miles behind the towing aircraft. All projectiles are non-explosive.		

A.1.1.4 Air-to-Air Missile Exercise

Air Warfare			
Air-to-Air Missile Exercise			
Short Description	Fixed-wing aircrews fire air-to-air missiles at air targets or simulate firing a missile.	**Typical Duration**	1–2 hours
Long Description	An event involves two or more fixed-wing aircraft and a target. Missiles are either high-explosive warheads, non-explosive practice munitions, or captive air training missiles with nothing released from the aircraft; most of these events involve captive air training missiles. The target is an unmanned aerial target drone, a tactical air-launched decoy, or a parachute suspended illumination flare. Target drones deploy parachutes and are recovered by small boat or rotary-wing aircraft; tactical air-launched decoys and illumination flares are expended and not recovered. These events typically occur at high altitudes.		
Typical Components	**Platforms:** Fixed-wing aircraft; rotary-wing aircraft; small boat **Targets:** Air targets, flares		
Standard Operating Procedures *(Section 2.13)*	Vessel safety Aircraft safety Weapons firing procedures Unmanned Aerial Vehicle Procedures	**Typical Locations**	TMAA
Stressors to Biological Resources	**Acoustic:** Aircraft noise Vessel noise Weapons noise **Explosive:** In-air explosives	**Physical Disturbance and Strike:** Aircraft and aerial targets Vessels and in-water devices Military expended materials **Ingestion:** Military expended materials – munitions Military expended materials – other than munitions	**Energy:** In-air electromagnetic devices **Entanglement:** Decelerators/parachutes
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants **Habitats:** Physical disturbance and strike – military expended material	**Sediments and Water Quality:** Chemicals Metals	Other materials
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** Accessibility Airborne acoustics Physical disturbance and strike	**Public Health and Safety:** Physical interactions
Military Expended Material	**Ingestible Material:** Target and missile (explosive) fragments **Non-Ingestible Material:** Medium parachutes (from illumination flares)	**Military Recoverable Material**	Undamaged targets, large or extra-large parachutes (recovered with drones)
Sonar and Other Transducer Bins	None		

Air Warfare	
Air-to-Air Missile Exercise	
In-Water Explosive Bins	None
Procedural Mitigation Measures	**Physical Disturbance and Strike:** *(Section 5.3.4)* Vessel movement
Assumptions Used for Analysis	Assumes that all missiles are explosive, although non-explosive practice munitions may be used. All missiles explode at high altitudes. All propellants and explosives are consumed. Assume 1.5 flares per Missile Exercise event.

A.1.1.5 Surface-to-Air Missile Exercise

Air Warfare			
Surface-to-Air Missile Exercise			
Short Description	Surface ship crews fire surface-to-air missiles at air targets.	**Typical Duration**	1–2 hours
Long Description	Surface ship crews defend against threat missiles and aircraft with ship-launched surface-to-air missiles. The event involves a simulated threat aircraft, anti-ship missile, or land-attack missile, which is detected by the ship's radar. Ship-launched surface-to-air missiles are fired (explosive) to disable or destroy the threat. The target typically is a remote-controlled drone, launched from a ship. Target drones deploy parachutes and are recovered by small boat or rotary-wing aircraft; when used, tactical air-launched decoys are not recovered.		
Typical Components	**Platforms:** Aircraft carrier, amphibious warfare ship, surface combatant **Targets:** Air targets, unmanned aerial vehicles		
Standard Operating Procedures *(Section 2.13)*	Vessel safety Aircraft safety Weapons firing procedures Unmanned aerial vehicle procedures	**Typical Locations** TMAA	
Stressors to Biological Resources	**Acoustic:** Aircraft noise Vessel noise Weapons noise **Explosive:** In-air explosives	**Physical Disturbance and Strike:** Aircraft and aerial targets Vessels and in-water devices Military expended materials **Ingestion:** Military expended materials – munitions Military expended materials – other than munitions	**Energy:** In-air electromagnetic devices **Entanglement:** None
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants **Habitats:** Physical disturbance and strike – military expended material	**Sediments and Water Quality:** Chemicals Metals Other materials	
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** Accessibility Airborne acoustics Physical disturbance and strike	**Public Health and Safety:** Physical interactions
Military Expended Material	**Ingestible Material:** Target and missile (explosive) fragments **Non-Ingestible Material:** Target launch rockets	**Military Recoverable Material**	Undamaged targets, large or extra-large parachutes (recovered with drones)
Sonar and Other Transducer Bins	None		

Air Warfare	
Surface-to-Air Missile Exercise	
In-Water Explosive Bins	None
Procedural Mitigation Measures	**Physical Disturbance and Strike:** *(Section 5.3.4)* Vessel movement
Assumptions Used for Analysis	Assumes that all surface-to-air missiles are high-explosive. The missile explodes at least 33 feet above the surface. All explosives and propellants are consumed.

A.1.2 Surface Warfare Training

Surface warfare is a type of naval warfare in which aircraft, surface ships, and submarines employ weapons and sensors in operations directed against enemy surface ships or small boats. The aircraft-to-surface component of surface warfare is conducted by long-range attacks using air-launched cruise missiles, precision-guided munitions, or aircraft guns and rockets. Surface warfare also is conducted by warships employing naval guns, and surface-to-surface missiles. Submarines attack surface ships using submarine-launched, anti-ship cruise missiles. Training in surface warfare includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile launch events. Gunnery and missile training generally involves the expenditure of ordnance against a towed surface target. Explosive missiles are not used on surface targets.

Surface warfare also encompasses maritime security, that is, the interception of a suspect surface ship by a Navy ship for the purpose of boarding-party inspection or the seizure of the suspect ship. Training in these tasks is conducted in visit, board, search, and seizure exercises.

A.1.2.1 Visit, Board, Search, and Seizure

<table>
<tr><th colspan="4">Surface Warfare</th></tr>
<tr><th colspan="4">Visit, Board, Search, and Seizure</th></tr>
<tr><td>Short Description</td><td colspan="2">Military personnel from ships and aircraft board suspect vessels, potentially under hostile conditions.</td><td>Typical Duration
Up to 3 hours</td></tr>
<tr><td>Long Description</td><td colspan="3">Military personnel from ships and aircraft board suspect vessels, potentially under hostile conditions. These activities involve training of boarding parties delivered by helicopters and surface ships to surface vessels for the purpose of simulating vessel search and seizure operations. Various training scenarios are employed and may include small arms with non-explosive blanks and surveillance or reconnaissance unmanned surface and aerial vehicles. The entire exercise may last 2–3 hours.</td></tr>
<tr><td>Typical Components</td><td colspan="3">Platforms: Rotary-wing aircraft, surface combatant, small boat
Targets: Surface targets</td></tr>
<tr><td>Standard Operating Procedures (Section 2.13)</td><td>Vessel safety
Aircraft safety
Laser safety
Unmanned Aerial Vehicle Procedures
Unmanned Surface Vehicle and Unmanned Underwater Vehicle Procedures</td><td colspan="2">Typical Locations
TMAA</td></tr>
<tr><td>Stressors to Biological Resources</td><td colspan="3">Acoustic:
Aircraft noise
Vessel noise
Weapons noise

Physical Disturbance and Strike:
Aircraft
Vessels and in-water devices
Military expended materials

Energy:
In-air electromagnetic devices

Explosive:
None

Ingestion:
Military expended materials – munitions
Military expended materials – other than munitions

Entanglement:
None</td></tr>
<tr><td>Stressors to Physical Resources</td><td colspan="3">Habitats:
Military expended materials

Air Quality:
Criteria air pollutants
Sediments and Water Quality:
Metals
Other materials</td></tr>
<tr><td>Stressors to Human Resources</td><td colspan="3">Cultural Resources:
None

Socioeconomic Resources:
Accessibility
Airborne acoustics
Physical disturbance and strike

Public Health and Safety:
Physical interactions</td></tr>
<tr><td>Military Expended Material</td><td>Ingestible Material:
Small-caliber projectile (casing only), compression pad or plastic piston, endcap, flare O-ring

Non-Ingestible Material:
Marine marker</td><td>Military Recoverable Material</td><td>None</td></tr>
</table>

Surface Warfare	
Visit, Board, Search, and Seizure	
Sonar and Other Transducer Bins	None
In-Water Explosive Bins	None
Procedural Mitigation Measures	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement
Assumptions Used for Analysis	None

A.1.2.2 Air-to-Surface Bombing Exercise

Surface Warfare			
Air-to-Surface Bombing Exercise			
Short Description	Fixed-wing aircrews deliver bombs against surface targets.	**Typical Duration**	1 hour
Long Description	Fixed-wing aircraft conduct bombing exercises against stationary floating targets (e.g., MK-58 smoke buoy), towed targets, or maneuvering targets. An aircraft clears the area, deploys a smoke buoy, and then delivers high-explosive or non-explosive practice munitions bombs on the target. An exercise support boat may be used to deploy towed or maneuvering targets for an aircraft to attack. Exercises for strike fighters typically involve a flight of two aircraft delivering unguided or guided munitions that may be either high-explosive or non-explosive. The following munitions may be employed by strike fighter aircraft in the course of bombing exercise: Unguided munitions include non-explosive subscale bombs (MK-76 and BDU-45), explosive and non-explosive general-purpose bombs (MK-80 series). Precision-guided munitions include laser-guided bombs (explosive, non-explosive), laser-guided training rounds (non-explosive), Joint Direct Attack Munition (explosive, non-explosive).		
Typical Components	**Platforms:** Fixed-wing aircraft, support craft **Targets:** Surface targets		
Standard Operating Procedures *(Section 2.13)*	Vessel safety Aircraft safety Weapons firing procedures	**Typical Locations**	TMAA (Use of explosives will not occur in the Portlock Bank Mitigation Area.)
Stressors to Biological Resources	**Acoustic:** Aircraft noise Vessel noise Weapons noise **Explosive:** Detonations at or near the surface	**Physical Disturbance and Strike:** Aircraft Vessels and in-water devices Military expended materials **Ingestion:** Military expended materials – munitions Military expended materials – other than munitions	**Energy:** In-air electromagnetic devices **Entanglement:** Decelerators/parachutes
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants **Habitats:** Physical disturbance and strike – military expended material	**Sediments and Water Quality:** Explosives Metals	
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** Accessibility Airborne acoustics Physical disturbance and strike	**Public Health and Safety:** In-water energy In-air energy Physical interactions
Military Expended Material	**Ingestible Material:** Small decelerators/parachutes, target fragments, bomb fragments **Non-Ingestible Material:** Mark 58 marine marker	**Military Recoverable Material**	Surface targets (mobile)

Surface Warfare	
Air-to-Surface Bombing Exercise	
Sonar and Other Transducer Bins	None
In-Water Explosive Bins	E9 E10 E12
Procedural Mitigation Measures	**Explosive Stressors:** *(Section 5.3.3)* Explosive bombs **Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement Non-explosive bombs and mine shapes
Assumptions Used for Analysis	Approximately 90 percent of non-explosive bombs are the sub-scale bombs such as the MK-76 and BDU-48. Use of explosives will not occur in the North Pacific Right Whale Mitigation Area from June 1 to September 30 or in the Portlock Bank area.

A.1.2.3 Air-to-Surface Gunnery Exercise

Surface Warfare			
Air-to-Surface Gunnery Exercise			
Short Description	Fixed-wing, helicopter, and tilt-rotor aircrews fire small-caliber or medium-caliber inert rounds at surface targets.	**Typical Duration**	1 hour
Long Description	Helicopters and tilt-rotor aircraft conduct attacks against an at-sea target. Targets simulate enemy ships, boats, and floating/near-surface mines. Each platform will engage the target with small-caliber weapons. Targets range from a smoke float or an empty steel drum to high-speed remote-controlled boats and jet-skis. Fixed-wing and helicopter aircrew, engage surface targets with medium-caliber guns. Targets simulate enemy ships, boats, swimmers, and floating/near- surface mines. Fixed-wing aircraft descend on a target firing medium-caliber non-explosive practice munitions. Helicopters will conduct attacks against an at-sea target. Aircrew will engage the target with small-caliber and medium-caliber non-explosive practice munitions. Targets range from a smoke float or an empty steel drum to high-speed remote-controlled boats and jet-skis.		
Typical Components	**Platforms:** Fixed-wing aircraft, rotary-wing aircraft, tilt-rotor aircraft **Targets:** Surface targets (e.g., MK 58 marine marker, empty steel drum, high-speed remote-controlled boats and jet-skis		
Standard Operating Procedures *(Section 2.13)*	Vessel safety Aircraft safety Weapons firing procedures	**Typical Locations**	TMAA
Stressors to Biological Resources	**Acoustic:** Aircraft noise Vessel noise Weapons noise **Explosive:** None	**Physical Disturbance and Strike:** Aircraft Vessels and in-water devices Military expended materials **Ingestion:** Military expended materials – munitions Military expended materials – other than munitions	**Energy:** In-air electromagnetic devices **Entanglement:** Decelerators/parachutes
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants **Habitats:** Physical disturbance and strike – military expended material	**Sediments and Water Quality:** Metals	
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** Accessibility Airborne acoustics Physical disturbance and strike	**Public Health and Safety:** Physical interactions

Surface Warfare			
Air-to-Surface Gunnery Exercise			
Military Expended Material	**Ingestible Material:** Small decelerators/parachutes, Projectiles, projectile casings, target fragments **Non-Ingestible Material:** MK 58 marine marker, surface target (stationary)	**Military Recoverable Material**	Surface targets (mobile)
Sonar and Other Transducer Bins	None		
In-Water Explosive Bins	None		
Procedural Mitigation Measures	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4, Section 5.3.4.1)* Vessel movement Small- and medium-caliber non-explosive practice munitions		
Assumptions Used for Analysis	Fixed-wing casings remain with aircraft, and helicopter shell casings are expended into the water. Two fixed-wing aircraft (300 rounds each) or one helicopter (400 rounds) per activity. One target used per event: expendable smoke float (50 percent), stationary target (45 percent), or remote-controlled target (5 percent).		

A.1.2.4 Surface-to-Surface Gunnery Exercise

<table>
<tr><th colspan="3">Surface Warfare</th></tr>
<tr><th colspan="3">Surface-to-Surface Gunnery Exercise</th></tr>
<tr><td>Short Description</td><td>Surface ship crews fire small-caliber, medium-caliber, or large-caliber guns at surface targets. Or small boat crews fire small-caliber or medium-caliber guns at surface targets.</td><td>Typical Duration
1 hour
Up to 3 hours</td></tr>
<tr><td>Long Description</td><td colspan="2">Small boat crews fire small-caliber or medium-caliber guns at surface targets. Boat crews may use high or low speeds to approach and engage targets simulating other boats, swimmers, floating mines, or near shore land targets with small-caliber (up to and including .50-caliber) or medium-caliber (up to and including 40 millimeter [mm]) weapons. A number of different types of boats are used depending on the unit using the boat and the training objective. Boats are most used to protect high-value units, such as aircraft carriers, nuclear submarines, liquid natural gas tankers, etc. while entering and leaving ports, as well as to conduct riverine operations, and various naval special warfare operations. The boats used by these units include small riverine craft, combat rubber raiding craft, rigid-hull inflatable boats, patrol craft, as well as other versions of these types of boats. These boats can be inboard or outboard, with diesel, or gasoline engines driving either propeller or water jet propulsion.

Surface ship crews fire small-caliber or medium-caliber weapons to practice defensive marksmanship, typically against high-speed mobile targets or a stationary floating target (a 10-foot-diameter inflatable red balloon [“Killer Tomato”]), a 50-gallon steel drum, or another available target, such as a biodegradable cardboard box. Some targets are expended during the exercise and are not recovered.

Ship crew qualifications conducted at sea employ stationary targets on deck. Small-caliber projectiles fired during these events will be expended in the water. Shipboard protection systems (Close-In Weapon System) utilizing small-caliber or medium-caliber projectiles would train against high-speed mobile targets.

Surface ship exercises also involve ships’ gun crews engaging surface targets at sea with their main battery large-caliber (typically 57 millimeter [mm], and 5-inch) guns. Targets include a high-speed maneuverable surface target or a specially configured remote-controlled watercraft. Some targets are expended during the exercise and are not recovered.

The exercise proceeds with the target boat approaching from about 10 nautical miles distance. The target is tracked by radar and when within a predetermined range, it is engaged first with large-caliber “warning shots.” As threats get closer all weapons may be used to disable the threat. This exercise may involve a single firing ship, or be undertaken in the context of a coordinated larger exercise involving multiple ships, including a major training exercise. Large-caliber guns will also be fired during weapon certification events and in conjunction with weapon maintenance. With the exception of some high-explosive large-caliber rounds, all other rounds would be non-explosive. High-explosive large-caliber rounds can either be fused for detonation on impact (with water surface or target), or for proximity to the target (in air detonation).</td></tr>
<tr><td>Typical Components</td><td colspan="2">Platforms: Small boat, patrol combatant, surface combatant, aircraft carrier, amphibious warship
Targets: Surface targets (e.g., stationary floating target, seaborne powered target, Killer Tomato, 50-gallon steel drum, cardboard box, high speed maneuverable/mobile surface target, or a specially configured remote-controlled watercraft)</td></tr>
</table>

Surface Warfare		
Surface-to-Surface Gunnery Exercise		
Standard Operating Procedures *(Section 2.13)*	Vessel safety Weapons firing procedures	**Typical Locations** TMAA
Stressors to Biological Resources	**Acoustic:** Vessel noise Weapons noise **Explosive:** Detonation of large-caliber rounds at or near the surface	**Physical Disturbance and Strike:** Vessels and in-water devices Military expended materials **Ingestion:** Military expended materials – munitions Military expended materials – other than munitions **Energy:** In-air electromagnetic devices **Entanglement:** None
Stressors to Physical Resources	**Habitats:** Physical disturbance and strike – military expended materials In-water explosives	**Air Quality:** Criteria air pollutants **Sediments and Water Quality:** Explosives Chemicals Metals Other materials
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** Accessibility Airborne acoustics Physical disturbance and strike **Public Health and Safety:** In-water energy Physical interactions
Military Expended Material	**Ingestible Material:** Projectile casings, non-explosive small-caliber and medium-caliber projectiles Target fragments Large-caliber projectile fragments **Non-Ingestible Material:** Surface targets (stationary)	**Military Recoverable Material** Surface target (mobile)
Sonar and Other Transducer Bins	None	
In-Water Explosive Bins	E5	
Procedural Mitigation Measures	**Acoustic Stressors:** *(Section 5.3.2)* Weapons firing noise **Explosive Stressors:** *(Section 5.3.3)* Explosive medium-caliber and large-caliber projectiles	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement Small-, medium-, and large-caliber non-explosive practice munitions
Assumptions Used for Analysis	Most medium-caliber events will involve boat crews training with MK 203 40-millimeter grenade launcher. One target used per event, typically a stationary target such as a 50-gallon steel drum.	

Surface Warfare	
Surface-to-Surface Gunnery Exercise	
	For small-caliber ship events, small-caliber gun rounds per event: 1,000 to 3,000 non-explosive practice munitions. For medium-caliber ship events, one target used per event. Approximately 50 percent of targets are "Killer Tomatoes" (usually recovered). Approximately 35 percent are high-speed maneuvering targets, which are intended to be recovered. Approximately 15 percent of targets are other stationary targets such as a steel drum. All explosive rounds detonating at or near the surface are modeled in the acoustic effects analysis as if the detonation occurs fully underwater, and assuming all.

A.1.2.5 Maritime Interdiction

Surface Warfare		
Maritime Interdiction		
Short Description	Helicopters, surface ships, and small boat crews conduct a suite of maritime security operations at sea, including maritime interdiction operations, force protection, and anti-piracy operations.	**Typical Duration** Up to 3 hours
Long Description	Helicopter and surface ship crews conduct a suite of maritime security operations (e.g., maritime interdiction operations, force protection, and anti-piracy operations). These activities involve training of boarding parties delivered by helicopters and surface ships to surface vessels for the purpose of simulating vessel search and seizure operations. Various training scenarios are employed and may include small arms with non-explosive blanks and surveillance or reconnaissance unmanned surface and aerial vehicles. The entire exercise may last 2–3 hours. Maritime Security Operations is a broad term used to describe activities intended train naval forces in the skills necessary to protect naval vessels from small boat attack, counter-piracy and drug operations (maritime interdiction operations and visit, board, search, and seizure), and protect key infrastructure (e.g., oil platforms). Maritime security operations need to remain broad as naval forces need to be able to tailor training events to respond to emergent threats. Maritime Security Operations events typically do not involve live-fire of weapons. All maritime security operations events involve vessel movement, sometimes at high rates of speed (naval vessels maneuvering to overtake suspect vessel or small boats (targets) closing in and maneuvering around naval vessels) and some events involve helicopters and boarding parties. Maritime security operations training events are conducted proximate to naval homeports (TMAA) including during times of transit in and out of port, as well as during major training exercises. Maritime Interdiction Operations: Ships and aircraft train in pursuing, intercepting, and ultimately detaining suspect vessels. Maritime Infrastructure Protection and Harbor Defense: Naval personnel train to defend oil platforms, similar at sea structures, harbors, piers, and other infrastructure. Warning Shot/Disabling Fire: Naval personnel train in the use of weapons to force fleeing or threatening small boats (typically operating at high speeds) to come to a stop. Ship Force Protection: Ship crews train in tracking multiple approaching, circling small craft, assessing threat potential, and communicating amongst crewmates and other vessels to ensure ships are protected against attack. Anti-Piracy Training: Naval personnel train in deterring and interrupting piracy activity. Training includes large vessels (pirate "mother ships"), and multiple small, maneuverable, and fast craft.	
Typical Components	**Platforms:** Rotary-wing aircraft, surface combatant, small boat **Targets:** Surface targets	

Surface Warfare				
Maritime Interdiction				
Standard Operating Procedures *(Section 2.13)*	Vessel safety Aircraft safety Laser safety Unmanned Aerial Vehicle Procedures Unmanned Surface Vehicle and Unmanned Underwater Vehicle Procedures	**Typical Locations** TMAA		
Stressors to Biological Resources	**Acoustic:** Aircraft noise Vessel noise Weapons noise **Explosive:** None	**Physical Disturbance and Strike:** Aircraft Vessels and in-water devices Military expended materials **Ingestion:** Military expended materials – munitions Military expended materials – other than munitions	**Energy:** In-air electromagnetic devices **Entanglement:** None	
Stressors to Physical Resources	**Habitats:** Military expended materials	**Air Quality:** Criteria air pollutants **Sediments and Water Quality:** Metals Other materials		
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** Accessibility Airborne acoustics Physical disturbance and strike	**Public Health and Safety:** Physical interactions	
Military Expended Material	**Ingestible Material:** Small-caliber projectile (casing only), compression pad or plastic piston, endcap, flare O-ring **Non-Ingestible Material:** Marine marker	**Military Recoverable Material**	None	
Sonar and Other Transducer Bins	None			
In-Water Explosive Bins	None			
Procedural Mitigation Measures	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement			
Assumptions Used for Analysis	None			

A.1.2.6 Air-to-Surface Missile Exercise

<table>
<tr><th colspan="3">Surface Warfare</th></tr>
<tr><th colspan="3">Air-to-Surface Missile Exercise</th></tr>
<tr><td>Short Description</td><td>Fixed-wing aircrews simulate firing precision-guided missiles, using captive air training missiles against surface targets.</td><td>Typical Duration
1 hour</td></tr>
<tr><td>Long Description</td><td colspan="2">Fighter, Electronic Attack, maritime patrol aircraft aircrews fire precision-guided missiles against surface targets. Aircraft involved may be unmanned.
Fixed-wing aircraft (fighters, Electronic Attack, or maritime patrol aircraft) approach an at-sea surface target from high altitude and launch precision guided missiles. Occurs year round, daytime only.</td></tr>
<tr><td>Typical Components</td><td colspan="2">Platforms: Fixed-wing aircraft, surface combatants
Targets: Recoverable floating target (stationary or towed), remotely operated target</td></tr>
<tr><td>Standard Operating Procedures (Section 2.13)</td><td>Vessel safety
Aircraft safety
Laser procedures
Weapons firing procedures</td><td>Typical Locations
TMAA</td></tr>
<tr><td>Stressors to Biological Resources</td><td colspan="2">Acoustic:
Aircraft noise
Vessel noise
Weapons noise
Physical Disturbance and Strike:
Aircraft
Vessels and in-water devices
Military expended materials
Energy:
In-air electromagnetic devices
Explosive:
None
Ingestion:
Military expended materials – munitions
Military expended materials – other than munitions
Entanglement:
Decelerators/parachutes</td></tr>
<tr><td>Stressors to Physical Resources</td><td colspan="2">Air Quality:
Criteria air pollutants
Habitats:
Physical disturbance and strike – military expended material
Sediments and Water Quality:
Metals</td></tr>
<tr><td>Stressors to Human Resources</td><td colspan="2">Cultural Resources:
None
Socioeconomic Resources:
Accessibility
Airborne acoustics
Physical disturbance and strike
Public Health and Safety:
Physical interactions</td></tr>
<tr><td>Military Expended Material</td><td>Ingestible Material:
Small decelerators/parachutes
Non-Ingestible Material:
Missiles (non-explosive), surface target (stationary)</td><td>Military Recoverable Material
Surface targets (mobile)</td></tr>
<tr><td>Sonar and Other Transducer Bins</td><td colspan="2">None</td></tr>
<tr><td>In-Water Explosive Bins</td><td colspan="2">None</td></tr>
</table>

Surface Warfare	
Air-to-Surface Missile Exercise	
Procedural Mitigation Measures	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4, Section 5.3.4.1)* Vessel movement Non-Explosive Missiles
Assumptions Used for Analysis	Assume one target per event.

A.1.2.7 Sea Surface Control

Surface Warfare			
Sea Surface Control			
Short Description	Aircraft, unmanned aerial systems, ships, and submarines use all available sensors to collect data on threat vessels.	**Typical Duration**	2–8 hours
Long Description	Aircraft, unmanned aerial systems operators, ships, and submarines use all available sensors to collect data on threat vessels. Passive sonobuoys are used to collect and analyze acoustic data, and photographic equipment is used to document the vessel with visual information. Occurs year round, daytime only.		
Typical Components	**Platforms:** Aircraft, unmanned aerial system, ships, submarines **Targets:** None		
Standard Operating Procedures *(Section 2.13)*	Aircraft safety Unmanned aircraft system procedures Vessel safety	**Typical Locations**	TMAA
Stressors to Biological Resources	**Acoustic:** Aircraft noise Vessel noise **Explosive:** None	**Physical Disturbance and Strike:** Aircraft and aerial target Military expended materials Vessel and in-water devices **Ingestion:** Military expended materials – other than munitions	**Energy:** In-air electromagnetic devices **Entanglement:** Wires and cables
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants	**Sediments and Water Quality:** None	
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** None	**Public Health and Safety:** None
Military Expended Material	**Ingestible Material:** Small decelerators/parachutes **Non-Ingestible Material:** Sonobuoys, sonobuoy wires	**Military Recoverable Material**	None
Sonar and Other Transducer Bins	None		
In-Water Explosive Bins	None		
Procedural Mitigation Measures	None		
Assumptions Used for Analysis	Sea Surface Control training is conducted by fixed-wing and rotary-wing aircraft and unmanned aerial systems. Aircrews use a variety of intelligence gathering and surveillance methods, including visual, infrared, electronic, radar, and acoustic.		

A.1.3 Anti-Submarine Warfare Training

Anti-submarine warfare (ASW) involves helicopters and maritime patrol aircraft, ships, and submarines. These units operate alone or in coordination to locate, track, and neutralize submarines. Controlling the undersea battlespace is a unique naval capability and a vital aspect of sea control. Undersea battlespace dominance requires proficiency in ASW. Every deploying strike group and most individual surface combatants must possess this capability.

Various types of active and passive sonar are used by the Navy to determine water depth and identify, track, and target submarines. Passive sonar “listens” for sound waves by using underwater microphones, called hydrophones, which receive, amplify, and process underwater sounds. No sound is introduced into the water when using passive sonar. Passive sonar can detect the presence, character, and indicate the movement of submarines. Passive sonar provides only a bearing (direction) to a sound-emitting source; it does not provide an immediately accurate range (distance) to the source. Active sonar is needed to immediately locate objects because active sonar provides both bearing and range to the detected contact (such as an enemy submarine).

The Navy’s ASW training plan, including the use of active sonar in at-sea training scenarios, includes multiple levels of training. Individual-level ASW training addresses basic skills such as search plans, detection and classification of contacts, distinguishing discrete acoustic signatures including those of ships, submarines, and marine life, and identifying the characteristics, functions, and effects of controlled jamming and evasion devices.

More advanced, integrated ASW training exercises involving active sonar are conducted in coordinated, at-sea operations during training events involving submarines, ships, aircraft, and helicopters. This training integrates the full anti-submarine warfare continuum from passive detection and tracking a submarine to active sonar transition for attacking a target using simulated weapons. Training events include detection and tracking exercises against “enemy” submarine contacts and exercising command and control tasks in a multi-dimensional battlespace.

A.1.3.1 Tracking Exercise—Helicopter

<table>
<tr><th colspan="4">Anti-Submarine Warfare</th></tr>
<tr><th colspan="4">Anti-Submarine Warfare Tracking Exercise - Helicopter</th></tr>
<tr><td rowspan="2">Short Description</td><td rowspan="2" colspan="2">Helicopter crews search for, track, and detect submarines.</td><td>Typical Duration</td></tr>
<tr><td>2–4 hours</td></tr>
<tr><td>Long Description</td><td colspan="3">Helicopters using sonobuoys and dipping sonar search for, detect, classify, localize, and track a simulated threat submarine with the goal of determining a firing solution that could be used to launch a torpedo; no torpedoes would be launched.

Sonobuoys (both passive and active) are typically employed by a helicopter operating at altitudes below 3,000 feet. Dipping sonar (both passive and active) is employed from an altitude of about 50 feet both before and after the search area has been narrowed based on the sonobuoy search.

The anti-submarine warfare target used for this exercise may be an expendable ASW target, a recoverable ASW target, or a live submarine. This exercise may involve a single aircraft, or occur during a coordinated larger exercise involving multiple aircraft and ships, including a major range event. The preferred range for this exercise is an instrumented range, but it may be conducted without instrumentation depending on training requirements and available assets.</td></tr>
<tr><td>Typical Components</td><td colspan="3">Platforms: Rotary-wing aircraft, submarines
Targets: Sub-surface targets</td></tr>
<tr><td rowspan="2">Standard Operating Procedures (Section 2.13)</td><td rowspan="2">Aircraft safety
Unmanned Surface Vehicle and Unmanned Underwater Vehicle Procedures</td><td colspan="2">Typical Locations</td></tr>
<tr><td colspan="2">TMAA</td></tr>
<tr><td>Stressors to Biological Resources</td><td>Acoustic:
Sonar and other transducers
Aircraft noise
Vessel noise

Explosive:
None</td><td>Physical Disturbance and Strike:
Aircraft
Vessels and in-water devices
Military expended materials

Ingestion:
Military expended materials – munitions
Military expended materials – other than munitions</td><td>Energy:
In-air electromagnetic devices

Entanglement:
Decelerators/parachutes</td></tr>
<tr><td>Stressors to Physical Resources</td><td colspan="3">Air Quality:
Criteria air pollutants

Habitats:
Physical disturbance and strike – military expended material

Sediments and Water Quality:
Chemicals
Metals
Other materials</td></tr>
<tr><td>Stressors to Human Resources</td><td>Cultural Resources:
None</td><td>Socioeconomic Resources:
Accessibility
Airborne acoustics
Physical disturbance and strike</td><td>Public Health and Safety:
In-water energy
Physical interactions</td></tr>
</table>

<table>
<tr><th colspan="4">Anti-Submarine Warfare</th></tr>
<tr><th colspan="4">Anti-Submarine Warfare Tracking Exercise - Helicopter</th></tr>
<tr><td>Military Expended Material</td><td>Ingestible Material:
Small decelerators/parachutes
Non-Ingestible Material:
Sonobuoys (non-explosive), sonobuoy wires, expendable sub-surface targets, marine marker</td><td>Military Recoverable Material</td><td>None</td></tr>
<tr><td>Sonar and Other Transducer Bins</td><td colspan="3">Mid-Frequency:
MF4
MF5
MF6</td></tr>
<tr><td>In-Water Explosive Bins</td><td colspan="3">None</td></tr>
<tr><td>Procedural Mitigation Measures</td><td colspan="3">Acoustic Stressors: (Section 5.3.2)
Active sonar
Physical Disturbance and Strike Stressors: (Section 5.3.4)
Vessel movement</td></tr>
<tr><td>Assumptions Used for Analysis</td><td colspan="3">Submarines may provide service as the target.</td></tr>
</table>

A.1.3.2 Tracking Exercise—Maritime Patrol Aircraft

Anti-Submarine Warfare		
Anti-Submarine Warfare Tracking Exercise—Maritime Patrol Aircraft		
Short Description	Maritime patrol aircraft crews search for, track, and detect submarines.	**Typical Duration** 2–8 hours
Long Description	Fixed-wing maritime patrol aircraft employ sonobuoys to search for, detect, classify, localize, and track a simulated threat submarine with the goal of determining a firing solution that could be used to launch a torpedo and destroy the submarine. Sonobuoys (both passive and active) are typically employed by a maritime patrol aircraft operating at altitudes below 3,000 feet. However, sonobuoys may be released at higher altitudes. Sonobuoys are deployed in specific patterns based on the expected threat submarine and specific water conditions. Depending on these two factors, these patterns will cover many different size areas. For certain sonobuoys, tactical parameters of use may be classified. The anti-submarine warfare target used for this exercise may be an expendable ASW training target, a recoverable ASW training target, or a live submarine. This exercise may involve a single aircraft, or be undertaken in the context of a larger coordinated scenario involving multiple aircraft and vessels.	
Typical Components	**Platforms:** Fixed-wing aircraft, submarines **Targets:** Sub-surface targets	
Standard Operating Procedures *(Section 2.13)*	Vessel safety Aircraft safety	**Typical Locations** TMAA
Stressors to Biological Resources	**Acoustic:** Sonar and other transducers Aircraft noise Vessel noise **Physical Disturbance and Strike:** Aircraft Vessels and in-water devices Military expended materials **Energy:** In-air electromagnetic devices **Explosive:** None **Ingestion:** Military expended materials – munitions Military expended materials – other than munitions **Entanglement:** Decelerators/parachutes	
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants **Habitats:** Physical disturbance and strike – military expended material **Sediments and Water Quality:** Chemicals Metals Other materials	
Stressors to Human Resources	**Cultural Resources:** None **Socioeconomic Resources:** Accessibility Airborne acoustics Physical disturbance and strike **Public Health and Safety:** In-water energy Physical interactions	
Military Expended Material	**Ingestible Material:** Small decelerators/parachutes **Non-Ingestible Material:** Sonobuoys, Expendable ASW Training Targets, expendable bathythermographs	**Military Recoverable Material** None

Anti-Submarine Warfare	
Anti-Submarine Warfare Tracking Exercise—Maritime Patrol Aircraft	
Sonar and Other Transducer Bins	**Mid-Frequency:** MF5, MF6 **Anti-Submarine Warfare:** ASW2
In-Water Explosive Bins	None
Procedural Mitigation Measures	**Acoustic Stressors:** *(Section 5.3.2)* Active Sonar **Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement
Assumptions Used for Analysis	A submarine may provide service as the target. If a target is air-dropped, one parachute per target.

A.1.3.3 Tracking Exercise—Submarine

<table>
<tr><th colspan="4">Anti-Submarine Warfare</th></tr>
<tr><th colspan="4">Anti-Submarine Warfare Tracking Exercise—Submarine</th></tr>
<tr><td rowspan="2">Short Description</td><td rowspan="2">Submarine crews search for, track, and detect submarines.</td><td colspan="2">Typical Duration</td></tr>
<tr><td colspan="2">8 hours</td></tr>
<tr><td>Long Description</td><td colspan="3">Submarine crews search for, detect, and track a threat submarine to develop a firing position to launch a torpedo.

A single submerged submarine operates at slow speeds and various depths while using its hull-mounted sonar to track a threat submarine. Passive sonar is used almost exclusively. The target for this exercise is either an expendable ASW training target, recoverable ASW training target, or live submarine.

This exercise could occur anywhere throughout the TMAA. This exercise may involve a single submarine, or be undertaken in the context of a larger coordinated scenario involving multiple aircraft, ships, and submarines.</td></tr>
<tr><td>Typical Components</td><td colspan="3">Platforms: Submarines
Targets: Sub-surface targets</td></tr>
<tr><td rowspan="2">Standard Operating Procedures (Section 2.13)</td><td rowspan="2">Vessel safety</td><td colspan="2">Typical Locations</td></tr>
<tr><td colspan="2">TMAA</td></tr>
<tr><td>Stressors to Biological Resources</td><td colspan="3">Acoustic:
Sonar and other transducers
Vessel noise

Physical Disturbance and Strike:
Aircraft, Vessels and in-water devices
Military expended materials

Energy:
None

Explosive:
None

Ingestion:
None

Entanglement:
None</td></tr>
<tr><td>Stressors to Physical Resources</td><td colspan="3">Air Quality:
None

Sediments and Water Quality:
Metals

Habitats:
Physical disturbance and strike – military expended material</td></tr>
<tr><td>Stressors to Human Resources</td><td colspan="3">Cultural Resources:
None

Socioeconomic Resources:
Physical disturbance and strike
Airborne acoustics

Public Health and Safety:
In-water energy
Physical interactions</td></tr>
<tr><td>Military Expended Material</td><td>Ingestible Material:
None
Non-Ingestible Material:
Acoustic countermeasures</td><td>Military Recoverable Material</td><td>None</td></tr>
<tr><td>Sonar and Other Transducer Bins</td><td colspan="3">Mid-Frequency:
MF3

Anti-Submarine Warfare:
ASW4

High-Frequency:
HF1</td></tr>
<tr><td>In-Water Explosive Bins</td><td colspan="3">None</td></tr>
</table>

Anti-Submarine Warfare		
Anti-Submarine Warfare Tracking Exercise—Submarine		
Procedural Mitigation Measures	**Acoustic Stressors:** *(Section 5.3.2)* Active sonar	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement
Assumptions Used for Analysis	ASW training targets can either be expendable, recoverable, or live submarine.	

A.1.3.4 Tracking Exercise—Ship

<table>
<tr><th colspan="4">Anti-Submarine Warfare</th></tr>
<tr><th colspan="4">Anti-Submarine Warfare Tracking Exercise—Ship</th></tr>
<tr><td>Short Description</td><td colspan="2">Surface ship crews search for, track, and detect submarines.</td><td>Typical Duration
2–4 hours</td></tr>
<tr><td>Long Description</td><td colspan="3">Surface ships search for, detect, and track threat submarines to determine a firing position to launch a torpedo.

A surface ship operates at slow speeds while employing sonobuoys, hull-mounted sonar, or towed array sonar. Passive or active sonar is employed depending on the type of threat submarine, the tactical situation, and environmental conditions. The target for this exercise is either an expendable ASW training target, a recoverable ASW training target, or a live submarine.

ASW Tracking exercise—Ship could occur anywhere throughout the TMAA. This exercise may involve a single ship, or be undertaken in the context of a larger coordinated scenario involving multiple aircraft, ships, and submarines.</td></tr>
<tr><td>Typical Components</td><td colspan="3">Platforms: Surface combatant; submarine
Targets: ASW training targets</td></tr>
<tr><td>Standard Operating Procedures (Section 2.13)</td><td>Vessel
Towed in-water device safety</td><td colspan="2">Typical Locations
TMAA</td></tr>
<tr><td>Stressors to Biological Resources</td><td colspan="3">Acoustic:
Sonar and other transducers
Vessel noise

Physical Disturbance and Strike:
Vessels and in-water devices
Military expended materials

Energy:
In-water electromagnetic devices

Explosive:
None

Ingestion:
None

Entanglement:
Wires and cables</td></tr>
<tr><td>Stressors to Physical Resources</td><td colspan="3">Air Quality:
Criteria air pollutants

Habitats:
Physical disturbance and strike – military expended material

Sediments and Water Quality:
Metals
Chemicals
Other materials</td></tr>
<tr><td>Stressors to Human Resources</td><td colspan="3">Cultural Resources:
None

Socioeconomic Resources:
Accessibility
Airborne acoustics
Physical disturbance and strike

Public Health and Safety:
In-water energy
Physical interactions</td></tr>
<tr><td>Military Expended Material</td><td>Ingestible Material:
None

Non-Ingestible Material:
Sonobuoy (non-explosive), sonobuoy wires</td><td>Military Recoverable Material</td><td>None</td></tr>
<tr><td>Sonar and Other Transducer Bins</td><td colspan="3">Mid-Frequency:
MF1
MF11
MF12

Anti-Submarine Warfare:
ASW1
ASW3</td></tr>
</table>

Anti-Submarine Warfare		
Anti-Submarine Warfare Tracking Exercise—Ship		
In-Water Explosive Bins	None	
Procedural Mitigation Measures	**Acoustic Stressors:** *(Section 5.3.2)* Active sonar	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement Towed in-water devices
Assumptions Used for Analysis	A Submarine may provide service as the target.	

A.1.4 Electronic Warfare

Electronic warfare is the mission area of naval warfare that aims to control the use of the electromagnetic spectrum and to deny its use by an adversary. Typical electronic warfare activities include threat avoidance training, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices to defeat tracking systems.

A.1.4.1 Counter Targeting Exercise

Electronic Warfare			
Counter Targeting Exercise			
Short Description	Ships and aircraft conduct jamming and deploy chaff to disrupt threat targeting and missile guidance radars.	**Typical Duration** 1–2 hours	
Long Description	A Counter Targeting exercise is a coordinated, defensive activity utilizing surface and air assets, that attempts to use jamming and chaff to show a false force presentation to inbound surface-to-surface platforms. During these exercises, electronic warfare jamming aircraft will position itself between the carrier strike group assets and the threat and jam the radar systems of potential hostile surface units. Carrier strike group ships will launch chaff to create false targets that saturate the threat radars return, thus masking their true position. These activities occur within the TMAA.		
Typical Components	**Platforms:** Fixed-wing aircraft, rotary-wing aircraft, surface combatants **Targets:** None		
Standard Operating Procedures *(Section 2.13)*	Aircraft safety Vessel safety	**Typical Locations** TMAA	
Stressors to Biological Resources	**Acoustic:** Aircraft noise Vessel noise **Explosive:** None	**Physical Disturbance and Strike:** Vessels and in-water devices Aircraft **Ingestion:** Military expended materials – munitions Military expended materials – other than munitions	**Energy:** In-air electromagnetic devices **Entanglement:** None
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants **Habitats:** Physical disturbance and strike – military expended material	**Sediments and Water Quality:** Metals Chemicals Other materials	
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** Accessibility Airborne acoustics	**Public Health and Safety:** Physical interactions

Electronic Warfare			
Counter Targeting Exercise			
Military Expended Material	**Ingestible Material:** Expended components of chaff-ship (chaff-ship fibers) Per aircraft flare cartridge: one silicone rubber compression pad OR one plastic piston Per aircraft chaff: chaff-air fibers, one chaff plastic endcap, one compression pad; OR one plastic piston, one plastic endcap **Non-Ingestible Material:** MK 53 decoy, chaff-ship cartridges Per flare cartridge: flare (typically consumed), one plastic endcap, O-ring (rubber, nitrile)	**Military Recoverable Material**	None
Sonar and Other Transducer Bins	None		
In-Water Explosive Bins	None		
Procedural Mitigation Measures	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement		
Assumptions Used for Analysis	None		

A.1.4.2 Chaff Exercise

Electronic Warfare			
Chaff Exercise			
Short Description	Surface ship crews deploy chaff to disrupt threat targeting and missile guidance radars.	**Typical Duration**	1–2 hours
Long Description	Surface ship crews deploy chaff to disrupt threat targeting and missile guidance radars to defend against an attack. Surface ship crews detect electronic targeting signals from threat radars or missiles, dispense chaff, and immediately maneuver to defeat the threat. The chaff cloud deceives the inbound missile and the vessel clears away from the threat. The typical event duration is approximately one and one-half hours. Chaff is a radar reflector material made of thin, narrow, metallic strips cut in various lengths to elicit frequency responses, which deceive enemy radars. Chaff is employed to create a target that will lure enemy radar and weapons systems away from the actual friendly platform. Ships may also train with advanced countermeasure systems, such as the MK 53 Decoy Launching System (Nulka).		
Typical Components	**Platforms:** Surface combatants, amphibious warfare ships, fixed-wing aircraft, rotary-wing aircraft **Targets:** None		
Standard Operating Procedures *(Section 2.13)*	Vessel safety Aircraft safety	**Typical Locations**	TMAA
Stressors to Biological Resources	**Acoustic:** Vessel noise Aircraft noise **Explosive:** None	**Physical Disturbance and Strike:** Vessels and in-water devices Aircraft **Ingestion:** Military expended materials – munitions Military expended materials – other than munitions	**Energy:** In-air electromagnetic devices **Entanglement:** None
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants **Habitats:** Physical disturbance and strike – military expended material	**Sediments and Water Quality:** Metals Chemicals Other materials	
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** Accessibility Airborne acoustics	**Public Health and Safety:** Physical interactions
Military Expended Material	**Ingestible Material:** Expended components of chaff-ship (chaff-ship fibers) **Non-Ingestible Material:** MK 53 decoy, chaff-ship cartridges	**Military Recoverable Material**	None
Sonar and Other Transducer Bins	None		

Electronic Warfare	
Chaff Exercise	
In-Water Explosive Bins	None
Procedural Mitigation Measures	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement
Assumptions Used for Analysis	None

A.1.4.3 Electronic Warfare Exercise

Electronic Warfare			
Electronic Warfare Exercise			
Short Description	Aircraft and surface ship crews control portions of the electromagnetic spectrum used by enemy systems to degrade or deny the enemy's ability to take defensive actions.	**Typical Duration**	1–2 hours
Long Description	Aircraft and surface ship crews control the electromagnetic spectrum used by enemy systems to degrade or deny the enemy's ability to take defensive actions. Electronic Warfare Operations can be active or passive, offensive, or defensive. Fixed-wing aircraft employ active jamming and deception against enemy search radars to mask the friendly inbound strike aircraft mission. Surface ships detect and evaluate enemy electronic signals from enemy aircraft or missile radars, evaluate courses of action concerning the use of passive or active countermeasures, then use ship maneuvers and either chaff, flares, active electronic countermeasures, or a combination of them to defeat the threat.		
Typical Components	**Platforms:** Fixed-wing aircraft, surface combatant **Targets:** Air targets, electronic warfare targets		
Standard Operating Procedures *(Section 2.13)*	Vessel safety Aircraft safety	**Typical Locations**	TMAA
Stressors to Biological Resources	**Acoustic:** Aircraft noise Vessel noise **Explosive:** None	**Physical Disturbance and Strike:** Aircraft and aerial target Vessels and in-water devices **Ingestion:** Military expended materials – other than munitions	**Energy:** In-air electromagnetic devices **Entanglement:** None
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants **Habitats:** None	**Sediments and Water Quality:** None	
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** Accessibility Airborne acoustics Physical disturbance and strike	**Public Health and Safety:** None
Military Expended Material	**Ingestible Material:** Expended components of chaff-ship (chaff-ship fibers) Per flare cartridge: one silicone rubber compression pad or one plastic piston **Non-Ingestible Material:** Chaff-ship cartridges Per flare cartridge: flare (typically consumed), one plastic endcap, O-ring (rubber, nitrile)	**Military Recoverable Material**	None

Electronic Warfare	
Electronic Warfare Exercise	
Sonar and Other Transducer Bins	None
In-Water Explosive Bins	None
Procedural Mitigation Measures	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement
Assumptions Used for Analysis	None

A.1.5 Naval Special Warfare

Naval special warfare conducts military activities in five Special Operations mission areas: unconventional warfare, direct action, special reconnaissance, foreign internal defense, and counterterrorism.

Naval special warfare training involves specialized tactics, techniques, and procedures, employed in training events that could include insertion/extraction activities using parachutes, rubber boats, or helicopters and other equipment.

A.1.5.1 Special Warfare Operations

Naval Special Warfare			
Special Warfare Operations			
Short Description	Personnel are inserted into and extracted from an objective area by aircraft, small boats, or subsurface platforms.	**Typical Duration**	2–8 hours
Long Description	Utilizing aircraft, small surface platforms, and subsurface platforms, personnel are inserted in the water. The insertion/extraction activities are confined to in-water training.		
Typical Components	**Platforms:** Small boat, helicopters, and submersibles **Targets:** None		
Standard Operating Procedures *(Section 2.13)*	Vessel safety Aircraft safety	**Typical Locations**	TMAA
Stressors to Biological Resources	**Acoustic:** Vessel noise Aircraft noise **Explosive:** None	**Physical Disturbance and Strike:** Vessels and in-water devices Aircraft and aerial targets **Ingestion:** None	**Energy:** None **Entanglement:** None
Stressors to Physical Resources	**Habitats:** Physical disturbance and strike – military expended material	**Air Quality:** Criteria air pollutants **Sediments and Water Quality:** None	
Stressors to Human Resources	**Cultural Resources:** None	**Socioeconomic Resources:** None	**Public Health and Safety:** None
Military Expended Material	**Ingestible Material:** None **Non-Ingestible Material:** None	**Military Recoverable Material**	None
Sonar and Other Transducer Bins	None		
In-Water Explosive Bins	None		
Procedural Mitigation Measures	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement		
Assumptions Used for Analysis	None		

A.1.6 Strike Warfare

Strike Warfare addresses combat (or interdiction) activities by air and surface forces against hostile land-based forces and assets. Strike warfare activities include training of fixed-wing fighter/attack aircraft in delivery of precision-guided munitions, nonguided munitions, rockets, and other ordnance against land targets in all weather and light conditions.

Training events typically involve a strike mission with a flight of four or more aircraft. The strike mission practices attacks on long-range targets (i.e., those geographically distant from friendly ground forces), or close air support of targets within close range of friendly ground forces. Some strike missions involve no-drop events in which prosecution of targets is practiced, but video footage is often obtained by onboard sensors. Strike exercises occur on the land and air training ranges outside the TMAA, and their impacts are covered under other environmental analysis. The Strike Warfare activity in the TMAA is limited to the launch and recovery of aircraft conducting the training in the land and air training ranges; therefore, no specific activity descriptions are provided.

A.1.7 Support Operations

Other training is conducted in the TMAA that falls outside of the primary mission areas, but supports overall readiness. Specifically, this includes Deck Landing Qualifications, which provides for helicopter crews to land on ships underway at sea.

A.1.7.1 Deck Landing Qualification

Support Operations		
Deck Landing Qualification		
Short Description	Ship's personnel launch and recover helicopters to achieve qualifications and certifications.	**Typical Duration:** Up to 12 hours
Long Description	Ship's personnel launch and recover helicopters to achieve qualifications and certifications.	
Typical Components	**Platforms:** Small boats, Navy vessels **Targets:** None	
Standard Operating Procedures *(Section 2.13)*	Vessel safety Unmanned aerial, surface, and sub-surface vehicle safety	**Typical Locations:** TMAA
Stressors to Biological Resources	**Acoustic:** Vessel noise, Aircraft noise **Physical Disturbance and Strike:** Vessels and in-water devices, Aircraft and aerial targets **Energy:** None **Explosive:** None **Ingestion:** None **Entanglement:** None	
Stressors to Physical Resources	**Air Quality:** Criteria air pollutants **Sediments and Water Quality:** None **Habitats:** None	
Stressors to Human Resources	**Cultural Resources:** None **Socioeconomic Resources:** None **Public Health and Safety:** None	
Military Expended Material	**Ingestible Material:** None **Non-Ingestible Material:** None	**Military Recoverable Material:** None
Sonar and Other Transducer Bins	None	
In-Water Explosive Bins	None	
Procedural Mitigation Measures	**Physical Disturbance and Strike Stressors:** *(Section 5.3.4)* Vessel movement	
Assumptions Used for Analysis	None	

Appendix B Acoustic and Explosive Concepts

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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Appendix B Acoustic and Explosive Concepts

This appendix introduces basic principles and terminology for acoustics and explosives to help the reader understand the analyses presented in this Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS). This appendix briefly explains the transmission of sound and explosive energy; introduces some of the basic mathematical formulas used to describe propagation; and defines acoustical terms, abbreviations, and units of measurement. The difference between transmission of sound in water and in air is also discussed. Finally, it discusses methods used to analyze what animals may hear.

A number of other sources provide a more extensive background on acoustics and explosives than presented in this overview and are recommended for further inquiry. These include, but are not limited to:

Marine Mammals and Noise (Richardson et al., 1995) for a general overview.

Principles of Underwater Sound (Urick, 1983), *Fundamentals of Acoustical Oceanography* (Medwin & Clay, 1998), and *Principles of Marine Bioacoustics* (Au & Hastings, 2008) for comprehensive explanations of underwater acoustics.

B.1 Terminology

The following terms are used in this document when discussing sound and the attributes of a sound source.

B.1.1 Sound

Sound is produced when an elastic medium (such as air or water) is set into motion, typically by a vibrating object within the medium. As the object vibrates, its motion is transmitted to adjacent "particles" of the medium. The motion of these particles is transmitted to adjacent particles, and so on. The result is a mechanical disturbance (the "sound wave") that moves away from the source and propagates at a medium-dependent speed (the "sound speed"). As the sound wave travels through the medium, the individual particles of the medium oscillate about their original positions but do not actually move with the sound wave. As the particles of the medium move back and forth they create small changes about the original values of the medium density, pressure, and temperature.

Sound may be described by both physical and subjective attributes. Physical attributes, such as sound amplitude and frequency, may be directly measured. Subjective (or sensory) attributes like loudness depend on an animal's perception of sound. Physical attributes of a sound at a particular point are usually obtained by measuring pressure changes as sound waves pass.

B.1.2 Signal Versus Noise

When sound is purposely created to convey information, communicate, or obtain information about the environment, it is often referred to as a signal. Examples of sounds that could be considered signals are sonar pings, marine mammal vocalizations and echolocation clicks, tones used in hearing experiments, and small sonobuoy explosions used for submarine detection.

Noise is undesired sound (American National Standards Institute, 1994). Sounds produced by naval aircraft and vessel propulsion are considered noise because they represent possible inefficiencies and increased detectability. Whether a sound is perceived as noise often depends on the receiver (i.e., the animal or system that detects the sound). For example, small explosives and sonar used to generate sounds that can locate an enemy submarine produce signals that are useful to sailors engaged in anti-submarine warfare, but are assumed to be noise when detected by marine mammals.

The combination of all sounds at a particular location, whether these sources are located near or far, is ambient noise (American National Standards Institute, 1994). Ambient noise includes natural sources, such as sound from crashing waves, rain, and animals (e.g., snapping shrimp), and anthropogenic sources, such as seismic surveys and vessel noise.

B.1.3 Frequency and Wavelength

Frequency is the physical attribute most closely associated with the subjective attribute "pitch"; the higher the frequency, the higher the pitch. Frequency is defined by the number of oscillations in the sound pressure or particle motion per second. One hertz (Hz) is equal to one oscillation per second, and one kilohertz (kHz) is equal to 1,000 oscillations per second. Human hearing generally spans the frequency range from 20 Hz to 20 kHz. The frequency range of a sound is called its bandwidth.

Pure tones have energy at a constant, single frequency. Complex tones contain energy at multiple, discrete frequencies, rather than a single frequency. A harmonic of a sound at a particular frequency is a multiple of that frequency (e.g., harmonic frequencies of a 2 kHz tone are 4 kHz, 6 kHz, 8 kHz, etc.). A source operating at a nominal frequency may emit several harmonic frequencies, but at lower amplitudes. Some sources may also emit subharmonics; however, these are typically many orders of magnitude less powerful than at the center frequency. Sounds with large bandwidth ("broadband" sounds) have energy spread across many frequencies.

In this document, sounds are generally described as either low- (less than 1 kHz), mid- (1 kHz–10 kHz), high- (10 kHz–100 kHz), or very high- (greater than 100 kHz) frequency. Hearing ranges of marine animals (e.g., fish, birds, sea turtles, and marine mammals) are quite varied and are species-dependent. For example, some fish can hear sounds below 100 Hz and some species of marine mammals have hearing capabilities that extend above 100 kHz. Acoustic impact analyses must therefore focus not only on the sound amplitude (i.e., pressure or particle motion, see Section B.1.4, Sound Amplitude), but on the sound frequency and the hearing capabilities of the species being considered.

The wavelength of a sound is the distance between wave peaks. Wavelength decreases as frequency increases. The frequency multiplied by the wavelength equals the speed of sound in a medium, as shown in this equation:

$$\text{Frequency } (s^{-1}) \times \text{wavelength (m)} = \text{sound speed (m/s)}$$

The approximate speed of sound in sea water is 1,500 m/s and in air is 340 m/s, although speed varies depending on environmental conditions [e.g., pressure, temperature, and, in the case of sea water, salinity; see Section B.3.1, Speed of Sound].

B.1.4 Sound Amplitude

Sound amplitude is the physical attribute most closely associated with the subjective attribute loudness. Amplitude is related to the amount that the medium particles oscillate about their original positions and can be thought of as the "strength" of a sound (as the amplitude increases, the loudness also increases). As the sound wave travels, the particles of the medium oscillate but do not actually travel with the wave. The result is a mechanical disturbance (i.e., the sound wave) that propagates away from the sound source.

Sound amplitude is typically characterized by measuring the acoustic pressure or particle motion (see Section B.2, Sound Metrics).

B.1.5 Impulsive Versus Non-Impulsive Sounds

Although no standard definitions exist, sounds may be broadly categorized as impulsive or non-impulsive. Impulsive sounds have short durations, rapid rise-times, broad frequency content, and high peak sound pressures. Impulsive sounds are often produced by processes involving a rapid release of energy or mechanical impacts (Hamernik & Hsueh, 1991). Explosions, air guns, weapon firing, and impact pile driving are examples of impulsive sound sources analyzed in this document. In contrast, sonars, vessel operation, vibratory pile driving, and underwater transducers lack the characteristics of impulsive sources and are thus examples of non-impulsive sound sources. Non-impulsive sounds can be essentially continuous, such as machinery noise, or intermittent, such as sonar pings.

B.1.6 Acoustic Impedance

Acoustic impedance is a property of the propagation medium (air, water, or tissue) that can be simply described as the opposition to flow of a pressure wave. Acoustic impedance is a function of the density and speed of sound in a medium. Sound transmits more readily through materials of similar acoustic impedance, such as water and animal tissue. When sound waves encounter a medium with different acoustic impedance (for example, an air-water interface), they reflect and refract (see Sections B.3.3.3, Refraction; and B.3.3.4, Reflection and Multipath Propagation), creating more complex propagation conditions. For example, sound traveling in air (low impedance) encountering the water surface (high impedance) will be largely reflected, preventing most sound energy in the air from being transmitted into the water. The impedance difference at the tissue-air interface in animals with gas-containing organs also makes these areas susceptible to damage when exposed to the shock wave near an explosion, since the transmission from high-impedance to low-impedance can result in large motion at the boundary.

B.1.7 Duty Cycle

Duty cycle describes the portion of time that a sound source actually generates sound. It is defined as the percentage of time during which a sound is generated over a total operational time period. For example, if a sonar source produces a one-second ping once every 10 seconds, the duty cycle is 10 percent. Duty cycles vary among different acoustic sources; in general, a low duty cycle could be considered 20 percent or less and a high duty cycle 80 percent or higher.

B.1.8 Resonance

Resonance occurs when an object is vibrated at a frequency near its “natural frequency” or resonant frequency. The resonant frequency can be considered the preferred frequency at which an object will oscillate at a greater magnitude than when exposed to other frequencies. In this document, resonance is considered in relation to the size of an air bubble or air cavity in an animal that is exposed to high pressure waves and the potential for injury. The natural frequencies of dolphin and beluga lungs near the surface are about 36 Hz and 30 Hz, respectively (Finneran, 2003), the natural frequency of lungs of a large whale would be lower, while the natural frequency of small air bubbles would be much higher. Resonant frequencies would tend to increase as an animal dives, since the increased water pressure would compress an air-filled structure and reduce its size.

B.2 Sound Metrics

The sound metrics described here are used in this document to quantify exposure to a sound or explosion.

B.2.1 Pressure

Sound pressure is the incremental variation in a medium's static pressure as a sound wave travels through it. Sound pressure is typically expressed in units of pascals (Pa) (1 Pa = 1 N/m^2 = 10 µbar = 1.45×10^{-4} psi), although explosive overpressure may also be described in pounds per square inch (psi).

Various sound pressure metrics are illustrated in Figure B-1 for (a) a non-impulsive sound (a pure tone in this illustration) and (b) an impulsive sound. As shown in Figure B-1, the non-impulsive sound has a relatively gradual rise in pressure from static pressure (the ambient pressure without the added sound), while the impulsive sound has a near-instantaneous rise to a high peak pressure. The peak pressure shown on both illustrations is the maximum absolute value of the instantaneous sound pressure during a specified time interval ("zero-to-peak" or "peak"), which accounts for the values of peak pressures below the static (ambient) pressure (American National Standards Institute, 2013). "Peak-to-peak" pressure is the difference between the maximum and minimum sound pressures. The root-mean-square (rms) value is often used to describe the average sound pressure level of sounds, and sound pressure levels provided in this EIS/OEIS are root-mean-square values unless otherwise specified. As the name suggests, this method takes the square root of the average squared sound pressure values over a time interval. The duration of this time interval can have a strong effect on the measured rms sound pressure for a given sound, especially where pressure levels vary significantly, as during an impulsive sound exposure. If the analysis duration includes a significant portion of the waveform after the sound pressure has returned to zero, the rms pressure would be relatively low. If the analysis duration includes only the highest pressures of the impulsive exposure, the rms value would be comparatively high. For this reason, it is important to specify the duration used to calculate the rms pressure for impulsive sounds.

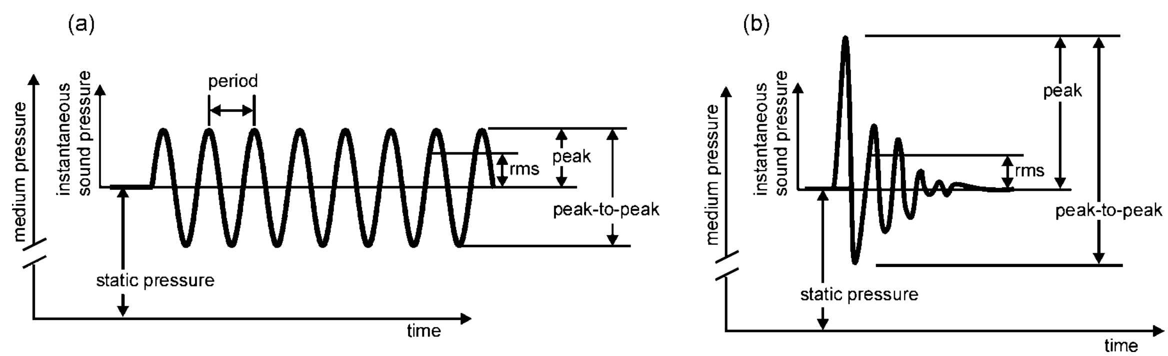


Figure B-1: Various Sound Pressure Metrics for a Hypothetical (a) Pure Tone (Non-Impulsive) and (b) Impulsive Sound

B.2.2 Sound Pressure Level

The most common sound level metric is sound pressure level (SPL). Because many animals can detect very large pressure ranges and judge the relative loudness of sounds by the ratio of the sound pressures (a logarithmic behavior), SPL is described by taking the logarithm of the ratio of the sound pressure to a reference pressure. Use of a logarithmic scale compresses the wide range of measured pressure values into a more useful scale.

Sound pressure levels are normally expressed in decibels. A decibel is 1/10 of a bel, a unit of level when the logarithm is to the base ten and the quantities concerned are proportional to power (American National Standards Institute, 2013). Sound pressure level in decibels is calculated as follows:

$$SPL = 20\log_{10}\left(\frac{P}{P_{ref}}\right)$$

where P is the sound pressure and P_{ref} is the reference pressure. Unless stated otherwise, the pressure P is the rms value of the pressure (American National Standards Institute, 2013). In some situations, SPL is calculated for the peak pressure rather than the rms pressure. On the occasions when rms pressure is not used, the pressure metric will be stated (e.g., peak SPL means an SPL calculated using the peak pressure rather than the rms pressure).

When a value is presented in decibels, it is important to also specify the value and units of the reference quantity. Normally the numeric value is given, followed by the text "re," meaning "with reference to," and the numeric value and unit of the reference quantity. For example, a pressure of 1 Pa, expressed in decibels with a reference of 1 micropascal (µPa), is written 120 dB re 1 µPa. The standard reference pressures are 1 µPa for water and 20 µPa for air. The reference pressure for air, 20 µPa, is the approximate lowest threshold of human hearing. It is important to note that because of the differences in reference units, the same sound pressures would result in different SPL values for each medium (the same sound pressure measured in water and in air would result in a higher SPL in water than in air, since the in-air reference is larger). Therefore, sound pressure levels in air and in water should never be directly compared.

B.2.3 Sound Exposure Level

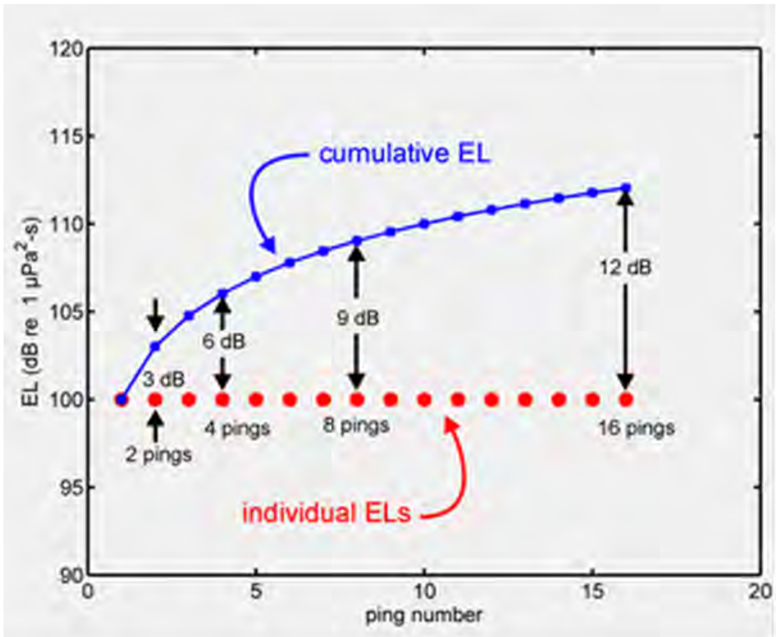
Sound exposure level (SEL) can be thought of as a composite metric that represents both the SPL of a sound and its duration. Individual time-varying noise events (e.g., a series of sonar pings or an impulsive sound) have two main characteristics: (1) a sound pressure that changes throughout the event and (2) a period of time during which the source is exposed to the sound. SEL can be provided for a single exposure (i.e., a single sonar ping or single explosive detonation) or for an entire acoustic event (i.e., multiple sonar pings or multiple explosive detonations). Cumulative SEL provides a measure of the net exposure of the entire acoustic event, but it does not directly represent the sound level heard at any given time. SEL is determined by calculating the decibel level of the cumulative sum-of-squared pressures over the duration of a sound, with units of dB re 1 micropascal squared seconds (re 1 μPa^2-s) for sounds in water and dB re (20 micropascal) squared seconds [dB re $(20\ \mu Pa)^2$-s] for sounds in air.

Some rules of thumb for SEL are as follows:

- The numeric value of SEL is equal to the SPL of a one-second sound that has the same total energy as the exposure event. If the sound duration is one second, SPL and SEL have the same numeric value (but not the same reference quantities). For example, a one-second sound with an SPL of 100 dB re 1 µPa has a SEL of 100 dB re 1 μPa^2-s.
- If the sound duration is constant but the SPL changes, SEL will change by the same number of decibels as the SPL.
- If the SPL is held constant and the duration (T) changes, SEL will change as a function of $10\log_{10}(T)$:
  - o $10\log_{10}(10) = 10$, so increasing duration by a factor of 10 raises SEL by 10 dB.

- o 10 $\log_{10}(0.1) = -10$, so decreasing duration by a factor of 10 lowers SEL by 10 dB.
- o Since 10 $\log_{10}(2) \approx 3$, so doubling the duration increases SEL by 3 dB.
- o 10 $\log_{10}(1/2) \approx -3$, so halving the duration lowers SEL by 3 dB.

Figure B-2 illustrates the summation of energy for a succession of sonar pings. In this hypothetical case, each ping has the same duration and SPL. The SEL at a particular location from each individual ping is 100 dB re 1 µPa^2-s (red circles). The upper, blue curve shows the running total or cumulative SEL.

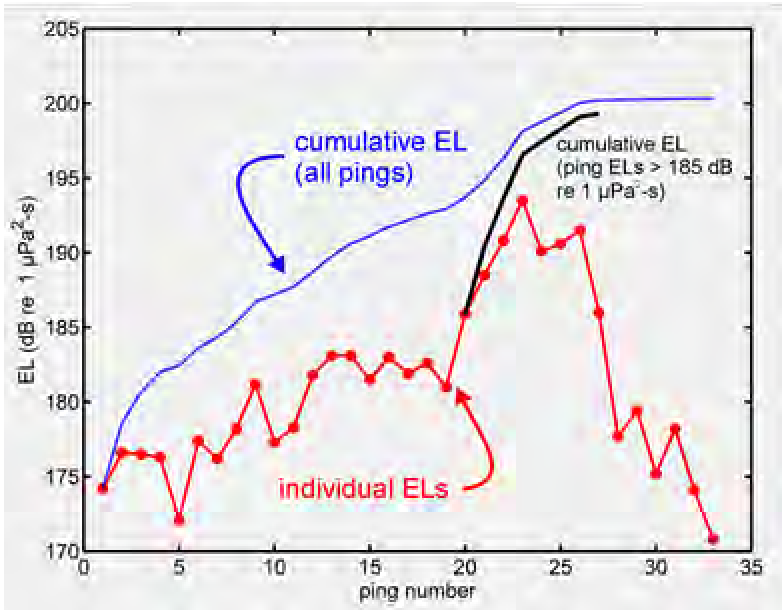


Note: EL = Exposure Level (i.e., Sound Exposure Level)

Figure B-2: Summation of Acoustic Energy from a Hypothetical, Intermittently Pinging, Stationary Sound Source

After the first ping, the cumulative SEL is 100 dB re 1 µPa^2-s. Since each ping has the same duration and SPL, receiving two pings is the same as receiving a single ping with twice the duration. The cumulative SEL from two pings is therefore 103 dB re 1 µPa^2-s. The cumulative SEL from four pings is 3 dB higher than the cumulative SEL from two pings, or 106 dB re 1 µPa^2-s. Each doubling of the number of pings increases the cumulative SEL by 3 dB.

Figure B-3 shows a more realistic example where the individual pings do not have the same SPL or SEL. These data were recorded from a stationary hydrophone as a sound source approached, passed, and moved away from the hydrophone. As the source approached the hydrophone, the received SPL from each ping increased, causing the SEL of each ping to increase. After the source passed the hydrophone, the received SPL and SEL from each ping decreased as the source moved farther away (downward trend of red line), although the cumulative SEL increased with each additional ping received (slight upward trend of blue line). The main contributions are from those pings with the highest individual SELs. Individual pings with SELs 10 dB or more below the ping with the highest level contribute little (less than 0.5 dB) to the total cumulative SEL. This is shown in Figure B-3, where only a small error is introduced by summing the energy from the eight individual pings with SEL greater than 185 dB re 1 µPa^2-s (black line), as opposed to including all pings (blue line).



Note: EL = Exposure Level (i.e., Sound Exposure Level)

Figure B-3: Cumulative Sound Exposure Level Under Realistic Conditions with a Moving, Intermittently Pinging Sound Source

B.2.4 Particle Motion

The particles of a medium (e.g., water or air) oscillate around their original position as a sound wave passes. This motion is quantified using average displacement (m or dB re 1 pm), velocity (m/s or dB re 1 nm/s^2), and acceleration (m/s^2 or dB re 1 μm/s^2) of the particles (Nedelec et al., 2016). Note that particle velocity is not the same as sound speed, which is how fast a sound wave moves through a medium. Particle motion is directional, whereas pressure measurement is not (Nedelec et al., 2016).

Far from a sound source and without any boundaries that could cause wave interference, particle velocity is directly proportional to sound pressure. Closer to a sound source, particle velocity begins to increase relative to sound pressure. Because this phenomenon is related to wavelength, it may be relevant only when very close to sound sources with extremely low frequencies.

B.2.5 Impulse

Impulse is a metric used to describe the pressure and time component of a pressure wave. Impulse is typically only considered for high energy exposures to impulsive sources, such as exposures close to explosives. Specifically, positive impulse is the time integral of the initial peak positive pressure with units of Pascal-seconds (Pa-s). Impulse is a measured quantity that is distinct from the term "impulsive," which is not a measurement term, but rather describes a type of sound (see Section B.1.5, Impulsive Versus Non-Impulsive Sounds).

B.3 Predicting How Sound Travels

While the concept of a sound wave traveling from its source to a receptor is relatively simple, sound propagation is quite complex because of the simultaneous presence of numerous sound waves of different frequencies and source levels, and other phenomena such as reflections of sound waves and subsequent constructive (additive) or destructive (cancelling) interferences between reflected and incident waves. Other factors such as refraction, diffraction, bottom types, and surface conditions also affect sound propagation. While simple examples are provided here for illustration, the Navy Acoustic Effects Model used to quantify acoustic exposures to marine mammals and sea turtles takes into account the influence of multiple factors to predict acoustic propagation [see technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018)].

B.3.1 Speed of Sound

The speed of sound is not affected by the SPL or frequency of the sound, but rather depends wholly on characteristics of the medium through which it is passing (e.g., the density and the compressibility). Sound travels faster through a medium that is harder to compress. For example, water is more difficult to compress than air, and sound travels approximately 340 m/s in air and 1,500 m/s in seawater.

The speed of sound in air is primarily influenced by temperature, relative humidity, and pressure, because these factors affect the density and compressibility of air. Generally, the speed of sound in air increases as air temperature increases.

The speed of sound in seawater also increases with increasing temperature and, to a lesser degree, with increasing hydrostatic pressure and salinity. Figure B-4 shows an example of how these attributes can change with depth. In seawater, temperature has the most important effect on sound speed for depths less than about 300 m. Below 1,500 m, the increasing hydrostatic pressure is the dominant factor because the water temperature is relatively constant. The variation of sound speed with depth in the ocean is called a sound velocity profile.

B.3.2 Source Directivity

Most sonar and other active acoustic sources do not radiate sound in all directions. Rather, they emit sounds over a limited range of angles, in order to focus sound energy on a specific area or object of interest. The specific angles are sometimes given as horizontal or vertical beam width. Some sources can be described qualitatively as “forward-looking,” when sound energy is radiated in a limited direction in front of the source, or “downward-looking,” when sound energy is directed toward the bottom.

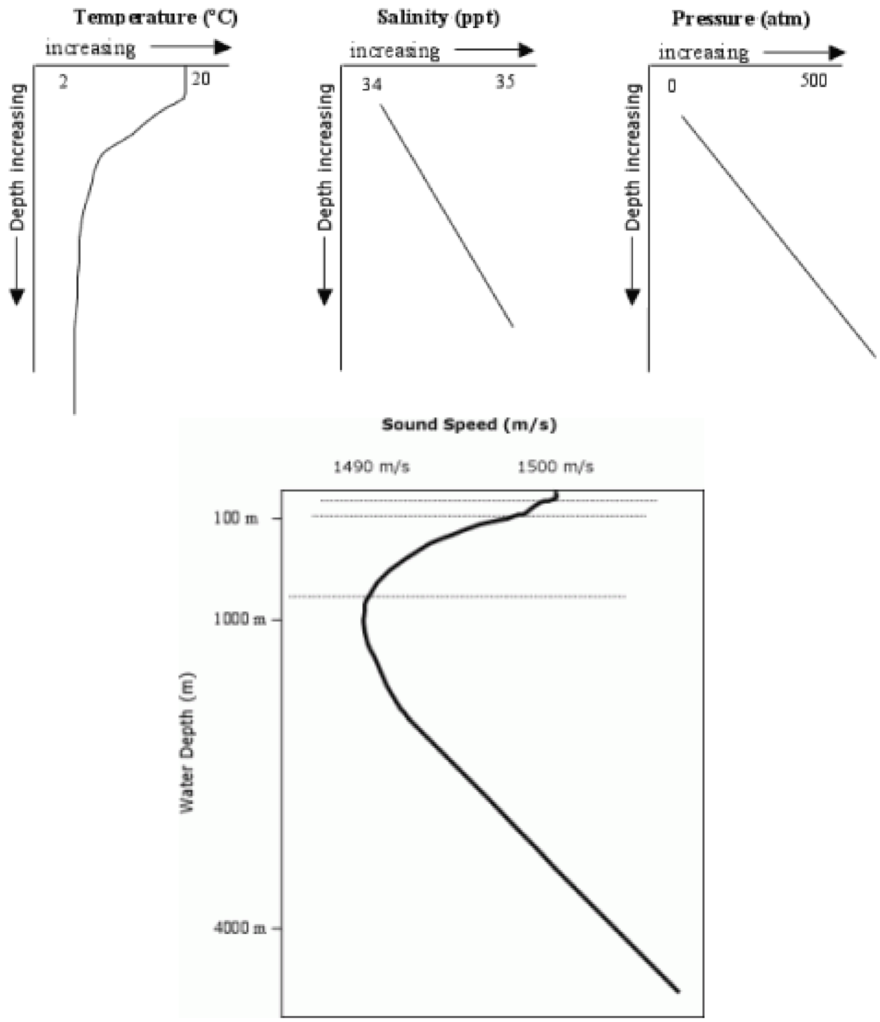
B.3.3 Transmission Loss

As a sound wave passes through a medium, the sound level decreases with distance from the sound source. This phenomenon is known as transmission loss (TL). The transmission loss is used to relate the source SPL (SL), defined as the SPL produced by a sound source at a distance of one meter, and the received SPL (RL) at a particular location, as follows:

$$RL = SL - TL$$

The main contributors to transmission loss are as follows (Urick, 1983):

- Geometric spreading of the sound wave as it propagates away from the source
- Sound absorption (conversion of sound energy into heat)
- Scattering, diffraction, multipath interference, and boundary effects



Source: Diogou (2014)

Figure B-4: Sound Velocity Profile (Sound Speed) Is Related to Temperature, Salinity, and Hydrostatic Pressure of Seawater

B.3.3.1 Geometrical Spreading Loss

Spreading loss is a geometric effect representing regular weakening of a sound wave as it spreads out from a source. Spreading describes the reduction in sound pressure caused by the increase in surface area as the distance from a sound source increases. Spherical and cylindrical spreading are common types of spreading loss.

In the simple case of sound propagating from a point source without obstruction or reflection, the sound waves take on the shape of an expanding sphere. An example of spherical spreading loss is shown in Figure B-5. As spherical propagation continues, the sound energy is distributed over an ever-larger area following the inverse square law: the pressure of a sound wave decreases inversely with the square of the distance between the source and the receptor. For example, doubling the distance between the receptor and a sound source results in a reduction in the pressure of the sound to one-fourth of its initial value; tripling the distance results in one-ninth of the original pressure, and so on. Since the surface area of a sphere is $4\pi r^2$, where r is the sphere radius, the change in SPL with distance r from the source is proportional to the radius squared. This relationship is known as the spherical spreading law. The transmission loss for spherical spreading between two locations is:

$$TL = 20 \log_{10} (r_2/r_1)$$

where r_1 and r_2 are distances from the source. Spherical spreading results in a 6 dB reduction in SPL for each doubling of distance from the sound source. For example, calculated transmission loss for spherical spreading is 40 dB at 100 m and 46 dB at 200 m.

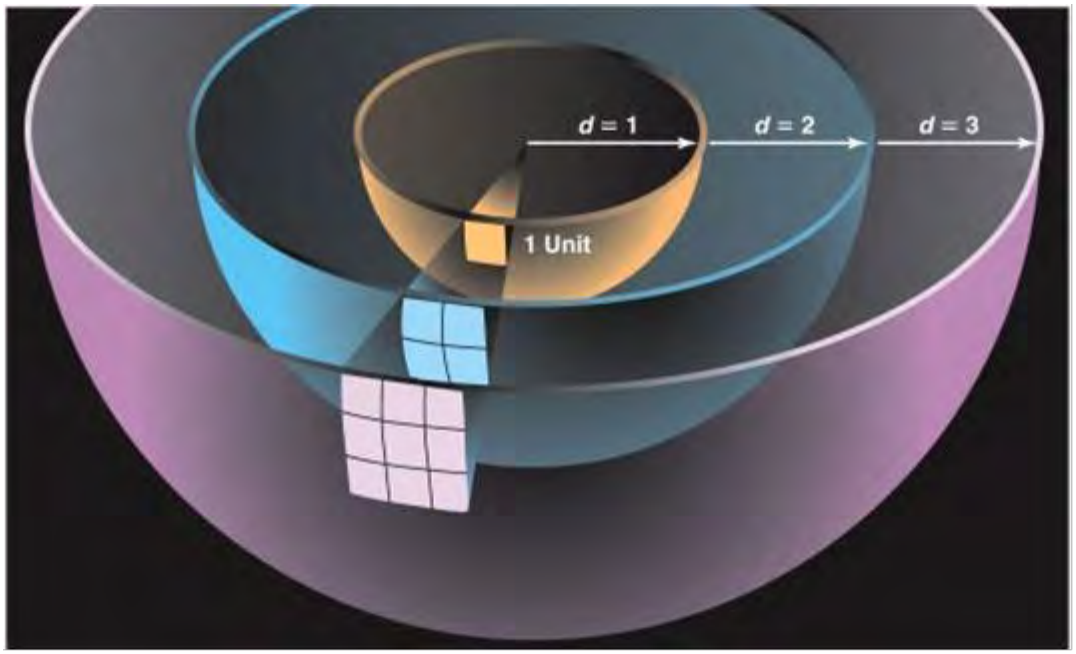


Figure B-5: Graphical Representation of the Inverse Square Relationship in Spherical Spreading

In cylindrical spreading, spherical waves expanding from the source are constrained by the water surface and the seafloor and take on a cylindrical shape. In this case the sound wave expands in the shape of a cylinder rather than a sphere, and the transmission loss is:

$$TL = 10\log_{10}(r_2/r_1)$$

Cylindrical spreading is an approximation of sound propagation in a water-filled channel with horizontal dimensions much larger than the depth. Cylindrical spreading predicts a 3 dB reduction in SPL for each doubling of distance from the source. For example, calculated transmission loss for cylindrical spreading is 30 dB at 1,000 m and 33 dB at 2,000 m.

The cylindrical and spherical spreading equations above represent two simple hypothetical cases. In reality, geometric spreading loss is more spherical near a source and more cylindrical with distance, and is better predicted using more complex models that account for environmental variables, such as the Navy Acoustic Effects Model [see technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018)].

However, when conducting simple spreading loss calculations in near shore environments, “practical spreading loss” can be applied, where:

$$TL = 15\log_{10}(r_2/r_1)$$

Practical spreading loss accounts for other realistic losses in the environment, such as absorption and scattering, which are not accounted for in geometrical spreading.

B.3.3.2 Absorption

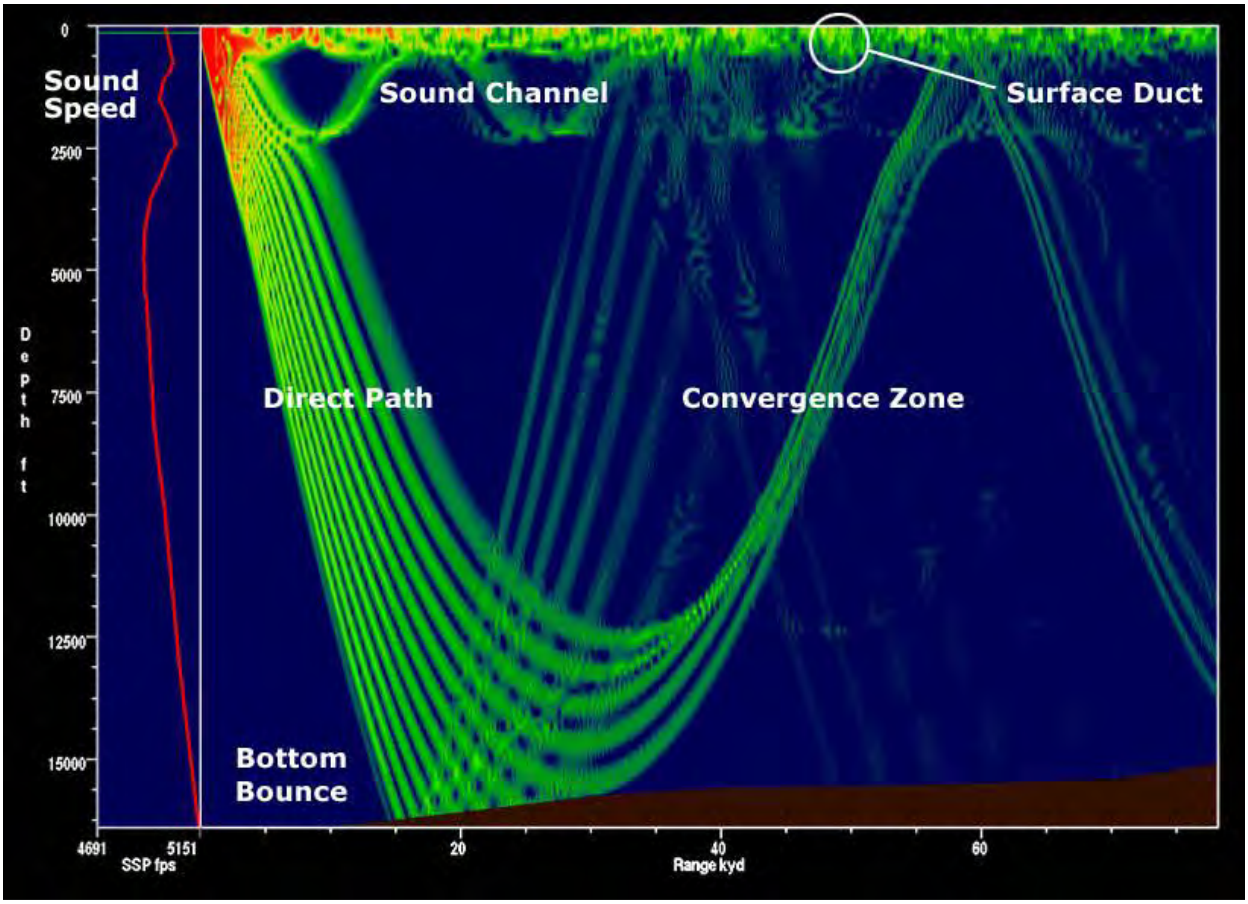
Absorption is the conversion of acoustic energy to kinetic energy in the particles of the propagation medium (Urick, 1983). Absorption is directly related to sound frequency, with higher frequencies having higher rates of absorption. Absorption rates range from 0.07 dB/km for a 1 kHz sound to about 30 dB/km for a 100 kHz sound. Therefore, absorption is the cause of a significant amount of attenuation for high and very high frequency sound sources, reducing the distance over which these sources may be perceived compared to mid- and low-frequency sound sources with the same source level.

B.3.3.3 Refraction

When a sound wave propagating in a medium encounters a second medium with a different density (e.g., the air-water boundary), part of the incident sound will be reflected back into the first medium and part will be transmitted into the second medium (Kinsler et al., 1982). The propagation direction will change as the sound wave enters the second medium; this phenomenon is called refraction. Refraction may also occur within a single medium if the properties of the medium change enough to cause a variation in the sound speed. Refraction of sound resulting from spatial variations in the sound speed is one of the most important phenomena that affect sound propagation in water (Urick, 1983).

As discussed in Section B.3.1 (Speed of Sound), the sound speed in the ocean primarily depends on hydrostatic pressure (i.e., depth) and temperature. Although the actual variations in sound speed are small, the existence of sound speed gradients in the ocean has an enormous effect on the propagation of sound in the ocean. If one pictures sound as rays emanating from an underwater source, the propagation of these rays changes as a function of the sound speed profile in the water column. Specifically, the directions of the rays bend toward regions of slower sound speed. This phenomenon creates ducts in which sound becomes “trapped,” allowing it to propagate with high efficiency for large distances within certain depth boundaries. During winter months, the reduced sound speed at the surface due to cooling can create a surface duct that efficiently propagates sound such as commercial shipping noise (Figure B-6). Sources located within this surface duct can have their sounds trapped, but sources located below this layer would have their sounds refracted downward. The deep sound channel, or sound frequency and ranging (SOFAR) channel, is another duct that exists where sound speeds are slowest deeper in the water column (600–1,200 m depth at the mid-latitudes).

Similarly, the path of sound will bend toward regions of lower sound speed in air. Air temperature typically decreases with altitude, meaning sounds produced in air tend to bend skyward. When an atmospheric temperature inversion is present, air is cooler near the earth’s surface. In inversion conditions, sound waves near the earth’s surface will tend to refract downward.



Note: 1 kiloyard (kyd) = 0.9 km

Figure B-6: Sound Propagation Showing Multipath Propagation and Conditions for Surface Duct

B.3.3.4 Reflection and Multipath Propagation

In multipath propagation, sound may not only travel a direct path (with no reflection) from a source to a receiver, but also be reflected from the surface or bottom multiple times before reaching the receiver (Urick, 1983). Reflection is shown in Figure B-6 at the seafloor (bottom bounce) and at the water surface. At some distances, the reflected wave will be in phase with the direct wave (their waveforms add together) and at other distances the two waves will be out of phase (their waveforms cancel). The existence of multiple sound paths, or rays, arriving at a single point can result in multipath interference, a condition that permits the addition and cancellation between sound waves, resulting in the fluctuation of sound levels over short distances.

Reflection plays an important role in the pressures observed at different locations in the water column. Near the bottom, the direct path pressure wave may sum with the bottom-reflected pressure wave, increasing the exposure. Near the surface, however, the surface-reflected pressure wave may destructively interfere with the direct path pressure wave, "cutting off" the wave and reducing exposure (called the Lloyd mirror effect). This can cause the sound level to decrease dramatically within the top few meters of the water column.

B.3.3.5 Diffraction, Scattering, and Reverberation

Diffraction, scattering, and reverberation are examples of what happens when sound waves interact with obstacles in the propagation path.

Diffraction may be thought of as the change of direction of a sound wave as it passes around an obstacle. Diffraction depends on the size of the obstacle and the sound frequency. The wavelength of the sound must be larger than the obstacle for notable diffraction to occur. If the obstacle is larger than the wavelength of sound, an acoustic shadow zone will exist behind the obstacle where the sound is unlikely to be detected. Common examples of diffraction include sound heard from a source around the corner of a building and sound propagating through a small gap in an otherwise closed door or window.

An obstacle or inhomogeneity (e.g., smoke, suspended particles, gas bubbles due to waves, and marine life) in the path of a sound wave causes scattering as these inhomogeneities reradiate incident sound in a variety of directions (Urick, 1983). Reverberation refers to the prolongation of a sound, after the source has stopped emitting, caused by multiple reflections at water boundaries (surface and bottom) and scattering.

B.3.3.6 Surface and Bottom Effects

Because the sea surface reflects and scatters sound, it has a major effect on the propagation of underwater sound in applications where either the source or receiver is at a shallow depth (Urick, 1983). If the sea surface is smooth, the reflected sound pressure is nearly equal to the incident sound pressure; however, if the sea surface is rough, the amplitude of the reflected sound wave will be reduced. Sound waves reflected from the sea surface experience a phase reversal. When the surface-reflected waves interact with the direct path waves near the surface, a destructive interference pattern is created in which the received pressure approaches zero.

The sea bottom is also a reflecting and scattering surface, similar to the sea surface. Sound interaction with the sea bottom is more complex, however, primarily because the acoustic properties of the sea bottom are more variable and the bottom is often layered into regions of differing density. As sound travels into the seafloor it reflects off of these different density layers in complex ways. For sources in contact with the bottom, such as during pile driving or bottom-placed explosives, a ground wave is produced that travels through the bottom sediment and may refract back into the water column.

For a hard bottom such as rock, the reflected wave will be approximately in phase with the incident wave. Thus, near the ocean bottom, the incident and reflected sound pressures may add together (constructive interference), resulting in an increased sound pressure near the sea bottom. Soft bottoms such as mud or sediment absorb sound waves and reduce the level in the water column overall.

B.3.3.7 Air-Water Interface

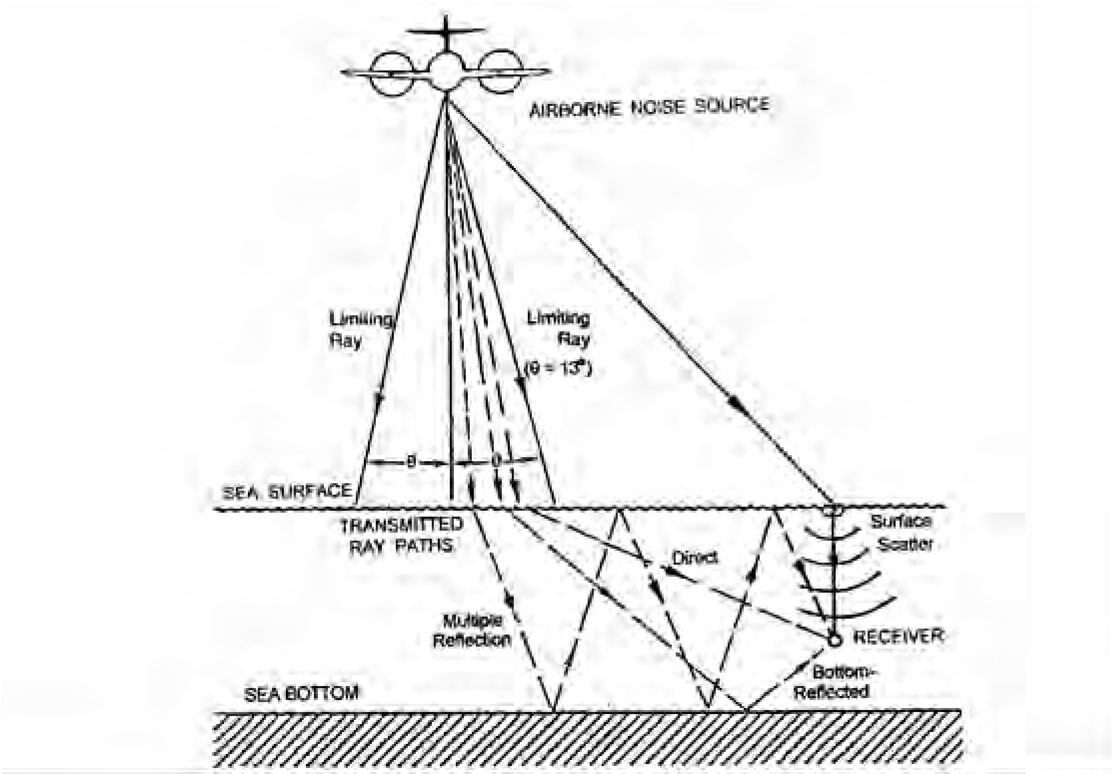
Sound from aerial sources such as aircraft and weapons firing may be transmitted into the water under certain conditions. The most studied of these sources are fixed-wing aircraft and helicopters, which create noise with most energy below 500 Hz. Noise levels in water are highest at the surface and are highly dependent on the altitude of the aircraft and the angle at which the aerial sound encounters the ocean surface. Transmission of the sound once it is in the water is identical to any other sound as described in the sections above.

Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors and has been addressed by Young (1973), Urick (1983), Richardson et al. (1995), Eller and Cavanagh (2000), Laney and Cavanagh (2000), and others. Sound is transmitted from an airborne source to a receptor underwater by four principal means: (1) a direct path, refracted upon passing through the air-water interface; (2) direct-refracted paths reflected from the bottom in shallow water; (3) evanescent transmission in which sound travels laterally close to the water surface; and (4) scattering from interface roughness due to wave motion.

When sound waves in air meet the water surface, the sound can either be transmitted across the air-water boundary or reflected off the water surface. When sound waves meet the water at a perpendicular angle (e.g., straight down from an in-air source to a flat water surface), the sound waves are both transmitted directly across the water surface in the same direction of travel and reflected 180° back toward the original direction of travel. This can create a localized condition at the water surface where the incident and reflected waves sum, doubling the in-air overpressure (+ 6 dB). As the incident angle of the in-air sound wave changes from perpendicular, this phenomenon is reduced, ultimately reaching the angle where sound waves are parallel to the water surface and there is no surface reflection.

The sound that enters the water is refracted due to the difference in sound velocity between air and water, as shown in Figure B-7. As the angle of the in-air incident wave moves away from perpendicular, the direction of travel of the underwater refracted waves becomes closer to parallel to the water surface. When the incident angle is reached where the underwater refracted sound wave is parallel to the water surface, all of the sound is reflected back into the air and no sound enters the water. This occurs at an angle of about 13-14°. As a result, most of the acoustic energy transmitted into the water through a relatively narrow cone extending vertically downward from the in-air source. The width of the footprint would be a function of the source altitude. Lesser amounts of sound may enter the water outside of this cone due to surface scattering (e.g., from water surface waves that can vary the angle of incidence over an area) and as evanescent waves that are only present very near the surface.

If a sound wave is ideally transmitted into water (that is, with no surface transmission loss, such as due to foamy, wave conditions that could decrease sound entering the water), the sound pressure level underwater is calculated by changing the pressure reference unit from 20 μPa in air to 1 μPa in water. For a sound with the same pressure in air and water, this calculation results in a +26 dB sound pressure level in water compared to air. For this reason, sound pressure levels in water and sound pressure levels in air should never be directly compared.



Source: Richardson et al. 1995

Figure B-7: Characteristics of Sound Transmission Through the Air-Water Interface

B.4 Auditory Perception

Animals with an eardrum or similar structure, including mammals, birds, and reptiles, directly detect the pressure component of sound. Some marine fish also have specializations to detect pressure changes, although most invertebrates and many marine fish do not have anatomical structures that enable them to detect the pressure component of sound and are only sensitive to the particle motion component of sound. This difference in acoustic energy sensing mechanisms limits the range at which these animals can detect most sound sources analyzed in this document. This is because far from a sound source (i.e., in the far field), particle velocity and sound pressure are directly proportional. But close to a source (i.e., in the near field), particle velocity increases relative to sound pressure and may become more detectable to certain animals. As sound frequency increases, the wavelength becomes shorter, resulting in a smaller near field.

Because mammalian ears can detect large pressure ranges and humans judge the relative loudness of sounds by the ratio of the sound pressures (a logarithmic behavior), sound amplitude is described by the SPL, calculated by taking the logarithm of the ratio of the sound pressure to a reference pressure (see Section B.2.2, Sound Pressure Level). Use of a logarithmic scale compresses the wide range of pressure values into a more usable numerical scale. On the decibel scale, the smallest audible sound in air (near total silence) to a human is 0 dB re 20 µPa. If the sound intensity increases by a factor of 10, the SPL would increase to 10 dB re 20 µPa. If the sound intensity increases by a factor of 100, the SPL would increase to 20 dB re 20 µPa, and if the sound intensity increases by a factor of 1000, the SPL would be 30 dB re 20 µPa. A quiet conversation has an SPL of about 50 dB re 20 µPa, while the threshold of pain is around 120–140 dB re 20 µPa.

As described in Section B.2.2 (Sound Pressure Level), SPLs under water differ from those in air because they rely on different reference pressures in their calculation; therefore, the two should never be directly compared.

While sound pressure and frequency are physical measures of the sound, loudness is a subjective attribute that varies with not only sound pressure but also other attributes of the sound, such as frequency. For example, a human listener would perceive a 60 dB re 20 µPa sound at 2 kHz to be louder than a 60 dB re 20 µPa sound at 50 Hz, even though the SPLs are identical. This effect is most noticeable at lower sound pressure levels; however, at very high sound pressure levels, the difference in perceived loudness at different frequencies becomes smaller.

To account for differences in hearing sensitivity at various frequencies, acoustic risk analyses commonly use auditory weighting functions—mathematical functions that adjust (or "weight") received sound levels across sound frequency based on how the listener's sensitivity or susceptibility to sound changes at different frequencies. For humans, the most common weighting function is called "A-weighting" (see Figure B-8). A-weighted sound levels are specified in units of "dBA" (A-weighted decibels). For example, if the unweighted received level of a 500 Hz tone at a human receiver was 90 dB re 20 µPa, the A-weighted sound level would be 90 dB – 3 dB = 87 dBA because the A-weighting function amplitude at 500 Hz is -3 dB. Many measurements of sound in air appear as A-weighted decibels in the literature because the intent of the authors is to assess noise impacts on humans.

The auditory weighting concept can be applied to other species. When used in analyzing the impacts of sound on an animal, auditory weighting functions adjust received sound levels to emphasize ranges of best hearing and de-emphasize ranges of less or no sensitivity. Auditory weighting functions were developed for marine mammals and sea turtles and are used to assess acoustic impacts. For more information on weighting functions and their derivation for this analysis see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis* (U.S. Department of the Navy, 2017).

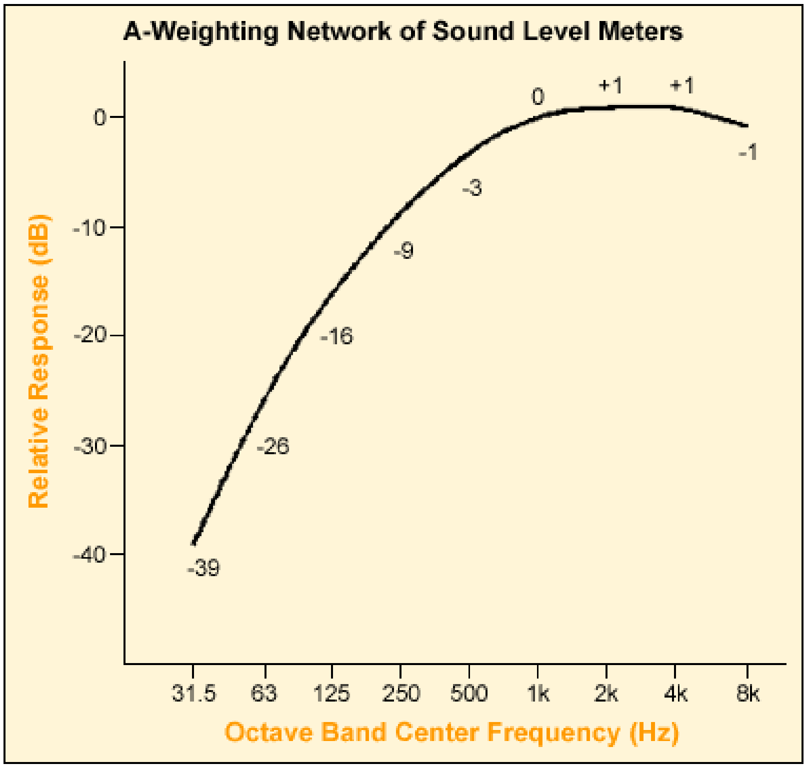


Figure B-8: A-weighting for Human Hearing of Sounds in Air (OSHA). The Numbers Along the Curve Indicate How a Received Sound Level Would Be Adjusted at that Frequency

B.5 Explosives

Explosive materials used in Navy testing and training activities are either (1) "high explosives," sometimes referred to as HE, which means that the explosive material has a very fast rate of detonation (exceeding the speed of sound), or (2) low explosives, which exhibit a relatively slow burn, or deflagration, such as black powder. Because low explosives are typically used in small quantities and have less destructive power, the below discussion focuses on high explosives.

This rate of detonation of a high explosive is highly supersonic, producing a high pressure, steep instantaneous shock wave front travelling through the explosive material. This shock front is produced by the supersonic expansion of the explosive products, but as the shock front travels away from the immediate area of the detonation, it begins to behave as an acoustic wave front travelling at the speed of sound.

The near-instantaneous rise from ambient to an extremely high peak pressure is what makes the explosive shock wave potentially damaging. The area under this positive pressure duration is calculated as the positive impulse.

The positive pressure produced by an explosion is also referred to as the overpressure. As the shock front passes a location, the positive pressure exponentially decays, as shown in Figure B-9. As the shock front travels away from the detonation, the waveform is stretched—the peak pressure decreases while the positive duration increases. The reduction in peak pressure reduces the rate at which the positive impulse is received. Both the reduction in peak pressure and stretching of the positive impulse reduce the potential for injury. In addition, absorption losses of higher frequencies over distance results in a softening of the shock front, such that the rise to peak pressure is no longer near-instantaneous.

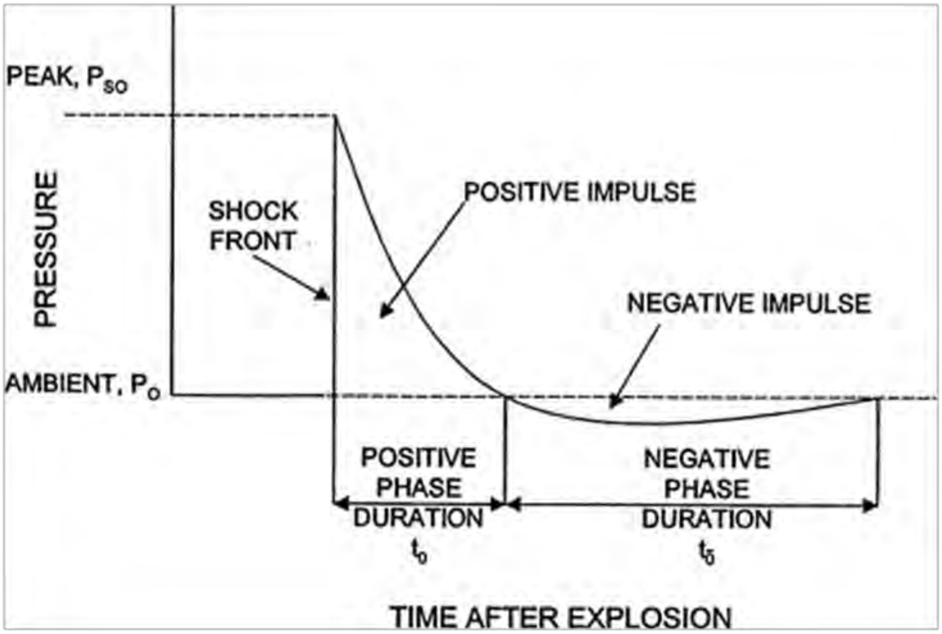


Figure B-9: Impulse Shown as a Function of Pressure over Duration at a Specific Location

The peak pressure experienced by a receptor (i.e., an animal) is a function of the explosive material, the net explosive weight, and the distance from the charge. Net explosive weight (NEW) is a way to classify and compare quantities of different explosive compounds. The net explosive weight for a charge is the energetic equivalent weight of trinitrotoluene (TNT). In general, shock wave effects near an explosive charge increase in proportion to the cube root of the explosive weight (Young, 1991). For example, shock wave impacts will double when the explosive charge weight is increased by a factor of eight (i.e., cube root of eight equals two). This relationship is known as the similarity principle, and the corresponding similitude equations allow for prediction of various explosive metrics for a given charge weight and material.

The similitude equations allow for a simple prediction of peak pressure in a uniform free field environment, and sources are provided below for using these equations for estimating explosive effects in air and in water. However, at longer distances or in more complex environments with boundaries and variations in the propagation medium, explosive propagation modeling is preferred.

B.5.1 Explosions in Air

Explosions in air produce an initial blast front that propagates away from the detonation. When pressure waves from an explosion in air meet the water surface, the pressure wave can be transmitted across the air-water boundary and reflected off the water surface. When pressure waves in air meet the water at a perpendicular angle (e.g., straight down from an in-air source to a flat water surface), the sound waves are both transmitted directly across the water surface in the same direction of travel and reflected 180° back toward the original direction of travel. For acoustic waves, this can create a localized condition at the water surface where the incident and reflected waves sum, doubling the in-air overpressure (+ 6 dB). For shock waves with high incident pressures travelling at supersonic speeds, the reflection from the water surface depends on the angle of incidence and the speed of the shock wave, and the reflected shock wave pressure can be greater than the incident shock wave pressure (Kinney & Graham, 1985; U.S. Department of the Navy, 1975).

In certain explosive geometries, depending on the size of the explosive and its height of detonation, a combined shock wave, called a Mach stem, can be created by the summing of the direct and reflected shock waves at larger angles of incidence (Kinney & Graham, 1985). In instances where this specific geometry does not occur, only the direct path wave is experienced because there is no surface reflection (waves are parallel to or angled away from the water surface, such as would occur when an explosive is detonated at the water surface), or separate direct and reflected pressure waves may be experienced.

B.5.1.1 Fragmentation

Missiles, rockets, projectiles, and other cased weapons will produce casing fragments upon detonation. These fragments may be of variable size and are ejected at supersonic speed from the detonation. The casing fragments will be ejected at velocities much greater than debris from any target due to the proximity of the casing to the explosive material. Unlike detonations on land targets, detonations during Navy training and testing would not result in other propelled materials such as crater debris.

Fragment density can be simply assumed to follow an inverse-square law with distance, in which the possibility of fragment strike is reduced by the square of the distance from the original detonation point. The forces of gravity and drag will further reduce the likelihood of strike with increasing distance than is accounted for in the inverse-square relationship (Zaker, 1975). The possible area of strike risk at any given distance from the detonation point is limited to the surface area of produced fragments, with drag and gravity reducing the number of produced fragments that travel to greater distances.

B.5.2 Explosions in Water

At the instant of explosion underwater, gas byproducts are generated at high pressure and temperature, creating a bubble. The heat causes a certain amount of water to vaporize, adding to the volume of the bubble. This action immediately begins to force the water in contact with the blast front in an outward direction, creating an intense, supersonic pressure shock wave. As the high-pressure wave travels away from the source, it slows to the speed of sound and acts like an acoustic wave similar to other impulsive sources that lack a strong shock wave (e.g., air guns). Explosions have the greatest amount of energy in lower frequencies below 500 Hz, although energy is present in frequencies exceeding 10 kHz (Urick, 1983). The higher frequency components exhibit more attenuation with distance due to absorption (see Section B.3.3.2, Absorption).

The shock wave caused by an explosion in deeper water may be followed by several bubble pulses in which the explosive byproduct gases expand and contract, with correlated high and low pressure oscillations. These bubble pulses lack the steep pressure front of the initial explosive pulse, but the first bubble pulse may still contribute to the total energy released at frequencies below 100 Hz (Urick, 1983). Subsequent bubble pulses contribute little to the total energy released during the explosion (Urick, 1983). If the detonation occurs at or just below the surface, a portion of the explosive power is released into the air and a pulsating gas bubble is not formed.

The pressure waves from an explosive can constructively add or destructively cancel each other in ocean environments with multi-path propagation, as described for acoustic waves in Section B.3.3.3 (Refraction) and Section B.3.3.4 (Reflection and Multipath Propagation). The received impulse is affected by the depth of the charge and the depth of the receiving animal. Pressure waves from the detonation may travel directly to the receiver or be reflected off the water surface before arriving at the receiver. If a charge is detonated closer to the surface or if an animal is closer to the surface, the time between the initial direct path arrival and the following surface-reflected tension wave arrival is reduced, resulting in a steep negative pressure cut-off of the initial direct path positive impulse exposure. Two animals at similar distances from a charge, therefore, may experience the same peak pressure but different levels of impulse at different depths.

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Appendix C Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training Activities

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Appendix C Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training Activities

Navy training activities would result in the incidental takes of marine mammals and sea turtles within the Study Area. The following appendix provides the estimated number of marine mammal and sea turtle impacts. Specifically, estimated impacts are derived from the quantitative analysis for activities under Alternative 1 that involve the use of acoustic or explosive stressors. The quantitative analysis takes into account Navy activities, marine species density layers, acoustic modeling, and other environmental parameters. A detailed explanation of the quantitative analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018). It is important to note that *impacts*, as discussed in this appendix, represent the estimated instances of take of marine mammals or sea turtles, not necessarily the number of individuals impacted (i.e., some marine mammals or sea turtles could be impacted several times, while others would not experience any impact).

The tables below represent the maximum estimated impacts under Alternative 1 for any given year. In addition, estimated impacts are provided over the duration of the Marine Mammal Protection Act (MMPA) Regulations and Letters of Authorization, which would be valid for a seven-year period. The No Action Alternative would not result in any impacts because the Proposed Action would not occur.

C.1 Estimated Marine Mammal Impacts from Sonar and Other Transducers Under Navy Training Activities

Table C-1 provides a summary of the estimated number of marine mammal impacts by species stock from exposure to sonar and other transducers used during Navy training activities under Alternative 1 over the course of a year (annual maximum usage) and seven years.

Table C-1: Estimated Marine Mammals Impacts from Sonar Training Activities

Species	Stock	*Alternative 1 – Annual*			*Alternative 1 – 7 Year*		
		Behavioral Response	*TTS*	*PTS*	*Behavioral Response*	*TTS*	*PTS*
Order Cetacea							
Suborder Mysticeti (baleen whales)							
Family Balaenopteridae (rorquals)							
Blue whale*	Central North Pacific	0	3	0	0	21	0
	Eastern North Pacific	3	32	0	21	224	0
Fin whale*	Northeast Pacific	104	1,125	0	728	7,875	0
Humpback whale	California, Oregon, & Washington†	1	8	0	7	56	0
	Central North Pacific	4	66	0	28	462	0
	Western North Pacific†	0	0	0	0	0	0
Minke whale	Alaska	4	44	0	28	308	0
North Pacific right whale*	Eastern North Pacific	0	2	0	0	14	0
Sei whale*	Eastern North Pacific	2	34	0	14	238	0
Family Eschrichtiidae (gray whale)							
Gray whale	Eastern North Pacific	0	0	0	0	0	0
	Western North Pacific†	0	0	0	0	0	0

Table C-1: Estimated Marine Mammals Impacts from Sonar Training Activities (continued)

Species	Stock	Alternative 1 – Annual			Alternative 1 – 7 Year		
		Behavioral Response	TTS	PTS	Behavioral Response	TTS	PTS
Suborder Odontoceti (toothed whales)							
Family Delphinidae (dolphins)							
Killer whale	Alaska Resident	0	0	0	0	0	0
	AT1 Transient	0	0	0	0	0	0
	Eastern Pacific, Offshore	64	17	0	448	119	0
	Gulf of Alaska, Aleutian Island, & Bering Sea Transient	119	24	0	833	168	0
Pacific white-sided dolphin	North Pacific	1,102	472	0	7,714	3,304	0
Family Phocoenidae (porpoises)							
Dall's porpoise	Alaska	310	8,710	19	2,170	60,970	133
Harbor porpoise	Gulf of Alaska	0	0	0	0	0	0
	Southeast Alaska	0	0	0	0	0	0
Family Physeteridae (sperm whale)							
Sperm whale*	North Pacific	107	5	0	749	35	0
Family Ziphiidae (beaked whales)							
Baird's beaked whale	Alaska	106	0	0	742	0	0
Cuvier's beaked whale	Alaska	429	3	0	3,003	21	0
Stejneger's beaked whale	Alaska	467	15	0	3,269	105	0

Table C-1: Estimated Marine Mammals Impacts from Sonar Training Activities (continued)

Species	Stock	Alternative 1 – Annual			Alternative 1 – 7 Year		
		Behavioral Response	TTS	PTS	Behavioral Response	TTS	PTS
Suborder Pinnipedia							
Family Otariidae (sea lions and fur seals)							
California sea lion	U.S. Stock	0	0	0	0	0	0
Steller sea lion	Eastern U.S.	0	0	0	0	0	0
	Western U.S.[†]	0	0	0	0	0	0
Northern fur seal	Eastern Pacific	2,836	25	0	19,854	181	0
	California	58	1	0	405	4	0
Family Phocidae (true seals)							
Harbor seal	Cook Inlet / Shelikof Strait	0	0	0	0	0	0
	North Kodiak	0	0	0	0	0	0
	Prince William Sound	0	0	0	0	0	0
	South Kodiak	0	0	0	0	0	0
Northern elephant seal	California	898	1,634	0	6,286	11,438	0
Ribbon seal	Alaska	0	0	0	0	0	0

*ESA-listed species (all stocks) within the TMAA. [†]Only designated stocks are ESA-listed.
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

C.2 Estimated Marine Mammal Impacts from Explosives Under Navy Training Activities

Table C-2 provides a summary of the estimated number of marine mammal impacts from exposure to explosives used during Navy training activities under Alternative 1 over the course of a year (annual maximum usage) and seven years.

Table C-2: Estimated Marine Mammals Impacts from Explosive Training Activities

Species	Stock	Alternative 1 – Annual				Alternative 1 – 7 Year			
		Behavioral Response	TTS	PTS	Injury	Behavioral Response	TTS	PTS	Injury
Order Cetacea									
Suborder Mysticeti (baleen whales)									
Family Balaenopteridae (rorquals)									
Blue whale*	Central North Pacific	0	0	0	0	0	0	0	0
	Eastern North Pacific	1	0	0	0	7	0	0	0
Fin whale*	Northeast Pacific	11	2	2	0	77	14	14	0
Humpback whale	California, Oregon, & Washington†	1	0	0	0	7	0	0	0
	Central North Pacific	7	2	0	0	49	14	0	0
	Western North Pacific†	0	0	0	0	0	0	0	0
Minke whale	Alaska	2	0	0	0	14	0	0	0
North Pacific right whale*	Eastern North Pacific	1	0	0	0	7	0	0	0
Sei whale*	Eastern North Pacific	1	0	0	0	7	0	0	0
Family Eschrichtiidae (gray whale)									
Gray whale	Eastern North Pacific	0	0	0	0	0	0	0	0
	Western North Pacific†	0	0	0	0	0	0	0	0

Table C-2: Estimated Marine Mammals Impacts from Explosive Training Activities (continued)

Species	Stock	*Alternative 1 – Annual*				*Alternative 1 – 7 Year*			
		Behavioral Response	*TTS*	*PTS*	*Injury*	*Behavioral Response*	*TTS*	*PTS*	*Injury*
Suborder Odontoceti (toothed whales)									
Family Delphinidae (dolphins)									
Killer whale	Alaska Resident	0	0	0	0	0	0	0	0
	AT1 Transient	0	0	0	0	0	0	0	0
	Eastern Pacific, Offshore	0	0	0	0	0	0	0	0
	Gulf of Alaska, Aleutian Island, & Bering Sea Transient	0	0	0	0	0	0	0	0
Pacific white-sided dolphin	North Pacific	0	0	0	0	0	0	0	0
Family Phocoenidae (porpoises)									
Dall's porpoise	Alaska	38	229	45	0	266	1,603	315	0
Harbor porpoise	Gulf of Alaska	0	0	0	0	0	0	0	0
	Southeast Alaska	0	0	0	0	0	0	0	0
Family Physeteridae (sperm whale)									
Sperm whale*	North Pacific	0	0	0	0	0	0	0	0
Family Ziphiidae (beaked whales)									
Baird's beaked whale	Alaska	0	0	0	0	0	0	0	0
Cuvier's beaked whale	Alaska	1	0	0	0	7	0	0	0
Stejneger's beaked whale	Alaska	0	0	0	0	0	0	0	0

Table C-2: Estimated Marine Mammals Impacts from Explosive Training Activities (continued)

Species	Stock	Alternative 1 – Annual				Alternative 1 – 7 Year			
		Behavioral Response	TTS	PTS	Injury	Behavioral Response	TTS	PTS	Injury
Suborder Pinnipedia									
Family Otariidae (sea lions and fur seals)									
California sea lion	U.S. Stock	0	0	0	0	0	0	0	0
Steller sea lion	Eastern U.S.	0	0	0	0	0	0	0	0
	Western U.S. †	0	0	0	0	0	0	0	0
Northern fur seal	Eastern Pacific	0	0	0	0	0	0	0	0
	California	0	0	0	0	0	0	0	0
Family Phocidae (true seals)									
Harbor seal	Cook Inlet / Shelikof Strait	0	0	0	0	0	0	0	0
	North Kodiak	0	0	0	0	0	0	0	0
	Prince William Sound	0	0	0	0	0	0	0	0
	South Kodiak	0	0	0	0	0	0	0	0
Northern elephant seal	California	6	9	8	0	42	63	56	0
Ribbon seal	Alaska	0	0	0	0	0	0	0	0

*ESA-listed species (all stocks) within the TMAA. †Only designated stocks are ESA-listed.
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

C.3 Estimated Sea Turtle Impacts from Sonar and Other Transducers Under Navy Training Activities

Based on the quantitative analysis, no sea turtle impacts are anticipated from exposure to sonar and other transducers used during Navy training activities under Alternative 1 over the course of a year (annual maximum usage) or seven years.

C.4 Estimated Sea Turtle Impacts from Explosives Under Navy Training Activities

Based on the quantitative analysis, no sea turtle impacts are anticipated from exposure to explosives used during Navy training activities under Alternative 1 over the course of a year (annual maximum usage) or seven years.

REFERENCES

U.S. Department of the Navy. (2018). *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Technical Report prepared by NUWC Division Newport, Space and Naval Warfare Systems Center Pacific, G2 Software Systems, and the National Marine Mammal Foundation). Newport, RI: Naval Undersea Warfare Center.

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Appendix D Federal Register Notices

This appendix contains the following Federal Register Notice:

- Notice of Intent to Prepare a Supplement to the Gulf of Alaska Navy Training Activities Environmental Impact Statement/Overseas Environmental Impact Statement

7538 Federal Register / Vol. 85, No. 27 / Monday, February 10, 2020 / Notices

DEPARTMENT OF DEFENSE

Department of the Navy

Notice of Intent To Prepare a Supplement to the Gulf of Alaska Navy Training Activities Environmental Impact Statement/Overseas Environmental Impact Statement

AGENCY: Department of the Navy, DoD.

ACTION: Notice.

SUMMARY: Pursuant to the National Environmental Policy Act (NEPA) of 1969 and regulations implemented by the Council on Environmental Quality, the Department of the Navy (DON) announces its intent to prepare a supplement to the 2011 Gulf of Alaska (GOA) Navy Training Activities Environmental Impact Statement (EIS)/ Overseas Environmental Impact Statement (OEIS) and 2016 Gulf of Alaska Navy Training Activities Supplemental EIS/OEIS. New information includes a new acoustic effects model, updated marine mammal density data, and evolving and emergent best available science. Proposed activities are consistent with those analyzed in the 2016 GOA Navy Training Activities Supplemental EIS/ OEIS and 2017 Record of Decision.

DATES: The public 30-day scoping period begins on February 10, 2020 and extends to March 11, 2020. Comments must be postmarked no later than March 11, 2020 for consideration in the Draft Supplemental EIS/OEIS.

ADDRESSES: The DON invites all interested parties to submit scoping comments on the GOA Supplemental EIS/OEIS by mail to the address below and through the project website at *http://www.GOAEIS.com.*

FOR FURTHER INFORMATION CONTACT: Naval Facilities Engineering Command, Northwest, Attn: Ms. Kimberly Kler, 1101 Tautog Circle, Suite 203, Silverdale, Washington 98315, 360–315–5103.

SUPPLEMENTARY INFORMATION: This Supplemental EIS/OEIS is a supplement to the 2011 GOA EIS/OEIS and 2016 GOA Supplemental EIS/OEIS, and supports renewal of current regulatory permits and authorizations for training requirements to achieve and maintain Fleet readiness as required by Title 10 of the U.S. Code. The DON's Proposed Action is unchanged since the 2016 GOA Supplemental EIS/OEIS and 2017 Record of Decision, and includes conducting one large-scale carrier strike group exercise per year, as well as the inclusion of anti-submarine warfare activities with the use of active sonar. The Proposed Action does not alter the Navy's original purpose and need as discussed in the 2016 GOA Supplemental EIS/OEIS. The DON needs to continue conducting at-sea joint exercises in the GOA to support the training of combat-capable naval forces.

The Study Area for the Supplemental EIS/OEIS is the same as the 2011 GOA EIS/OEIS and 2016 GOA Supplemental EIS/OEIS. As part of this process, the DON will seek the issuance of regulatory permits and authorizations under the Marine Mammal Protection Act and Endangered Species Act to support continued at-sea training and testing requirements within the Study Area. The renewed permits would begin in 2022 and extend for a period of 7 years; thereby ensuring critical Department of Defense requirements into the future are met.

Pursuant to 40 CFR 1501.6, the DON will invite the National Marine Fisheries Service to be a cooperating agency in preparation of this Supplemental EIS/OEIS.

The analysis in the Supplemental EIS/ OEIS will address the following resources: Marine mammals, fishes, threatened and endangered species, and Alaska Native Traditional Resources.

The DON will use the scoping process to identify public concerns and local issues to address in the Supplemental EIS/OEIS. Federal agencies, Alaska Native Tribes, state agencies, local agencies, the public, and interested persons are encouraged to provide comments to the DON to identify specific issues or topics of environmental concern the commenter believes the DON should consider. Written comments must be postmarked no later than March 11, 2020 for review and consideration in the development of the Draft Supplemental EIS/OEIS and mailed to: Naval Facilities Engineering Command, Northwest, Attention: GOA Supplemental EIS/OEIS Project Manager, 1101 Tautog Circle, Suite 203, Silverdale, Washington 98315–1101. Comments can also be submitted online via the project website at *http://www.GOAEIS.com.* Also at this website, those interested in receiving electronic project updates can subscribe to receive notifications via email for key milestones throughout the environmental planning process.

Dated: February 4, 2020.

D.J. Antenucci,

Commander, Judge Advocate General's Corps, U.S. Navy, Federal Register Liaison Officer.

[FR Doc. 2020–02537 Filed 2–7–20; 8:45 am]

BILLING CODE 3810–FF–P

DEPARTMENT OF EDUCATION

[Docket No.: ED–2019–ICCD–0135]

Agency Information Collection Activities; Submission to the Office of Management and Budget for Review and Approval; Comment Request; Study of State Policies To Prohibit Aiding and Abetting Sexual Misconduct in Schools

AGENCY: Office of Elementary and Secondary Education (OESE), Department of Education (ED).

ACTION: Notice.

SUMMARY: In accordance with the Paperwork Reduction Act of 1995, ED is proposing a new information collection.

DATES: Interested persons are invited to submit comments on or before March 11, 2020.

ADDRESSES: To access and review all the documents related to the information collection listed in this notice, please use *http://www.regulations.gov* by searching the Docket ID number ED–2019–ICCD–0135. Comments submitted in response to this notice should be submitted electronically through the Federal eRulemaking Portal at *http://www.regulations.gov* by selecting the Docket ID number or via postal mail, commercial delivery, or hand delivery. If the *regulations.gov* site is not available to the public for any reason, ED will temporarily accept comments at *ICDocketMgr@ed.gov.* Please include the docket ID number and the title of the information collection request when requesting documents or submitting comments. *Please note that comments submitted by fax or email and those submitted after the comment period will not be accepted.* Written requests for information or comments submitted by postal mail or delivery should be addressed to the Director of the Strategic Collections and Clearance Governance and Strategy Division, U.S. Department of Education, 400 Maryland Ave. SW, LBJ, Room 6W208B, Washington, DC 20202–4537.

FOR FURTHER INFORMATION CONTACT: For specific questions related to collection activities, please contact Andrew Abrams, 202–245–7500.

SUPPLEMENTARY INFORMATION: The Department of Education (ED), in accordance with the Paperwork Reduction Act of 1995 (PRA) (44 U.S.C. 3506(c)(2)(A)), provides the general public and Federal agencies with an opportunity to comment on proposed, revised, and continuing collections of information. This helps the Department assess the impact of its information collection requirements and minimize

Appendix E Agency Correspondence

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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Appendix E Agency Correspondence

This appendix contains correspondence between the Navy and relevant government agencies.

E.1 National Marine Fisheries Service Cooperating Agency Status

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910
THE DIRECTOR

Dr. Susan T. Goodfellow
Director, Energy and
Environmental and Readiness Division
Department of the Navy
2000 Navy Pentagon
Washington, DC 20350-2000

Dear Dr. Goodfellow:

Thank you for your letter requesting the National Marine Fisheries Service (NOAA Fisheries) be a cooperating agency in the preparation of a Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (SEIS/OEIS) to evaluate potential environmental effects in the Department of the Navy's (Navy) Gulf of Alaska (GOA) Training Study Area. Activities conducted in the GOA Training Study Area will achieve and maintain military readiness and include current, emerging, and future training activities (Phase III). We support the Navy's decision to prepare a SEIS/OEIS on this activity and agree to be a cooperating agency, due, in part, to our responsibilities under section 101(a)(5)(A) of the Marine Mammal Protection Act and under section 7 of the Endangered Species Act. NOAA Fisheries will make every effort to support the Navy in the development of a SEIS/OEIS, including:

- Participating, as necessary, in meetings hosted by the Navy for the discussion of issues related to the Phase III SEIS/OEIS;
- Providing timely comments on working drafts of the Phase III SEIS/OEIS in accordance with the approved project schedule and commenting protocols;
- Responding to Navy requests for information, in particular, those related to review of the acoustic effects analysis and evaluation of the effectiveness of protection and mitigation measures; and
- Adhering to the overall schedule as set forth by the Navy in coordination with NMFS.

THE ASSISTANT ADMINISTRATOR
FOR FISHERIES

If you need any additional information, please contact Jolie Harrison at (301) 427-8420.

Sincerely,

RAUCH.SAMUEL.D.III.1365850948 Digitally signed by RAUCH.SAMUEL.D.III.1365850948 Date: 2020.03.23 15:10:12 -04'00'
Samuel D. Rauch III
Deputy Assistant Administrator for
Regulatory Programs
National Marine Fisheries Service

cc: Jim Balsiger, NMFS AKRO
Vicki Wedell, NMFS HQ NMS
Steve Leathery, NMFS HQ NEPA
Ron Carmichael, Navy
Brian Ward, Navy

2

E.2 U.S. Fish and Wildlife Service Consultation

From: Spegon, Jennifer <jennifer_j_spegon@fws.gov>
Sent: Thursday, February 20, 2020 3:52 PM
To: Kler, Kimberly H CIV USN (USA)
Subject: [Non-DoD Source] Notice of Intent to prepare a Supplemental Environmental Impact Statement and Overseas Environmental Impact Statement, Gulf of Alaska, Alaska

Ms. Kimberly Kler

Thank you for your letter, January 24, 2020, indicating the Department of the Navy's (Navy's) proposal to continue military training activities in the Gulf of Alaska, and the Notice of Intent to prepare a Supplemental Environmental Impact Statement and Overseas Environmental Impact Statement as posted in the Federal Register, February 10, 2020.

The letter indicates the Navy is not proposing new activities or an increase from current levels. The U.S. Fish and Wildlife Service (Service) previously reviewed these activities under Consultation 07CAAN00-2010-I-0075 and 07CAAN00-2010-I-0075-R001. It appears there are no changes to the previous activities, the geographic parameters, or levels of activities occurring in the area previously subject to consultation with the Service. If this is case then, reinitiation of consultation under section 7 of the Endangered Species Act would not be required. Our previous findings discussed in those consultations remain valid.

However, if new information reveals project impacts that may affect listed species or critical habitat in a manner or to an extent not previously considered, or if this action is subsequently modified in a manner which was not previously considered, section 7 consultation must be reinitiated.

Thank you for your coordination in meeting our joint responsibilities under the ESA. For more information or if you have any questions please contact me at the number below.

Thank you,
Jennifer Spegon

Jennifer Spegon
Ecological Services
Anchorage Fish and Wildlife Field Office
U.S. Fish and Wildlife Service
4700 BLM Road
Anchorage, AK 99507
Phone: (907) 271-2768
FAX: (907) 271-2786
jennifer_j_spegon@fws.gov

Appendix F Public Participation

Gulf of Alaska Navy Training Activities

Draft Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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Appendix F Public Participation

This Appendix includes a summary of public involvement activities conducted by the United States (U.S.) Navy during the scoping period for the Supplemental Environmental Impact Statement (SEIS)/Overseas Environmental Impact Statement (OEIS) for the Gulf of Alaska (GOA) Navy Training Activities.

F.1 Project Website

A public website was established to provide the public with project information and to accept comments electronically. The project website address is www.goaeis.com and has been active since 2011. The website address was included in the *Notice of Intent to Prepare a Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement for Gulf of Alaska Navy Training Activities* as well as newspaper advertisements, agency letters, news release, and postcards for the Notice of Intent. The scoping fact sheet booklet, posters, public notifications, maps, frequently asked questions, reference documents, informational videos, and various other materials are available on the project website and will be updated and made available throughout the course of the project.

F.2 Scoping Period

The public scoping period began with issuance of the Notice of Intent in the *Federal Register* on February 10, 2020 (85 Federal Register 7538). The public scoping period ran from February 10, 2020, to March 11, 2020. The public was able to provide comments on the scope of the analysis by mail and through the project website.

F.2.1 Public Scoping Notification

The Navy made significant efforts to notify the public to ensure maximum public participation during the scoping process. A summary of these efforts follows.

F.2.1.1 Notification Letters

Tribal letters were mailed on February 6, 2020, via priority mail to 24 tribal chairpersons of federally recognized tribes. Stakeholder letters were mailed first-class on February 7, 2020, to 128 federal, state, and local elected officials and government agencies. Entities that received the scoping notification letter can be found in Table F.2-1 and an example of a stakeholder letter can be found in Figure F.2-1.

Table F.2-1: Entities that Received the Scoping Notification Letter

Federally Recognized Tribes and Tribal Groups	
Alutiiq Tribe of Old Harbor	Native Village of Tyonek
Kaguyak Village	Ninilchik Traditional Council
Kenaitze Indian Tribe (IRA)	Salamatof Tribe (Village of Salamatof)
Knik Tribe	Seldovia Village Tribe (IRA)
Native Village of Afognak	Sun'aq Tribe of Kodiak
Native Village of Akhiok	Tangirnaq Native Village (Woody Island)
Native Village of Chenega	Yakutat Tlingit Tribe
Native Village of Eklutna (Eklutna Native Village)	Alutiiq Museum
Native Village of Eyak	Chugachmiut, Inc.
Native Village of Karluk	Chugash Alaska Corporation
Native Village of Larsen Bay	Cook Inlet Region, Inc.
Native Village of Nanwalek (English Bay)	Cook Inlet Tribal Council
Native Village of Ouzinkie	Goldbelt Inc.
Native Village of Port Graham	Kodiak Area Native Association
Native Village of Port Lions	Koniaq, Inc.
Native Village of Tatitlek	Sealaska Corporation
Federal Elected Officials and Federal Agencies	
U.S. Senators (Alaska)	
U.S. Representatives (Alaska)	
Alaska Maritime National Wildlife Refuge	
Alaska Science Center	
Federal Aviation Administration	
Northwest Mountain Region	
Marine Mammal Commission	
National Oceanic and Atmospheric Administration	
National Marine Fisheries Service	
Alaska Fisheries Science Center	
Kodiak Laboratory	
Kasitsna Bay Lab	
Alaska Regional Office	
Habitat Conservation Division	
Office of Protected Resources	
Marine Mammal and Sea Turtle Conservation	
Sustainable Fisheries Division	
National Park Service	
Glacier Bay National Park & Preserve	
North Pacific Fisheries Management Council	
Office of Aviation Services	
U.S. Environmental Protection Agency	
Anchorage Operations Office	
NEPA Compliance Division	
Region 10	
Environmental Review and Sediment Management Unit	
U.S. Army Corps of Engineers	
Alaska District	
U.S. Department of Agriculture	
Forest Service	
Alaska Region	

Chugach National Forest U.S. Department of Commerce U.S. Department of the Interior Bureau of Indian Affairs Bureau of Land Management Alaska State Office Bureau of Ocean Energy Management Office of Environmental Policy and Compliance U.S. Fish and Wildlife Service Alaska Region Anchorage Field Office Kodiak National Wildlife Refuge U.S. Geological Survey Alaska Science Center Western Fisheries Research Center
State Elected Officials and State Agencies
Office of the Governor and Staff Alaska State Representatives (Districts 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 20, 21, 22, 23, 24, 27, 28, 29, 30, 31, 32, 33, 35, 36) Alaska State Senators (Districts A, B, C, D, F, G, K, L, N, O, P, Q, R, S) Alaska Department of Commerce Community, and Economic Development Division of Community and Regional Affairs Alaska Department of Environmental Conservation Commissioner's Office Division Administrative Services Division of Air Quality Division of Environmental Health Division of Spill Prevention and Response Alaska Department of Fish and Game Division of Commercial Fisheries Division of Habitat Division of Sport Fisheries Fairbanks Division of Sport Fishing Division of Sport Fisheries and Division of Subsistence Division of Wildlife Conservation Alaska Department of Military & Veterans Affairs Alaska Department of Natural Resources Division of Forestry Division of Parks & Outdoor Recreation Division of Geological & Geophysical Surveys Division of Mining Land and Water Anchorage Division of Oil and Gas Public Information Center Alaska Department of Transportation & Public Facilities Alaska Marine Highway Division of Ports & Harbors North Region Fairbanks Statewide Aviation Kachemak Bay Conservation Society Regulatory Commission of Alaska

Local Elected Officials and Local Agencies
City and Borough of Juneau City of Cordova Fairbanks North Star Borough Kenai Peninsula Borough Kenai Peninsula Borough School District Kodiak Island Borough Matanuska-Susitna Borough Municipality of Anchorage

DEPARTMENT OF THE NAVY
COMMANDER
UNITED STATES PACIFIC FLEET
250 MAKALAPA DRIVE
PEARL HARBOR, HAWAII 96860-3131

IN REPLY REFER TO:
5090
Ser N465/0142
January 24, 2020

Dear Sir or Madam:

SUBJECT: NOTICE OF INTENT TO PREPARE A SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT FOR GULF OF ALASKA NAVY TRAINING

This letter is to inform you that the Department of the Navy (Navy) is preparing a supplement to the 2011 Gulf of Alaska (GOA) Navy Training Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS), referred to as the 2011 GOA Final EIS/OEIS, and the 2016 GOA Navy Training Activities Final Supplemental EIS/OEIS, referred to as the 2016 GOA Final Supplemental EIS/OEIS. The Navy is proposing to continue periodic military readiness activities in the GOA. These activities include the use of active sound navigation and ranging, known as sonar, and weapon systems that may use non-explosive or explosive munitions at sea. These activities would be performed while employing marine species mitigation measures. The Navy welcomes your comments during the scoping period.

The purpose of this Supplemental EIS/OEIS is to update the 2011 and 2016 impact analyses with new information and analytical methods the Navy developed and has used since 2016. New information includes an updated acoustic effects model, updated marine mammal density data, and evolving and emergent best available science. The Navy is not proposing new activities or an increase in activities from current levels. Proposed training activities are similar to those that have occurred in the GOA for decades and are consistent with those analyzed in the 2011 and 2016 impact analyses.

The Navy is preparing a Supplemental EIS/OEIS to renew required regulatory permits and authorizations under the Marine Mammal Protection Act and the Endangered Species Act. Current federal regulatory permits and authorizations expire in April 2022. This upcoming Supplemental EIS/OEIS will support naval training requirements to achieve and maintain fleet readiness as required by Title 10 of the U.S. Code.

The Proposed Action's activities are the same as the actions presented in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final Supplemental EIS/OEIS, which are to continue periodic military training activities within a Temporary Maritime Activities Area in the GOA (Enclosure 1). The Temporary Maritime Activities Area and Proposed Action, including the location, number, and frequency of major training exercises, remain unchanged from the

Figure F.2-1: Stakeholder Scoping Notification Letter

5090
Ser N465/0142
January 24, 2020

2016 impact analysis. In the Supplemental EIS/OEIS, the Navy will include the analysis of at-sea activities projected to meet readiness requirements beyond 2022 and into the reasonably foreseeable future, which reflects the most up-to-date compilation of training activities deemed necessary to accomplish military readiness.

The Navy will accept scoping comments throughout the public comment period from Feb. 10, 2020, to March 11, 2020. All comments must be postmarked or received online by 11:59 p.m. Pacific Standard Time on **March 11, 2020**, for consideration in the Draft Supplemental EIS/OEIS. All comments submitted during the scoping period will become part of the public record and substantive comments will be considered in the development of the Draft Supplemental EIS/OEIS.

Comments may be submitted online at **www.GOAEIS.com** or by mail to:

Naval Facilities Engineering Command Northwest
Attention: GOA Supplemental EIS/OEIS Project Manager
1101 Tautog Circle, Suite 203
Silverdale, WA 98315-1101

If you would like additional project information, including details on the key differences between the 2016 GOA Final Supplemental EIS/OEIS and the upcoming Supplemental EIS/OEIS, please visit the project website at **www.GOAEIS.com**, or contact Ms. Kimberly Kler, GOA Supplemental EIS/OEIS Project Manager, at kimberly.kler@navy.mil.

Please help the Navy inform the community about the intent to prepare a Supplemental EIS/OEIS for Navy training activities in the GOA by sharing this information with your staff and interested individuals.

Sincerely,

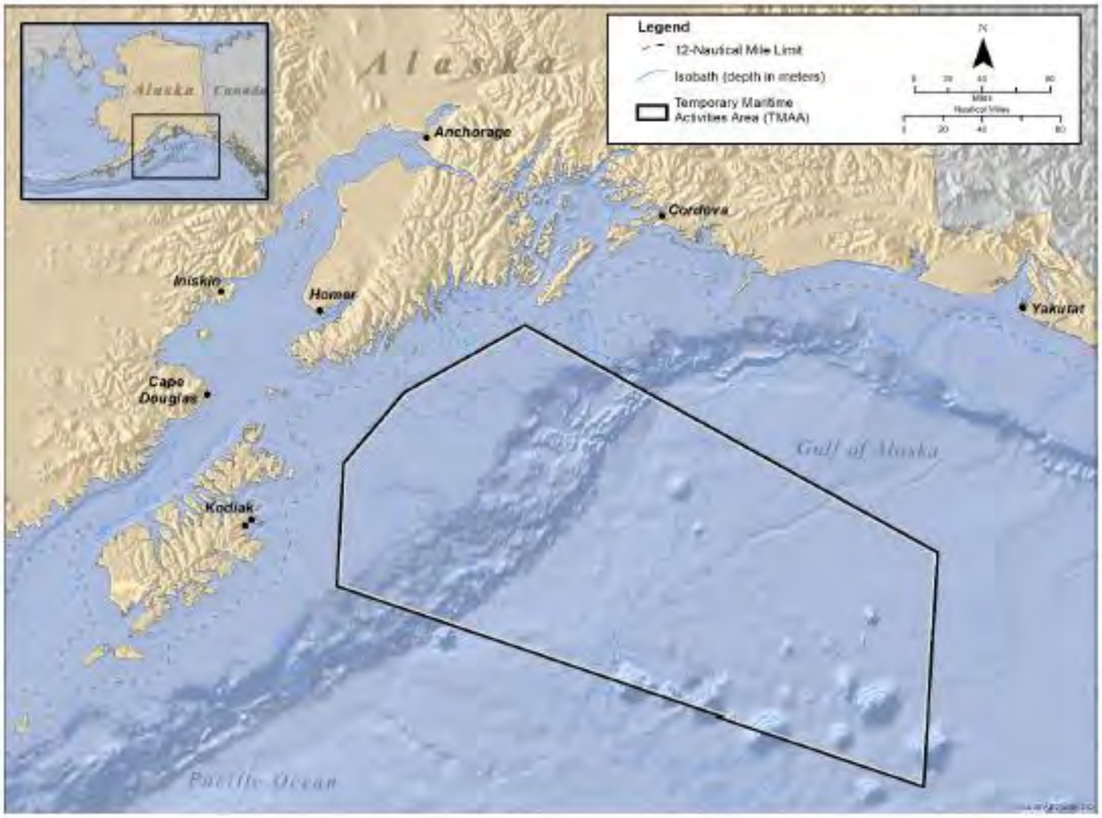
D. A. MCNAIR
Director, Environmental Readiness Division
By direction of the Commander

Enclosure: 1. GOA Navy Training Activities Supplemental EIS/OEIS Study Area

2

Figure F.2-1: Stakeholder Scoping Notification Letter (continued)

Enclosure 1: Gulf of Alaska Navy Training Activities Supplemental EIS/OEIS Study Area



Enclosure (1)

Figure F.2-1: Stakeholder Scoping Notification Letter (continued)

F.2.1.2 Postcard Mailers

A postcard was mailed first-class to 556 individuals, community groups, tribal staff, and nongovernmental organizations on February 7, 2020. The postcard provided information about the Proposed Action, the website address, and how to submit public comments. An example of the postcard is shown in Figure F.2-2.

GULF of ALASKA

NAVY TRAINING ACTIVITIES SUPPLEMENTAL EIS/OEIS

The Navy welcomes your input!

The U.S. Navy invites you to participate in the National Environmental Policy Act public involvement process for the Gulf of Alaska (GOA) Navy Training Activities Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS).

The Navy is preparing a Supplemental EIS/OEIS to update previous environmental impact analyses with new information and analytical methods the Navy developed and has used since 2016. The Supplemental EIS/OEIS will include the analysis of at-sea activities projected to meet readiness requirements beyond 2022 and into the reasonably foreseeable future.

The Navy is requesting your comments on the scope of the analysis to be considered during the development of the Draft Supplemental EIS/OEIS.

Public Involvement

You can participate in the public involvement process in the following ways:

- Visit **www.GOAEIS.com** to learn more about the project and submit comments online.
- Mail written comments to:

  Naval Facilities Engineering
  Command Northwest
  Attention: GOA Supplemental EIS/OEIS
  Project Manager
  1101 Tautog Circle, Suite 203
  Silverdale, WA 98315-1101

Comments must be postmarked or received online by 11:59 p.m. Pacific Standard Time on **March 11, 2020**, for consideration in the development of the Draft Supplemental EIS/OEIS.

Figure F.2-2: Postcard Mailer for Scoping (Front)

Proposed Action

The Proposed Action's activities are the same as the actions presented in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final Supplemental EIS/OEIS, which are to continue periodic military training activities within a Temporary Maritime Activities Area in the Gulf of Alaska. Activities include the use of sonar and weapon systems at sea, while employing marine species mitigation measures. The Temporary Maritime Activities Area and Proposed Action, including the location, number, and frequency of major training exercises, remain unchanged from the 2016 impact analysis.

Naval Facilities Engineering
Command Northwest
Attention: GOA Supplemental
EIS/OEIS Project Manager
1101 Tautog Circle, Suite 203
Silverdale, WA 98315-1101

For more information or to submit comments online, visit **www.GOAEIS.com**.

Figure F.2-2: Postcard Mailer for Scoping (Back)

F.2.1.3 Newspaper Advertisements

Display advertisements were placed in local newspapers to advertise the public's opportunity to comment on the scope of the analysis. The advertisements included a description of the Proposed Action, the website address, the duration of the comment period, and information on how to provide comments. The newspapers and publication dates are shown in Table F.2-2. An example of the advertisement is shown in Figure F.2-3.

Table F.2-2: Newspaper Publications

Newspaper	Newspaper Coverage	Publication Frequency	Publication Dates
Anchorage Daily News	Anchorage	Daily except Saturday	Monday, Feb. 10, 2020 Tuesday, Feb. 11, 2020 Wednesday, Feb. 12, 2020
Cordova Times	Cordova and Prince William Sound	Friday only	Friday, Feb. 14, 2020 Friday, Feb. 21, 2020 Friday, Feb. 28, 2020
Juneau Empire	Juneau and Southeastern Alaska	Tuesday–Friday and Sunday	Tuesday, Feb. 11, 2020 Wednesday, Feb. 12, 2020 Thursday, Feb. 13, 2020
Kodiak Daily Mirror	Kodiak	Monday–Friday	Monday, Feb. 10, 2020 Tuesday, Feb. 11, 2020 Wednesday, Feb. 12, 2020
Peninsula Clarion	Kenai-Soldotna Area	Tuesday–Friday and Sunday	Tuesday, Feb. 11, 2020 Wednesday, Feb. 12, 2020 Thursday, Feb. 13, 2020

The U.S. Navy
INVITES YOU TO PARTICIPATE
in the Gulf of Alaska Navy Training Activities Supplemental EIS/OEIS Scoping Process

The U.S. Navy is preparing a Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) to assess the potential environmental effects associated with continuing periodic military readiness activities within a specified area of the Gulf of Alaska beyond 2022 and into the reasonably foreseeable future.

Public Involvement Opportunity

The Navy is requesting your comments on the scope of the analysis to be considered during the development of the Draft Supplemental EIS/OEIS. Comments will be accepted online at **www.GOAEIS.com** or by mail to:

Naval Facilities Engineering Command Northwest
Attention: GOA Supplemental EIS/OEIS Project Manager
1101 Tautog Circle, Suite 203
Silverdale, WA 98315-1101

All comments must be postmarked or received online by 11:59 p.m. Pacific Standard Time on March 11, 2020, for consideration in the development of the Draft Supplemental EIS/OEIS.

Please visit www.GOAEIS.com for project information.

Figure F.2-3: Newspaper Announcement for Scoping

F.2.1.4 News Release

Commander, Navy Region Northwest Public Affairs Office distributed a news release to local and regional media outlets on February 10, 2020. The news release provided information on the Proposed Action, the website address, and how to submit comments. The news release from the Commander, Navy Region Northwest is shown in Figure F.2-4.

COMMANDER, NAVY REGION NORTHWEST

Public Affairs Office
1100 Hunley Road, Silverdale, WA 98315-1100
Phone: 360-396-1630 Fax: 360-396-7127

FOR IMMEDIATE RELEASE **February 10, 2020**
Release #20-0210

U.S. NAVY INVITES PUBLIC COMMENT ON THE GULF OF ALASKA NAVY TRAINING ACTIVITIES SUPPLEMENTAL ENVIRONMENTAL ANALYSIS

SILVERDALE, Wash. – The U.S. Navy is inviting the public to participate in the development of a supplement to the Gulf of Alaska (GOA) Navy Training Activities Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS).

The Navy is preparing the Supplemental EIS/OEIS to renew required regulatory permits and authorizations required under the Marine Mammal Protection Act and the Endangered Species Act. The current federal regulatory permits and authorizations required for military training activities in the Gulf of Alaska will expire in April 2022.

With this Supplemental EIS/OEIS, the Navy is not proposing any new training locations or an increase in the current levels of training activities in the Gulf of Alaska.

The Navy has trained periodically in the Gulf of Alaska for more than 30 years. This training is critical for the readiness of military personnel who protect and defend the United States and its allies.

In this Supplemental EIS, the Navy will analyze a Proposed Action where activities are the same as the actions presented in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final Supplemental EIS/OEIS, which are to continue periodic military training activities in the Temporary Maritime Activities Area (TMAA) in the Gulf of Alaska.

Proposed activities include the continued use of active sonar and weapon systems that may use non-explosive or explosive munitions at sea in the Gulf of Alaska study area. The Navy will perform these activities while employing marine species mitigation measures.

The Navy will update previous environmental impact analyses with new information and analytical methods the Navy developed and has used since 2016, to include:

- Improved acoustic models, updated marine mammal densities, and updated marine species criteria and thresholds.
- The most current and best available science and analytical methods.

– more –

Figure F.2-4: Commander, Navy Region Northwest Scoping News Release

- A review of procedural mitigation measures, where appropriate, and consider additional geographic and/or temporal mitigation measures, where applicable.

The Navy welcomes public comments during the 30-day scoping period from **February 10, 2020 to March 11, 2020**, for consideration in the development of the Supplemental EIS/OEIS.

Government agencies, elected officials, community organizations and individuals are encouraged to submit comments on the scope, content or issues for consideration in the development of the Supplemental EIS/OEIS.

All comments must be postmarked or received online **by 11:59 p.m. Pacific Standard Time on March 11, 2020,** for consideration in the Draft Supplemental EIS/OEIS. Written comments may be submitted via the project website at www.GOAEIS.com or by mail to:

Naval Facilities Engineering Command Northwest
Attention: GOA Supplemental EIS/OEIS Project Manager
1101 Tautog Circle, Suite 203
Silverdale, WA 98315-1101

Since the Navy has engaged in both National Environmental Policy Act (NEPA)-related public involvement and extensive outreach in Alaska on an ongoing basis, the Navy will not be holding public scoping meetings during the outreach period.

The Navy will hold open house public meetings after the release of the Draft Supplemental EIS/OEIS, which is tentatively scheduled for release in the winter of 2020.

Visit the project website at www.GOAEIS.com to learn more about the project, review prior NEPA-related documents, and submit comments.

Media seeking further information should contact Ms. Julianne Stanford with the Navy Region Northwest Public Affairs Office at 360-396-5393 or at julianne.stanford@navy.mil.

-2-

Figure F.2-4: Commander, Navy Region Northwest Scoping News Release (continued)

F.2.1.5 Website Subscriber Email Notification

Email subscribers from the 2016 GOA Final SEIS/OEIS were carried forward to start with 44 initial website subscribers. An email notification was sent to these 44 website subscribers on February 10, 2020, announcing the Navy's Intent to Prepare an SEIS/OEIS. The website subscriber email notification is shown in Figure F.2-5. As of November 2020, there were 48 website subscribers.

GULF of ALASKA
NAVY TRAINING ACTIVITIES SUPPLEMENTAL EIS/OEIS

The U.S. Navy is announcing its intent to prepare a Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement for Gulf of Alaska Navy Training Activities

You previously requested to receive information regarding the Department of the Navy's Gulf of Alaska (GOA) Navy Training Activities Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). This email provides an update on the project and ways to participate in the environmental planning process.

The Navy is announcing its intent to prepare a supplement to the 2011 GOA Final EIS/OEIS and the 2016 GOA Final Supplemental EIS/OEIS. The Navy is proposing to continue periodic military readiness activities in the Gulf of Alaska. These activities include the use of active sound navigation and ranging, known as sonar, and weapon systems that may use non-explosive or explosive munitions at sea. These activities would be performed while employing marine species mitigation measures.

The purpose of this Supplemental EIS/OEIS is to update the 2011 and 2016 impact analyses with new information and analytical methods the Navy developed and has used since 2016. New information includes an updated acoustic effects model, updated marine mammal density data, and evolving and emergent best available science.

The Navy is not proposing new activities or an increase in activities from current levels. Proposed training activities are similar to those that have occurred in the Gulf of Alaska for decades and are consistent with those analyzed in the 2011 and 2016 impact analyses.

The Navy is preparing a Supplemental EIS/OEIS to renew required regulatory permits and authorizations under the Marine Mammal Protection Act and the Endangered Species Act. Current federal regulatory permits and authorizations expire in April 2022.

Scoping, which is conducted in accordance with the National Environmental Policy Act (NEPA), is a process in which the public is encouraged to participate in the development of an environmental impact statement by identifying the scope of the analysis, including potential environmental issues and viable alternatives.

Substantive comments received during the scoping process are used to determine the scope of issues to be analyzed in depth and identify potential alternatives to be considered. Written comments will be accepted via the project website or by mail during

Figure F.2-5: Subscriber Email Notification

the scoping period from **Feb. 10, 2020, until 11:59 p.m. Pacific Standard Time on March 11, 2020**. Mail written comments to:

Naval Facilities Engineering Command Northwest
Attention: GOA Supplemental EIS/OEIS Project Manager
1101 Tautog Circle, Suite 203
Silverdale, WA 98315-1101

All comments must be postmarked or received online by 11:59 p.m. Pacific Standard Time on **March 11, 2020**, for consideration in the Draft Supplemental EIS/OEIS.

The Navy welcomes and appreciates your substantive comments during the scoping process. For more information about this upcoming Supplemental EIS/OEIS and to submit comments, visit www.GOAEIS.com.

The Navy appreciates your interest and participation in the environmental planning process.

Gulf of Alaska Supplemental EIS/OEIS
www.GOAEIS.com

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Gulf of Alaska Supplemental EIS/OEIS · 1101 Tautog Circle, Suite 203 · Silverdale, WA 98315-1101 · USA

mailchimp

Figure F.2-5: Subscriber Email Notification (continued)

F.2.2 Public Scoping Comments

Scoping comments were submitted in two ways:

- Written letters
- Comments submitted via the project website

The Navy received written and electronic comments from federal agencies, state agencies, federally recognized tribes, nongovernmental organizations, individuals, and community groups. A total of 25 comments were received, including 22 website comments (submitted using the electronic comment form on the project website) and 3 mailed comments.

F.3 Expanded Public Outreach

Navy personnel conducted expanded outreach with stakeholders and the public at four Alaska public events prior to and during the scoping period: Post Northern Edge, the Alaska Federation of Natives Convention, the Alaska Marine Science Symposium, and the Alaska Forum on the Environment Convention. Expanded outreach will continue throughout the development of this SEIS/OEIS to ensure stakeholders are kept informed. Outreach events are shown in Table F.3-1.

Table F.3-1: Expanded Outreach in Alaska

Stakeholders	Conducted By	Format of Outreach	Date
Post Northern Edge	CNRNW Flag Officer U.S. Pacific Fleet	Coastal community meetings with ship tours and band events	Sept. 11–20, 2019
Alaska Federation of Natives Convention	U.S. Pacific Fleet NAVFAC Northwest	Stewards of the Sea Outreach booth	Oct. 17–19, 2019
Alaska Marine Science Symposium	U.S. Pacific Fleet NAVFAC Northwest	Stewards of the Sea Outreach booth	Jan. 27–28, 2020
Alaska Forum on the Environment Convention	U.S. Pacific Fleet NAVFAC Northwest	Stewards of the Sea Outreach booth; public presentation during Military Training in Alaska panel	Feb. 10–14, 2020

Notes: CNRNW = Commander, Navy Region Northwest; U.S. = United States; NAVFAC = Naval Facilities Engineering Command.

F.4 Notification of Availability of the Draft Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement

The Draft SEIS/OEIS public review and comment period will begin with issuance of the Notice of Availability and Notice of Public Meetings in the Federal Register. The Federal Register notices will include notification of the availability of the Draft SEIS/OEIS and where it can be accessed; an overview of the Proposed Action and its purpose and need; public commenting information; and the locations, dates, and times of the virtual public meetings. The purpose of the virtual public meetings is to inform the public about the Proposed Action and environmental analysis, and to solicit public comments on the environmental issues addressed and analyzed in the Draft SEIS/OEIS. Comments will be accepted by mail, through the project website at www.goaeis.com, and at the virtual public meetings.

F.4.1 Notification of Draft Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement and Virtual Public Meetings

The Navy will make significant efforts to facilitate maximum public participation during the Draft SEIS/OEIS public review and comment period. The following is a summary of these efforts.

- Tribal and stakeholder notification letters
- Postcard mailer
- Press releases
- Newspaper advertisements
- Public service announcements
- Social media (Facebook) posts
- Virtual public meetings
- Expanded public outreach

Due to federal and state guidance and measures put in place in response to COVID-19, the Navy will be unable to hold in-person public meetings in Alaska; however, virtual public meetings will be held to safely and effectively engage the public. The Navy will take additional steps to help facilitate continued communication about the Proposed Action, alternatives under consideration, and results of the environmental analysis.