GULF of ALASKA

Navy Training Activities

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT/
OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

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Gulf of Alaska Navy Training Activities
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Supplemental Environmental Impact Statement/ Overseas Environmental Impact Statement

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FINAL 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:	Final 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 parts 1500 et seq. [2019]); Navy Procedures for Implementing NEPA (32 Code of Federal Regulations part 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 Proposed Action is to conduct an annual exercise, historically referred to as Northern Edge, for up to 21 consecutive days between April and October.

This SEIS/OEIS evaluates the potential environmental impacts of continuing training activities upon the expiration of the current authorizations and consultations in 2022 and into the foreseeable future. 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 GOA Study Area, 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 and 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 Oliver Hazard Perry Class Frigate, and their associated systems, have been replaced with the EA-18G aircraft, Littoral Combat Ship, and Constellation Class Frigate), and use of the Portable Underwater Tracking Range is no longer proposed. Consistent with the previous analysis for Alternative 1, the sinking exercise activities are not part of Alternative 1 for this SEIS/OEIS. While the revised GOA Study Area now includes the Western Maneuver Area, in addition to the existing Temporary Maritime Activities Area (TMAA), the type and number of training events would not change, and the majority of training would still occur in the TMAA. Activities using active acoustics or explosives would not occur in the Western Maneuver Area. A mitigation area, referred to as the "Continental Shelf and Slope Mitigation Area," has been added to Alternative 1 in the TMAA, where the Navy would prohibit the use of explosives from the sea surface up to 10,000 feet altitude during training over the entire continental shelf and slope out to the 4,000 meter depth contour.

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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ES Executive Summary

ES.1 Introduction

The United States (U.S.) Department of the Navy (Navy) has prepared this 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 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 Study Area (Figure ES-1). In addition to the existing Temporary Maritime Activities Area (TMAA) which is the same at-sea training area analyzed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, certain limited activities would be conducted in the Western Maneuver Area (WMA). The GOA Study Area is now comprised of the TMAA and the WMA. The Navy also proposes implementing a new mitigation area over the continental shelf and slope of the TMAA. To protect marine species and biologically important habitat, use of explosives (sea surface up to 10,000 feet altitude) would be prohibited in this area.

The Proposed Action includes all military readiness activities previously conducted pursuant to the Record of Decision (ROD) following the 2016 GOA Final SEIS/OEIS. The Navy would conduct an annual exercise, historically referred to as Northern Edge, over a time period of up to 21 consecutive days during the April to October timeframe. Although the types of activities and number of events in the Proposed Action are consistent with 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 Oliver Hazard Perry Class Frigate, and their associated systems, have been replaced with the EA-18G aircraft, Littoral Combat Ship, and Constellation Class Frigate), and use of the Portable Underwater Tracking Range is no longer proposed. Consistent with the previous analyses for Alternative 1, the sinking exercise activity will not be part of the Proposed Action for this SEIS/OEIS.

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 GOA Study Area (the TMAA was 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.

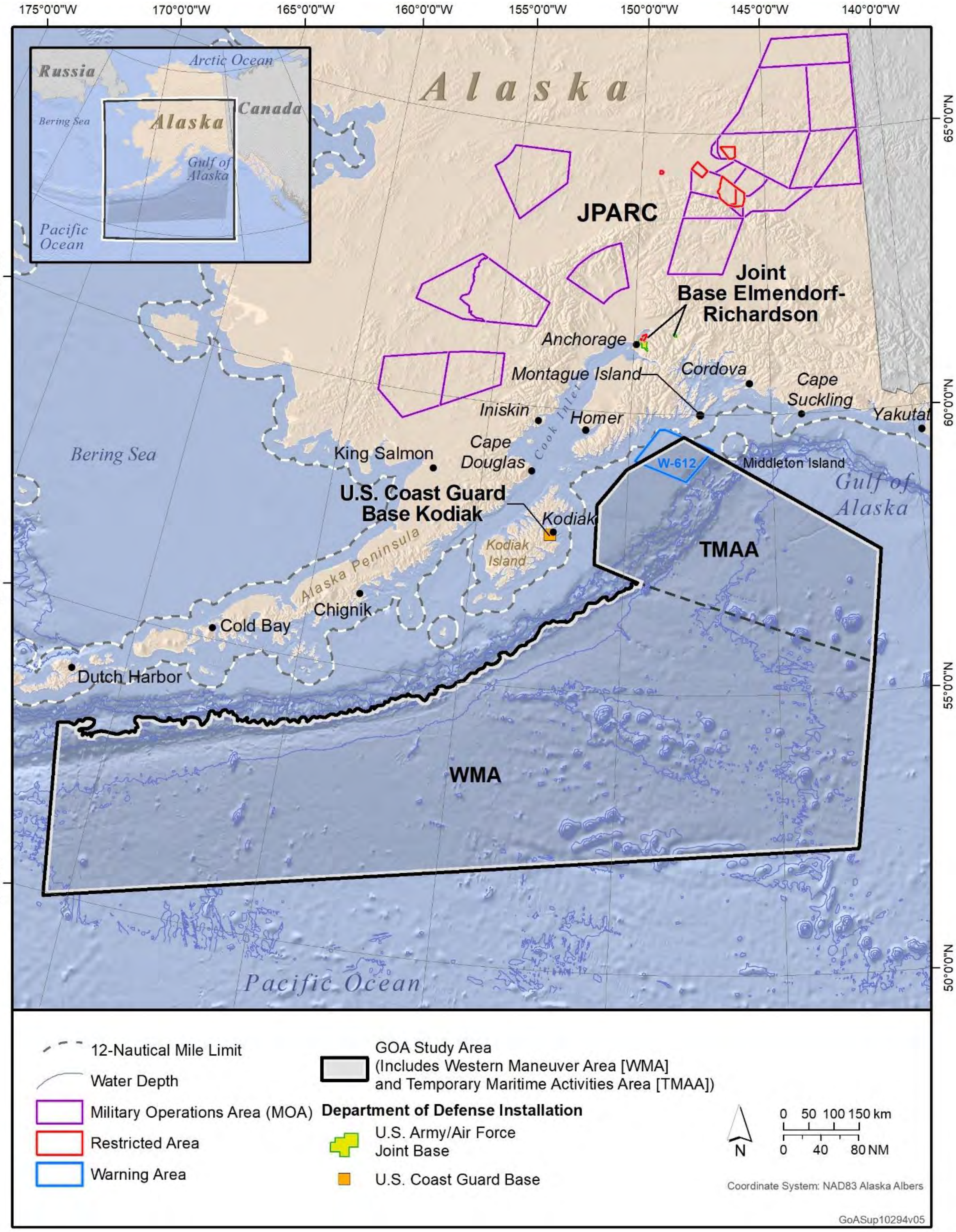

Figure ES-1: Gulf of Alaska Study Area

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

In this SEIS/OEIS, the Navy reevaluates potential impacts from the ongoing military training activities in the GOA Study Area. The GOA Study Area 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 GOA Study Area.

This 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 RODs were issued. The Navy seeks to continue military readiness activities previously conducted and described in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. This SEIS/OEIS assesses 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 federal regulations and authorizations issuance under the MMPA. After the Final SEIS/OEIS is published and in accordance with the Council on Environmental Quality (CEQ) Regulations, 40 CFR section 1505.2, the Navy's ROD will provide the Navy's 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 five newspapers, distributed press releases, and mailed notification letters to 24 tribal chairpersons of federally recognized tribes and 128 federal, state, and local elected officials and government agencies. In addition, the Navy mailed postcards to 556 individuals, community groups, tribal staff, nongovernmental organizations, and key stakeholders and parties previously expressing an interest in this project. The public was also provided notification of the intent to prepare an SEIS/OEIS via a post on the project website (https://goaeis.com/) and by email (44 recipients).

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 had not changed, public scoping meetings were not held, but notice of the scoping period was broadly disseminated and 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 Draft Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement Comment Period

The Draft SEIS/OEIS public review and comment period began with the issuance of the Notice of Availability (85 Federal Register 80093) and the Notice of Virtual Public Meetings (85 Federal Register 80076) in the *Federal Register* December 11, 2020. The Draft SEIS/OEIS public review and comment period ran from December 11, 2020, to February 16, 2021. The *Federal Register* notices included notification of the availability of the Draft SEIS/OEIS and where it could be accessed; an overview of the Proposed Action and its purpose and need; public commenting information; and virtual public meeting information, including how to submit questions. The public was able to provide comments on the Proposed Action and Draft SEIS/OEIS environmental analysis by mail and through the project website. *Federal Register* notices can be found in Appendix D (Federal Register Notices). Public comments received and responses to comments can be found in Appendix G (Public Comments and Responses).

Due to the widespread outbreak of respiratory illness from the coronavirus pandemic (COVID-19), and restrictions on travel and large public gatherings, the Navy took additional steps to broaden efforts to notify, inform, and involve the public during the Draft SEIS/OEIS public review and comment period. In place of in-person public meetings the Navy held two virtual public meetings using the Zoom video conferencing platform. The Navy's goal was to provide an opportunity for the public to learn more about the project and the environmental impact analysis, and provide official comment as well as have their questions answered, just as they would at an in-person public meeting. Notification materials provided details on the virtual public meetings, instructions on how to submit a question for discussion with Navy representatives at the virtual public meetings, and commenting methods.

ES.4.3 Supplement to the 2020 Draft Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement Comment Period

The Notice of Intent to Prepare a Supplement to the Draft SEIS/OEIS was published February 1, 2022. The Supplement to the 2020 Draft SEIS/OEIS public review and comment period began with the issuance of the Notice of Availability (87 Federal Register 15414) in the *Federal Register* on March 18, 2022. The Supplement public review and comment period ran from March 18, 2022, to May 2, 2022. The *Federal Register* notice included notification of the availability of the Supplement and where it could be accessed; an overview of the Proposed Action and its purpose and need; and public commenting information. The public was able to provide comments on the Proposed Action and Supplement environmental analysis by mail and through the project website. *Federal Register* notices can be found in Appendix D (Federal Register Notices). Public comments received and responses to comments can be found in Appendix G (Public Comments and Responses).

ES.4.4 Additional Outreach

Prior to the start of the Alaska Command sponsored exercise, Northern Edge 2015 (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.

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, with these events taking place in Anchorage, Cordova, Seward, Kodiak and Fairbanks, Alaska; and Seattle, Washington. Additionally, the Navy has periodically presented information and updates on Exercise Northern Edge and Marine Species Monitoring Program projects to the North Pacific Fisheries Management Council during scheduled meetings open to the public. Expanded outreach will continue into the foreseeable future to ensure stakeholders are kept informed of the Navy's training activities in the GOA Study Area.

ES.5 Proposed Action and Alternatives

Through this 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[1] and incidental takes of threatened and endangered marine species under the ESA.

ES.5.1 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. These alternatives considered included alternative training locations, reduced training, alternate time frame, simulated training, training without the use of active sonar, and alternatives including additional geographic mitigation measures within the Study Area. After thorough consideration of each previously considered alternative, the Navy once again determined that

[1]NMFS' issuance of an MMPA incidental take authorization (i.e., Letter of Authorization) is a major federal action (NMFS' Proposed Action) and is considered a connected action under NEPA (40 CFR 1508.25), with a discrete purpose and need relative to NMFS' statutory and regulatory obligations. Consequently, NMFS has an independent responsibility to comply with NEPA. If NMFS makes the findings necessary to issue the requested authorization, NMFS will rely on the information and analyses in this document and intends to adopt this SEIS/OEIS to fulfill its NEPA obligations, and issue its own ROD, if appropriate.

they did not meet the purpose of and need for the Proposed Action, and they were eliminated from further analysis.

ES.5.2 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 GOA Study Area 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 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. To present a clearer picture of the expected environmental impacts of 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 GOA Study Area would limit the Navy’s ability to train and meet its statutory requirements to achieve and maintain fleet readiness. Through training in various environments, Navy personnel develop the unique skills required to accomplish their overall mission and be prepared to safely and effectively use sensors, weapons, and technologies in realistic scenarios. Consequently, the No Action Alternative does not meet the purpose of and need for the Proposed Action.

ES.5.3 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. Though the types of activities and level of events are the same, there have been changes in the platforms and systems used as part of those activities, and use of the Portable Underwater Tracking Range is no longer proposed. While the revised GOA Study Area is larger than the area analyzed in previous documents, including the 2020 GOA Draft SEIS/OEIS, no new or increased levels of training activities would occur, and no increases in vessel numbers, underway steaming hours, or aircraft events would occur. The use of sonar and explosives would be limited to the TMAA portion of the Study Area as previously analyzed and authorized. 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 Study Area, a Status Quo Alternative would allow the Navy to meet current and future training requirements necessary to achieve and maintain fleet readiness.

ES.5.3.1 The Western Maneuver Area

The 2011 GOA Final EIS/OEIS Study Area consisted of three components: (1) GOA TMAA, (2) U.S. Air Force overland Special Use Airspace and air routes over the GOA and State of Alaska, and (3) U.S. Army training lands. Collectively, for the purposes of this Supplemental EIS/OEIS, these areas are referred to as the Joint Pacific Alaska Range Complex. The 2020 GOA Draft SEIS/OEIS only analyzed activities occurring within the TMAA, a component of the Joint Pacific Alaska Range Complex. To address the need for a broader area in which to maneuver during training and to accomplish more realistic training, the

GOA Study Area now includes the WMA in addition to the existing TMAA (hereafter referred to together as the “GOA Study Area”) (Figure ES-1). The TMAA is unchanged from the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS. The WMA is located south and west of the TMAA and provides an additional 185,806 square nautical miles of surface, sub-surface, and airspace in which to maneuver in support of activities occurring within the TMAA. The boundary of the WMA follows the bottom of the continental slope at the 4,000 meter (m) depth contour, and was configured to avoid overlap and impacts on critical habitat, biologically important areas, marine mammal migration routes, and primary fishing grounds. Currently, the TMAA allows for a single, predictable air and surface axis of approach to the Study Area, which does not replicate real-world conditions or scenarios, which are unpredictable. The WMA provides a larger surface area and access to more international airspace through coordination with FAA regional centers. Access to this more expansive area allows for multiple air lanes approaching the TMAA and additional sea space for vessel maneuvering, which increases training complexity and more closely represents the real-world conditions Navy sailors will experience.

ES.5.3.2 Proposed Activities in the Western Maneuver Area

While the revised GOA Study Area is larger than the area discussed in the 2020 GOA Draft SEIS/OEIS, no new or increased levels of training activities would occur, and no increases in vessel numbers, underway steaming hours, or aircraft events would occur. The majority of training, approximately 70 percent, would still occur in the TMAA. The activities conducted in the WMA would be limited to activities mainly involving vessel movements and aircraft training (Table ES-1). The exception would be non-explosive gunnery activities, which would only include training with non-explosive practice munitions in the WMA. Activities using active acoustics or explosives would not occur in the WMA; these activities would only be conducted in the TMAA. Training activities proposed in the WMA are shown in Table ES-1. Additional information on these training activities can be found in Appendix A.

Table ES-1: Training Activities Proposed to Occur in the Western Maneuver Area

Activity Name	*Activity Description*
Air Warfare	
Air Combat Maneuver	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.
Air Defense Exercise	Surface and air assets trained in coordination and tactics for defense of the strike group from airborne threats.
Surface Warfare	
Maritime Interdiction	Vessels and aircraft conduct a suite of maritime security operations at sea, including maritime interdiction operations, force protection, and anti-piracy operations.
Sea Surface Control	Airborne assets investigate surface contacts of interest and attempt to identify, via onboard sensors, the type, course, speed, name, and other pertinent data about the ship of interest.
Surface-to-Surface Gunnery Exercise (Non-Explosive Practice Munitions)	Surface ship crews fire small-caliber, medium-caliber, or large-caliber guns at surface targets.

Table ES-1: Training Activities Proposed to Occur in the Western Maneuver Area (continued)

Activity Name	***Activity Description***
Electronic Warfare	
Electronic Warfare Exercise	Aircraft and surface ship crews control portions of the electromagnetic spectrum used by enemy systems.
Other Training Activities	
Deck Landing Qualification	Ship's personnel launch and recover fixed-wing and rotary-wing aircraft to achieve qualifications and certifications.

ES.5.3.3 Continental Shelf and Slope Mitigation Area

In the 2016 GOA Final SEIS/OEIS and associated consultation documents, the Navy restricted explosive use during training in the Portlock Bank area, and from June 1 to September 30 within the North Pacific Right Whale Mitigation Area. These previous restrictions were designed to avoid or reduce potential impacts on North Pacific right whales, Portlock Bank fishery resources, and other marine species that inhabit the highly productive waters of the mitigation areas. The Proposed Action now includes the addition of the Continental Shelf and Slope Mitigation Area within the TMAA. In this area, shown on Figure ES-2, the Navy is proposing to expand its mitigation for explosives, and would prohibit the use of explosives from the sea surface up to 10,000 feet altitude during training over the entire continental shelf and slope out to the 4,000 m depth contour to protect marine species and biologically important habitat. The Navy will continue to restrict the use of surface ship hull mounted MF1 mid-frequency active sonar from June 1 to September 30 within the North Pacific Right Whale Mitigation Area.

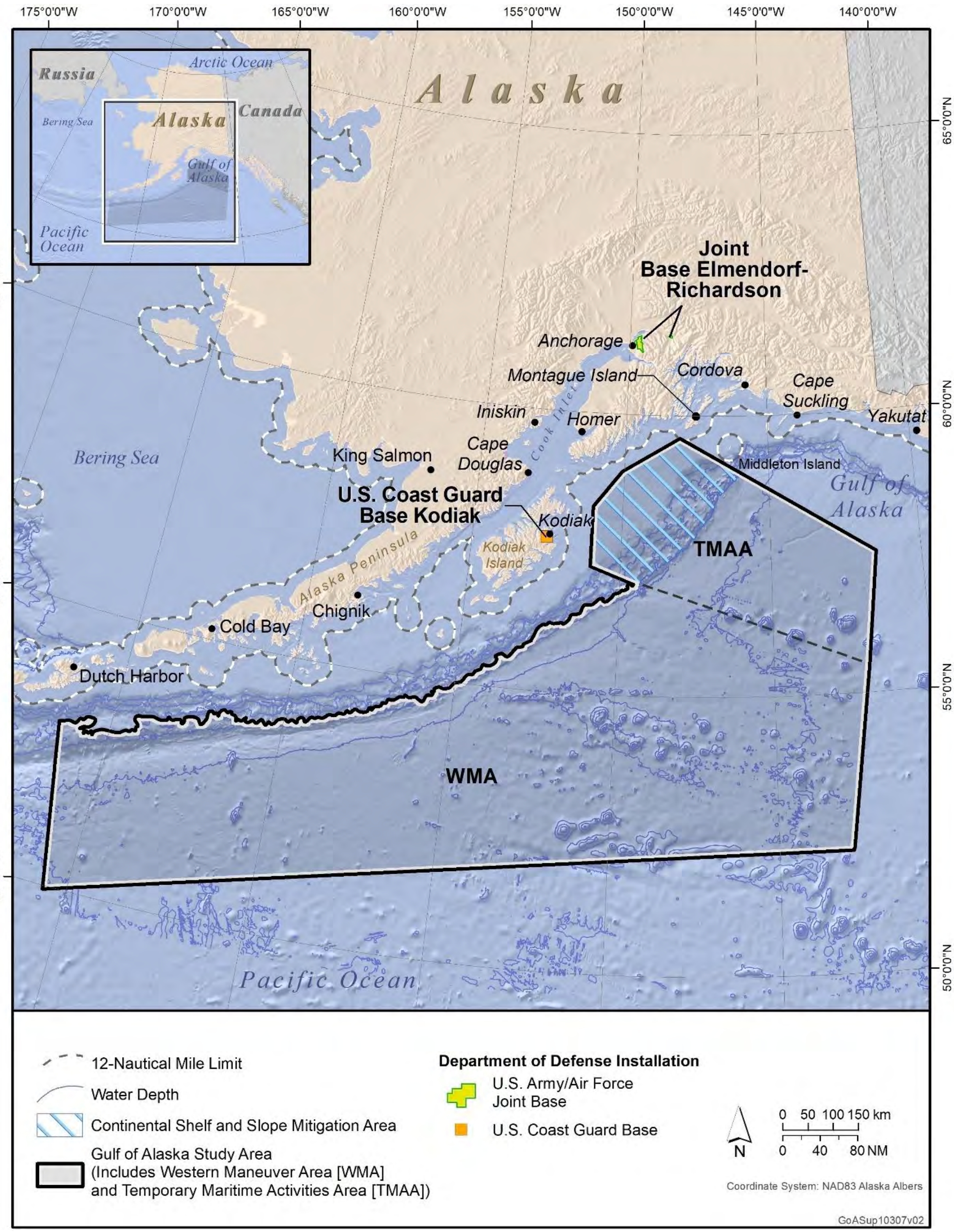

Figure ES-2: Continental Shelf and Slope Mitigation Area

ES.6 Summary of Environmental Impacts

Table ES-2 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 (e.g., traffic patterns), 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 GOA Study Area in this SEIS/OEIS, and, for several of the resources, the existing baseline conditions have not changed appreciably. The Navy reviewed new research, literature, laws, and regulatory guidance as described in this SEIS/OEIS and determined that the new information 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-2 below.

Table ES-2: Summary of Environmental Impacts for the Proposed Action

Resource Category	*Summary of Impacts under Alternative 1*	*Explanation of Differences from 2016 SEIS/OEIS*
Fishes	*Impacts from acoustic and explosive stressors:* • Pursuant to the ESA, acoustic and explosive stressors may affect ESA-listed salmonid species and green sturgeon. Impacts, however, are expected to be temporary and infrequent as most activities would be temporary, localized, and infrequent. More severe impacts such as mortality or injury could lead to permanent or long-term consequences for individuals, but overall long-term consequences for fish populations are not expected.	• Overall impact determinations for species analyzed the 2016 GOA Final SEIS/OEIS remain unchanged with some exceptions due to new and emergent data on species occurrence within the GOA Study Area and the implementation of a new mitigation measure. The addition of the Continental Shelf and Slope Mitigation Area will substantially decrease the overall take of ESA-listed salmonids, specifically Chinook and coho. In addition, the potential exposure of ESA-listed green sturgeon to an explosive stressor in the TMAA is extremely unlikely due to the demersal nature of this species. • One Chinook salmon ESA candidate evolutionarily significant unit was added to the analysis. • New analysis was conducted for green sturgeon to account for new literature on the species' occurrence. • New analysis was conducted for stressors associated with vessel movements, aircraft training, and non-explosive practice ordnance within the WMA. Activities occurring in WMA are unlikely to significantly impact fishes as many fish species occur most frequently over the continental shelf and slope, and the WMA is in open ocean waters with a minimum depth of 4,000 m. Activities using active acoustics or explosives would not occur in the WMA. The limited number and types of training activities occurring in the WMA are described in Table ES-1. These activities are the same as those described and analyzed in the TMAA and exclude activities using active sonar and other transducers or explosives. For those activities that occur in both the WMA and the TMAA, the analysis for the WMA would be the same as for the TMAA and would not significantly impact fishes.
Sea Turtles	*All stressors:* Sea turtles rarely occur in the GOA Study Area and are unlikely to co-occur with the Proposed Action; therefore, impacts are not expected to occur. Under the ESA, all stressors from the Proposed Action may affect but are not likely to adversely affect ESA-listed sea turtles.	• No change in impact determinations. • Activities using active acoustics or explosives would not occur in the WMA. The limited number and types of training activities occurring in the WMA are described in Table ES-1. These activities are the same as those described and analyzed in the TMAA and exclude activities using active sonar and other transducers or explosives. For those activities that occur in both the WMA and the TMAA, the analysis for the WMA would be the same as for the TMAA and would not significantly impact sea turtles. • Sea turtles are not expected to be impacted by acoustic and explosive stressors within the TMAA. This conclusion is based on the best available science characterizing the known distribution of leatherback sea turtles as rare within the GOA. • Impacts from training activities in the Continental Shelf and Slope Mitigation Area would either remain the same as previously analyzed or would be reduced.

Table ES-2: Summary of Environmental Impacts for the Proposed Action (continued)

<table>
<tr><th>Resource Category</th><th>Summary of Impacts under Alternative 1</th><th>Explanation of Differences from 2016 SEIS/OEIS</th></tr>
<tr><td>Marine Mammals</td><td>Impacts from acoustic and explosive stressors:
Pursuant to the ESA, acoustic and explosive stressors may affect ESA-listed North Pacific right whales, humpback whales, blue whales, sei whales, grey whales, sperm whales, Steller sea lions, and northern sea otters. Model results showed that sonar use would not result in permanent hearing loss for any ESA-listed marine mammal.
The Navy’s modeling of acoustic effects and analyses predicted some marine mammals would be exposed to acoustic and explosive stressors resulting in Level B and Level A harassment, as defined under the MMPA.
The modeling and analyses predicted no marine mammal mortalities as a result of acoustic or explosive stressors.
Impacts are expected to be temporary and infrequent as most training activities would be short term, localized, and infrequent. The level of effects varies by species, and not all species would be impacted.</td><td>No difference in the type of impacts predicted within the TMAA.
The addition of the Continental Shelf and Slope Mitigation Area would reduce impacts on marine mammals and important shelf and slope habitat in the TMAA by prohibiting the use of explosives over the shelf and slope in the TMAA. Impacts from training activities in the Continental Shelf and Slope Mitigation Area would either remain the same as previously analyzed or would be further reduced.
New analysis was conducted for stressors associated with vessel movements, aircraft training, and non-explosive practice ordnance within the WMA. Activities using active acoustics or explosives would not occur in the WMA. Marine mammals in the WMA would encounter only those stressors associated with vessel movements, aircraft training, and non-explosive practice ordnance. Vessel maneuvering activities in the WMA would introduce the risk of a ship strike, primarily for large cetaceans, in a region where training activities were not initially proposed. However, relocating some vessel maneuvering activities from the TMAA into the WMA would slightly reduce the probability of a ship strike in the TMAA, such that, when considered together, the probability of a ship strike would remain approximately the same as presented in the 2020 GOA Draft SEIS/OEIS.
The limited number and types of training activities occurring in the WMA are described in Table ES-1. These activities are the same as those described and analyzed in the TMAA and exclude activities using active sonar and other transducers or explosives. For those activities that occur in both the WMA and the TMAA, the analysis for the WMA would be the same as for the TMAA and would not significantly impact marine mammals.</td></tr>
</table>

Table ES-2: Summary of Environmental Impacts for the Proposed Action (continued)

Resource Category	*Summary of Impacts under Alternative 1*	*Explanation of Differences from 2016 SEIS/OEIS*
Birds	*Impacts from acoustic and explosive stressors:* • Under the MBTA, impacts would not result in a significant adverse effect on populations of seabirds, shorebirds, and other birds protected under the MBTA. • Under the ESA, impacts from sonar, vessel noise, and aircraft disturbance may include behavioral reactions, physiological stress, and masking. Model results showed that sonar use would not result in hearing loss. • In addition to behavioral reactions, physiological stress, and masking, impacts from weapon noise may include hearing loss, and impacts from explosives may include hearing loss, non-auditory injury and mortality; but mitigation would reduce the likelihood of adverse effects on individual birds.	• Updated sound exposure level effects estimates 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. • Seabirds, including the ESA-listed short-tailed albatross, are expected to occur in higher abundance along the continental shelf and slope. By prohibiting activities that introduce acoustic and explosive stressors to locations further offshore within the TMAA, the addition of the Continental Shelf and Slope Mitigation Area would reduce impacts on seabirds and important prey species. Therefore, impacts from training activities in the Continental Shelf and Slope Mitigation Area would either remain the same, as previously analyzed, or would be reduced. • Activities using active acoustics or explosives would not occur in the WMA. The distance from shore that the aircraft activity would occur in the WMA, and the altitude at which they would occur, would limit the potential for overlap with birds, as birds would be most likely to occur over the continental shelf and slope, and the WMA begins after water depths of 4,000 m in open ocean waters. The limited number and types of training activities occurring in the WMA are described in Table ES-1. These activities are the same as those described and analyzed in the TMAA and exclude activities using active sonar and other transducers or explosives. For those activities that occur in both the WMA and the TMAA, the analysis for the WMA would be the same as for the TMAA and would not significantly impact birds.

Table ES-2: Summary of Environmental Impacts for the Proposed Action (continued)

Resource Category	*Summary of Impacts under Alternative 1*	*Explanation of Differences from 2016 SEIS/OEIS*
Socioeconomic Resources and Environmental Justice	• Significant impacts on socioeconomic resources, including commercial and recreational fishing, fisheries research and management, civilian access, and tourism are not expected to occur. • Impacts on environmental justice are not expected to occur.	• No difference in the type of impacts predicted within the TMAA. • New analysis was conducted for stressors associated with vessel movements, aircraft training, and non-explosive practice ordnance within the WMA. • No significant impacts are expected on socioeconomic resources within the WMA. Most of the productive commercial fishing areas are located in shallower waters on the continental shelf, far inshore of the WMA. Similarly, most commercial shipping, tourism, and recreational activities would occur along to the coastline, over the continental shelf, and inshore of the WMA. • No impacts on environmental justice are anticipated from activities in the WMA, which would occur in waters deeper than 4,000 m and more than 20 nautical miles offshore of sparsely populated areas along the Alaska Peninsula and Aleutian Islands between Kodiak Island and Dutch Harbor. Therefore, there would be no disproportionately high and adverse human health or environmental effects on any minority populations or low-income populations from activities proposed in the WMA. • Designation of the Continental Shelf and Slope Mitigation Area would further reduce or eliminate potential conflicts between Navy activities and commercial fishing, commercial shipping, or recreation vessels that are known to utilize the area. • Other training activities that do not use explosives would continue to be conducted as planned in the Continental Shelf and Slope Mitigation Area; however, any impacts on socioeconomic resources previously anticipated from the use of explosives in the TMAA would not occur. Impacts from training activities in the Continental Shelf and Slope Mitigation Area would either remain the same as previously analyzed or would be reduced. Therefore, the addition of the Continental Shelf and Slope Mitigation Area would not significantly impact socioeconomic resources and may benefit fisheries and commercial fishing.

Notes: Alt = Alternative, EIS/OEIS = Environmental Impact Statement/Overseas Environmental Impact Statement, ES = Executive Summary, ESA =Endangered Species Act, FR = Federal Register, GOA = Gulf of Alaska, m = meter(s), NMFS = National Marine Fisheries Service, SEIS = Supplemental Environmental Impact Statement, TMAA = Temporary Maritime Activities Area, MBTA = Migratory Bird Treaty Act, MMPA = Marine Mammal Protection Act, WMA = Western Maneuver Area.

ES.7 Cumulative Impacts

Marine mammals are the primary resource considered in the cumulative impacts analysis. Marine mammal species occurring in the GOA Study Area may be impacted by multiple ongoing and future actions related to human activities, including Navy training activities. Explosive detonations and non-impulsive sources, such as sonar, under Alternative 1 have the potential to disturb or injure marine mammals in the TMAA. However, explosives would not be used in the Continental Shelf and Slope Mitigation Area inside the TMAA, only in the deeper waters of the TMAA; as such, no mortalities and very few injuries are expected or predicted by the Navy's acoustic effects model. No explosives or non-impulsive acoustic sources would be used in the WMA.

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. No new training activities are proposed under Alternative 1, and the number of training activities that would be conducted annually remains the same as described in the 2020 GOA Draft SEIS/OEIS. Aircraft and vessel maneuvering activities originally planned for the TMAA would now be more widely distributed within both the TMAA and WMA to achieve more realistic training scenarios. Maneuvering activities in the WMA would occur in deep offshore waters (greater than 4,000 m) located beyond the continental shelf and slope. The types of training activities in the WMA described in Table ES-1 are the same as those described in the TMAA (with the exception of active acoustics or explosive use) and would not significantly impact resources in the GOA Study Area. 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 and cumulatively not significant.

ES.8 Standard Operating Procedures, Mitigation, and Monitoring

Within the GOA 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 resources. Marine species monitoring efforts are designed to track compliance with take authorizations under the MMPA and ESA, evaluate the effectiveness of mitigation measures, improve understanding of the effects training activities have on marine resources, and understand species habitat use and distribution within a study area.

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 has coordinated with NMFS and the U.S. Fish and Wildlife Service on these measures through the consultation and permitting processes. The Navy ROD will document all mitigation measures the Navy will implement under the Proposed Action. Under the Proposed Action, the Navy ROD will document all mitigation measures the Navy will implement, and the NMFS ROD, MMPA Regulations and Letter of Authorization 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 included in this SEIS/OEIS may be considered by NMFS 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 may develop an additional set of measures contained in reasonable and prudent alternatives, reasonable and prudent measures, or conservation recommendations in the 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 GOA Study Area. 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, ESA-listed species, and fishery resources from active sonar, explosives, or 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 and public review of the Navy's 2020 Draft GOA 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 GOA), 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 proposed to 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. For example, the Navy has been conducting a Lookout Effectiveness Study in association with the University of St. Andrews for several years to assess the ability of shipboard Lookouts to observe marine mammals while conducting hull-mounted sonar training activities at sea. The University of St. Andrews' final report was submitted to NMFS and then later posted publicly on the U.S. Navy's Marine Species Monitoring Program website in July 2022. Taken together, mitigation, monitoring, and adaptive management 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, 2009). 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 regulations. While ESA consultation with the USFWS has been completed, the Navy is consulting, and will continue to consult, with other 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

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. 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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Appendices

Acronyms and Abbreviations

Acronym	Definition
°C	Degrees Celsius
°N	Degrees North
°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
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CDC	Center for Disease Control and Prevention
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulation
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 µPa^{2}s	Decibels referenced to 1 micropascal squared seconds
dBA	A-weighted decibel(s)
dBA re 20 µPa	A-weighted decibel(s) referenced to 20 micropascals
dBA re 20 µPa^{2}s	A-weighted decibel(s) referenced to 20 micropascals squared seconds
DDT	dichlorodiphenyltrichloroethane
DoD	Department of Defense
DOI	Department of Interior
DPS	Distinct Population Segment
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
EW	Electronic Warfare
FMP	Fishery Management Plan
FONSI	Finding of No Significant Impact
FR	Federal Register
ft.	Foot/feet
FY	Fiscal Year
GOA	Gulf of Alaska
HE-ET	High Explosive-Electronic Time
HF	High Frequency
HFAS	High-Frequency Active Sonar
HM	Hull-mounted
Hz	hertz
IRA	Indian Reorganization Act
JPARC	Joint Pacific Alaska Range Complex
kg	Kilogram(s)
kHz	kilohertz

Acronym	Definition
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
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
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	Permanent Threshold Shift
ROD	Record of Decision
SAR	Stock Assessment Report
SE	Southeast
SEIS	Supplemental Environmental Impact Statement
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SINKEX	Sinking Exercise
SOCAL	Southern California
SPL	Sound Pressure Level
SPL_{peak}	peak sound pressure level
SRM	Spatial release from masking
SST	Sea Surface Temperature
SUA	Special Use Airspace
SURTASS LFA	Surveillance Towed Array Sensor System Low Frequency Active
TMAA	Temporary Maritime Activities Area
TNT	trinitrotoluene
TORP	Torpedoes
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
WMA	Western Maneuver Area
yd.	Yard(s)

1 Purpose and Need

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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 GOA. 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) Temporary Maritime Activities Area (TMAA), (2) U.S. Air Force overland Special Use Airspace (SUA) and air routes over the GOA and State of Alaska, and (3) U.S. Army training lands. Collectively, for the purposes of this Supplement, these areas are referred to as the Joint Pacific Alaska Range Complex (JPARC). The 2016 GOA Final SEIS/OEIS and the 2020 GOA Draft SEIS/OEIS only analyzed activities occurring within the TMAA, a component of the JPARC. To address the need for a broader area in which to maneuver during training and to accomplish more realistic training, the GOA Study Area now includes the Western Maneuver Area (WMA) in addition to the existing TMAA (Figure 1-1).

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.

Following the release of the 2020 GOA Draft SEIS/OEIS and completion of the Northern Edge 2021 exercise, the Navy recognized that the size and shape of the GOA TMAA (approximately 42,146 square nautical miles) no longer provides sufficient space for the realistic maneuvering of vessels and aircraft during training exercises. The GOA Study Area was revised to include the WMA, in addition to the existing TMAA. This additional space, an additional 185,806 square nautical miles, would enable Navy personnel and units to practice more realistic, complex training scenarios in a safer, more efficient manner that would better prepare them to respond to real-world incidents. The WMA would provide air, surface, and submarine forces with sufficient maneuver areas for realistic training; the TMAA allows for only a single, predictable air axis approach, which is unrealistic in current real-world scenarios.

[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.

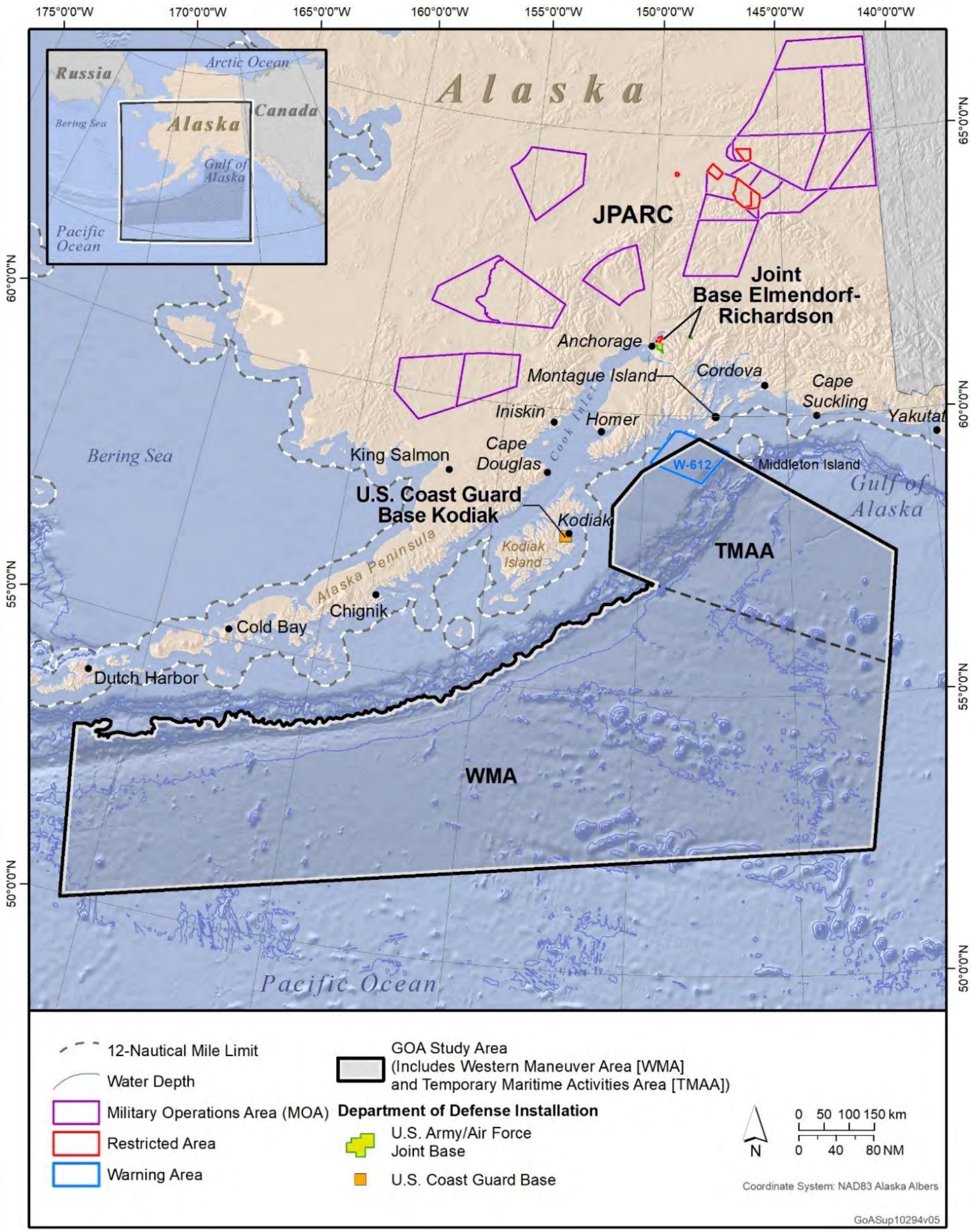

Figure 1-1: Gulf of Alaska Study Area

The addition of the WMA provides airspace for multiple air lanes and sea space for increased training complexity and maneuverability. It would also maximize airfield diverts available for aircrew safety. As currently configured, the TMAA only allows for Anchorage divert, whereas the WMA would allow for Cold Bay and King Salmon diverts. It also would improve access for commercially based assets used as Opposition Force vessels (contracted fishing vessels), historically out of Kodiak; TMAA geographic limitations require long transit to exercise areas and lost training time.

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 is seeking the reissuance of the federal regulatory incidental take authorizations under the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) to support military readiness activities within the GOA Study Area upon the expiration of the current authorizations and consultations in 2022. The Navy is consulting with NMFS to renew these authorizations.[2] The Navy completed ESA consultations with the USFWS, and the USFWS issued a Letter of Concurrence in April 2022.

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 still 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))[3]. This SEIS/OEIS identifies and evaluates new information that is applicable to the Proposed Action and its environmental impacts.

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[2] NMFS' issuance of an MMPA incidental take authorization (i.e., Letter of Authorization) is a major Federal action (NMFS' Proposed Action) and is considered a connected action under NEPA (40 CFR 1508.25), with a discrete purpose and need relative to NMFS' statutory and regulatory obligations. Consequently, NMFS has an independent responsibility to comply with NEPA. If NMFS makes the findings necessary to issue the requested authorization, NMFS will rely on the information and analyses in this document and intends to adopt this SEIS/OEIS to fulfill its NEPA obligations, and issue its own ROD, if appropriate.

[3] The associated Final SEIS/OEIS was prepared using the 1978 CEQ NEPA Regulations. NEPA reviews initiated prior to the effective date of the 2020 and 2022 CEQ regulations may be conducted using the 1978 version of the

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 (in this case 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 GOA 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 and to obtain an updated Biological Opinion/Incidental Take Statement under the ESA from NMFS for the period of April 2017 through April 2022. To support the reissuance of the MMPA authorization and Biological Opinion/Incidental Take Statement, 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.

regulations. The effective date of the 2020 CEQ NEPA Regulations was September 14, 2020, the effective date of the 2022 CEQ NEPA Regulations was May 20, 2022. This review began on February 10, 2020, and the Navy decided to proceed under the 1978 regulations.

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, in addition to the expanded study area encompassing the WMA. 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 used this analysis to support regulatory consultations and submitted requests 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 Oliver Hazard Perry Class Frigate, and their associated systems, have been replaced with the EA-18G aircraft, Littoral Combat Ship, and Constellation Class Frigate), and use of the Portable Underwater Tracking Range is no longer proposed. Consistent with the previous analysis for Alternative 1, the sinking exercise activity will not be part of the Proposed Action for this SEIS/OEIS.

While the revised GOA Study Area is larger, the type and number of training events would not change, and the majority of training (approximately 70 percent) would still occur only in the TMAA. The activities conducted in the WMA (approximately 30 percent) would be limited to vessel and aircraft training, and events associated with these activities. The exception would be non-explosive gunnery activities in the WMA. Activities using active acoustics, such as sonar, or use of explosives during training events, would not occur in the WMA.

In addition, the Navy proposes implementing a new mitigation area within the continental shelf and slope area of the TMAA, called the "Continental Shelf and Slope Mitigation Area." To protect marine species and biologically important habitat, use of explosives (up to 10,000 feet altitude) would be prohibited in this area.

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. NMFS' purpose, described in greater detail below, is to evaluate the Navy's Proposed Action pursuant to NMFS' regulatory authority under the MMPA. As stated in Section 1.1 (Introduction), this SEIS/OEIS only addresses the Navy's activities in the GOA Study Area.

The Navy is requesting 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 appropriately requesting rulemaking and the issuance of an LOA for this action.

As noted above, NMFS' purpose is to evaluate the Navy's Proposed Action pursuant to NMFS' authority under the MMPA, and to determine whether to authorize incidental take of marine mammals 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. NMFS 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. NMFS cannot issue an incidental take authorization unless it can make the required findings. The need for NMFS' 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 proposed training activities (and corresponding mitigation measures) for which the Navy is seeking authorization of the take of marine mammals. 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 if issued.

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 operations 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[4] and environmental conditions to humanitarian assistance and disaster relief efforts.[5] 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.

Training is focused on preparing for worldwide deployment. Naval forces generally deploy in specially organized units called Strike Groups. A Strike Group may be organized around one or more aircraft carriers, together with several surface combatant ships and submarines, collectively known as a Carrier Strike Group. An Expeditionary Strike Group may be organized around various amphibious warfare ships together with surface combatant ships and submarines. A naval force known as a Surface Action Group consists of three or more surface combatant ships. The Navy and Marine Corps deploy Carrier Strike Groups, Expeditionary Strike Groups, and Surface Action Groups on a continuous basis. The number and composition of Strike Groups deployed and the schedule for deployment are determined based on worldwide requirements and commitments.

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

[4] 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.
[5] Evacuation of non-combatants from American embassies under hostile conditions, as well as humanitarian assistance/disaster relief like the U.S. Naval Ship Mercy and U.S. Naval Ship Comfort coronavirus pandemic (COVID-19) response in 2020 and Hurricane Dorian relief in the Bahamas in 2019.

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 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 GOA Study Area 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 GOA Study Area meets this requirement.

The Navy also requires extensive areas of ocean to conduct its training in order to properly separate and/or 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 requires 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 The Strategic Importance of the Temporary Maritime Activities Area and the Western Maneuver Area

The TMAA (Figure 1-1) is composed of the 42,146 square nautical miles of surface and subsurface OPAREA and overlying airspace that also 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, which is 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 59° 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. Apart from the limited activities that may occur in the WMA, the only Navy training activities that currently occur outside the TMAA are aircraft flights to and from inland Air Force bases and ranges, which were addressed in the June 2013 JPARC EIS.

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 GOA 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 freshwater 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.

Since the 1990s, the Department of Defense has conducted 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 at the United States Indo-Pacific Command (USINDOPACOM) who coordinates the activities. The USINDOPACOM is a combatant command in charge of achieving U.S. national security objectives while protecting national interests. USINDOPACOM is also responsible for organizing and planning for the Northern Edge exercise. Major joint training exercise activities are planned to demonstrate and evaluate the ability of the services to jointly engage in a conflict and carry out plans in response to a threat to national security. To avoid the severe environmental conditions probable 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 Northern Edge exercises have occurred only every other year. To date the Navy has conducted five exercises under these analyses, in June 2011, June 2015, May 2017, May 2019, and May 2021.

Following the release of the 2020 GOA Draft SEIS/OEIS and completion of the Northern Edge 2021 exercise, the Navy recognized that the size and shape of the TMAA (approximately 42,146 square nautical miles) in the GOA does not provide sufficient space for the realistic maneuvering of vessels and aircraft during training exercises. To address the need for a broader area in which to maneuver during training, the GOA Study Area now includes the WMA in addition to the existing TMAA (Figure 1-1). The WMA is located south and west of the TMAA and provides an additional 185,806 square nautical miles of surface, sub-surface, and airspace in which to maneuver in support of activities occurring within the TMAA. The WMA is bounded by the following coordinates: 55° 30’N, 142° 00’W; to 52° 14’N, 142° 49’W; to 49° 55’N, 165° 38’W; to 52° 54’N, 166° 30’W; following the -4,000 isobath to 57° 01’N, 149° 18’W. The northern boundary of the WMA follows the bottom of the slope at the 4,000 meter contour line and was configured to avoid overlap and impacts on critical habitat, biologically important areas, marine mammal migration routes, and primary fishing grounds. Currently, the TMAA allows for a single, predictable air and surface axis of approach to the Study Area, which does not replicate real-world conditions or scenarios, which are unpredictable. The addition of the WMA provides airspace for multiple air lanes and sea space for increased training complexity. Airspace training in the WMA would be conducted following procedures for international flight in airspace over the high seas (U.S. Department of the Navy, 2021). Similar to the TMAA, training in the WMA is expected to continue into the reasonably foreseeable future.

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, as well as socioeconomics and environmental justice 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 or changes to 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 1-2. As was done for the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, the Navy complied with all the substantive and procedural NEPA 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*) (Appendix F, Public Participation, has 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 GOA).

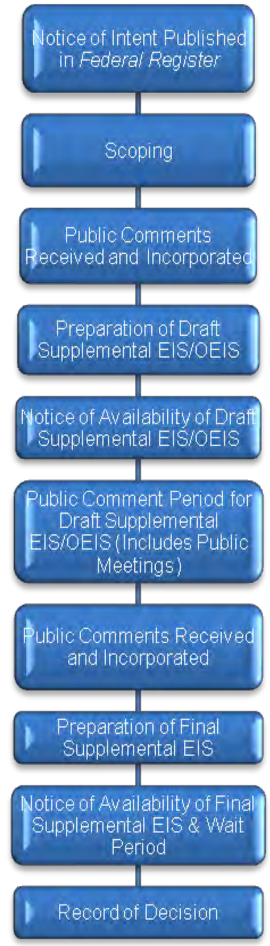

Figure 1-2: National Environmental Policy Act Process

The 2020 GOA Draft SEIS/OEIS Notice of Availability (85 Federal Register 80093) and the Notice of Virtual Public Meetings (85 Federal Register 80076) was published in the Federal Register December 11, 2020. The public was able to provide comments from December 11, 2020 to February 16, 2021 on the Draft SEIS/OEIS. The Notice of Availability for the Supplement to the Draft SEIS/OEIS was published in the *Federal Register* March 18, 2022 (87 Federal Register 15415), and the public was invited to provide comments through May 2, 2022. For each notice, advertisements were also placed in the five newspapers listed above.

The Final SEIS/OEIS addresses all public comments received on the 2020 Draft SEIS/OEIS and 2021 Supplement to the 2020 Draft SEIS/OEIS. Responses to public comments may include factual corrections, supplements, or modifications to analysis; and inclusion of new information. Additionally, responses may explain why the comments do not warrant further agency response (see Appendix G, Public Comments and Responses).

Finally, the decision maker will issue a ROD no earlier than 30 days after the Final SEIS/OEIS is made available to the public.

For a description of how the Navy complied with each of these requirements during the development of this SEIS/OEIS, please see Appendix F (Public Participation).

1.6.2 Executive Order 12114

EO 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 Study Area. The GOA Study Area 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 GOA Study Area. Additionally, the 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), and socioeconomics and environmental justice. 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 in this SEIS/OEIS. This SEIS/OEIS analyzes the impacts under two alternatives—the No Action Alternative and Alternative 1. Alternative 1 was derived from Alternative 1 in the 2016 GOA SEIS/OEIS, which was ultimately selected in the 2017 ROD (U.S. Department of the Navy, 2017). Alternative 2 from the 2016 GOA SEIS/OEIS was eliminated from consideration because including one additional Carrier Strike Group exercise during the summer months and conducting two sinking exercises goes beyond the Navy's need for training at this time and into the near future.

The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this SEIS/OEIS. NMFS is a cooperating agency pursuant to 40 CFR section 1501.6, because of its expertise and regulatory authority over marine resources. Additionally, NMFS is required to review applications and, if appropriate, issue an incidental take authorization under the MMPA.

NMFS' issuance of an MMPA incidental take authorization (i.e., Letter of Authorization) is a major Federal action (NMFS' Proposed Action) and is considered a connected action under NEPA (40 CFR 1508.25), with a discrete purpose and need relative to NMFS' statutory and regulatory obligations.

NMFS has an independent responsibility to comply with NEPA and intends, after independent review, to rely on the information and analysis in the Final SEIS/OEIS to fulfill its NEPA requirements. NMFS intends to adopt this Final SEIS/OEIS and issue a ROD if appropriate.

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

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 GOA. 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 August 6, 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

Final 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 to continue ongoing military training activities in the Gulf of Alaska (GOA). The National Marine Fisheries Service's (NMFS') Proposed Action is to issue regulations and a 7-year Letter of Authorization under the Marine Mammal Protection Act (MMPA), that would authorize Level A and Level B take of certain marine mammals incidental to the use of sonar and other transducers and explosives. This analysis is a supplement to the 2011 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/OEIS (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), as well as the addition of the Western Maneuver Area (WMA), collectively referred to as the GOA Study Area. The GOA Study Area 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 GOA Study Area.

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). This SEIS/OEIS only analyzes activities occurring within the GOA Study Area. Information on the JPARC can be found in the Environmental Impact Statement for the Modernization and Enhancement of Ranges, Airspace, and Training Areas in the Joint Pacific Alaska Range Complex in Alaska (U.S. Department of Army & Air Force, 2013).

2.1.1 Gulf of Alaska Temporary Maritime Activities Area

The TMAA is depicted in Figure 2-1 and is described in Section 2.1.1 (Gulf of Alaska Temporary Maritime Activities Area) of the 2011 GOA Final EIS/OEIS. The Navy has added a mitigation area to the TMAA, referred to as the "Continental Shelf and Slope Mitigation Area." The Navy is proposing to expand its mitigation for explosives and would prohibit the use of explosives from the sea surface up to 10,000 feet altitude during training over the entire continental shelf and slope out to the 4,000 meter (m) depth contour of the TMAA. The TMAA is located entirely in international waters and is 12 nautical miles (NM) or greater from land. A full description of the TMAA is provided in Section 1.5 (Overview and Strategic Importance of the Temporary Maritime Activities Area and Western Maneuver Area) of this SEIS/OEIS.

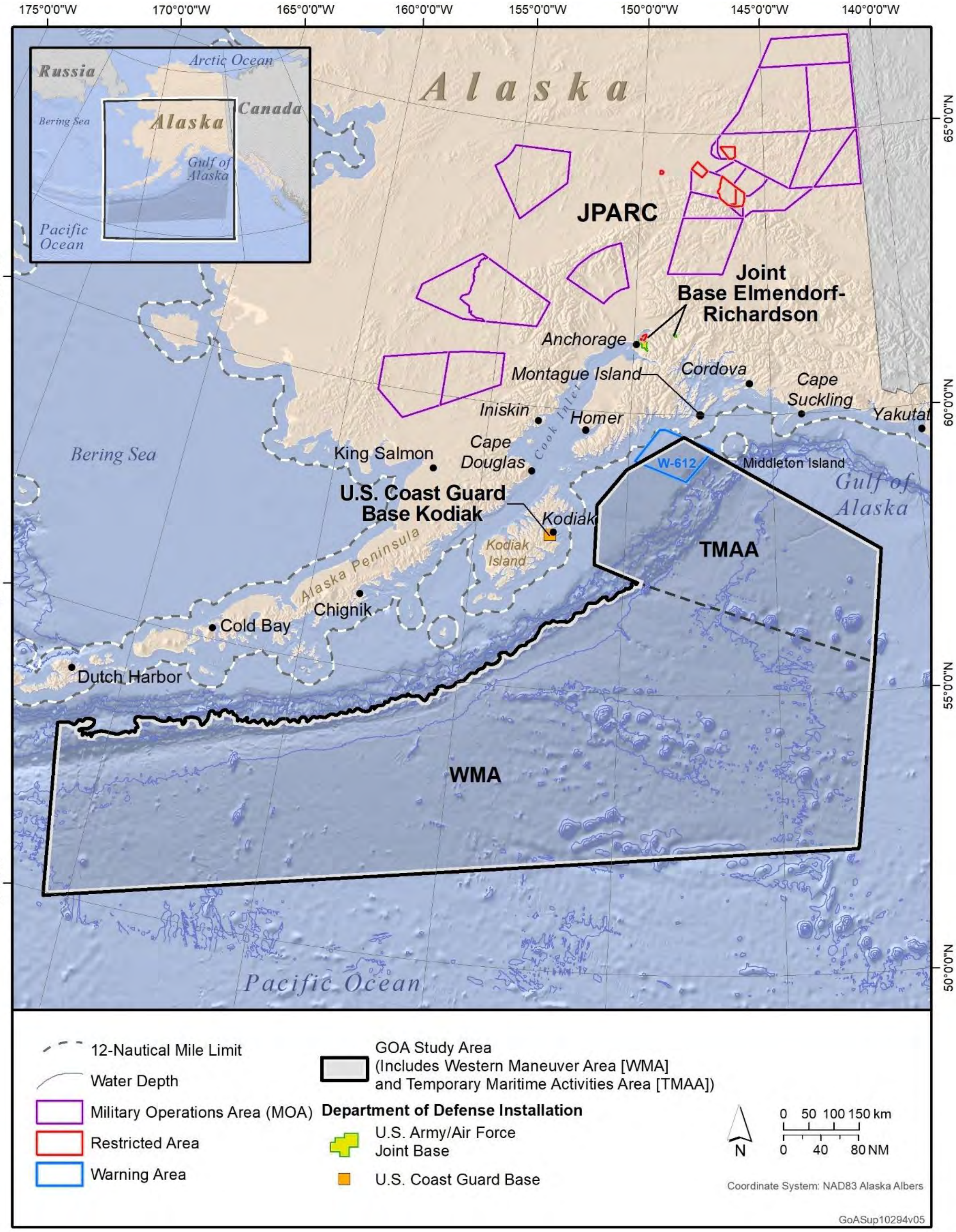

Figure 2-1: Gulf of Alaska Study Area

2.1.2 Western Maneuver Area

The 2020 Draft GOA SEIS/OEIS only analyzed activities occurring within the TMAA, a component of the JPARC. To address the need for a broader area in which to maneuver during training and to accomplish more realistic training, the GOA Study Area now includes the WMA in addition to the existing TMAA (Figure 2-1). The WMA is located south and west of the TMAA and provides an additional 185,806 square nautical miles of surface, sub-surface, and airspace in which to maneuver in support of activities occurring within the TMAA. The WMA is bounded by the following coordinates: 55° 30'N, 142° 00'W; to 52° 14'N, 142° 49'W; to 49° 55'N, 165° 38'W; to 52° 54'N, 166° 30'W; following the -4,000 m isobath to 57° 01'N, 149° 18'W. The northern boundary of the WMA follows the bottom of the slope at the 4,000 m depth contour, and was configured to avoid overlap and impacts to critical habitat, biologically important areas, marine mammal migration routes, and primary fishing grounds. Currently, the TMAA allows for a single, predictable air and surface axis of approach to the Study Area, which does not replicate real-world conditions and/or scenarios which are unpredictable. The addition of the WMA provides access to more controlled airspace for multiple air lanes and sea space for increased training complexity. Airspace training in the WMA would be conducted following procedures for international flight in airspace over the high seas (U.S. Department of the Navy, 2021). Training in the WMA is expected to continue into the reasonably foreseeable future.

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.

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 training through radar search, detection, identification, and engagement of airborne threats. Surface ships conduct air warfare training 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 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 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 over land in air training ranges that are outside of the GOA Study Area as identified in the Environmental Impact Statement for the Modernization and Enhancement of Ranges, Airspace, and Training Areas in the Joint Pacific Alaska Range Complex in Alaska (U.S. Department of Army & Air Force, 2013), 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.

2.3 Proposed Activities

Training activities proposed by the Navy in this SEIS/OEIS are identified in Table 2-2 and Table 2-3 at the end of this chapter. These tables list the current name of the activity and a brief description of the 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 Oliver Hazard Perry Class Frigate, and their associated systems, have been replaced with the EA-18G aircraft, Littoral Combat Ship, and Constellation Class Frigate), and use of the Portable Underwater Tracking Range (PUTR) is no longer proposed. Consistent with the previous analysis for Alternative 1, the sinking exercise activity will not be part of the Proposed Action for this SEIS/OEIS.

While the revised GOA Study Area is larger than the area analyzed in the 2020 GOA Draft SEIS/OEIS, no new or increased levels of training activities would occur, and no increases in vessel numbers, underway steaming hours, or aircraft events would occur. The majority of training would still occur in the TMAA, approximately 70 percent, and approximately 30 percent would occur in the WMA. The activities conducted in the WMA would be limited to vessel and aircraft training, and several events associated with these activities. The exception would be non-explosive gunnery activities in the WMA. Activities using active acoustics or explosives would not occur in the WMA. They would continue to occur in the TMAA. Training activities proposed to occur in the WMA include Air Combat Maneuver, Air Defense Exercise, Maritime Security Operations, Sea Surface Control, Electronic Warfare Exercise, Surface-to-Surface Gunnery Exercise (non-explosive practice munitions only), and Deck Landing Qualification (Table 2-2).

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, standard operating procedures benefit environmental and cultural resources (some of which have high socioeconomic value in the GOA Study Area). 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

U.S. Indo-Pacific Command (USINDOPACOM) determines exercise dates and locations within the Study Area based on a number of factors, to include weather conditions, effectiveness of training, availability of forces, deployment schedules, maintenance periods, other exercise schedules within the Pacific region, as well as important environmental considerations. Airspace and sea space deconfliction allows for the necessary separation of multiple military units to prevent interference with equipment sensors and to avoid interaction with established commercial air traffic routes, commercial shipping lanes, and non-military use of the Study Area (e.g., Alaska Native tribal, recreational, and commercial fishing). These factors are considered to ensure the safety of military personnel, the public, commercial aircraft, commercial and recreational vessels, and military assets. Military aircraft fly in accordance with

Federal Aviation Administration Regulations (Part 91, General Operating and Flight Rules, Annex 2 Rules of the Air to the Convention of International Civil Aviation), or with due regard for the safety of all air traffic, 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 (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 remains on the surface or on the seafloor. 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.

2.3.2.3 Vessel Lighting

Addressed in Chief of Naval Operations Instruction 3120.32D, the "Darken Ship Bill" requires darkened ships to ensure that white lights are not visible from outside the ship. This standard operating procedure reduces the potential for light attraction to vessels by seabirds.

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. Chapter 5 (Mitigation) of this SEIS/OEIS provides a full description of each mitigation measure that would be implemented under Alternative 1. It also presents a discussion of how the Navy developed and assessed each measure and includes a map of the marine species habitats that overlap the mitigation areas. The Navy has updated Chapter 5 (Mitigation) in its entirety based on its ongoing analysis of the best available science and practicality of implementing potential mitigation measures. Under the Proposed Action, the Navy ROD will document all mitigation measures the Navy will implement and the NMFS ROD, MMPA Regulations and Letter of Authorization, Endangered Species Act (ESA) Biological Opinion, and other consultation documents will include the mitigation measures applicable to the resources for which the Navy has consulted.

Mitigation measures 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 2-1.

Table 2-1: 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 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 Continental Shelf and Slope Mitigation Area Temporary Maritime Activities Area

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. However, for this SEIS/OEIS, the Navy has added a newly developed mitigation area, known as the Continental Shelf and Slope Mitigation Area (Figure 2-2), that represents a substantial increase in mitigation over what was included in the 2016 GOA Final SEIS/OEIS. Previously, the Navy restricted explosive use within Portlock Bank (see Figure 5-2 in Section 5.4, Geographic Mitigation to be Implemented, of this SEIS/OEIS), and from June 1 to September 30 within the North Pacific Right Whale Mitigation Area. As described in the 2020 GOA Draft SEIS/OEIS, these previous restrictions were designed to avoid or reduce potential impacts on North Pacific right whales, fishery resources, and other marine species that inhabit the highly productive waters of these areas. Mitigation within the new Continental Shelf and Slope Mitigation Area would prohibit explosive detonations below 10,000 ft. altitude (including at the water surface) over the entire continental shelf and slope out to the 4,000-meter (m) depth contour within the TMAA. As described in Section 5.4.2.2 (Continental Shelf and Slope Mitigation Area), the new mitigation area overlaps important fishery habitats, North Pacific right whale feeding habitat, gray whale migration habitat, NMFS-designated critical habitat for humpback whale feeding, migration, maturation, and foraging habitat for juvenile, immature, or maturing adult salmonids (Chinook salmon, coho, chum, green sturgeon, sockeye, and steelhead), and foraging habitat for ESA-listed short-tailed albatross. The Navy will continue to restrict the use of surface ship hull-mounted mid-frequency (MF1) active sonar from June 1 to September 30 within the North Pacific Right Whale Mitigation Area.

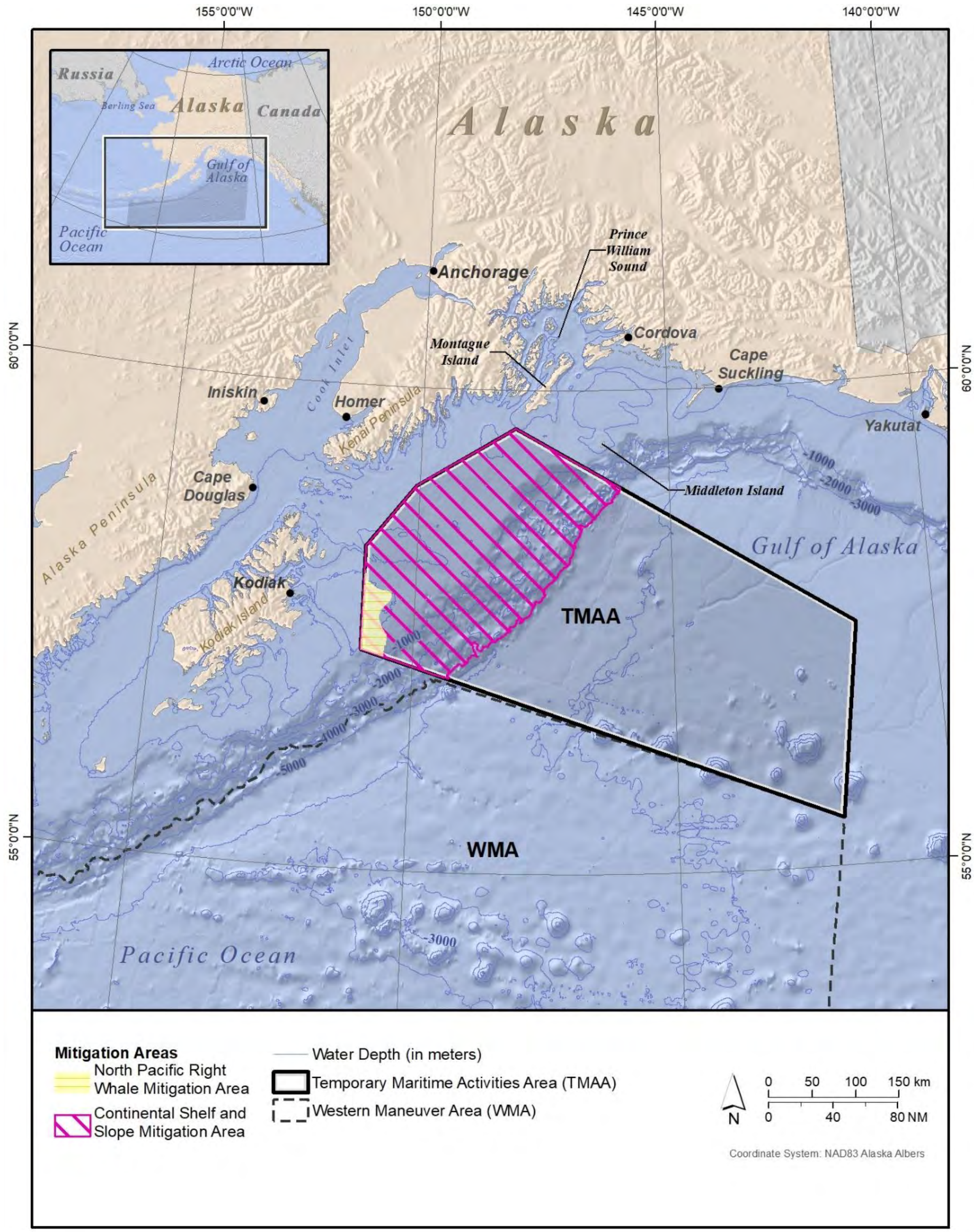

Figure 2-2: Mitigation Areas

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 (CEQ) 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). CEQ 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 program managers and scientists. However, there was only one action alternative that met both met the purpose and need and was practical and feasible to implement.

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, and they were eliminated from further analysis.

2.5.1 Alternative 2 from 2011 GOA Final EIS/OEIS

As described in Section 2.6 (Alternative 2 - Increase Training Activities, Accommodate Force Structure Changes, Conduct One Additional Annual Exercise, and Conduct One SINKEX During Each Summertime Exercise) from the 2011 GOA SEIS/OEIS, Alternative 2 was eliminated from consideration in this SEIS/OEIS because including one additional Carrier Strike Group exercise during the summer months and conducting two sinking exercises goes beyond the Navy's need for training at this time and into the near future. 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 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, characteristics, and cold-water 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.

2.5.3 Reduced Training

As described in Section 2.3.2.2 (Reduced Training) in the 2011 GOA Final EIS/OEIS, a cessation or reduction 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.

2.5.4 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.

2.5.5 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 actual 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.

2.5.6 Training Without the Use of Active Sonar

In order to be proficient in detecting and countering 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 the 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.

2.5.7 Alternatives Including Geographic Mitigation Measures Within the Study Area

The Navy considered, but did not develop, an alternative based solely on geographic mitigation. Developing such an alternative would mean that geographic or temporal restrictions would be included for one action alternative but not for others. Such a framework would not meet the Navy's purpose and need for the reasons described below and outlined in Chapter 1 (Purpose and Need).

NEPA regulations allow agencies to "Include appropriate mitigation measures not already included in the Proposed Action or alternatives" (40 CFR section 1502.14[f]). The Navy defines its Proposed Action and alternatives prior to conducting its environmental analyses. As a general approach, the Navy develops mitigation outside of (i.e., after) the alternatives development framework, and mitigation is designed to be implemented under all action alternatives carried forward. This approach allows the Navy to refine and tailor its mitigation measures based on the findings of its environmental analyses, potential benefits to marine resources, suggestions received through public comments during scoping and on the Draft SEIS/OEIS, consultations with environmental regulatory agencies, and operational practicality assessments. The Navy carries over applicable existing mitigation measures developed during previous EIS/OEIS projects and develops new mitigation as appropriate. For the GOA SEIS/OEIS, the Navy developed the new Continental Shelf and Slope Mitigation Area, which represents a substantial increase in geographic mitigation over what was carried over from the previous GOA EIS/OEIS projects.

As described in Section 5.2 (Mitigation Development Process), the Navy conducts extensive biological effectiveness and operational practicality assessments of all potential mitigations. Navy Senior Leadership reviews and approves all mitigations included in a Draft or Final SEIS/OEIS. Therefore, if the Navy were to create a geographic mitigation alternative, all mitigations included in that alternative would have been verified as effective and practical, and approved by Navy Senior Leadership prior to publication of the Draft EIS/OEIS. From an MMPA compliance standpoint, NMFS would consequently require the Navy to implement those mitigations that benefit marine mammals under all action alternatives (i.e., not only the mitigation alternative) in order to meet the least practicable adverse impact standard. In other words, approved and effective mitigation would be implemented regardless of its association with an alternative; therefore, basing an alternative solely on geographic mitigation would not be reasonable. Overall, the Navy's mitigation development process ensures that it includes the maximum level of mitigation that is practical to implement under the Proposed Action.

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. Navy policy defines the "baseline" composition of deployable naval forces. The baseline is intended as an adaptable structure to be tailored to meet specific requirements. Thus, while the baseline composition of a CSG calls for a specified number of ships, aviation assets, and other forces, a given CSG may include more or fewer units, depending on their mission. The typical baseline naval force structures established by Navy policy for a CSG are as follows: one Aircraft Carrier; one Carrier Air Wing consisting of four Strike Fighter squadrons, one Electronic Combat squadron, one tactical airborne early warning squadron, two Combat Helicopter squadrons, and two logistics aircraft; five Surface Combatant Ships where "Surface Combatant" refers to guided missile cruisers, destroyers, frigates, and Littoral Combat Ship platforms; one attack submarine; and one logistic support ship.

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 and, as described earlier, the use of the PUTR is no longer proposed.

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 CEQ 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 section 1502.14). CEQ guidance identifies two approaches in developing the No Action Alternative (46 Federal Register 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 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 better illustrates the projected environmental impacts of the

Proposed Action and further supports NMFS' regulatory process by presenting the scenario where no authorization 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 Study Area. Consequently, the No Action Alternative of not conducting the proposed live, at-sea training activities in the GOA Study Area 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 take authorization 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 Study Area.

Cessation of proposed Navy at-sea training activities would not meet the purpose and need and 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, less the requirement to use the PUTR. While the revised GOA Study Area is larger than the area analyzed in the 2020 GOA Draft SEIS/OEIS, no new or increased levels of training activities would occur, and no increases in vessel numbers, underway steaming hours, or aircraft events would occur. 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 Study Area, a Status Quo Alternative would allow the Navy to meet current and future training requirements necessary to achieve and maintain fleet readiness.

While the revised GOA Study Area is larger than the area analyzed in the 2020 GOA Draft SEIS/OEIS, no new or increased levels of training activities would occur, and no increases in vessel numbers, underway steaming hours, or aircraft events would occur. The majority of training would still occur in the TMAA, approximately 70 percent in the TMAA and 30 percent in the WMA. The activities conducted in the WMA would be limited to vessel movements and aircraft training, and several events associated with these movements. The exception would be non-explosive gunnery activities in the WMA. Activities using active acoustics or explosives would not occur in the WMA. They would continue to occur in the TMAA. Training activities proposed to occur in the WMA include Air Combat Maneuver, Air Defense Exercise, Maritime Security Operations, Sea Surface Control, Electronic Warfare Exercise, Surface-to-Surface Gunnery Exercise (non-explosive practice munitions only), and Deck Landing Qualification (Table 2-2).

Table 2-2: Training Activities Proposed to Occur in the Western Maneuver Area

Activity Name	Activity Description
Air Warfare	
Air Combat Maneuver	Fixed-wing aircrews aggressively maneuver against threat aircraft to gain a tactical advantage.
Air Defense Exercise	Aircrew and ship crews conduct defensive measures against threat aircraft or simulated missiles.
Surface Warfare	
Maritime Security Operations	Vessels and aircraft conduct a suite of maritime security operations at sea, including maritime interdiction operations, force protection, and anti-piracy operations.
Sea Surface Control	Aircraft, unmanned aerial systems, ships, and submarines use all available sensors to collect data on threat vessels.
Surface-to-Surface Gunnery Exercise (Non-Explosive Practice Munitions)	Surface ship crews fire non-explosive small-caliber, medium-caliber, or large-caliber guns at surface targets.
Electronic Warfare	
Electronic Warfare Exercise	Aircraft and surface ship crews control portions of the electromagnetic spectrum used by enemy systems.
Other Training Activities	
Deck Landing Qualification	Ship's personnel launch and recover helicopters to achieve qualifications and certifications.

Table 2-3 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 Oliver Hazard Perry Class Frigate, and their associated systems, have been replaced with the EA-18G aircraft, Littoral Combat Ship, and Constellation Class Frigate), and use of the PUTR is no longer proposed. The table describes the activities in terms of the activity name and the number of annual events. The quantity of ordnance and expendables (i.e., items not recovered during training) 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 in the TMAA, are presented in Appendix A (Navy Activities Descriptions) of this SEIS/OEIS.

Table 2-3: Current and Proposed Training Activities Within the GOA Study Area[1]

Range Activity	*No. of events[2] (annual)*	
	Alternative 1 (2016 Final SEIS/OEIS)	*Alternative 1 (Proposed)*
Air Warfare		
Aircraft Combat Maneuver	300 sorties[3]	300 sorties[3]
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		
Maritime Security Operations[4]	26 events	26 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
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
Electronic Warfare Exercise	5 events	5 events
Naval Special Warfare		
Special Warfare Operations	10 events	10 events
Strike Warfare		
Air-to-Ground Bombing Exercise[2]	150 sorties[3]	150 sorties[3]
Personnel Recovery[2]	4 events	4 events
Support Operations		
Deck Landing Qualification	6 events	6 events

[1]The majority of training would occur only in the TMAA (approximately 70 percent in the TMAA and 30 percent in the WMA). The use of sonar or explosives would only occur in the TMAA.
[2]This SEIS/OEIS covers the launch and recovery of aircraft from vessels in the GOA Study Area. 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.
[3]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.
[4]Maritime Security Operations was previously two separate activities: Visit, Board, Search, and Seizure; and Maritime Interdiction. The two activities have been combined in this SEIS/OEIS to align with current Navy naming conventions.

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3 Affected Environment and Environmental Consequences

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Final Supplemental 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, in addition to expanding the Study Area to include the Western Maneuver Area (WMA), 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, 2020b), 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 GOA Study Area (the Temporary Maritime Activities Area [TMAA] and Western Maneuver Area [WMA]) as well as the analysis of resources potentially impacted by the Proposed Action described in Chapter 2 (Description of Proposed Action and Alternatives). The GOA Study Area is described in Section 2.1.1 (Gulf of Alaska Temporary Maritime Activities Area) and 2.1.2 (Western Maneuver Area) and depicted in Figure 2-1 (Gulf of Alaska Study Area).

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.
- Describe any changes to existing resource conditions from the 2020 Draft GOA SEIS/OEIS with the addition of the WMA and Continental Shelf and Slope Mitigation Area.
    - Determine if a proposed activity needs to be analyzed based the addition of the WMA and Continental Shelf and Slope Mitigation Area.
    - Determine if the affected environment changed.
    - Determine if there is a new method of analysis for the GOA Study Area.
- Identify resource sections for analysis within the 2022 Supplement to the 2020 Draft GOA SEIS/OEIS.
    - Analyze resource-specific impacts for individual stressors.
    - Examine potential population-level impacts.

Although the size of the Study Area would increase with the addition of the WMA, the number and type of proposed training activities remains the same as in the 2020 GOA Draft SEIS/OEIS. Only limited training activities and the maneuvering of vessels and aircraft would occur in the WMA (see Table 2-3). Approximately 70 percent of training would still occur in the TMAA and 30 percent would occur in the WMA. No training activities involving the use of active sonar or explosives would occur in the WMA. In the WMA, gunnery training events would only use non-explosive practice munitions.

[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.

Physical disturbance and strike is a stressor carried forward for analysis for marine mammals due to ship maneuvering activities in the WMA; detailed analysis of the impacts from other stressors already analyzed for marine mammals in the TMAA is not warranted within the WMA and is discussed in detail in Section 3.8. Detailed analysis of the impacts from the stressors already analyzed for fishes, sea turtles, and birds in the TMAA is not warranted within the WMA and is discussed in detail in Sections 3.6, 3.7, and 3.9.

Updates to the baseline environment, termed the affected environment, were included in respective resource sections if new species, habitats, or socioeconomic or environmental justice resources were found to occur in the WMA.

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 parts 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 GOA from 2009 to 2022. 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 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, behind only the National Oceanic and Atmospheric Administration Fisheries and National Science Foundation (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 fishes 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 acoustics in water and explosives at or near the surface of the water during training and testing 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 Acoustic 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) which can be found on the SEIS/OEIS project website at goaeis.com.

3.0.1.1.2.1 Physical Environment Data

Physical environment data plays an important role in acoustic propagation of underwater sound sources used in the impact modeling process. Physical environment parameters that influence propagation modeling include bathymetry, seafloor composition/sediment type, wind speed, and sound speed profiles. Because acoustic activities rely heavily on the accuracy of propagation loss estimates, the Navy has invested heavily in measuring and modeling relevant environmental parameters. The results of this effort are databases that comprise part of the Oceanographic and Atmospheric Master Library. Historical data are used to define a typical environmental state given a specific season and region for propagation analysis. Additional information regarding use of physical environment data for acoustic propagation in the modeling process is available 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).

3.0.1.1.2.2 Marine Mammal and Sea Turtle Data

Marine mammal and sea turtle data input to the Navy Acoustic Effects Model include densities (discussed in Section 3.0.1.1.2.3, Marine Species Density Database), group size, depth distribution, and guild and stock breakouts. In the Navy Acoustic Effects Model, marine species are represented as "animats," which function as a dosimeter and record acoustic energy from all active underwater sources during a simulation. Since many marine mammals are known to travel and feed in groups, species-specific group sizes are incorporated into animat distributions. Species-specific group sizes are estimated using literature review, survey data, and density data; uncertainty of group size estimates are statistically represented by the standard deviation. The Navy Acoustic Effects Model accounts for depth distributions by changing each animat's depth during the simulation process according to the typical depth pattern observed for each species. Depth distribution information was collected by literature review and is presented as a percentage of time the animal typically spends within various depth bins in the water column. In some cases, sighting data used in the density database are ambiguous regarding species classification, and a density can only be reported as a group of similar species, or "guilds." The proportion of each species within each guild is estimated based on sightings, where species could be determined. Based on these proportions, predicted impacts on guilds are separated out to the species level. Similarly, species are divided into multiple stocks based on life history and genetic stock structure for management purposes. For some stocks there is enough survey information to support stock-specific density models. In these cases, a density layer for the stock is provided and is modeled independently of other stocks. In other cases, predicted impacts were assigned by stock, as opposed to the species as a whole. Additional information regarding utilization of marine mammal and sea turtle data is available 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).

3.0.1.1.2.3 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 survey effort and data analysis. NMFS 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, and effort involved in providing survey coverage to sufficiently estimate density. 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, 2020b), hereafter referred to as the Density Technical Report, which can be found on the SEIS/OEIS website at goaeis.com. 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., average sea surface temperature, seafloor depth). Such models are 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, 2020b). 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.

3.0.1.1.2.4 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. 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. 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) which can be found on the SEIS/OEIS website at goaeis.com, 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 fishes 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).

3.0.1.1.2.5 The Navy Acoustic Effects Model and Quantitative Analysis

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; each animat records its individual sound "dose." The distribution of animats in the Navy Acoustic Effects Model starts with the extraction of species density estimates from the density database for a given area and month. In order to incorporate statistical uncertainty surrounding density estimates into the Navy Acoustic Effects Model, 30 distributions were produced for each species for each season, each of which varied according to the standard deviations provided with the density estimates.

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 that could be affected.

All explosive munitions such as bombs that detonate in the TMAA actually occur in-air above the water, upon impact with above-water targets, or upon impact with the water surface. However, for this analysis, sources detonating at or near (within 10 meters [m]) the surface are modeled as if detonating completely underwater at a depth of 0.1 m. This modeling overestimates the amount of explosive and acoustic energy entering the water.

The model estimates the impacts caused by individual training and testing 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 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 or sea turtles 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).

Impact ranges to effects from sonar and other transducers were calculated for permanent threshold shift (PTS) for an exposure of 30 seconds since that was estimated to be the maximum amount of time a marine mammal would realistically be exposed to levels that could cause the onset of PTS. Since ranges to PTS are relatively short, 30 seconds allows an animal enough time at a nominal swim speed of 1.5 m per second to avoid higher sound levels. Due to lower acoustic thresholds for temporary threshold shift (TTS) versus PTS, ranges to TTS are longer. Range to effects for explosives were estimated by modeling the distance that noise from a source would need to propagate to reach exposure level thresholds (e.g., behavioral response, TTS, PTS, and non-auditory injury) for a specific marine species hearing group. For some sources, ranges were modeled with varying source depth and cluster size (i.e., number of explosions). Modeled ranges for non-auditory injury considered varying propagation conditions, animal mass, and explosive bin (i.e., net explosive weight). For representative animal masses and explosive bins, the larger of the range to slight lung injury or gastrointestinal tract injury was used as a conservative estimate. Animals within water volumes encompassing the estimated range to non-auditory injury 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. A detailed explanation of the Navy Acoustic Effects Model and 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).

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, TTS, PTS, non-auditory injury, and mortality. 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.

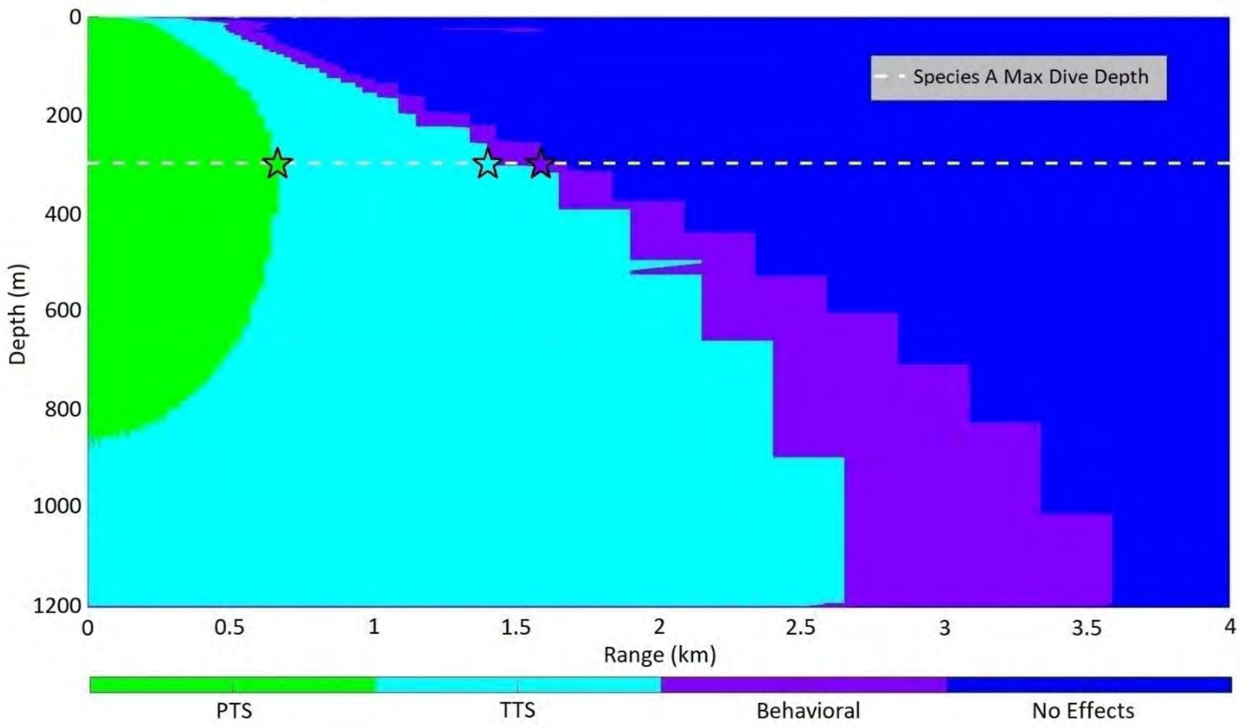

Figure 3.0-1: Hypothetical Range to Effects Example

3.0.1.1.3 Accounting for Mitigation

3.0.1.1.3.1 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 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. The Navy Acoustic Effects Model estimated zero PTS takes for sea turtles in the TMAA. Therefore, mitigation for active sonar is discussed qualitatively, but was not factored into the quantitative analysis for sea turtles under Alternative 1. The impact analysis quantifies the potential for mitigation to reduce the risk of PTS for marine mammals. 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 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.

3.0.1.1.3.2 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 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 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).

3.0.1.1.4 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, 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***	***2022 Final SEIS/OEIS Section #***	***2022 Final 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 GOA Study Area 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 Oliver Hazard Perry Class Frigate, and their associated systems, have been replaced with the EA-18G aircraft, Littoral Combat Ship, and Constellation Class Frigate) used as part of the proposed activities, but those changes would not affect the analysis or change the conclusions reached in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. One change, the elimination of the Portable Underwater Tracking Range, would result in reduced bottom disturbance and entanglement hazards, and restrictions for fishermen. 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 2011 GOA Final EIS/OEIS and 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 under Alternative 1 of the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a), for which a ROD was issued in 2017 (U.S. Department of the Navy, 2017c). No new activities are being proposed in this SEIS/OEIS that would affect air quality in the GOA Study Area. Finally, there is no new information, science, or regulations that would change the analysis or conclusions that were reached in the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a).
- 3.2 Sediments and Water Quality – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action under Alternative 1 of the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a), for which a ROD was issued in 2017 (U.S. Department of the Navy, 2017c). 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 GOA Study Area. Finally, there is no new information, science, or regulations that would change the analysis or conclusions that were reached in the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a).
- 3.3 Marine Habitats – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action under Alternative 1 of the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a), for which a ROD was issued in 2017 (U.S. Department of the Navy, 2017c). No new activities are being proposed in this SEIS/OEIS that would affect marine habitats in the GOA Study Area. Finally, there is no new information, science, or regulations that would change the analysis or conclusions.
- 3.4 Marine Vegetation – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action under Alternative 1 of the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a), for which a ROD was issued in 2017 (U.S. Department of the Navy, 2017c). No new activities are being proposed in this SEIS/OEIS that would affect marine vegetation in the GOA Study Area. Finally, there is no new information, science, or regulations that would change the analysis or conclusions.
- 3.5 Marine Invertebrates – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action under Alternative 1 of the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a), for which a ROD was issued in 2017 (U.S. Department of the Navy, 2017c). No new activities are being proposed in this SEIS/OEIS that would affect marine invertebrates in the GOA Study Area. Finally, there is no new information, science, or regulations that would change the analysis or conclusions.
- 3.10 Cultural Resources – The Proposed Action in this SEIS/OEIS is consistent with the Proposed Action from the 2020 GOA Draft SEIS/OEIS (U.S. Department of the Navy, 2020a) and in Alternative 1 of the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a), for which a ROD was issued in 2017 (U.S. Department of the Navy, 2017c)and the existing baseline

conditions have not changed appreciably. After consultations with Alaska Native tribes from the Kodiak and Kenai Peninsula region and the Alaska State Historic Preservation Officer (see Appendix E, Correspondence), 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. Based on tribal input, the mitigation area for Portlock Bank has been expanded with the proposed Continental Shelf and Slope Mitigation Area. There are still no relevant subsistence uses of marine mammals implicated by this action. None of the training activities in the GOA 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 under Alternative 1 of the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016a), for which a ROD was issued in 2017 (U.S. Department of the Navy, 2017c). No new activities are being proposed in this SEIS/OEIS that would affect public health and safety in the GOA Study Area. Finally, there is no new information, science, or regulations that would change the analysis or conclusions.

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 the annual harvest from commercial fisheries.

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.

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.

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

2011 GOA Final EIS/OEIS	*Updated Stressor List*	*2020 GOA Draft SEIS/OEIS*	*2022 GOA Final SEIS/OEIS*	
			TMAA[1]	**WMA**
Vessel Movements	Vessel Noise	Not reanalyzed	Not reanalyzed	Analyzed
	Vessel Strike	Not reanalyzed	Not reanalyzed	Analyzed
Aircraft Overflights	Aircraft Noise	Not reanalyzed	Not reanalyzed	Analyzed
	Aircraft and Aerial Target Strike (Birds)	Not reanalyzed	Not reanalyzed	Analyzed
Explosive Ordnance	In-Air Explosions	Reanalyzed for Birds	N/A	N/A
	Explosions at or Near the Surface	Reanalyzed for all biological resources	N/A	N/A
Sonar	Sonar and Other Active Acoustic Sources	Reanalyzed for all biological resources	Not reanalyzed	N/A
Weapons Firing Disturbance	Weapons Noise	Not reanalyzed	Not reanalyzed	Analyzed[2]
Expended Materials	Physical Disturbance and Strike	Not reanalyzed	Not reanalyzed	Analyzed
	Entanglement	Not reanalyzed	Not reanalyzed	Analyzed
	Ingestion	Not reanalyzed	Not reanalyzed	Analyzed

[1]No explosives at or near the surface up to 10,000 feet in the Continental Shelf and Slope Mitigation Area.
[2]Non-explosive practice munitions during gunnery exercises only.

3.0.4.1 Acoustic Sources

A major component of noise in the ocean are human-generated noise other than Navy training activities (see Duarte et al. (2021) for a review summary in that regard); however, 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 the accuracy 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. Sonar and other transducers are only used in the TMAA portion of the GOA Study Area.

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 for which the source would be used. Unless stated otherwise, a reference distance of 1 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 (SPL):
  - 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

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)**
Mid-Frequency (MF) Tactical and non-tactical sources that produce signals from 1 to 10 kHz (continued)	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%	H	0	14
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 and the WMA. 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 and the WMA 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 GOA Study Area, the conclusions of the studies are relevant to vessel noise in the TMAA and the WMA. 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 and the WMA, 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 and the WMA from established airfields on land. The majority of aircraft noise would be generated at air stations, which are outside the TMAA and the WMA. Takeoffs and landings occur at established airfields as well as on vessels at sea across the TMAA and the WMA. 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 and the vessel is constantly moving while conducting flight operations. 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 the WMA 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, 2016b)). 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 145 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 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 $\mu Pa^2 s$)[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 $\mu Pa^2 s$ = 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 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, or in Air Traffic Control Assigned Airspace and in overlying airspace where U.S. military aircraft and missile and projectile firings operate with due regard for the safety of all air and surface traffic. 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). Explosives are only used in the TMAA portion of the GOA Study Area that is seaward of the 4,000 m depth contour.

There are no fully underwater explosives proposed for use in the TMAA. All explosives used during the proposed activities would detonate at or above the water’s surface. The Navy Acoustic Effects Model cannot account for the highly non-linear effects of cavitation and surface blow off for shallow underwater explosions, nor can it estimate the explosive energy entering the water from a low-altitude detonation. Therefore, in order to estimate possible marine species exposures to explosive energy, the Navy's modeling conservatively considers all detonations occurring within 33 ft. (10 m) above the water's surface, as if the detonation occurred as a point source located 0.1 m underwater (U.S. Department of the Navy, 2018). The Navy model for underwater impacts assumes that all acoustic energy from the detonation remains underwater with all energy reflected into the water rather than released into the air. As a result of these conservative modeling assumptions, the modeling will tend to overestimate potential effects to marine species.

Navy activities in the TMAA involve explosions occurring at or near the surface and are herein considered for the potential to result in noise impacts on marine species underwater. 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 at or Near the Surface

Explosive detonations at or near the surface of the water during training activities include bombs and naval gun shells. For purposes of the analysis for explosives at or near the surface, 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. All of the explosive bins proposed for use in the TMAA (Table 3.0-8) meet this criteria and were modeled to occur at a depth of 0.1 m. This approach overestimates the potential underwater impacts due to low-altitude and surface explosives by assuming that all explosive energy is released and remains under the water surface. 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.

The Navy has expanded its mitigation for explosives detonated at or near the surface in an area called the Continental Shelf and Slope Mitigation Area. The mitigation area extends over the entire continental shelf and slope out to the 4,000 m depth contour. The Navy would not detonate explosives below 10,000 ft. altitude (including at the water surface) in this area to protect marine species and important habitats. Additional information is presented in Chapter 5 (Mitigation) of this SEIS/OEIS.

In order to better organize and facilitate the analysis of Navy training activities using explosives that detonate at 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 Sources). Explosives detonated in water or near the water surface are binned by net explosive weight.

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 that Detonate at or Near the Water Surface During Training in the Temporary Maritime Activities Area

Explosives (Source Class and Net Explosive Weight) (lb.)*	Number of Explosives with the Proposed Action (Annually)	Representative Underwater Detonation Depth[1]
E5 (> 5–10 lb. NEW)	56	0.3 ft. (0.1 m)
E9 (> 100–250 lb. NEW)	64	0.3 ft. (0.1 m)
E10 (> 250–500 lb. NEW)	6	0.3 ft. (0.1 m)
E12 (> 650–1,000 lb. NEW)	2	0.3 ft. (0.1 m)

*All the E5, E9, E10, and E12 explosives would occur in-air, at or above the surface of the water, and would also occur offshore away from the continental shelf and slope.

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

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.

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
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 large caliber projectiles used during Navy training activities do not contain high explosives.
Notes: AMRAAM = Advanced Medium-Range Air-to-Air Missile, HE-ET = High Explosive-Electronic Time, lb. = pound(s), ft. = foot/feet.

Projectiles and bombs 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.

3.0.4.3 Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities

Marine species in and around the TMAA may potentially be impacted by exposures to 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 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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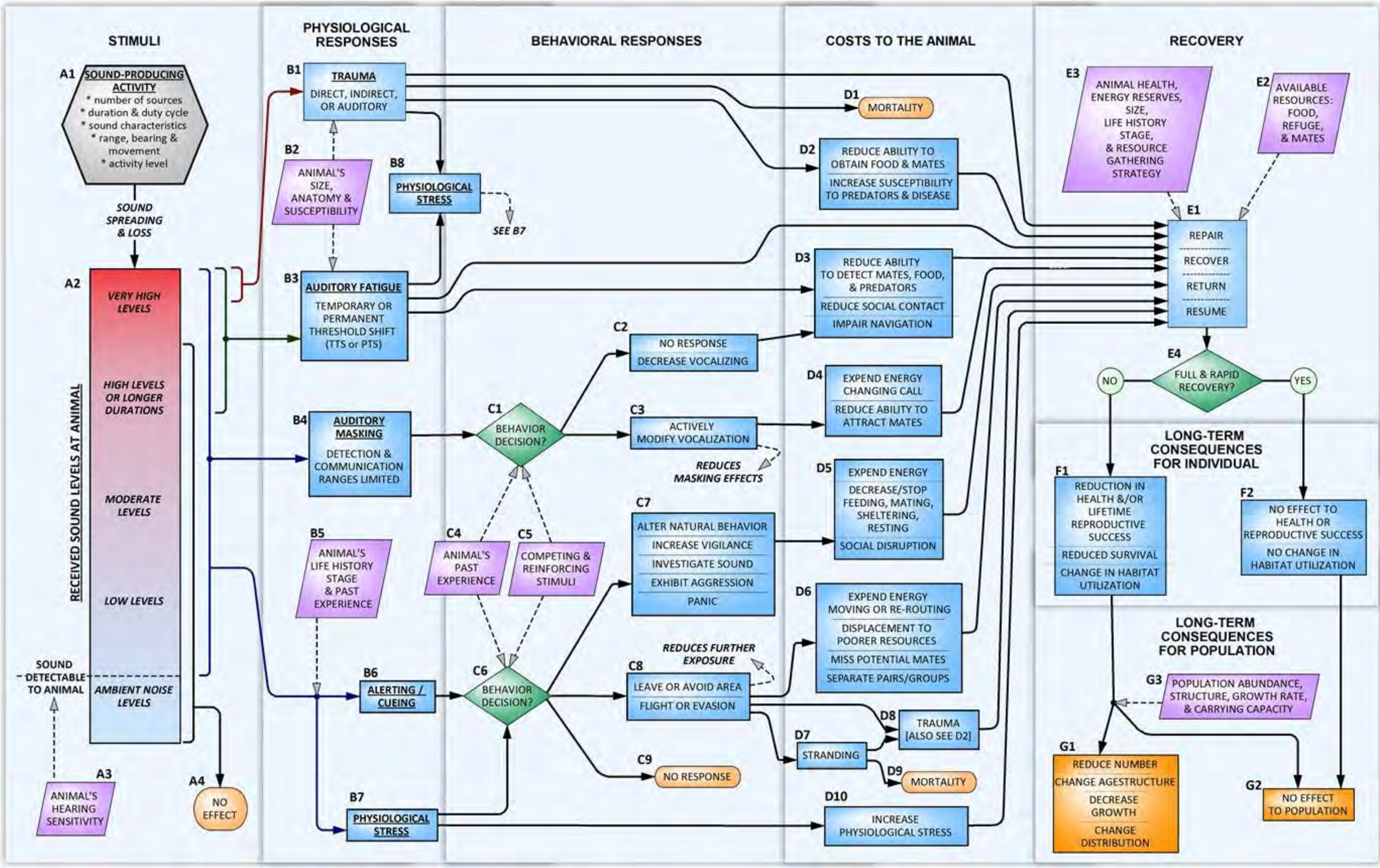

Figure 3.0-3: Flow Chart of the Evaluation Process of Sound-Producing Activities

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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 always involves tissue damage 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 on 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.

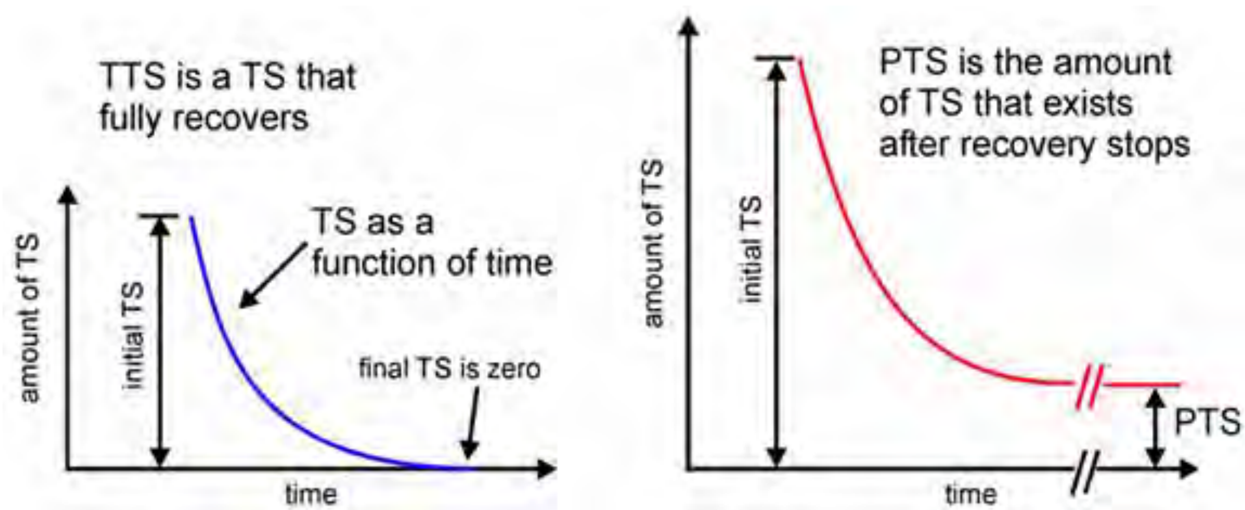

Figure 3.0-4: Two Hypothetical Threshold Shifts

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, but it may reduce the biological relevancy or recognizability of transmitted signals such as mating calls.

If masking impairs an animal's ability to effectively transmit or 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 (e.g., 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). For social/schooling species a stress response may be elicited by observing behavior of other individuals rather than directly detecting a sound.

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 lipids 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 or lead to premature physiological degradation and early mortality.

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 from 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 behavioral 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 behavioral 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 minimizing 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 other 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 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 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

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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 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 Oliver Hazard Perry Class Frigate, and their associated systems, have been replaced with the EA-18G aircraft, Littoral Combat Ship, and Constellation Class Frigate), and use of the Portable Underwater Tracking Range (PUTR) is no longer proposed. 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 analyses, the National Marine Fisheries Service (NMFS) is a cooperating agency with the Navy for this supplemental analysis, specifically where it relates to fishes and other marine resources under that agency's regulatory purview.

The purpose of this SEIS/OEIS section is to provide any new or changed information since the 2016 GOA Final SEIS/OEIS that are relevant to the analysis of potential impacts on fishes associated with the Proposed Action in the GOA Study Area, beyond May 2022. This section analyzes proposed Navy training activities in the GOA Study Area and incorporates the analysis of impacts from the 2022 Supplement to this SEIS/OEIS (U.S. Department of the Navy, 2022). prepared to address proposed activities occurring in the Navy's Western Maneuver Area (WMA) and the Continental Shelf and Slope Mitigation Area. Collectively, the Temporary Maritime Activities Area (TMAA) and the WMA are referred to as the GOA Study Area or Study Area throughout this section. The current NMFS (2017) Biological Opinion for Navy training activities in the TMAA was effective from April 26, 2017, through April 26, 2022. The Navy consulted with NMFS as required by section 7(a)(2) under the Endangered Species Act (ESA) to evaluate effects from future Navy training activities in the entire GOA Study Area. On April 2, 2021, Navy requested section 7 consultation with NMFS; on March 2, 2022 the Navy submitted an Addendum to include proposed activities in the WMA. NMFS plans on issuing a Biological Opinion in the fall of 2022.

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 GOA Study Area 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 continuous reviews of the best available science, recent GOA fish research studies, 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. Information on groundfish and other commercially important fish species are presented in Section 3.11.1.1.2 (Commercial and Recreational Fishing).

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. Fish species present in the WMA would be the same as those in the TMAA. The GOA Study Area supports two primary categories of fishes: anadromous salmonids (genus *Oncorhynchus*; hereafter referred to as salmonids) and groundfishes. Pacific salmonids found within the northeastern portion of the GOA 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 GOA 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 GOA Study Area. Further, a discussion of the 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 GOA Study Area. 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 GOA Study Area 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 nautical miles (NM) from the northern point of the TMAA portion of the GOA Study Area, the nearest shoreline (Kenai Peninsula) is located approximately 24 NM north of the GOA Study Area'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 portion of the GOA Study Area were described in the 2011 GOA Final EIS/OEIS. Habitat types in the WMA portion of the Study Area would be like those previously described for the offshore portion of the TMAA.

3.6.2.1 General Background

3.6.2.1.1 Endangered Species Act-Listed Species in the Gulf of Alaska Study Area

Many ESA-listed fish species (including various salmonids and green sturgeon) from the U.S. West Coast may occur within the GOA Study Area. 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 NMFS (2016a). 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 GOA Study Area during certain periods of their life cycle. Salmon and steelhead that originate from Alaskan rivers may be present in the GOA Study Area, 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 GOA, they were not identified to a DPS so it is unclear whether they were part of the ESA-listed Southern DPS. Based on their migration patterns, it is possible that ESA-listed green sturgeon could be present within the on-shelf portion of the GOA Study Area. 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 May 20, 2020. Based on the results of these five-year reviews, NMFS will make the requisite determinations under the ESA.

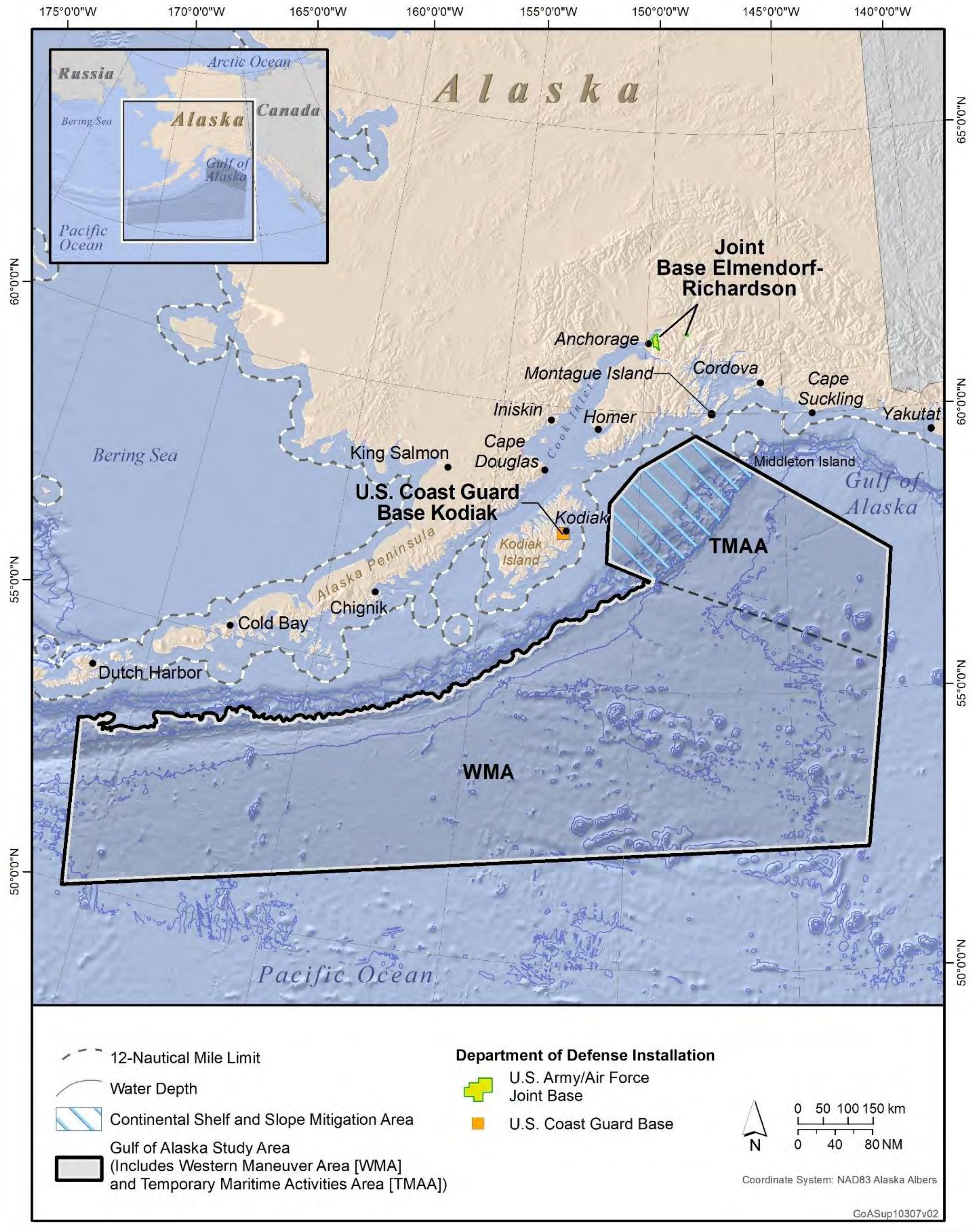


Figure 3.6-1: Gulf of Alaska Study Area

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

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

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

Species and Regulatory Status				*Presence in the GOA Study Area*	
Common Name (Scientific Name)	***Distinct Population Segment (DPS)/ Evolutionarily Significant Unit (ESU)***	***Federal Status***	***Critical Habitat Designation***	***Documented Presence in the GOA Study Area[1] (TMAA/WMA)***	***Likelihood of Presence in the GOA Study Area***
	Southern Oregon/Northern California Coasts ESU	T	Designated (Not in GOA Study Area)	-/-	Potential
	Central California Coast ESU	E	Designated (Not in GOA Study Area)	-/-	Potential
Chum Salmon (*Oncorhynchus keta*)	Hood Canal Summer-run ESU	T	Designated (Not in GOA Study Area)	-/-	Likely
	Columbia River ESU	T	Designated (Not in GOA Study Area)	-/-	Likely
Sockeye Salmon (*Oncorhynchus nerka*)	Snake River ESU	E	Designated (Not in GOA Study Area)	-/-	Likely
	Ozette Lake ESU	T	Designated (Not in GOA Study Area)	-/-	Likely
Steelhead (*Oncorhynchus mykiss*)	Puget Sound DPS	T	Designated (Not in GOA Study Area)	TMAA/-	Likely
	Upper Columbia River DPS	T	Designated (Not in GOA Study Area)	TMAA/-	Likely
	Middle Columbia River DPS	T	Designated (Not in GOA Study Area)	TMAA/-	Likely
	Lower Columbia River DPS	T	Designated (Not in GOA Study Area)	TMAA/-	Likely
	Snake River Basin DPS	T	Designated (Not in GOA Study Area)	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 Gulf of Alaska Study Area (continued)

Species and Regulatory Status				*Presence in the GOA Study Area*	
Common Name (Scientific Name)	***Distinct Population Segment (DPS)/ Evolutionarily Significant Unit (ESU)***	***Federal Status***	***Critical Habitat Designation***	***Documented Presence in the GOA Study Area[1] (TMAA/WMA)***	***Likelihood of Presence in the GOA Study Area***
	Upper Willamette River DPS	T	Designated (Not in GOA Study Area)	TMAA/-	Likely
	Northern California DPS	T	Designated (Not in GOA Study Area)	-/-	Potential
	California Central Valley DPS	T	Designated (Not in GOA Study Area)	-/-	Potential
	Central California Coast DPS	T	Designated (Not in GOA Study Area)	TMAA/-	Potential
	South-Central California Coast DPS	T	Designated (Not in GOA Study Area)	-/-	Potential
	Southern California DPS	E	Designated (Not in GOA Study Area)	-/-	Unlikely
Green Sturgeon (*Acipenser medirostris*)	Southern DPS[2]	T	Designated (Not in GOA Study Area)	-/-	Potential

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

3.6.2.1.2 Endangered Species Act-Listed Species Unlikely to be Present in the Gulf of Alaska Study 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 GOA Study Area. 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 GOA. 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 GOA, coded wire tag (CWT) data reviewed by Hayes et al. (2011) indicates that a few steelhead originating from California systems have been found in this region, and may occur in the GOA Study Area. The northwestern limit of the known ocean range of California Chinook salmon (Sacramento River) was established by a CWT salmon recovery in the GOA near Kodiak Island in 1984 (Myers et al., 1999). Thus, there is potential for ESA-listed fish from Washington south to Central California to occur in the GOA Study Area.

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 lateral line, which consists of a series of receptors along the body, and the inner ear, which functions similarly to the inner ear in other vertebrates (Popper et al., 2019; Popper & Schilt, 2008; Schulz-Mirbach et al., 2020). 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 bony fishes contain three dense otoliths (i.e., small calcareous bodies, although some fishes may have more) 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 pressures or very close to a sound source. The inner ears 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, increase sensitivity and allow for high-frequency hearing capabilities and better sound pressure detection (e.g., Vetter & Sisneros, 2020).

Although many researchers have investigated hearing and vocalizations in fish species (Ladich & Fay, 2013; Popper et al., 2014), 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 estimated 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 continues to help clarify how various anatomical features interact within the auditory system and influence 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 (e.g., codfishes) and can only detect sounds below 1 kHz while 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; Mickle & Higgs, 2021). 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 GOA Study Area include a number of salmonid ESUs/DPSs as well as green sturgeon (see Table 3.6-1 for details). Each ESA-listed species is classified into a specific hearing group described above based on available data from similar or surrogate fishes and knowledge of that fishes' anatomy and physiology. As discussed above, most marine fishes investigated to date lack hearing capabilities greater than 1,000 Hz. Notably, this includes salmonid species and green sturgeon, fishes with a swim bladder that is not involved in hearing. Although it is assumed that salmonids and green sturgeon 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). For example, Atlantic salmon (*Salmo salar*) have only been tested to detect up to 580 Hz and likely have similar hearing capabilities to other salmonids due to their close evolutionary relationship and similarities in the structure of the ears (Hawkins & Johnstone, 1978; Popper et al., 2007). Therefore, salmonids may only be able to detect lower frequencies and have a lower hearing sensitivity compared to fishes in the same hearing group. Available data suggest species without a swim bladder can detect sounds from 20 to 1,000 Hz, with best sensitivity at lower ranges (Casper et al., 2003; Casper & Mann, 2006; Casper & Mann, 2009; Myrberg, 2001). This data is largely derived from studies conducted using cartilaginous fishes, such as sharks and rays. 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 of fishes vocalize during courtship or 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).

Combined research methods that utilize 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, allow for specific behaviors to be paired with those sounds, identify sex specific vocalizations, and may be useful in determining more approximate estimates of the total number of soniferous (e.g., sound producing) fishes in a given habitat (Bussmann, 2020; Parmentier et al., 2021; 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 GOA 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 GOA 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 GOA 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 GOA (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 GOA 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

GOA (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 GOA that provide high-energy nutrition to pollock and salmon.

The Blob has also significantly reduced the Pacific cod (*Gadus microcephalus*) population in the GOA 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 GOA (Alaska Ocean Acidification Network, 2019; Johnson, 2016). Extensive shell dissolution has been documented in pteropods in both the GOA 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 GOA 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 Alaskan waters; both species 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, 2018). However, salmonids that use the GOA 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 of their biomass is accumulated in the marine environment (Irvine & Fukuwaka, 2011). Some stocks may expand their distribution 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 GOA, 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 GOA, which promote northward movement towards the cooler and more productive Alaskan continental shelf. With temperatures rising in the GOA 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 GOA 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 GOA 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 the GOA waters. These fisheries include the following: groundfish fisheries managed by NMFS under the FMP for Groundfish of the GOA (North Pacific Fishery Management Council, 2020a); salmon fisheries under the FMP for the Salmon Fisheries in the Exclusive Economic Zone (EEZ) off Alaska(North Pacific Fishery Management Council et al., 2021); 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 GOA. State fisheries do not operate in the GOA Study Area 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 GOA Study Area and are known to incidentally capture ESA-listed salmonids (Balsiger, 2019, 2021; 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. NMFS (2017) 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 GOA Study Area.

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 meters (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., 2021). 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 et al., 2018). In general, the early life history stages of fish are more susceptible to oil pollution than juveniles or adults (North Pacific Fishery Management Council et al., 2018).

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 actions may be warranted and plans to conduct status reviews of both Chinook salmon ESUs. Based on the best scientific and commercial data available, including the ESU configuration report, NMFS determined that listing the Oregon Coast and Southern Oregon and Northern California Coastal spring-run Chinook salmon populations as threatened or endangered ESUs was not warranted (86 FR 45970).

3.6.2.2.2 Distribution

Chinook salmon distribution in marine waters varies seasonally and inter-annually due to a variety of environmental factors (North Pacific Fishery Management Council et al., 2021). However, there are general migration and ocean distribution patterns characteristic of populations in specific geographic areas (North Pacific Fishery Management Council et al., 2021). 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 (Balsiger, 2021; North Pacific Fishery Management Council et al., 2021; Quinn & Myers, 2005; Sharma, 2009). As such, southern stocks (south of Cape Blanco) are less likely to use habitats in the GOA than northern stocks. However, as described in Section 3.6.2.7 (Site-Specific Information on Endangered Species Act-Listed Salmonids in the Gulf of Alaska Study Area), juveniles from southern ESUs have been documented in the GOA, so it is possible that some individuals from southern populations could migrate into the Study Area.

Listed spring-run Chinook salmon from northern West Coast ESUs that originate from the Columbia River Basin are more likely to migrate into the GOA Study Area than other listed Chinook salmon (Balsiger, 2021; Quinn, 2018; Sharma, 2009).

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, 2009). 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 GOA 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 GOA, though they are distributed more widely throughout the GOA than juveniles (Echave et al., 2012; National Marine Fisheries Service, 2017). Most mature adults in the GOA 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 GOA Study Area), 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.

Instead of an even distribution in the GOA waters, Chinook salmon tend to be much more associated with on-shelf habitats than other Pacific salmonids, such as chum, sockeye, and pink salmon. Echave et al. (2012) found that 95 percent of sampled juvenile Chinook salmon distribution occurred within shallower (18–447 m) waters. Similarly, recent juvenile salmon trawl studies found that juvenile Chinook salmon occurred infrequently in offshore GOA waters. In a juvenile salmonid trawl survey that included 52 trawl sets at 49 on-shelf and off-shelf locations within the GOA, juvenile Chinook salmon were only captured at two nearshore survey locations (Somov et al., 2020). Although the survey methods may have been better suited for more surface-oriented juvenile salmonids, Pakhomov et al. (2019) only captured three juvenile Chinook at 58 GOA juvenile salmonid trawl locations.

Recent pop-up satellite archival tag studies by Seitz and Courtney (2022) lend further support to the distribution summaries of Echave et al. (2012) and NMFS (2017), that large, immature Chinook salmon are not broadly distributed throughout the GOA, but instead prefer on-shelf habitats.

Chinook salmon do not concentrate at the surface, as do other Pacific salmon, but are most abundant at depths of 30–70 m (North Pacific Fishery Management Council et al., 2021). 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). However, preliminary evidence from the 2019 GOA Expedition suggests that adult salmonids may congregate in schools during the winter months (Beamish & Riddell, 2020).

Site-specific presence of ESA-listed Chinook salmon ESUs in the GOA, including CWT recoveries, is described in Section 3.6.2.7 (Site-Specific Information on Endangered Species Act-Listed Salmonids in the Gulf of Alaska Study Area). With the exception of 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 GOA Study Area.

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.

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

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) (North Pacific Fishery Management Council et al., 2021).
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 et al., 2021; 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).

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

Common Name (Scientific Name)	*Temporal Patterns*	*Horizontal Distribution*	*Vertical Distribution*
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).
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 GOA.	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 GOA but migrate in the southern portions of the GOA Study Area 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),
Sources: (Echave et al., 2012);(North Pacific Fishery Management Council et al., 2021); (National Marine Fisheries Service, 2017) unless specified otherwise

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 GOA, 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., 2021). Morris et al. (2007) found that juvenile coho from the lower Columbia River and coastal Oregon were recovered in or near the GOA Study Area. 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., 2021; Orsi & Wertheimer, 1995).

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 GOA, though only a small number of CWT recoveries were observed.

Within the GOA, 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 GOA is described in Section 3.6.2.7 (Site-Specific Information on Endangered Species Act-Listed Salmonids in the Gulf of Alaska Study 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 GOA, 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 GOA (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 GOA.

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 trawl sets between 0 and 60 m in depth in coastal British Columbia showed that 85.7 percent of sockeye salmon were captured in the top 15 m (Beamish et al., 2007b). 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 Pacific salmon (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 GOA 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 GOA 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). Seitz and Courtney (2021b) found tagged steelhead mainly occupied continental shelf and slope habitats, including Bureau of Ocean Energy Outer Continental Shelf planning areas throughout the GOA, the Aleutian Islands, and the Bering Sea. In addition, steelhead kelts had directed, surface-oriented, and extensive westerly migrations that followed prevailing currents from the GOA to the waters near the Aleutian Islands and into the Bering Sea.

Site-specific presence of ESA-listed steelhead DPSs in the GOA is described in Section 3.6.2.7 (Site-Specific Information on Endangered Species Act-Listed Salmonids in the Gulf of Alaska Study 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 Study Area

Salmon Bycatch in the Groundfish Fishery

Fishermen participating in fisheries off Alaska sometimes incidentally catch and discard fish they do not want, cannot sell, or are not allowed to keep (National Marine Fisheries Service, 2022). These non-target fish are collectively known as bycatch.

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 non-listed 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 GOA, 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 GOA 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, 2020b). Over the past six years, non-Chinook bycatch in the GOA 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 GOA 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 GOA 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 GOA (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 GOA, 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 GOA 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, 2020b).

In 2012, NMFS implemented Amendment 93 to the GOA Groundfish FMP, which required retention of salmon bycatch 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 GOA (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 GOA/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 GOA 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 GOA (Guthrie III et al., 2020).

Two primary factors dictate the observed trends in genetic stock composition of trawl fishery bycatch in the GOA. 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 GOA, 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 GOA groundfish fishery to include ESA-listed fish (Balsiger, 2021; 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 GOA (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 GOA Study Area, the data will be biased toward those areas where these groundfish fisheries occur, thus providing an incomplete representation of salmonid occurrence in the TMAA.

Balsiger (2021) found most of the Chinook salmon represented by Coded Wire Tags (CWTs) and harvested in the GOA originated from hatchery production and that wild stocks of Chinook salmon are under-represented by CWTs, especially outside of Alaskan production. CWT Chinook salmon recovered as bycatch in the GOA are comprised of stocks originating from Alaska, British Columbia, Washington, Idaho, and Oregon (Balsiger, 2021). In addition, Chinook salmon tagged in Alaska and harvested in the GOA have historically originated from Cook Inlet and Southeast Alaska, with most CWT Alaska Chinook salmon originating from Southeast Alaska.

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 et al., 2021). 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 GOA.

As expected, most of the CWT recoveries in the GOA 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 (Balsiger, 2021). Relatively high abundances of Snake River spring/summer-run Chinook have also been detected in U.S. research surveys (Table 3.6-3). Though predominantly detected in Washington and Oregon coastal waters, a small number of CWT Snake River fall-run Chinook have also been captured in the GOA. It was not surprising to find a few coho migrating through the GOA, as they tend to utilize offshore areas during their marine residence.

Although chum and sockeye ESUs were not identified in the GOA bycatch summaries (likely due to few CWT fish), it is likely that some fish from these listed ESUs may be present in the GOA 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 GOA. There were no apparent differences in distribution in the GOA between coastal and interior stocks of steelhead.

Although Oregon and Washington steelhead are well represented in the GOA, 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 GOA (Burgner et al., 1992; Masuda, 2019). The only presumed California steelhead presence in the GOA was based on archival tags (using water temperature data), which determined that Scott Creek kelts (from the Central California Coast DPS) migrated into the GOA (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 GOA. 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 GOA and the TMAA is very low.

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

Species	ESU/DPS	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	(Balsiger, 2021; Masuda, 2019)
			Juvenile	1	NMFS research surveys	1996–2017	(Balsiger, 2021; Masuda, 2019)
	Upper Columbia River Spring-run ESU	E	Adult	1	Groundfish fisheries	1981–2018	(Balsiger, 2021; Masuda, 2019)
				1	Rockfish trawl fishery	2013–2018	(Balsiger, 2021; Masuda, 2019)
			Juvenile	27	NMFS research surveys	1996–2017	(Balsiger, 2021; Masuda, 2019)
	Lower Columbia River ESU	T	Adult	38	Groundfish fisheries	1981–2018	(Balsiger, 2021; Masuda, 2019)
				2	Rockfish trawl fishery	2013–2018	(Balsiger, 2021; Masuda, 2019)
			Juvenile	11	NMFS research surveys	1996–2017	(Balsiger, 2021; Masuda, 2019)
	Snake River Spring/Summer-run ESU	T	Adult	1	Groundfish fisheries	1981–2018	(Balsiger, 2021; Masuda, 2019)
				2	Rockfish trawl fishery	1981–2018	(Balsiger, 2021; Masuda, 2019)
			Juvenile	41	NMFS research surveys	1996–2017	(Balsiger, 2021; Masuda, 2019)
	Snake River Fall-run ESU	T	Adult	7	Groundfish fisheries	1981–2018	(Balsiger, 2021; Masuda, 2019)
				6	Rockfish trawl fishery	2013–2018	(Balsiger, 2021; Masuda, 2019)
			Juvenile	6	NMFS research surveys	1996–2017	(Balsiger, 2021; Masuda, 2019)
	Upper Willamette River ESU	T	Adult	200	Groundfish fisheries	1981–2018	(Balsiger, 2021; Masuda, 2019)
				28	NMFS research surveys	1996–2017	(Balsiger, 2021; Masuda, 2019)
			Juvenile	8	Rockfish trawl fishery	2013–2018	(Balsiger, 2021; 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 Gulf of Alaska (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	(Balsiger, 2021; 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

2019 International GOA Expedition

Scientists estimate that one-third of all Pacific salmon overwinter in the GOA (Beamish & Riddell, 2020). 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 GOA (Beamish & Riddell, 2020; 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 (Beamish & Riddell, 2020; 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 Southeast 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 GOA 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 GOA, 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 squid 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 GOA, including the southern portion of the GOA Study Area (Hunt, 2019). This is the first documented occurrence of *Chrysaora* in the GOA, 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 GOA Study Area and provides baseline information on salmonid stock presence and relative abundance within deep water offshore habitats similar to those found in the GOA Study Area.

In March 2020, researchers continued their study on the winter ecology of Pacific salmon by returning to the GOA for a second expedition (Beamish & Riddell, 2020; Somov et al., 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 and found similar catches by species and total abundances of salmon as in 2019 (Beamish & Riddell, 2020; Somov et al., 2020). In 2020, two-thirds of salmon individuals were captured in just two highly productive sets in the south central survey area (Somov et al., 2020). Surveys are planned to continue in 2021 and 2022 throughout the entire North Pacific Ocean

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, 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 GOA 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 GOA. 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 GOA.

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 GOA. The central GOA region encompassed the shelf portion of the GOA Study Area. 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 GOA than the eastern GOA. 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 GOA, 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 GOA into Prince William Sound during the fall and spring, suggesting that fish spawning in the Sound migrate out into the GOA. As part of the GOA 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 GOA (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 GOA Study Area. 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 GOA.

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 GOA (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 and Bering Sea. 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 and no portion of the WMA 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 GOA 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 GOA Study Area.

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 GOA, Bering Sea, and Aleutian archipelago is uncommon for North American green sturgeon.

In 2019, the Northwest Fisheries Science Center (NWFSC) initiated a study to characterize the distribution of salmonids within the Northwest Training and Testing area by deploying 107 stationary acoustic receivers in a grid pattern along the Washington coast to detect tagged fish (Smith & Huff, 2019, 2020, 2021, 2022). Concurrent with the ongoing NWFSC study, in 2020, the Washington Department of Fish and Wildlife (WDFW) initiated a green sturgeon tagging study. In total, 110 green sturgeon were implanted with acoustic transmitters in 2020 and 2021 (Heironimus et al., 2022). These studies were conducted in support of the U.S. Navy's Annual Marine Species Monitoring Reports for the Pacific. The acoustic receiver array detected 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) throughout much of the year. However, in August and September, green sturgeon were less abundant in nearshore coastal waters as they aggregated in large numbers in estuarine habitats (Heironimus et al., 2022). By October these fish began to move back into coastal waters. 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 coastal habitats.

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 GOA. 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 GOA 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 GOA Study Area 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 GOA 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 GOA Study Area), which may provide more suitable green sturgeon habitat.

Although GOA 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 GOA), 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 GOA Study Area within untrawlable areas so they are not detected by research surveys or as groundfish bycatch. Green sturgeon may also migrate through the GOA to access Alaska Peninsula and Bering Sea habitats. Since green sturgeon have been documented as far north as Graves Harbor (in the eastern GOA) (73 FR 52300), it is possible that Southern DPS fish could be present in the GOA and the onshelf portion of the GOA Study Area. However, it is more likely that any green sturgeon in the GOA 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 GOA continental shelf (<200 m deep), these areas represent a very small portion of the GOA Study Area (Huff et al., 2020). Thus, the probability that listed Southern DPS green sturgeon would be present in the GOA Study Area 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 GOA.

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 North Pacific Fishery Management Council (NPFMC) is responsible for Alaskan fishery issues and has prepared and implemented FMPs for fisheries off Alaska, including fisheries within the GOA Study Area. Three applicable FMPs encompass regional fisheries for certain species, including:

- Fishery Management Plan for Groundfish of the Gulf of Alaska (North Pacific Fishery Management Council, 2020a);
- Fishery Management Plan for Salmon Fisheries in the EEZ off Alaska (North Pacific Fishery Management Council et al., 2021); and
- Fishery Management Plan for the Scallop Fishery off Alaska (North Pacific Fishery Management Council, 2014).

Within each of the FMPs, the NPFMC designated EFH for each of the managed species included in the management unit by life stage, when sufficient information was available. The NPFMC classified EFH for each managed groundfish and scallop species in terms of five basic life stages: (1) eggs, (2) larvae, (3) early juvenile, (4) late juvenile, and (5) adult. Eggs are those individuals that have been spawned, but not hatched and are completely dependent on the egg's yolk for nutrition. Early juveniles are individuals that have hatched and can capture prey, while late juveniles are those individuals that are not sexually mature but possess fully formed organ systems that are similar to adults. Adults are sexually mature individuals. Due to their anadromous life history, the NPFMC modified the life stages for salmon to include: (1) freshwater eggs, (2) freshwater larvae/juveniles, (3) estuarine juveniles, (4) marine juveniles, (5) marine immature/maturing adults, and (6) freshwater adults.

The information available for almost all species is primarily broad geographic distributions based on specific samples from surveys and fisheries, which have not been linked with habitat characteristics. Furthermore, the NPFMC's ability to precisely define the habitat (and its location) of each life stage of each managed species in terms of its oceanographic (temperature, salinity, nutrient, current), trophic (presence of food, absence of predators), and physical (depth, substrate, latitude, longitude) characteristics is limited. Consequently, the information included in the habitat descriptions for each species and life stage is restricted primarily to their position in the water column (e.g., demersal, pelagic), broad biogeographic and bathymetric areas (e.g., 100–200 meter zones), and references to known bottom type associations. As a result of insufficient information, not all species in a FMP have designated EFH descriptions.

The FMPs and associated Amendments describing seasonal and year-round locations of designated EFH for the managed fisheries, Alaska EFH species shapefiles, and supporting information were taken from National Oceanic and Atmospheric Administration (NOAA) Fisheries' *Essential Fish Habitat (EFH) in Alaska* web page (https://www.fisheries.noaa.gov/alaska/habitat-conservation/essential-fish-habitat-efh-alaska). EFH in the GOA Study Area is described in the corresponding FMPs for life stages of species/species complexes of groundfish and various life stages of Pacific salmon. As the Proposed Action does not overlap with freshwater or estuarine habitats, the descriptions of EFH below are limited to the marine life stages of protected species that overlap with the GOA Study Area. EFH descriptions were presented in the 2011 GOA Final EIS/OEIS and updated in the 2016 GOA Final SEIS/OEIS. Although the Groundfish and Salmon FMPs have been updated since the 2016 GOA Final SEIS/OEIS was issued, the analyses previously presented remains valid. Information on shellfish (invertebrate) fisheries, such as the scallop fishery in the GOA Study Area, are presented in Section 3.11 (Socioeconomic Resources and Environmental Justice). Designated information levels for each life stage that occurs within the GOA Study Area are provided for groundfish in Table 3.6-4 and for salmon in Table 3.6-5. Overlap of groundfish and salmon EFH with the GOA Study Area is presented in Figure 3.6-2 and Figure 3.6-3, respectively. There is no groundfish overlap (Figure 3.6-2) and minimal overlap for salmon EFH (Figure 3.6-3) with the GOA Study Area. Note that each figure presents all species and life stages combined.

Table 3.6-4: Essential Fish Habitat Information Levels Currently Available for GOA Groundfish, by Life History Stage

Groundfish FMP Species	Eggs	Larvae	Early Juveniles	Late Juveniles	Adults
Alaska plaice	1	1	2	2	2
Arrowtooth flounder	1	1	1	2	2
Atka mackerel	1	x	x	1	1
Blackspotted/Rougheye rockfish	1	x	x	1	1
Dover sole	1	1	x	2	2
Dusky rockfish	1	x	x	1	1
Flathead sole	1	1	2	2	2
Forage fish complex	x	x	x	x	x
Grenadiers	x	x	x	x	x
Northern rockfish	1	x	x	2	2
Northern rock sole	1	1	2	2	2
Octopuses	x	x	x	x	2
Other rockfish (sharpchin/harlequin)	1	x	x	1	1
Pacific cod	x	1	2	2	2
Pacific Ocean perch	1	x	x	1	1
Rex sole	1	1	x	2	2
Sablefish	x	1	1	2	2
Sharks	x	x	x	x	x
Sculpins	x	x	na	x	2
Shortraker rockfish	1	x	x	2	2
Skates	1	x	1	2	2
Southern rock sole	1	1	1	2	2
Squids	x	x	x	1	1
Thornyhead rockfish (shortspine and longspine)	x	x	2	2	2
Walleye pollock	1	1	2	2	2
Yelloweye rockfish	1	x	x	1	1
Yellowfin sole	1	1	2	2	2

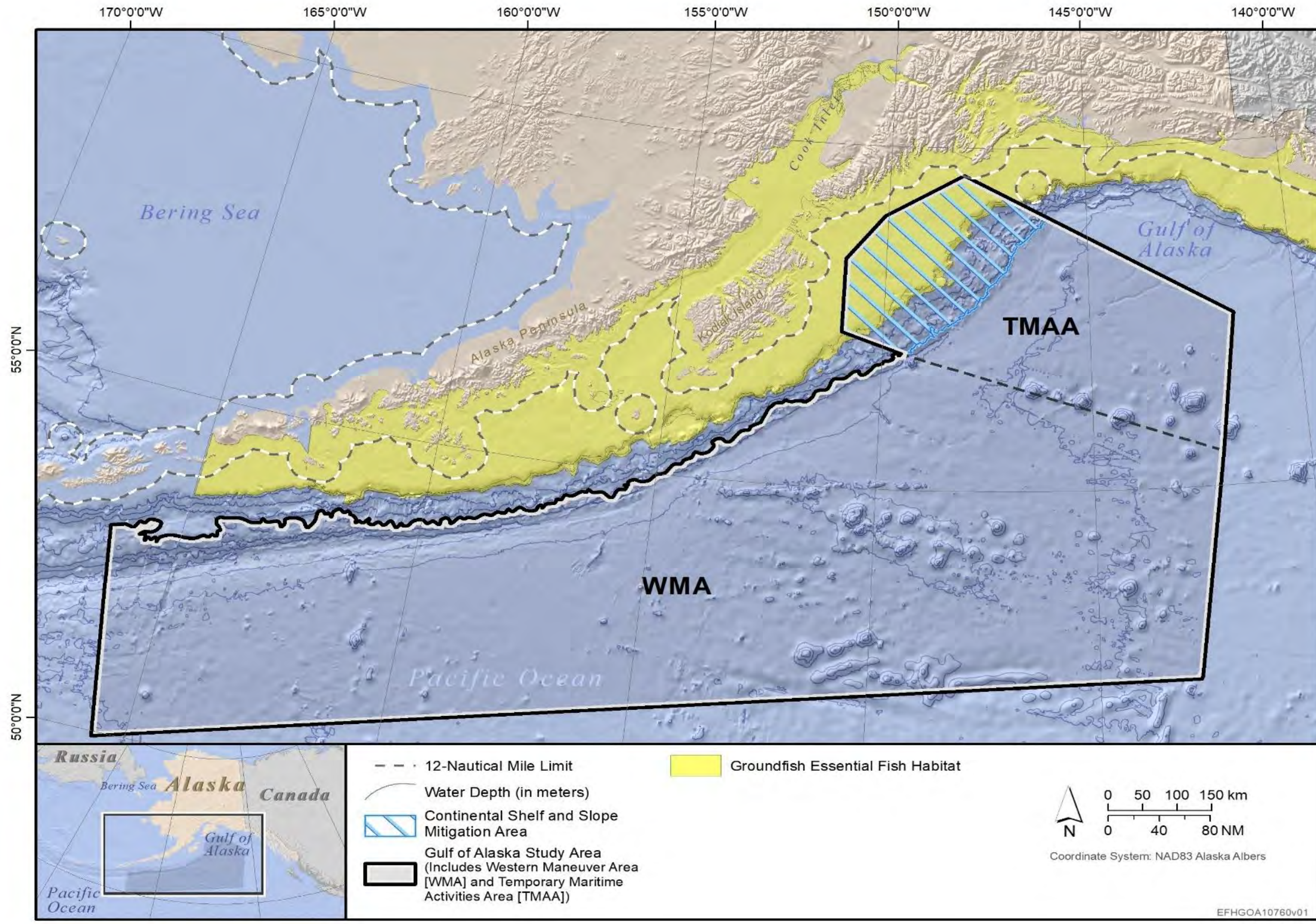
Adapted from North Pacific Fishery Management Council (2020a).

x - Indicates insufficient information is available to describe EFH
1 - Indicates general distribution data are available for some or all portions of the geographic range of the species
2 - Indicates quantitative data (density or habitat-related density) are available for the habitats occupied by a species of life stage
na - One juvenile stage exists – see Late Juveniles

Table 3.6-5: Salmon Species with EFH Designated in the Gulf of Alaska Study Area

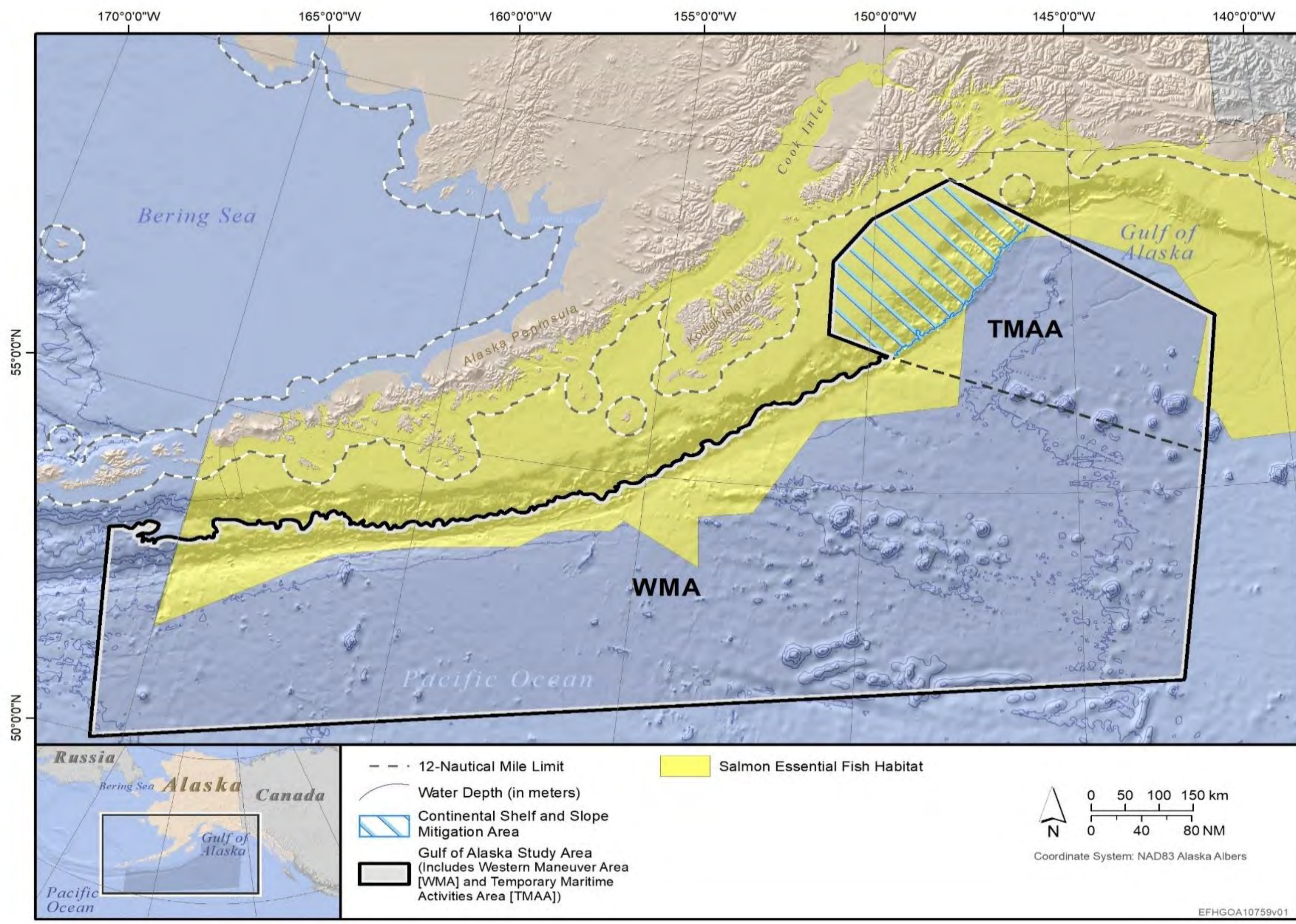
Fishery Management Plan	Species	Eggs and Larvae	Freshwater Juveniles	Estuarine Juveniles	Marine Juveniles	Marine Immature/ Maturing Adults	Freshwater Adults
Salmon	Chinook	-	-	-	X	X	-
	Chum	-	-	-	X	X	-
	Coho	-	-	-	X	X	-
	Pink	-	-	-	X	X	-
	Sockeye	-	-	-	X	X	-

Source: North Pacific Fishery Management Council et al. (2021).



Note: Figure is all species and life stages combined

Figure 3.6-2: Groundfish Essential Fish Habitat in the GOA Study Area



Note: Figure is all species and life stages combined

Figure 3.6-3: Salmon Essential Fish Habitat in the GOA Study Area

3.6.3 Environmental Consequences

As presented in Section 1.3 (Proposed Action), there are no changes to the current Proposed Action in regard to number of training activities proposed or conducted annually from that presented in the 2016 GOA Final SEIS/OEIS. However, aircraft and vessel maneuvering activities originally planned for only the TMAA would now be more widely distributed within both the TMAA and WMA to achieve more realistic training scenarios. Maneuvering activities in the WMA would occur in deep offshore waters (greater than 4,000 m) located beyond the continental shelf and slope. The limited types of training activities occurring in the WMA described in Table 2-3 are the same as those described in the TMAA and would not significantly impact fishes. Therefore, the detailed analysis of the impacts from the stressors already analyzed for fishes in the TMAA is not warranted for fishes within the WMA. This analysis also considers the newly adopted Continental Shelf and Slope Mitigation Area that was not previously considered in Navy's draft analysis.

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 GOA Study Area. The stressors analyzed for impacts on fish in the TMAA 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; Duarte et al., 2021; Hastings & Popper, 2005; Hawkins et al., 2015; Hawkins & Popper, 2020; Ladich & Popper, 2004; Lindseth & Lobel, 2018; Mann, 2016; Mickle & Higgs, 2018; 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 to fishes in the TMAA 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 pallid sturgeon (*Scaphirhynchus albus*) and paddlefish (*Polyodon spathula*) 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 $\mu Pa^2 s$) 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.

The studies discussed in the paragraph above included species both with and without swim bladders. The majority of fish that exhibited injuries were those with swim bladders. Lake sturgeon (*Acipenser fulvescens*), a physostomous fish, was found to be less susceptible to injury from impulsive sources than Nile tilapia (*Oreochromis niloticus*) or hybrid striped bass, both of which are 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 present in each species. 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 and are unable to react quickly enough to reduce pressure appreciably in response to an impulsive sound stressor. 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 (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. They may also have long-term competitive disadvantages for prey and mates, relative to uninjured conspecifics.

Other potential effects from exposure to impulsive sound sources include bubble formation and neurotrauma. It is speculated that high sound pressure levels may 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, leading to vessel rupture 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. Barring other proxies to rely upon, species tested to date can be used as 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 morhua*), saithe (*Pollachius virens*), and spotted wolffish (*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 (Jorgensen 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 (Jorgensen et al., 2005). Fishes may be more

[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).

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.

To investigate potential injury to the auditory system in fishes, Sapozhnikova et al. (2020) exposed freshwater fish (peled, *Coregonus peled*) to tonal, 300 Hz sound at 176–186 dB re 1 µPa sound pressure level (SPL) (peak to peak), for up to 18 days. After exposure, cellular changes to hearing structures were assessed. Hair cell bundles of the saccule were significantly less dense in sound-exposed fish compared to untreated controls, and changes were only observed for fish exposed longer than five days. Changes to otolith crystal structure and fusion of stereocilia (”hair-like” structures of the hair cells) similar to that observed after ototoxic antibiotic exposure were also observed after sound exposure, but no direct measurements of hearing loss were taken. The exposure was intended to simulate conditions of common aquaculture systems and therefore may not be applicable to exposures under other environmental conditions. Additionally, freshwater fishes are known to have better hearing than marine species, making them more susceptible to auditory impacts. However, this study does demonstrate some of the more severe physical impacts to the auditory system that could result from extremely long duration exposures to low frequency tonal signals.

Although these studies (Hastings, 1991; Hastings, 1995; Sapozhnikova et al., 2020) illustrate the highest known exposures (long duration exposures to moderately high sound levels) of tonal signals on freshwater fishes and fishes with enhanced hearing capabilities, direct comparisons of these results to impacts from transitory sonar signals on fishes should be treated with caution as the conditions of the exposures (e.g., exposure duration, fishes inability to avoid the source) would not likely occur in an open ocean or coastal environment. 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,* the anadromous form of which is 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. In the absence of other proxies to rely upon, those species tested to date can be used as 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). A PTS can occur over a small range of frequencies related to the sound exposure or be broader, depending on the degree of tissue damage. As with TTS, the animal does not typically 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).

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) and that cellular changes in hearing structures can occur after long-term exposures to fishes (Sapozhnikova et al., 2020). However, it is not known if nerve damage would occur in fishes, whether either type of impact would recover in fishes (similar to hair cell regeneration noted in other studies), or what the direct relation to hearing impairment would be. One study 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 few 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 (*Chrysophrys 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 $\mu Pa^2 s$. 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*), to an air gun array, as well as 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*). Fish in cages were exposed to multiple air gun shots with a cumulative sound exposure level of 190 dB re 1 $\mu Pa^2 s$. 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 $\mu Pa^2 s$. 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 $\mu Pa^2 s$. 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 exposure 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 between groups. 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

There are only a few studies 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. Like 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. (2020b) 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.

Rogers et al. (2020) is one of the few studies to look at the effects of vessel noise playbacks on fishes. Researchers exposed oyster toadfish, a fish with a swim bladder not involved in hearing, to one of three noise conditions and measured hearing thresholds before and after exposure. Two groups of fish were exposed to recorded boat noise (30–12,000 Hz frequency range) for either 1 or 12 hours continuously, and a third group was exposed to 12 hours of biological noise (male oyster toadfish vocalizations or boatwhistles with a fundamental frequency of 180 Hz). Sound pressure levels for all noise conditions were maintained at approximately 150 dB SPL re 1 µPa and fell within the oyster toadfish hearing range of 80-550 Hz. Exposures to biological signals, even more moderately long duration of 12 hours, did not result in any hearing impairment whereas significant TTS was noted after exposure to both vessel noise conditions. This evidence suggests that a 1-hour exposure to broadband noise at ~150 dB SPL is sufficient to produce greater than 6 dB of TTS in oyster toadfish, which may have other implications if exposure durations increase, threshold shifts are larger or take a long time to recover. A direct comparison of results such as those from the above studies to fishes exposed to continuous sound sources in natural settings should be treated with caution due to differences between laboratory and open ocean or coastal environments. 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 by transiting vessels. Additionally, fish used in laboratory experiments are often held in a tub or tank during exposures without any possibility to avoid the noise source. 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 less likely that TTS would occur in fishes with a swim bladder not involved in hearing or in fishes without a swim bladder.

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

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 pile driving) have the potential to mask sounds that are biologically important to fishes. Researchers have studied masking in fishes using continuous 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 is 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. A similar study measured meagre (*Argyrosomus regius*) thresholds for the detection of conspecific vocalizations during exposure to boat noise at relative sound pressure levels of 130 dB re 1 µPa (Vieira et al., 2021). As seen in previous studies, thresholds for fish calls were elevated by up to 20 dB during presentation of the noise stimulus, demonstrating a masking effect. 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 conspecific vocalizations such as those made during reproductive phases or sounds emitted from a reef for navigating larvae (de Jong et al., 2020; Higgs, 2005; Neenan et al., 2016; Vieira et al., 2021). 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. Research has documented observations of the same effect in additional species (e.g., Brown et al., 2021).

The *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014) highlights the lack of data 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 decreases 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. Typically, 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; Guh et al., 2021; 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 common response that has been observed in fishes involves the production of cortisol (a stress hormone) when exposed to sounds such as boat noise, tones, or predator vocalizations. For example, 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. Butler and Maruska (2020a) exposed mouth-brooding freshwater female African cichlids (a species likely to have hearing specializations) to noise within their hearing range (0.1–2 kHz) for three hours and then measured the effects of sound on several factors including cortisol levels. Like other findings, cortisol levels were higher in fish exposed to noise immediately after exposure. Although results have varied, a sudden increase in sound pressure level (i.e., presentation of a sound source or acute/short-term exposure), increase in overall background noise levels or long-duration or continuous exposure to sound can increase other hormone levels and alter metabolic rates indicative of a stress response, such as increased ventilation and oxygen consumption (Lara & Vasconcelos, 2021; 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). Other studies have examined various factors such as early stage development or survival rates as indicators of stress from a given noise exposure. For example, 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). It has been shown that chronic or long-term (days or weeks) exposures of continuous man-made sounds can also lead to a reduction in embryo viability, decreased growth rates, and early mortality including larvae and fishes infected with parasites (Lara & Vasconcelos, 2021; Masud et al., 2020; Nedelec et al., 2015; Sierra-Flores et al., 2015). Furthermore, Masud et al. (2020) found that guppies exposed to only a 24-hour exposure to broadband white noise showed increased disease susceptibility compared to those exposed for longer durations (up to seven days).

Not all studies have shown the same effects described above. For example, 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. Although cortisol levels did not differ significantly between the periods for either sex, increases in androgen (testosterone and 11-ketotestosterone) levels were noted. Specifically, male orange-fin anemonefish showed higher levels of testosterone and 11- ketotestosterone after exposure to short-term motorboat-noise playbacks, and both males and females showed increases in the same hormones following long-term exposures. Implications for such physiological changes are still unknown, especially considering there was no observed change in aggressive behaviors monitored during the study (reaction that were proposed to be linked to increases in these androgens).

Kusku et al. (2020) measured respiratory changes as secondary indicators of stress in Nile tilapia 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. By contrast, 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.

In summary, 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 in response to several different types of sound sources. Most 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 reactions to sound can include disruption to or alteration of 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, or learn to tolerate or habituate to the noise exposure (e.g., Bruintjes et al., 2016; Currie et al., 2020; Hubert et al., 2020b; 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 representative understanding of how free-swimming fishes may react to the same or similar sound exposures (Hawkins et al., 2015), especially when the experimental population consists of those species bred and raised in captivity (e.g., generations of captive zebrafish used in biological studies).

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. General 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) and impact pile driving, sources that do not occur in the TMAA. 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. White trevally (*Pseudocaranx dentex*) and pink snapper 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 white 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 $\mu Pa^2 s$ 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).

A more recent study by a research group in the Netherlands exposed tagged Atlantic cod to simulated seismic survey event (Hubert et al., 2020a). The seismic event occurred continuously over three-and-a-half days utilizing 36 air guns (without the hydrophone array needed to collect geological data). The location was selected due to high site fidelity of cod in the areas immediately surrounding windfarm turbines in the North Sea and allowed the research group to monitor general movements patterns and overall behavior before, during, and after the survey. Cod were more likely to be inactive during sound exposures and immediately following the surveys, differing from baseline diurnal movement patterns and overall behavioral time budgets (van der Knaap et al., 2021). This is one of few studies to be conducted in a species' natural environment and over the course of several days.

Some studies have shown a lack of behavioral reactions to air gun noise. The same research group in the Netherlands also exposed cod to playbacks of an air gun in a large net pen (Hubert et al., 2020a). Unlike the study conducted in the North Sea, cod exposed in a net pen showed very little change in behavior or overall use of space within the net pen. 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 $\mu Pa^2 s$, did not react by changing direction or swim speed (Pena et al., 2013). Although these levels are similar to those tested in other studies that 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 air gun surveys 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 adult pollack (*Pollachius pollachius*), 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 (including juvenile saithe and cod) throughout the course of the study. A similar study monitored several factors, such as species abundance, composition, behavior and movement patterns, over the course of several months (to capture long-term monitoring before, during and after exposure) as indicators of behavioral responses to a five-day seismic survey (Meekan et al., 2021). This study utilized multiple methods such as underwater baited cameras, tagging, and passive acoustic monitoring to understand each variable under investigation. Overall, the results suggested that there was little, if any, short- or long-term impacts on the demersal fishes from exposure to the full-scale survey. Unlike the previously described 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 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 nearshore marine fishes 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 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 (e.g., larger coverage of acoustic detection array) 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 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 varied across 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 $\mu Pa^2 s$. 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.

Short et al. (2020) studied the effect of a broadband, pulsed, acoustically random noise exposure (60–2,000 Hz) on the swimming behavior of a captive freshwater shoaling species (Eurasian minnows, *Phoxinus phoxinus*). In response to the noise exposure, group responses were more consistent in their escape behavior (e.g., startled, consistent speed, less erratic path, stronger group cohesion, more synchronized orientation) compared to fish tested individually. Although the pulsed tones were broadband, unlike most sonar sources that have a limited center frequency, the study provides insight into the differences in group versus individual reactions particularly for shoaling species. Similar to the antipredator defense strategies, individual shoaling fish benefit from being in a group.

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 (0.02–10 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; impaired movement patterns or changes in vertical distribution in the water column, swim speeds, distance traveled, and feeding efficacy such as reduced foraging/hunting attempts; changes in vocalizations (reduce chorusing); and increased mistakes during foraging (i.e., lowered discrimination between food and non-food items) (e.g., Bracciali et al., 2012; Ceraulo et al., 2021; 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; Vieira et al., 2021; Voellmy et al., 2014a; Voellmy et al., 2014b). Both playbacks and actual noise conditions from nearby boats have also resulted in alterations in reproductive and nesting behaviors, such as changes in visual displays or mating vocalizations; signaling and aggression towards potential mates, competitors, and conspecifics; diminished territorial interactions; and reduced parental care behaviors such as egg fanning and vigilance or even a lower number of live eggs compared to control nests with no sound exposure (Amorim et al., 2022; Butler & Maruska, 2020b; 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 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 (i.e., less energy across all frequencies) compared to vessels powered by the two-stroke engine, which may explain the overall reduced response to this engine type.

Vessel noise may also lead 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 (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 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 with zebrafish, 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 can reduce 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). Short et al. (2020) studied the effect of a pulsed, acoustically random noise exposure (60–2,000 Hz) on the swimming behavior of a captive shoaling species (Eurasian minnows). In response to the noise exposure, group responses were more consistent in their escape behavior (e.g., startled, consistent speed, less erratic path, stronger group cohesion, more synchronized orientation) compared to fish tested individually. Similar to the antipredator defense strategies, individual shoaling fish benefit from being in a group.

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). For example, Soudijn et al. (2020) attempted to design a theoretical population consequences model without quantitative data on sound exposure levels. Atlantic cod energy expenditure, food intake, mortality rate, and reproductive output were analyzed in order to assess cod's potential impacts from sound exposure. The model predicted decreased food intake, increased energy expenditure, and decreased population growth rate as a result of increased continuous noise. Models such as these are common among other taxa and often times come to similar conclusions. Conversely, some animals may 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

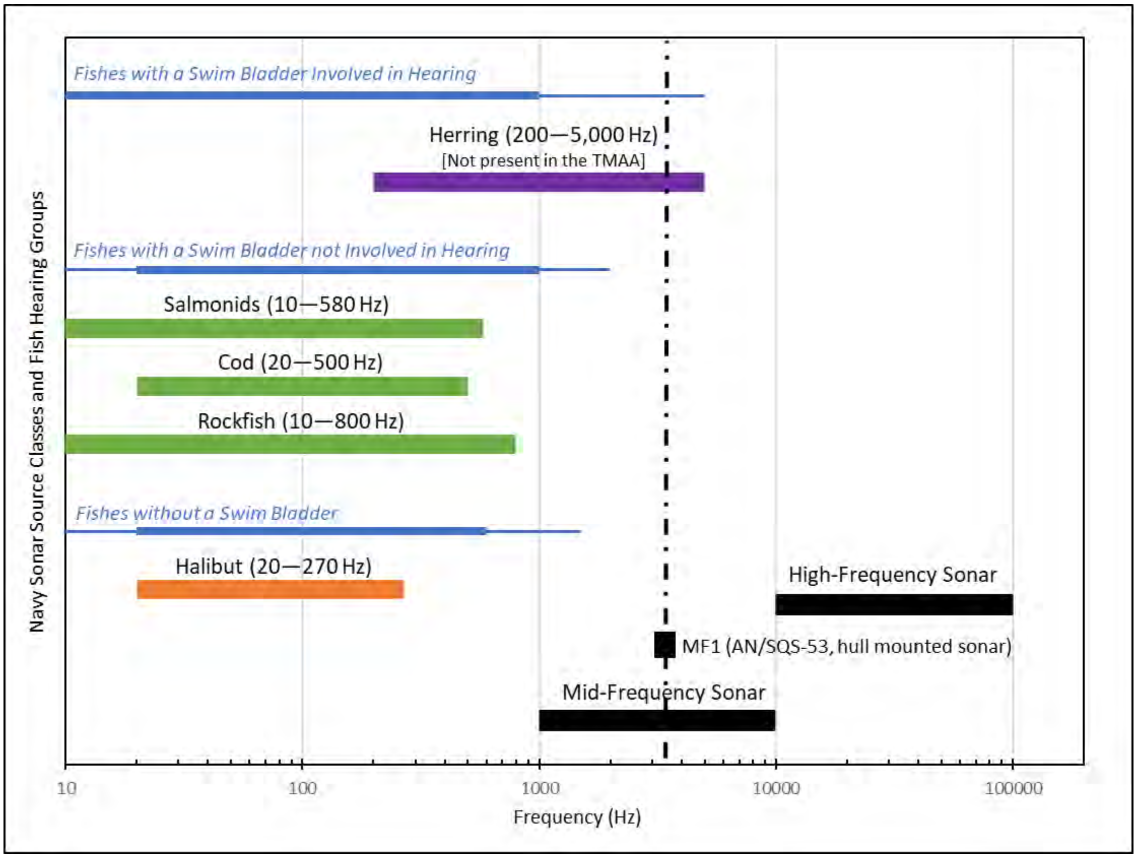
Sonar and other transducers proposed for use could be used throughout the TMAA. Activities that involve the use of sonar will not be conducted in the WMA and therefore this portion of the Study Area is not analyzed in this section. Sonar and other transducers emit sound waves into the water to detect 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 3.6-4 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, including several example species.

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 3.6-4 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).



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 3.6-4: Fish Hearing Groups and Navy Sonar Bin Frequency Ranges

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 Navy calculated the cumulative sound exposure level of 222 dB re 1 μPa^{2}s. (Halvorsen et al., 2012c; Kane et al., 2010). This is then rounded down for a final threshold of 220 dB re 1 μPa^{2}s. 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 are therefore 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 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 GOA Study Area, and the use of active sonar would no longer 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

Sonars would be used during activities in the TMAA, but not the WMA. 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. 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 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 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 are not analyzed further. As shown in Figure 3.6-4, 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 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 GOA and may occur in the TMAA. As presented 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 3.6-4, 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.

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.

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.

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 has consulted 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 GOA Study Area. 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 GOA Study Area 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 GOA Study Area. A detailed description of the acoustic characteristics and typical sound levels of vessel noise is in Section 3.0.4.1 (Acoustic Sources). Proposed training activities would be almost identical to what is currently conducted under the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. In addition to the TMAA, the area in which activities involving vessel maneuvers could occur has expanded since the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS to include the WMA.

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 in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to fishes is not warranted. Expansion of the GOA Study Area to include the WMA does constitute a change to the affected environment; however, no additional fishes occur in the WMA that were not analyzed previously in the TMAA, and the activities proposed for the WMA are the same activities that have been occurring in the TMAA.

New evidence suggests that ESA-listed green sturgeon may be present over the continental shelf 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. However, green sturgeon are not anticipated to occur in the WMA as this portion of the Study Area begins at the 4,000 m contour line, outside of the range and depth at which benthic sturgeon would likely occur. Therefore, impacts to green sturgeon in the WMA are not anticipated.

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

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 has consulted 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 GOA Study Area. 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 GOA Study Area 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 noise is in Section 3.0.4.1 (Acoustic Sources). Proposed training activities would be almost identical to what is currently conducted under the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. In addition to the TMAA, the area in which activities involving aircraft maneuvers could occur has expanded since the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS to include the WMA.

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).

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 in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to fishes is not warranted. Expansion of the GOA Study Area to include the WMA does constitute a change to the affected environment; however, no additional fishes occur in the WMA that were not analyzed previously in the TMAA, and the activities proposed for the WMA are the same activities that have been occurring in the TMAA.

New evidence suggests that ESA-listed green sturgeon may be present over the continental shelf 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. However, green sturgeon are not anticipated to occur in the WMA as this portion of the Study Area begins at the 4,000 m contour line, outside of the range and depth at which benthic sturgeon would likely occur. Therefore, impacts to green sturgeon in the WMA are not anticipated.

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

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 has consulted 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 GOA Study Area. 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) within the GOA Study Area. 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. A detailed description of the acoustic characteristics and typical sound levels of noise from weapons firing is in Section 3.0.4.1 (Acoustic Sources). Proposed training activities would be almost identical to what is currently conducted and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS.

In addition to the TMAA, the area in which activities involving the firing of weapons could occur has expanded since the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS to include the WMA.

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 in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to fishes is not warranted. Expansion of the GOA Study Area to include the WMA does constitute a change to the affected environment; however, no additional fishes occur in the WMA that were not analyzed previously in the TMAA, and the activities proposed for the WMA are the same activities that have been occurring in the TMAA.

New evidence suggests that ESA-listed green sturgeon may be present over the continental shelf 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. However, green sturgeon are not anticipated to occur in the WMA as this portion of the Study Area begins at the 4,000 m contour line, outside of the range and depth at which benthic sturgeon would likely occur. Therefore, impacts to green sturgeon in the WMA are not anticipated.

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

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 has consulted 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 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 and the newly adopted Continental Shelf and Slope Mitigation Area proposed after issuance of the Draft SEIS.

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 detrimental effects on the tissues or organs of a fish. The blast wave from an explosion at or near the surface of the water 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. 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 which lack 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 swim bladder, kidney, liver, and spleen 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 the positive peak pressure, the duration of the positive pressure exposure, and 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 explosions at or near the surface of the water 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 (*Lagodon rhomboids*) and spot (*Leistomus xanthurus*) 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.

Observations of the inner ear and lateral line in fishes exposed to explosives are lacking. As summarized within Sections 3.6.3.1.1.1 (Injury due to Impulsive Sound Sources) and 3.6.3.1.1.2 (Hearing Loss due to Impulsive Sound Sources), impacts on these sensory system organs have been observed during exposure to other impulsive sources such as air guns and playbacks of impact pile driving noise (Booman et al., 1996; Casper et al., 2013a; McCauley et al., 2003), which would indicate that similar effects may be possible in fishes exposed to explosions. 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). Additional research is needed to understand the potential for sensory cell damage from explosive exposures, the severity and implication of such affects for individual fish, and at what sound levels these impacts may occur.

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 explosives within the TMAA that would be used during Navy training activities at or near the surface (within 10 m above the surface), synthesizing the background information presented above. Activities that involve the use of explosives will not be conducted in the WMA and therefore this portion of the Study Area is not analyzed in this section. The proposed use of explosives for training activities would be almost identical to what is currently conducted, 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. In addition, the analysis below considers the newly adopted Continental Shelf and Slope Mitigation Area proposed after issuance of the Draft SEIS.

As discussed above, sound and energy from explosions at or near the surface 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.

No underwater detonations are proposed in this action, but fishes could be exposed to detonations in air or near the water surface. The Navy Acoustic Effects Model cannot account for the highly non-linear effects of cavitation and surface blow off for shallow underwater explosions, nor can it estimate the explosive energy entering the water from a low-altitude detonation. Thus, for this analysis, sources detonating in air or near (within 10 m) the surface are modeled as if detonating completely underwater at a depth of 0.1 m, with all energy reflected into the water rather than released into the air. Therefore, the amount of explosive and acoustic energy entering the water, and consequently the estimated impacts, are likely to be overestimated.

Criteria and Thresholds used to Estimate Impacts on Fishes from Explosives

Mortality and Injury from Explosives

Criteria and thresholds proposed for use by the Navy 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 overestimates 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, 2018), NMFS does not currently have formal criteria established for explosive thresholds effects on fishes. Therefore, the Navy's recommended 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 Navy's recommended 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 explosion at or near the surface of the water 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 are 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). As summarized therein, 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). Temporary Threshold Shift 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.

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^2s]), > indicates that the given effect would occur above the reported threshold.

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.

As previously discussed no underwater detonations are proposed in this action, but fishes could be exposed to sound and energy produced by detonations at or near the water surface. The Navy Acoustic Effects Model cannot account for the highly non-linear effects of cavitation and surface blow off for shallow underwater explosions, nor can it estimate the explosive energy entering the water from a low-altitude detonation. Thus, for this analysis, in-air sources detonating at or near (within 10 m) the surface are modeled as if detonating completely underwater at a depth of 0.1 m, with all energy reflected into the water rather than released into the air. Therefore, the amount of explosive and acoustic energy entering the water, and consequently the estimated ranges to effects, are likely to be overestimated. In addition, some but not all fishes 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. Ranges may vary greatly depending on factors such as the cluster size (the number of rounds fired [or buoys dropped] within a very short duration), location, depth, and season of the event.

Table 3.6-10 provides ranges to mortality and injury per the Navy's proposed threshold 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) SPL_{peak} = Peak sound pressure level. (2) Range to effects for in-air and near surface explosions are calculated within the model as if they occur in water (at 0.1 m depth); therefore, these ranges likely overestimate the actual area of effect. Ranges represent modeled predictions in different areas and seasons within the TMAA. Each cell contains the estimated average, minimum and maximum range to the specified effect.

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) SELcum = Cumulative sound exposure level, TTS = Temporary Threshold Shift, < indicates that the given range would be less than the estimated range provided. (2) Range to effects for in-air and near surface explosions are calculated within the model as if they occur in water (at 0.1 m depth); therefore, these ranges likely overestimate the actual area of effect. Ranges 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.

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 GOA Study area, and the use of explosives would no longer 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

Explosives would be used during activities in the TMAA, but not the WMA. Training activities under Alternative 1 would use surface or near-surface detonations and explosive ordnance. Explosions that would occur just above or at the water surface are treated as underwater detonations within the acoustic modeling process for purposes of predicting ranges to effect. Due to limitations of the Navy Acoustic Effects Model discussed above in Section 3.6.3.2.2.2 (Impact Ranges for Explosives), the amount of explosive and acoustic energy entering the water, and consequently the estimated ranges to effects, are likely to be overestimated. 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 with one exception. Consistent with the previous analyses for Alternative 1, the SINKEX 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.

As described in Chapter 5 (Mitigation), the Navy will not detonate explosives below 10,000 ft. altitude (including at the water surface) in the Continental Shelf and Slope Mitigation Area during training. This mitigation is designed to help the Navy avoid or reduce potential impacts on fish and fishery resources throughout the entire continental shelf and slope. The mitigation area encompasses migration, maturation, and foraging habitat for juvenile, immature, and maturing adult salmonids (Chinook, coho, chum, and sockeye salmon, steelhead and green sturgeon). The mitigation will be particularly beneficial to surface-oriented fishes and those that occur in the top tens of meters of the water column, such as coho, chum, sockeye salmon and steelhead, which otherwise would have had a higher potential of being exposed to and affected by detonations at or near the surface. As a result of the mitigation area, all training activities that involve the use of explosions just above or at the water surface would occur in the open ocean portion of the TMAA beyond the 4,000 m depth contour. 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 (i.e., number of days) explosions may impact fishes present within the TMAA

Sound and energy from explosions could result in various impacts such as mortality, injury, and temporary hearing loss in exposed 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 explosions at or near the surface 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 explosions in air or near the water's surface 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. 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.

Recent data reveal that several ESA-listed populations of salmonids are not known to migrate as far north as the TMAA; or, if they are present off the coast of Alaska, are not anticipated to occur in the offshore portions of the Action Area where explosive training activities predominantly occur. These populations include the Puget Sound, Snake River Fall-run, California Coastal, Sacramento River Winter-run, and Central Valley Spring-run ESU of Chinook; the Southern Oregon/Northern California Coast and Central California Coast ESU of coho salmon; and the Northern California, California Central Valley, Central California Coast, South-Central California Coast, and Southern California DPS of steelhead. The potential overlap of these ESA-listed populations with training activities that involve the use of explosives would be so unlikely as to be discountable, and they are not considered further in this analysis. In addition, the Southern DPS of green sturgeon (not previously analyzed), although rare, has the potential to occur in the TMAA. However, should green sturgeon occur within the TMAA, due to their preferred habitat associations, they would be limited to occupying demersal habitats within coastal areas on the shelf rather than in the open ocean. As a result, green sturgeon would not occur beyond the Continental Shelf and Slope Mitigation Area into areas where explosives are used and therefore impacts would not be anticipated.

Other ESA-listed populations of salmonids are known to migrate north to mature in the GOA and may occur in the TMAA. These populations include the Upper Columbia River Spring-run, Lower Columbia River, Snake River Spring/Summer-run, and Upper Willamette River ESU of Chinook; the Lower Columbia River and Oregon Coast ESU of coho salmon; the Hood Canal Summer-run and Columbia River ESU of chum salmon; the Snake River and Ozette Lake ESU of sockeye salmon; and the Puget Sound, Upper Columbia River, Middle Columbia River, Lower Columbia River, Snake River Basin, and Upper Willamette River DPS of steelhead (see Section 3.6.2, Affected Environment, for details). Recent data show that Chinook and likely coho populations (due to similarities between species) prefer on-shelf habitats and occur much less frequently beyond the 4,000 m isobath compared to other species. Although the possibility exists that individuals from either species could occur in open-basin habitats beyond this isobath (particularly for Chinook), the Continental Shelf and Slope Mitigation Area would greatly minimize potential impacts from explosions. Impacts, if any, would only be anticipated to occur beyond the 4,000 m isopleth, outside of the Mitigation Area. For the remaining ESA populations of chum, sockeye, and steelhead, 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 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. Fish from each of these populations 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.

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.

Pursuant to the ESA, the use of explosives during training activities, as described under Alternative 1, may affect ESA-listed salmonids. The use of explosives during training activities would have no effect on green sturgeon. The Navy has consulted 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 Fishes

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 GOA Study Area. 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. On June 28, 2022, the Navy submitted an Essential Fish Habitat Assessment to NMFS Alaska Region, which analyzed the effects of the Proposed Action on designated EFH. The Navy concluded that the Proposed Action would have either a “no adverse effect” or a “may adversely affect” determination, but adverse effects would be minimal in scale, and range in duration from a temporary to permanent impact, depending on the stressor type and habitat affected. Based on this analysis, three stressors (explosives at or near the surface, military expended materials, and explosive byproduct contaminants) may adversely affect EFH in the GOA Study Area. Navy training in the GOA Study Area would have no effect on climate change.

On August 11, 2022, NMFS provided their letter concurring with the Navy’s findings and, thus, concluding consultation. Changes to the Proposed Action since the 2011 EFH consultation includes the removal of the following activities: Sinking Exercise (SINKEX), Portable Undersea Tracking Range on the seafloor, Tracking Exercises with explosive sonobuoys, and underwater explosives. In the August 11, 2022 letter, NMFS agreed that "the removal of these training activities, as well as the addition of a Continental Shelf and Slope Mitigation Area, which prohibits the use of explosives from the sea surface up to 10,000 feet altitude during training over the entire continental shelf and slope out to the 4,000 meter depth contour of the TMAA, significantly avoids adverse effects to EFH."

Endangered Species Act Determinations

As part of the SEIS/OEIS, the Navy consulted under section 7 of the ESA with NMFS for the ESA-listed fishes. New information, including distribution studies and coded wire tagging recovery data (e.g., Balsiger, 2021; Beamish & Riddell, 2020; Seitz & Courtney, 2021a; Seitz & Courtney, 2022) was reviewed and incorporated into this SEIS/OEIS. Navy training activities in the GOA Study Area are not being substantially modified in a manner that would affect ESA-listed fish, but the development of the Continental Shelf and Slope Mitigation Area was created to minimize the overlap of Navy explosives training with sensitive species such as salmonids.

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. NMFS determined that listing the Oregon Coast and Southern Oregon and Northern California Coastal spring-run Chinook salmon populations as threatened or endangered ESUs was not warranted (86 FR 45970). In addition, NMFS responded to a petition to list the Northern California summer-run steelhead as an endangered DPS under the ESA (85 FR 6527). 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).

The Proposed Action 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.

Pursuant to the ESA, the Navy has determined that the continuation of the Navy's activities in the GOA Study Area may affect ESA-listed Chinook, coho, chum, sockeye salmon, steelhead, and green sturgeon. Consultation with NMFS for ESA-listed fishes is ongoing. NMFS plans on issuing a Biological Opinion in the fall of 2022.

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3.7 Sea Turtles

Gulf of Alaska Navy Training Activities

Final Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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3.7 Sea Turtles

3.7.1 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 (e.g., EA-6B aircraft and Oliver Hazard Perry Class Frigate, and their associated systems, have been replaced with the EA-18G aircraft, Littoral Combat Ship, and Constellation Class Frigate), and use of the Portable Underwater Tracking Range (PUTR) is no longer proposed. 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 sea turtles and other marine resources under that agency's regulatory purview.

A brief summary follows of the continued interagency cooperation between Navy and NMFS as set forth in section 7(a)(2) of the Endangered Species Act (ESA) (16 United States Code part 1536).

- On April 19, 2017, NMFS issued the most recent Biological Opinion and incidental take statement (FPR-2015-9118) for the Navy to "take" listed marine species incidental to activities in the Temporary Maritime Activities Area (TMAA) from April 2017 through April 2022. In that incidental take statement, NMFS determined that the Navy's actions were not likely to jeopardize the continued existence of any ESA-listed marine species, including leatherback sea turtle, or result in the destruction or adverse modification of any critical habitat during the five-year period of the Marine Mammal Protection Act Final Rule and continuing into the reasonably foreseeable future.

- On April 2, 2021, Navy requested section 7 consultation with NMFS; on March 2, 2022, Navy submitted an addendum to include proposed activities in the Western Maneuver Area (WMA). NMFS plans on issuing a Biological Opinion in the fall of 2022.

The purpose of this SEIS/OEIS section is to provide any new or changed information since the 2016 GOA Final SEIS/OEIS that is relevant to the analysis of potential impacts on sea turtles associated with the Proposed Action in the GOA Study Area, beyond May 2022. This section analyzes proposed Navy training activities in the GOA Study Area and incorporates the analysis of impacts from the 2022 Supplement to this SEIS/OEIS prepared to address proposed activities occurring in the Navy's WMA. Collectively, the TMAA and the WMA are referred to as the GOA Study Area or Study Area throughout this section.

3.7.2 Affected Environment

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. Sea turtle species present in the WMA would be the same as those in the TMAA.

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 trends within the GOA Study Area, sea turtle diving abilities, and hearing and vocalizations for sea turtles, with specific updates for leatherback sea turtles where species-specific information has appeared in new literature.

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). Benson et al. (2020) have noted declines of western Pacific leatherbacks in foraging grounds off the coast of Central California, which tracks with declining trends in nesting at Indonesian index beaches (the primary location of most of western Pacific leatherback nesting activity) (Gaspar & Lalire, 2017; National Marine Fisheries Service, 2016).

Specifically within the GOA, the Navy reviewed the latest science regarding the potential presence of Pacific leatherback sea turtles. Approximately 20 sightings of leatherbacks have been recorded in Alaskan waters over the past six decades, with the most recent occurring in 2013 (Cushing et al., 2021). Prior to 2013, the last confirmed sighting of a leatherback in Alaskan waters was in 1993 (Hodge & Wing, 2000). No tagged leatherbacks have been tracked to Alaska in recent telemetry studies, with tags ending at approximately 50°N. The rare occurrence of leatherback sea turtles in Alaska suggests that they are ranging into marginal habitat (Hodge & Wing, 2000). In a study analyzing the movements of 135 leatherbacks fitted with satellite tracking tags, the turtles were found to inhabit waters with sea surface temperature (SST) ranging from 11.3 to 31.7 degrees Celsius (°C) (mean of 24.7°C) (Bailey et al., 2012). Sea surface temperature in the GOA is frequently colder. An average of three years of SST data in the GOA for the month of May indicated that temperatures in the TMAA ranged from 6.7 to 8.7°C, several degrees below the minimum temperature reported by Bailey et al. (2012). Analyzing several years of SST data for the month of August, when temperatures are warmest, showed the average temperature in the TMAA was still below 15°C, which is at the lower end of the temperature range characteristic of leatherback habitat and nearly 10°C below the mean temperature where Bailey et al. (2012) reported leatherbacks occurred.

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.

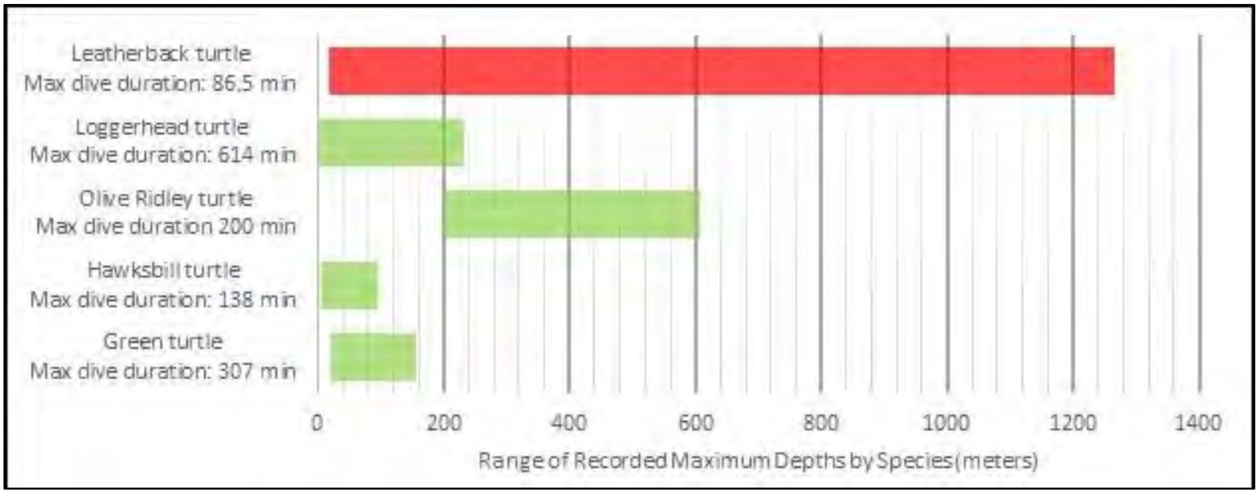
3.7.2.1.1 Species Unlikely to be Present in the Temporary Maritime Activities Area

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.

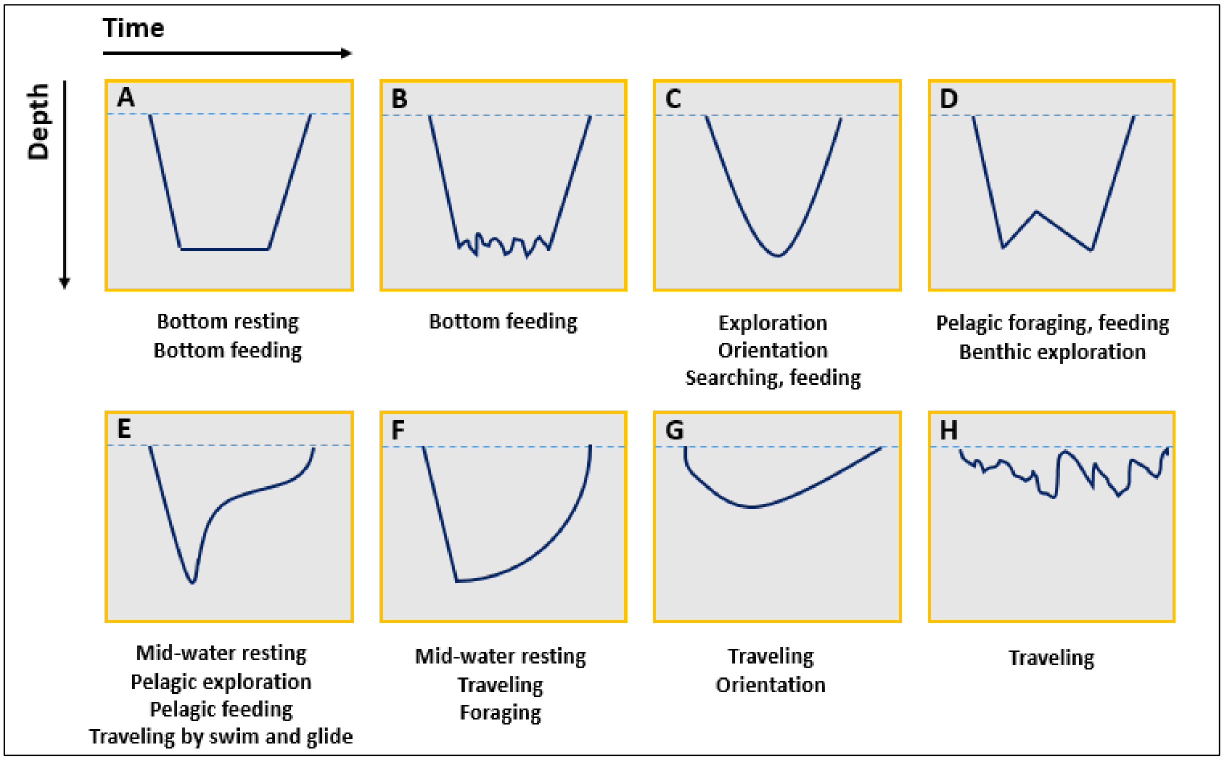


Sources: Hochscheid (2014), Sakamoto et al. (1993), Rice and Balazs (2008), Gitschlag (1996), Salmon et al. (2004)

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

3.7.2.1.3 Hearing and Vocalization

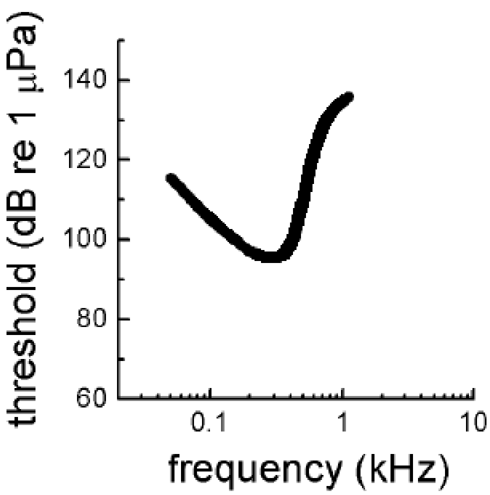
Since the release of the Navy's 2016 GOA Final SEIS/OEIS, the Navy's literature search has found additional sources to improve the understanding of sea turtle hearing and vocalization. Sea turtle ears are adapted for hearing underwater and in air, with auditory structures that may receive sound via bone 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).



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



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

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). Vocalizations from juvenile green turtles have been characterized as pulses, low amplitude calls, frequency modulated sounds, and squeaks (Charrier et al., 2022).

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 SST 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., 2019b).

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 GOA appear to be due to starvation (Jones et al., 2019; Walsh et al., 2018). Thompson et al. (2019a) analyzed forage fish and determined that size and condition were negatively correlated to increasing sea surface temperatures and periodic Pacific Decadal Oscillation, which is described as Pacific climate variability that includes a longer period of extreme temperatures, either being warm or cool in the interior north Pacific and cool or warm along the Pacific Coast (National Oceanic and Atmospheric Administration, 2021). 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.

Increasing ocean water temperatures over the past few years have resulted in a warmer than normal "blob" of water off the west coast of North America that extends into the GOA (Peterson et al., 2014). The warmer ocean temperatures shortened the upwelling season in 2013 by six weeks. Ocean upwelling is related to marine ecosystem productivity. Whether increasing temperatures may expand the range for leatherbacks into the GOA is speculative; however, it is clear that high water temperatures lead to low entrainment of nutrients and, therefore, decrease biological productivity (Peterson et al., 2014).

During the 2019 GOA Expedition spring trawl surveys, several pelagic squid species were regularly encountered, although 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 GOA, including the southern portion of the TMAA (Hunt, 2019). This is the first documented occurrence of *Chrysaora* in the GOA, which is notable because they may present competition for food resources for higher trophic-level species, which includes leatherback sea turtles, along with coho, Chinook, and steelhead salmon. 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 in the GOA Study Area. 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. Aircraft and ship maneuvering activities originally planned for the TMAA would now be widely distributed within the WMA to achieve more realistic training scenarios. Maneuvering activities in the WMA would occur in deep offshore waters (greater than 4,000 m) located beyond the continental slope. Activities using active acoustics or explosives would not occur in the WMA. Gunnery activities could occur in the WMA and would only include training with non-explosive practice munitions.

For this SEIS/OEIS, the Navy Acoustic Effects Model was utilized to estimate impacts to leatherback sea turtles. The GOA Large Marine Ecosystem (an area off the southern coast of Alaska and the western coast of Canada) was used as the potential area of species occurrence to generate the leatherback sea turtle density estimate. While the Navy did model acoustic effects on the leatherback sea turtle, the Navy did not rely on model predictions for its analysis of sea turtles after further review of the best available science. The likelihood of an individual leatherback sea turtle occurring in the GOA Study Area is extremely low (see updates regarding potential occurrence of Pacific leatherback sea turtles in Section 3.7.2.1, General Background).

Because leatherback sea turtles occur in the GOA only rarely (less than one detected occurrence per year since 1960), the Navy does not expect individual sea turtles to co-occur with the Navy's activities within the GOA Study Area. Therefore, it is extremely unlikely that sea turtles would be exposed to stressors caused by the Navy activities, and associated effects are discountable.

Because the existing baseline conditions have not changed appreciably, and no new Navy training activities are proposed in the GOA Study Area 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 GOA Study Area due to low expected occurrence in the TMAA and the WMA, 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 ESA are in the current National Marine Fisheries Service (NMFS) Biological Opinion (National Marine Fisheries Service, 2017). NMFS 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 sea turtle critical habitat.

3.7.4 Summary of Stressor Assessment (Combined Impacts of All Stressors) on Sea Turtles

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 and the WMA. 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.

Endangered Species Act

As part of this SEIS/OEIS, the Navy has consulted 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 GOA Study Area 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 GOA Study Area. Based on the current Biological Opinion, the likelihood of Navy training activities in the GOA Study Area impacting leatherback sea turtles is discountable due to their low abundance in the GOA Study Area and low likelihood that any leatherback sea turtles would occur in the GOA Study Area during training activities. Therefore, sea turtles are not likely to be adversely affected by the Proposed Action (National Marine Fisheries Service, 2017).

Pursuant to the ESA, the Navy has determined that the continuation of the Navy's activities in the GOA Study Area may affect sea turtles. Consultation with NMFS for ESA-listed sea turtles is ongoing. NMFS plans on issuing a Biological Opinion in the fall of 2022.

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3.8 Marine Mammals

Gulf of Alaska Navy Training Activities
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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 (e.g., EA-6B aircraft and Oliver Hazard Perry Class Frigate, and their associated systems, have been replaced with the EA-18G aircraft, Littoral Combat Ship, and Constellation Class Frigate), and use of the Portable Underwater Tracking Range (PUTR) is no longer proposed. 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 analyses, 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 this SEIS/OEIS section is to provide any new or changed information since the 2016 GOA Final SEIS/OEIS that is relevant to the analysis of potential impacts on marine mammals associated with the Proposed Action in the GOA Study Area, beyond May 2022. This section analyzes proposed Navy training activities in the GOA Study Area and incorporates the analysis of impacts from the 2022 Supplement to this SEIS/OEIS prepared to address proposed activities occurring in the Navy's Western Maneuver Area (WMA). Collectively, the Temporary Maritime Activities Area (TMAA) and the WMA are referred to as the GOA Study Area or Study Area throughout this section. The current NMFS (2017) Biological Opinion for Navy training activities in the TMAA was effective from April 26, 2017, through April 26, 2022. The Navy is currently consulting with NMFS as required by section 7(a)(2) under the Endangered Species Act (ESA) to evaluate effects from future Navy training activities in the entire GOA Study Area.

The TMAA is located 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 WMA is located west of the TMAA and beyond the continental slope. The boundary of the WMA follows the bottom or seaward boundary of the continental slope, defined by the 4,000 meter (m) depth contour. The WMA was configured so that it would not overlap with critical habitat, biologically important areas, and marine mammal migration routes. No marine mammal species occur in the WMA that are not also present in the TMAA and that were not already analyzed in the 2020 GOA Draft SEIS/OEIS.

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 GOA Study Area 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 designated 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.

The Navy and NMFS have conducted three rounds of analysis of impacts on marine mammals from Navy at-sea training and testing activities in multiple Navy range complexes in the Pacific (see for example 83 FR 66846, December 27, 2018); two rounds of analysis have been conducted for Navy training activities in the GOA, and the analysis in this SEIS/OEIS represents the third round of analysis. Refer to Section 3.8.4 (Summary of Stressor Assessment [Combined Impacts of All Stressors] on Marine Mammals) and Section 3.8.6.1 (Summary of Science in the Temporary Maritime Activities Area by the Navy Related to Potential Effects on Marine Mammals) for general background information on the Navy's analysis of marine mammals in the Atlantic and Pacific.

This section summarizes the continued interagency cooperation between the Navy and NMFS and the Navy and U.S. Fish and Wildlife Service (USFWS) set forth in section 7(a)(2) of the Endangered Species Act (ESA) (16 United States Code part 1536).

- On April 19, 2017, NMFS issued the most recent Biological Opinion and incidental take statement (FPR-2015-9118) for the Navy to "take" listed marine species incidental to activities in the TMAA from April 2017 through April 2022. In that incidental take statement, NMFS determined that the Navy's actions were not likely to jeopardize the continued existence of any ESA-listed marine mammal or result in the destruction or adverse modification of critical habitat during the five-year period of the Marine Mammal Protection Act (MMPA) Final Rule and continuing into the reasonably foreseeable future.
- On April 2, 2021, Navy requested section 7 consultation with NMFS; on March 2, 2022, the Navy submitted an addendum to include proposed activities in the WMA. NMFS plans on issuing a Biological Opinion in the fall of 2022.
- The Navy received a Letter of Concurrence from USFWS on March 29, 2022 concurring with the Navy's determination that the Proposed Action may affect but is not likely to adversely affect northern sea otter and that there would be no effect on northern sea otter critical habitat.

The approach to the analysis of potential impacts on marine mammals resulting from the Proposed Action was based on the review of scientific publications cited in this section, recent Navy reports, and other documents that analyzed potential impacts from the same or similar activities on marine mammals (U.S. Department of the Navy, 2018b, 2018c). The Navy's analysis is also informed by the analysis and conclusions drawn by NMFS pursuant to the MMPA (82 FR 19530) and the Endangered Species Act (ESA) in the current NMFS Biological Opinion (National Marine Fisheries Service, 2017b) and by USFWS in their Letter of Concurrence dated March 29, 2022 concurring with the Navy's assessment of effects on northern sea otter.

3.8.2 Affected Environment

Based in part on the results of monitoring during Navy training and testing activities in multiple locations in the Pacific and Atlantic and Navy-sponsored behavioral response studies, it has been the Navy's and NMFS's assessment that it is unlikely there would be population-level impacts on marine mammals or long-term consequences on individuals as a result of Navy training and testing activities. This assessment extends, and is generally applicable to, the continuation of training in the TMAA and the addition of maneuvering activities in the WMA proposed in the SEIS/OEIS, which are similar to training activities the Navy has conducted for decades in other locations in the Pacific.

The results of the acoustic effects modeling for training activities occurring in the TMAA are described in detail in this section and continue to support the Navy's and NMFS's overall assessment that population-level impacts and long-term consequences to individuals are unlikely based on (1) no mortalities are or have been predicted as a result of training activities in the TMAA; (2) the vast majority of effects from acoustic and explosive stressors are non-injurious temporary threshold shift (TTS) or behavioral effects; (3) acoustic disturbances from sonar and explosives are short-term, intermittent, and (in the case of sonar), transitory; (4) the reduction or avoidance of impacts through implementation of mitigation measures; and (5) over 14 years of comprehensive monitoring data indicating negligible observable effects to marine mammal populations as a result of Navy training (National Marine Fisheries Service, 2017e).

Scientific research to date indicates marine mammal populations continue to remain viable where Navy training is conducted, and there is a lack of direct evidence suggesting Navy training has had or may have long-term consequences to marine mammal populations. Although limited, the evidence from Navy monitoring reports and other focused scientific investigations on impacts from Navy training and testing should be considered in an analysis of impacts on marine mammals. Examples of information derived from monitoring and research on marine mammal responses to Navy activities suggests that:

- the ESA-listed blue whale population in the Pacific, which includes the GOA Study Area 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 for 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 negligible at the population level for marine mammals. There is no evidence that Navy training occurring in the GOA Study Area has negatively impacted regional marine mammal populations. In fact, for some of the most intensively used Navy training areas in the Pacific, the continued multi-year presence and long-term residence of individuals 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), females with and without calves, and higher species' abundances on the Navy ranges for some species (Moore & Barlow, 2017; Schorr et al., 2018; U.S. Department of the Navy, 2017b) provide no indications of significant impacts from training activities and do provide evidence of generally increasing and healthy marine mammal populations. This background information contributes to the analysis of environmental consequences on marine mammals due to the Proposed Action. Since the 2016 GOA Final SEIS/OEIS, monitoring during Navy training and testing activities at ranges around the Pacific has continued (see for example, U.S. Department of the Navy (2018a)), adding to a growing body of research on marine mammal responses to Navy activities and further supporting assessments of potential impacts and whether or not those impacts are likely to be significant.

3.8.2.1 General Background

The Navy identified the following stocks of marine mammals that have the potential to be present in the TMAA (Table 3.8-1) (Carretta et al., 2020b; Muto et al., 2020a). The species and stock names are provided in Table 3.8-1 along with an abundance estimate and associated coefficient of variation as provided by the SARs (Carretta et al., 2020b; Muto et al., 2020a; U.S. Fish and Wildlife Service, 2017). General anticipated occurrence in the TMAA, as defined in the table (see footnote #4), and ESA and MMPA status are also summarized in the table.

All species also have the potential to occur in the WMA portion of the GOA Study Area. Certain species, for example, harbor porpoise, gray whale, and most pinnipeds, prefer shallow, nearshore habitat and would be less likely to occur in the WMA than in the TMAA.

The analysis of impacts on marine mammals is focused on stressors from acoustics and explosives, which are only used in the TMAA and not the WMA. Therefore, occurrence in the TMAA, as shown in Table 3.8-1, is most relevant to the analysis of impacts on marine mammals. For species that occur in deepwater habitat (> 4,000 m), occurrence in the WMA is likely similar to occurrence in the TMAA; however, for those species that prefer nearshore habitat over the continental shelf and slope, occurrence in the WMA would be rare or extralimital.

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

Common Name	***Scientific Name***	***Stock[1]***	***Stock Abundance[2] (CV)***	***Occurrence in TMAA[3]***	***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[4]	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
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[5]	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

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

Common Name	*Scientific Name*	*Stock*[1]	*Stock Abundance*[2] *(CV)*	*Occurrence in TMAA*[3]	*ESA/MMPA Status*
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[5]	2,347 (N/A)	Likely	-
		Eastern North Pacific Northern Resident[5]	302 (N/A)	Extralimital	-
		Eastern North Pacific Offshore[5]	300	Likely	
		West Coast Transient[5]	(N/A)	Extralimital: few sightings	-
		AT1 Transient[5]	7 (N/A)	Rare; more likely inside Prince William Sound and Kenai Fjords	-
		Eastern North Pacific GOA, Aleutian Island, and Bering Sea Transient[5]	587 (N/A)	Likely	-
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	North Pacific	26,880 (N/A)	Likely	-

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

Common Name	Scientific Name[1]	Stock[1]	Stock Abundance[2] (CV)	Occurrence in TMAA[3]	ESA/MMPA Status
Suborder Odontoceti (toothed whales) (continued)					
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	-
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 east of the TMAA and primarily over the continental shelf)	-
		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	-
Northern fur seal	*Callorhinus ursinus*	Eastern Pacific	620,660 (0.2)	Likely	Depleted
		California	14,050 (N/A)	Rare	-

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

Common Name	*Scientific Name*	*Stock*[1]	*Stock Abundance*[2] *(CV)*	*Occurrence in TMAA*[3]	*ESA/MMPA Status*
Suborder Pinnipedia*[8] *(continued)					
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	
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]Stock names, abundances, and CVs (if available) are provided in the Pacific Stock Assessment Reports Carretta et al. (2020b); Muto et al. (2020a); (U.S. Fish and Wildlife Service, 2018), Alaska Stock Assessment Report (Muto et al., 2020a), and USFWS stock assessment for sea otter (U.S. Fish and Wildlife Service, 2018). Exceptions are for blue whales and the California, Oregon, Washington stock of humpback whales, which reflect more recent data from Calambokidis and Barlow (2020).

[2]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.

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

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

[3]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).

[4]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., 2020a; 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).

[5]Only for of the six stocks of killer whales are analyzed in this SEIS/OEIS: Eastern North Pacific Alaska Resident; AT1 Transient, Eastern North Pacific GOA, Aleutian Island, and Bering Sea Transient; and Eastern North Pacific Offshore. The Western Coast Transient and Eastern North Pacific Northern Resident.

Notes: 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 Exclusive Economic 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., 2020a). 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 GOA Study Area

There has been no change in the species unlikely to be present in the GOA Study Area since the 2016 GOA Final SEIS/OEIS. The species carried forward for analysis are those likely to be found in the GOA Study Area based on the most recent data available. Several species that may be present in the eastern North Pacific Ocean have an extremely low probability of presence in the GOA Study Area. These species are considered extralimital, meaning there may be a small number of sighting or stranding records within the GOA Study Area, 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 incorporated into acoustic effects modeling with marine mammal density estimates, and these characteristics have been updated for the analysis in this SEIS/OEIS based on the results of new scientific research (U.S. Department of the Navy, 2020b).

3.8.2.1.3 Diving Behavior

Diving behavior has been incorporated into the acoustic effects modeling for marine mammals, and the data describing diving behavior have been updated for the analysis in this SEIS/OEIS based on the results of new scientific research (U.S. Department of the Navy, 2020b).

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; Mooney et al., 2020; Mulsow et al., 2011; Nachtigall et al., 2008; Nachtigall et al., 2007; Supin et al., 2001; Sysueva et al., 2018; Wang et al., 2020). 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). For odontocetes, the procedure for determining audiograms through AEP methods has been standardized (American National Standards Institute & Acoustical Society of America, 2018).

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 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 the 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.

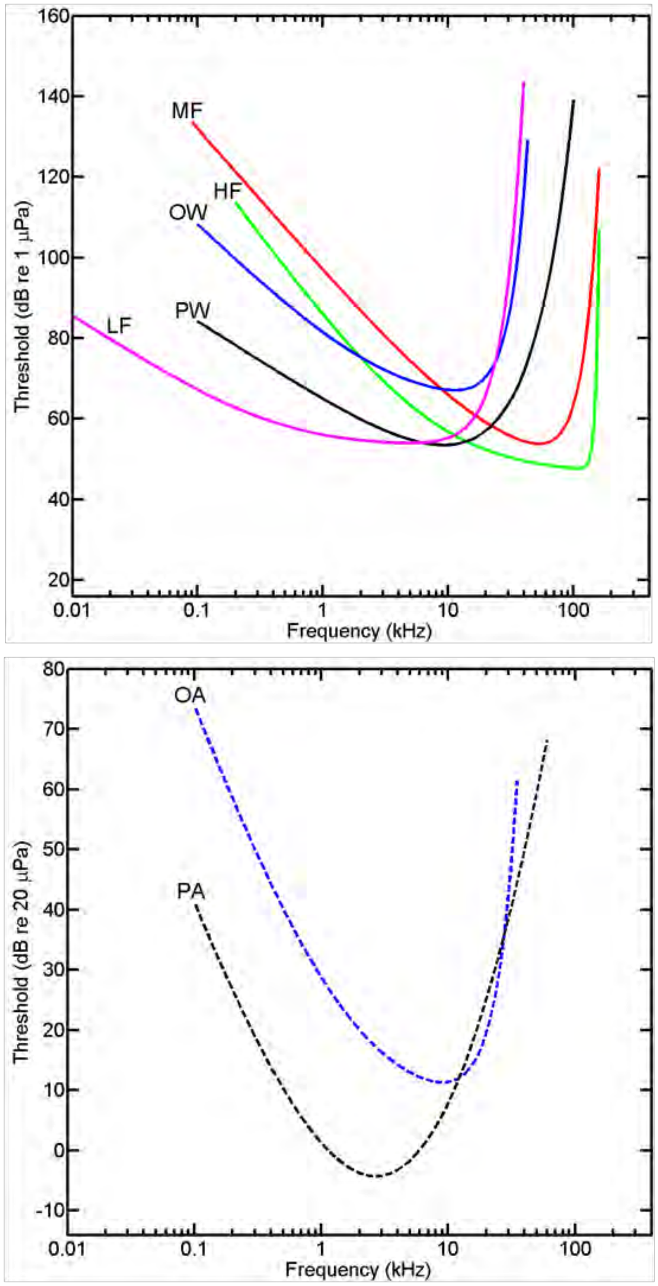
Few field studies aim to determine the hearing range of low-frequency cetaceans. Recorded vocalizations, behavioral responses, and anatomical models of mysticete ears suggest that peak hearing sensitivity is likely below 2 kHz (Matthews & Parks, 2021).However, Frankel and Stein (2020) exposed migrating 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 published behavioral audiograms (Cunningham & Reichmuth, 2015; Kastelein et al., 2019b; Sills et al., 2021). This 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; Kastelein et al., 2009), 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 Gulf of Alaska Study Area

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, 2017a).

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 Gulf of Alaska Study Area

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 and hunt prey.

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; Matthews & Parks, 2021; 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

Marine mammal populations can be influenced by various natural factors as well as human activities. There can be direct effects, such as from disease, hunting, and whale watching, or indirect effects such as through reduced prey availability or lowered reproductive success of individuals (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 NMFS Technical Memoranda 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 occurrences of serious injury and mortality 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 GOA Study Area.

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 on strandings in Alaska see NMFS Marine Mammal Stranding Response Fact Sheet; National Marine Fisheries Service (2016b) and NMFS Alaska region stranding reports (Savage, 2020; Savage, 2021). 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).

3.8.2.1.5.1 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, 2020b; 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). Gulland et al. (2022) summarize research on climate change effects on marine mammals and highlight the uncertainty in predicting effects and the associated challenges in addressing unanticipated consequences.

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 the North Pacific in 2015–2016, which probably contributed to population declines and breeding failures observed among several predators in the GOA (von Biela et al., 2019); see also National Marine Fisheries Service (2018e); Savage (2017); Savage (2020). Also note that because many marine mammals migrate to the GOA Study Area 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. Acidification of the ocean could potentially impact the mobility, growth, and reproduction of calcium carbonate-forming organisms such as crustaceans and many plankton species, which are the direct prey of some marine mammals and an important part of the marine food web. Additionally, changes in ocean acidity may have the effect of slightly altering how sound propagates underwater (Lynch et al., 2018; Meyers et al., 2019; Rossi et al., 2016).

Climate change-driven modifications to the function of marine ecosystems and food webs 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 or inaccessibility of traditional 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.

3.8.2.1.5.2 Human-Related Impacts

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; increased ocean acidification; and general habitat deterioration or destruction.

Fishery Bycatch of Marine Mammals from Alaska Fisheries

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, 464 serious injuries or mortalities of marine mammals from stocks present in the GOA Study Area were attributed to various types of fishing gear over the five-year period from 2013–2017 (Delean et al., 2020). Pinnipeds, particularly Steller sea lions, were most frequently affected with 409 injuries or mortalities (for all pinnipeds). For Steller sea lions, entanglement in marine debris and fishing gear was the most common mechanism leading to injury or mortality followed by injuries related to hooking in fishing gear used primarily in the troll fishery. (Delean et al., 2020) cite unpublished research by the Alaska Department of Fish and Game on over 1,400 Steller sea lions showing that ingestion of fishing gear used in both the commercial and recreational fisheries lowered survival rates compared with sea lions that avoided ingesting gear. Reducing survival rates of individuals, particularly mature adults, could have population-level impacts if impacts are widespread. Interactions with fishing gear were reported to have caused an estimated 33 serious injuries or mortalities of large cetaceans from 2013 to 2017 (Delean et al., 2020). Humpback whales were the most frequently impacted species with entanglement being the most common means of injury and mortality. Sperm whales and killer whales are known to forage on longline gear for fish as the gear is hauled back in, which increases their susceptibility to injury or mortality. (Delean et al., 2020) reported six sperm whale interactions with three resulting in serious injuries or mortalities from 2013–2017. There were also 22 serious injuries or mortalities of small cetaceans reported over that same time period due to multiple types of fishing gear; however, gillnets were the type associated with half of the injuries and mortalities. Sea otters are also known to be become trapped and drowned in shallow shellfish and fish traps, including Dungeness crab traps used in Alaska waters, resulting in mortality (Hatfield et al., 2011). While marine mammal bycatch is a global concern, there is evidence indicating that Alaska fisheries have some of the lowest bycatch rates worldwide (Savoca et al., 2020).

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 EEZ 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 GOA Study Area.

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 GOA Study Area. 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 GOA Study Area. 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[1] 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 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; Laist et al., 2001; 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 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 GOA Study Area.

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

[1] 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.

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., 2014b). 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., 2014a; 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 GOA Study Area 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 airguns, 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 GOA Study Area. 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 GOA Study Area 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 airguns 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. NMFS 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 Debris 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; Feist et al., 2021). 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 GOA Study Area (Díaz-Torres et al., 2016; Lian et al., 2020; 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).

On the U.S. West Coast, for the marine mammal stocks that are present in the GOA Study Area, 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[2] 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 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 GOA Study Area. 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 are well documented and 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

[2] 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.

Council & National Oceanic and Atmospheric Administration Marine Debris 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; Feist et al., 2021; 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, 2020b). 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 GOA Study Area. Species of large whales found entangled in 2015 and 2016 included stocks that are present in the GOA Study Area 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., 2021a; Rice et al., 2015; Rice et al., 2018b; Rice et al., 2020; 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 GOA Study Area, 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). From 2013 to 2017, seal bombs were reported to have caused both serious and non-serious injuries to pinnipeds, including California sea lion, harbor seal, and northern fur seal, in the West Coast region (Carretta et al., 2019a). Despite the routine use of seal bombs in the fishing industry and associated injuries, some of which have resulted in mortality (Carretta et al., 2019a; Delean et al., 2020), and likely disturbance to numerous others (Wiggins et al., 2019), there appears to be no population-level impacts as suggested by the increasing or stable populations of harbor seals, California sea lions, and northern fur seals in the Pacific Coast region (Carretta et al., 2020b; Muto et al., 2020a). It is likely that 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 GOA Study Area, 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., 2020; 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 GOA Study Area 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).

3.8.2.1.5.3 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., 2020a; 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 (73 FR 12024-12030). Critical habitat was designated in 2008 in an area on the continental shelf located south of Kodiak Island and outside of the Study Area (73 FR 19000-19014) (Figure 3.8-2). On July 12, 2022, NMFS published a 90-day finding on a petition to expand North Pacific right whale critical habitat along the continental shelf and slope between the existing critical habitat off

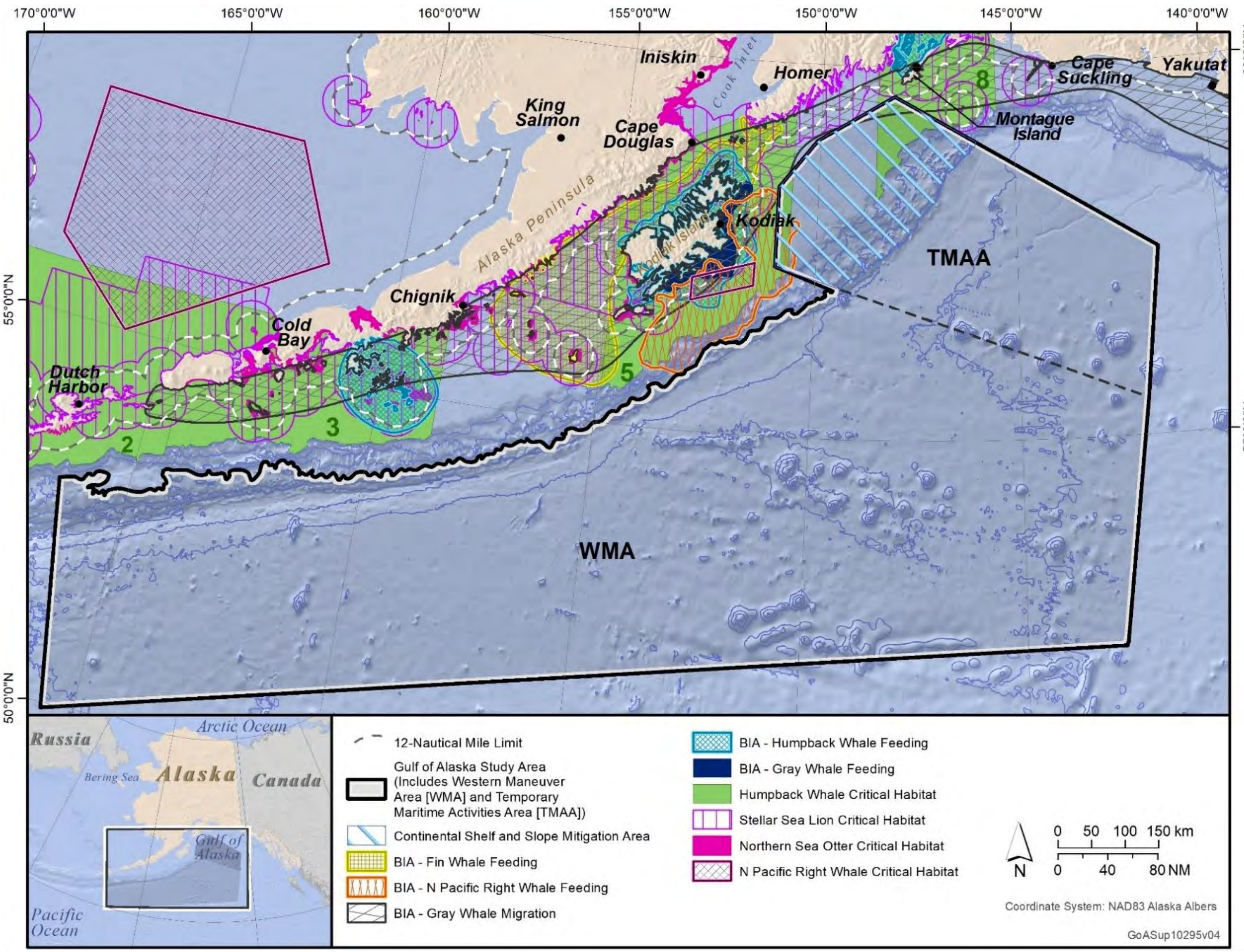


Figure 3.8-2: Critical Habitat and Biologically Important Areas for Marine Mammals in Proximity to the Gulf of Alaska Study Area

Kodiak Island and in the Bering Sea and including Unimak Pass (Center for Biological Diversity and Save the North Pacific Right Whale, 2022).

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., 2020a). 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

Occurrence of the North Pacific right whale in the GOA Study Area is considered rare, but right whales could occur year round in the Study Area, with a higher likelihood of occurrence 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 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 GOA Line-Transect Survey for marine mammals within the TMAA (Rone et al., 2014). Six of the possible detections shown in Figure 33 of Rone et al. (2014) occurred within the TMAA. 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 as a primary focus and design to locate North Pacific right whales in the nearshore waters of the GOA, including the designated critical habitat located off Kodiak Island, the biologically important area for feeding (Figure 3.8-2), 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, reported no right whale sightings (Rone et al., 2017). However, a survey of the GOA in August 2021 resulted in sightings of two separate pairs of right whales, four individuals total, just three days apart; a remarkable event considering that NMFS estimates that there are only 30 individuals from the Eastern stock that inhabit Alaska waters (Crance et al., 2022; National Marine Fisheries Service, 2021). The sighting that occurred on August 21, 2021 within Barnabas Trough was inside the boundaries of the North Pacific right whale critical habitat (Crance et al., 2022).

As noted in the 2016 GOA Final SEIS/OEIS, right whales have routinely been observed or acoustically detected in the Bering Sea and Bristol Bay Alaska region (Matsuoka et al., 2021; Matsuoka et al., 2018a; Muto et al., 2020a), but less frequently detected in the Gulf of Alaska (Rice et al., 2021a; Rice et al., 2019; Širović et al., 2015a). Passive acoustic monitoring at five sites in the TMAA between July 2011 and September 2017 totaling over 4,349 days of survey effort detected calls on only 2 days during the summer of 2013. The calls were detected at the Quinn hydrophone in deep offshore waters beyond the continental slope (Rice et al., 2021a; Rice et al., 2019, 2020; Širović et al., 2015a). For additional information about important North Pacific right whale feeding areas in the GOA Study Area, 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, 2020c).

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 GOA Study Area 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 GOA Study Area 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., 2020a; National Marine Fisheries Service, 2016a). As noted in the 2018 Alaska SAR (Muto et al., 2020a), 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 GOA Study Area, 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., 2020a; 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 GOA Study Area), British Columbia, Washington, and Oregon in the summer and then migrate to winter in the Hawaiian Islands (Muto et al., 2020a; Palacios et al., 2020b).

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 GOA Study Area), 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., 2020a; 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 Study Area according to NMFS (Mate et al., 2018c; National Marine Fisheries Service, 2016d, 2019b, 2019c). On April 21, 2021, NMFS issued a final rule to designate critical habitat for the Western North Pacific DPS, Central America DPS, and the Mexico DPS pursuant to section 4 of the ESA (86 FR 21082). Not all critical habitat areas, or units as they are referred to in the rules, initially identified in the proposed rule were ultimately designated as critical habitat. Units 4 (Central Peninsula Area), 6 (Cook Inlet), and 7 (Kenai Peninsula Area) were excluded from the critical habitat designation due to their low conservation value and because humpbacks are not expected to rely on the areas for feeding. Unit 2 (Aleutian Islands Area), Unit 3 (Shumagin Islands Area), and Unit 5 (Kodiak Island Area) were designated as critical habitat for both the Mexico DPS and the Western North Pacific DPS, and Unit 8 (Prince William Sound Area) was designated as critical habitat only for the Mexico DPS (Figure 3.8-2). In addition, NMFS expanded the definition of the essential feature of the designated critical habitat (i.e., prey) for all three DPSs by identifying specific species of prey relevant to each DPS and region. For the Western North Pacific DPS, prey species were identified as Euphausiids (*Thysanoessa* and *Euphausia*) and small pelagic schooling fishes, such as Pacific herring (*Clupea pallasii*), capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus*), and Pacific sand lance (*Ammodytes personatus*). For the Mexico DPS, prey species included all those listed for the Western North Pacific DPS as well as the euphausiids (*Nyctiphanes* and *Nematoscelis*) and the small pelagic fishes, Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax*). Critical habitat for the Central America DPS was not designated in the GOA.

As shown in Figure 3.8-2, the portion of the TMAA over the continental shelf overlaps with the critical habitat areas designated as Unit 5 and Unit 8. The total area of overlap is approximately 8,700 km^2, which is approximately 10 percent of the total combined area of Units 5 and 8 (86 FR 21082). The GOA Study Area does not overlap with or encroach upon Units 2 and 3. Both critical habitat areas are located over the continental shelf, several miles—in most locations about 20 NM—shoreward of the WMA (Figure 3.8-2). Activities occurring in the WMA would not affect critical habitat.

Unit 5 is "occupied critical habitat" for the Western North Pacific DPS and described as having a high conservation value (National Marine Fisheries Service, 2019b, 2019c). Unit 8 was also determined to have a low conservation value and "limited conservation benefit" for the Western North Pacific DPS, and was excluded because "… whales from the WNP DPS have not been directly observed …" in Unit 8 (National Marine Fisheries Service, 2019b, 2019c). However, Unit 8 was determined to have a high conservation value as critical habitat for the threatened Mexico DPS of humpback whales (86 FR 21082). Sighting data from three line transect surveys (in the summers of 2009, 2013, and 2015) that included Unit 8 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)). However, the survey in August 2021 did record several sightings inside or adjacent to Unit 8 (Crance et al., 2022).

NMFS identified prey as the one essential feature of the critical 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. As noted above, prey species identified by NMFS are krill (e.g., 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).

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., 2020a); 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., 2020a).

The Central North Pacific stock and the Hawaii DPS portion of the humpback whale population also occurs in the GOA Study Area. 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., 2020a; 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 per year since the late 1980s, based on the 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 GOA Study Area since the 2016 GOA Final SEIS/OEIS, however there has been new research relevant to the presence of humpbacks in the GOA Study Area. Consistent with the information presented in the 2016 GOA Final SEIS/OEIS, humpback whale typically are present in higher numbers during 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; Palacios et al., 2021; Wade et al., 2016). Migrations vary and are seasonally dynamic with the timing of migrations changing from year to year based on factors such as 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 altogether, and potentially increasing their predation on herring in the GOA (Straley et al., 2017). Palacios et al. (2021)

summarized a Navy-sponsored long-term tagging study to characterize the movements, occurrence, and residence times of large whales in the TMAA and surrounding GOA. From 1995 to 2019, the study tracked the movements of 255 humpback whales tagged off Mexico, Hawaii, southeast Alaska, the eastern Aleutian Islands, and the U.S. West Coast. Only one whale, a calf tagged off Mexico (and presumably with its mother), spent time in the TMAA. The track of a whale tagged off southeast Alaska crossed the southeast corner of the TMAA between its last two reported locations, but it is not clear if the whale actually entered the TMAA. Five out of 25 whales tagged off Hawaii were headed towards the GOA based on their trajectories before the tags stopped transmitting.

Passive acoustic monitoring (Debich et al., 2013; Debich et al., 2014a; Rice et al., 2021a; Rice et al., 2015; Rice et al., 2018b) has documented the presence of humpback whales year round in the GOA Study Area, although fewer have been present based on line transect surveys of the TMAA and surrounding waters (Crance et al., 2022; 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. (2018c) and Barlow et al. (2020a). Their presence in the GOA 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).

Humpback whales in the Western North Pacific DPS, which was designated as threatened since the 2016 GOA Final SEIS/OEIS, mainly feed in Russian waters, but may also feed in the GOA (Muto et al., 2020a; 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). These 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 GOA Study Area), British Columbia, Washington, and Oregon in the summer and then migrate to winter breeding areas in the Hawaiian Islands (Muto et al., 2020a; National Marine Fisheries Service, 2016d, 2016e; Palacios et al., 2021).

The Mexico DPS individuals are also present in feeding areas off the coast of Alaska (including the nearshore waters of the GOA Study Area), 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., 2020a; National Marine Fisheries Service, 2016d, 2016e; Wade et al., 2016). Two biologically important feeding areas have been identified in the GOA. One is located in nearshore waters surrounding Kodiak Island, where highest densities are expected from July through September, and the second is located in Prince William Sound, where highest densities are expected from September through December (Ferguson et al., 2015). Neither area overlaps with the GOA Study Area. For additional information about important humpback whale feeding areas in the GOA Study Area, 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, 2020c).

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 GOA Study Area since the 2016 GOA Final SEIS/OEIS. The blue whale is listed as endangered under the ESA (35 FR 18319) 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., 2020a; National Marine Fisheries Service, 2018b). NMFS 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 GOA Study Area 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., 2020a).

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 GOA Study Area 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 monitoring data, blue whale occurrence in the GOA Study Area is considered to be year round with the highest number of whales expected to be present from June to December (Debich et al., 2013; Debich et al., 2014a; Rice et al., 2021a; 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. Palacios et al. (2021) summarized a Navy-sponsored long-term tagging study to characterize the movements, occurrence, and residence times of large whales in the TMAA and surrounding GOA. From 1993 to 2018, 241 blue whale tracks originating primarily off southern and central California were recorded. No blue whales were tracked within the TMAA; and only one whale traveled north of Vancouver Island, Canada.

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, 2020c).

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 (35 FR 12222), but there is no designated critical habitat for this species in the Pacific (Carretta et al., 2020b; Muto et al., 2020a; National Marine Fisheries Service, 2010).

3.8.2.5.2 Abundance

NMFS has determined there are no reliable estimates of current and historical abundances for the entire Northeast Pacific fin whale stock (Muto et al., 2020a). 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

Fin whale occurrence in the GOA Study Area is considered year round with a potential for higher numbers of whales in fall and winter (Rice et al., 2021a). There have been no changes to the known distribution of fin whales in the GOA Study Area since the 2016 GOA Final SEIS/OEIS, although there is new research suggesting general connectivity among fin whales in the Pacific and confirming year round residency in the eastern GOA (Archer et al., 2019). Fin whales were found to feed in association with high densities of zooplankton near the Kodiak Archipelago (Witteveen et al., 2014).

Passive acoustic monitoring from 2011 through 2015 detected fin whale vocalizations year round in the GOA Study Area (Rice et al., 2021a; Rice et al., 2018b; Wiggins & Hildebrand, 2018) and in the western GOA in the spring and fall (Archer et al., 2019). Fin whale 20 Hz calls were more common from September through January, whereas 40 Hz calls showed no clear seasonal patterns (Rice et al., 2021a). These acoustic data are not necessarily reflective of the survey data (Rone et al., 2017), which indicated fin whale presence in greater numbers, and which was factored into the derivation of fin whale densities in the TMAA consistent with the analysis provided in the 2016 GOA Final SEIS/OEIS and the analysis in this document. An August 2021 survey covering the continental shelf and slope in and adjacent to the TMAA reported 125 fin whale sightings (including duplicates and resights) and an additional 43 sightings that could have been either a fin whale or sei whale. The majority of observations occurred over the shelf (Crance et al., 2022). Palacios et al. (2021) summarized a Navy-sponsored long-term tagging study to characterize the movements, occurrence, and residence times of large whales in the TMAA and surrounding GOA. From 1993 to 2018, 46 fin whale tracks originating primarily off southern and central California were recorded. Only one fin whale recorded locations within the TMAA.

A biologically important area for fin whale feeding behavior has been identified extending across the mouth of Cook Inlet, through the Shelikof Strait, and southwest of Kodiak Island (Ferguson et al., 2015). No part of the biologically important area overlaps with the GOA Study Area.

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, 2020c).

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 (35 FR 12222) 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

Sei whale occurrence in the GOA Study Area is considered year round but rare. There have been no changes to the known distribution of sei whales in the GOA Study Area 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 recent, confirmed sightings of sei whales in the GOA (and these occurred outside the TMAA) were two whales sighted in 2011 west of Kodiak Island (Davis et al., 2011), and two sightings in 2015: a sei whale within an aggregation of fin and humpback whales at Albatross Bank off Kodiak Island and a second sei whale observed approximately 300 km south of Kodiak Island (Rone et al., 2017). Both sightings in 2015 were within the WMA. 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 GOA Study Area during summer 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, 2020c).

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 GOA Study Area are considered the Alaska stock in the current SAR (Muto et al., 2020a).

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., 2020a; Rone et al., 2017).

3.8.2.7.3 Distribution

Minke whale occurrence in the GOA Study Area is considered likely year round. There have been no changes to the known distribution of minke whales in the GOA Study Area 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, 2020c).

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 GOA Study Area: 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., 2020a).

The Western North Pacific gray whale DPS is listed as endangered (35 FR 18319), 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 (59 FR 31094), 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, 2020a). As of February 2020, the strandings totaled 236 known individuals along their migratory corridor (National Oceanic and Atmospheric Administration, 2020a). 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, 2020a). 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

Gray whale occurrence in the GOA Study Area is considered seasonal with the highest likelihood of occurring between June and August. There have been no changes to the known distribution of gray whales in the GOA Study Area 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 and detected most frequently in summer with intermittent calls detected from May to October (Rice et al., 2021a; Rice et al., 2015; Rice et al., 2018b; Wiggins et al., 2017). A biologically important area for gray whale migration behavior has been identified extending along the coast from southeast Alaska to the southwest tip of the Alaska Peninsula (Ferguson et al., 2015). The area occurs over the continental shelf and there are two small areas of overlap with the TMAA: at the northernmost corner of the TMAA and east of Kodiak Island. Both the Western subpopulation and the Eastern subpopulation are expected to migrate through the GOA, 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). A gray whale biologically important area for feeding behavior is located along the seaward coast of Kodiak Island and does not overlap with the GOA Study Area. Palacios et al. (2021) summarized a Navy-sponsored long-term tagging study to characterize the movements, occurrence, and residence times of large whales in the TMAA and surrounding GOA. From 1994 to 2013, 69 gray whales were tracked in the North Pacific from tagging locations off Oregon, California, Mexico, and Russia. None of the 33 whales tagged off Oregon and California entered the TMAA. Two of 29 whales tagged off Mexico spent time in the TMAA and the track of a third crossed the TMAA, but it's not certain the whale entered the TMAA, and, of the 7 whales tagged off Russia, 1 recorded time in the TMAA and the track of another crossed the TMAA. For additional information about important gray whale migration and feeding areas in the GOA Study Area, see Section 5.4.1.3 (Gray Whales) of this SEIS/OEIS.

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, 2020c).

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) (35 FR 18319), and is considered depleted under the MMPA throughout its range. 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). Whitehead (2002) estimate there are approximately 100,000 sperm whales worldwide; however, that estimate is nearly 20 years old. There have been no changes in sperm whale abundance estimates in the GOA since the 2016 GOA Final SEIS/OEIS (Carretta et al., 2020b). Rone et al. (2017) summarized sperm whale detections during surveys of the TMAA in 2013 and 2015, when 22 and 45 individuals were sighted, respectively. Abundance estimates in the TMAA based on those two surveys ranged between 129 whales in 2013 and 345 whales in 2015 with a mix of age and sex classes, including one calf sighted in 2015. During an August 2021 survey of the continental shelf and slope within and adjacent to the TMAA, 35 sperm whale sightings were recorded, with nearly all observations occurring over the slope (Crance et al., 2022).

3.8.2.9.3 Distribution

Sperm whale occurrence in the GOA Study Area is considered likely year round in waters deeper than 1,000 m and most often in waters deeper 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 based on higher numbers of acoustic detections (Diogou et al., 2019). There have been no changes to the known distribution of sperm whales in the GOA Study Area 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 detections were most common at the shelf break and farther offshore (Rice et al., 2018b), consistent with recent surveys (Crance et al., 2022; Rone et al., 2017). A related study analyzed sperm whale clicks at four sites in the GOA from 2011 through 2015, and showed highest presence, measured as average daily minutes per week, on the slope from April through November with less but notable presence on Kodiak Shelf (Rice et al., 2021a).

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, 2020c).

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 GOA Study Area are not listed under the ESA.

Four killer whale stocks are likely to be present in the GOA Study Area. These stocks include (1) the Eastern North Pacific Alaska Resident stock; (2) the AT1 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., 2020a). Preliminary genetic data for killer whales in Alaska waters indicate that the current stock structure needs revision, but this revision is awaiting completion of a stock structure evaluation before any new stocks are identified (Muto et al., 2020a).

3.8.2.10.2 Abundance

The abundance of the Eastern North Pacific Alaska Resident stock of killer whales is estimated to be 2,347 whales, and the stock continues to increase by about 3 percent per year (GulfWatch Alaska, 2019; Matkin et al., 2018; Muto et al., 2020a). As of 2018, there were only 7 whales remaining in the AT1 Transient stock, and there has been no recruitment into the stock since 1984 (Muto et al., 2020a). The Eastern North Pacific GOA, Aleutian Islands, and Bering Sea Transient stock of killer whales has an abundance estimated at 587 whales; data on population trends are not available (Muto et al., 2020a). NMFS considers the population trajectory for Eastern North Pacific Offshore killer whales with an abundance of 300 whales to be stable (Carretta et al., 2020b).

3.8.2.10.3 Distribution

Killer whale occurrence in the GOA Study Area is considered likely year round. Based on data from Olsen et al. (2018), the Alaska Resident killer whales 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 four killer whale stocks may be present, but the one offshore stock and the two transient stocks are more likely to occur in deep ocean habitat farther offshore, which makes up the majority of the GOA Study Area, than the resident stock. The Alaska Resident killer whales are more likely to occur over the shelf and inshore of the TMAA.

Acoustic detections of killer whale whistles, pulsed calls, and clicks, are similar across all stocks but are distinguishable between stocks in the context of accompanying behaviors (e.g., feeding behaviors) (Myers et al., 2021). Passive acoustic monitoring has confirmed that killer whales occur year round and predominantly over the continental shelf (Kenai Shelf and Kodiak Shelf) inshore of the TMAA (Myers et al., 2021; Rice et al., 2021a; Schorr et al., 2022). Fewer calls were detected over the slope, and those occurred mostly from May through August. Clicks were also detected farther offshore at Quinn Seamount and over the slope mainly from March to August, indicative of foraging behavior (Rice et al., 2021a).

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, 2020c).

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. NMFS 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 GOA Study Area (Muto et al., 2020a). 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., 2020a).

3.8.2.11.3 Distribution

Pacific white-sided dolphin occurrence in the GOA Study Area is considered likely year round. There have been no changes to the known distribution of Pacific white-sided dolphins in the GOA Study Area 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, 2020c).

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 GOA Study Area 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., 2020a).

3.8.2.12.3 Distribution

Harbor porpoise occurrence in the GOA is considered likely year round from nearshore waters extending out to approximately the 200 m isobath in the GOA, and with the highest likelihood of occurrence in waters less than 100 m deep (Hobbs & Waite, 2010). These habitat preferences limit occurrence within the GOA Study Area, mainly to nearshore portions of the TMAA over the continental shelf. The WMA extends seaward from the 4,000 m isobath, which approximates the bottom of the continental slope; therefore, harbor porpoises are not expected to occur in the WMA. There have been no changes to the known distribution of harbor porpoise in the GOA Study Area 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, 2020c).

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., 2020a).

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., 2020a). Density estimates derived from line-transect survey data collected in and near the TMAA (Rone et al., 2017) were used in the analyses. An August 2021 survey of the continental shelf and slope within an adjacent to the TMAA reported 109 Dall's porpoise sightings, reconfirming their presence in waters over the shelf and slope in the GOA (Crance et al., 2022).

3.8.2.13.3 Distribution

Dall's porpoise occurrence in the GOA Study Area is considered likely year round. There have been no changes to the known distribution of Dall's porpoise in the GOA Study Area 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, 2020c).

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., 2020a).

3.8.2.14.2 Abundance

No data are available regarding population trends for the stock of Cuvier's beaked whales in the GOA Study Area (Muto et al., 2020a).

3.8.2.14.3 Distribution

Cuvier's beaked whale occurrence in the GOA Study Area is considered likely year round with greater presence in late fall and early winter (Rice et al., 2021a). Passive acoustic monitoring at three sites in the TMAA between May and September in 2015 and April and September in 2017 (Rice et al., 2018b) detected Cuvier's beaked whales most commonly in spring at the deep water monitoring site located approximately in the middle of the TMAA (Site "AB"). No detections occurred in summer (July through September) or at the shallowest (900 m) site at any time (Rice et al., 2018b). From 2011 through 2015, clicks by Cuvier's beaked whales were detected over the slope and at two seamounts (Quinn and Pratt) primarily in winter (Rice et al., 2021a).

Acoustic sampling using free-floating hydrophones detected many beaked whales in waters over the bathymetrically featureless areas of the abyssal plain off Southern California, which is contrary to the conventional wisdom that beaked whales are primarily found over slope waters; in deep, enclose basins; or at seamounts (Griffiths & Barlow, 2016). These results are consistent with the acoustic monitoring conducted in the GOA in 2015 and 2017 using stationary hydrophones (Rice et al., 2018b). Research involving tagged Cuvier's beaked whales In Southern California has documented movements in excess of hundreds of kilometers indicating potential widespread use of the GOA Study Area. 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 of over 450 km to an area south of Mexico and back into California waters (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, 2020c).

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., 2020a). The Alaska stock of Baird's beaked whales is not listed under the ESA (Muto et al., 2020a).

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., 2020a).

3.8.2.15.3 Distribution

The occurrence of Baird's beaked whale in the GOA Study Area is considered likely year round. There have been no changes to the known distribution of Baird's beaked whales in the GOA Study Area 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, 2018). If that one sample involving a 400 NM excursion is reflective of more general behavior, Baird's beaked whales present in the GOA Study Area may have much larger home ranges than the waters bounded by the TMAA. From 2011 through 2015, clicks by Baird's beaked whales were detected almost exclusively over the slope and at two seamounts (Quinn and Pratt) with only two detections on the shelf (i.e., on Kenai Shelf) in 2014. Detections on the slope occurred from late fall through early winter, and detections at Quinn Seamount occurred from late winter through early spring. There were fewer detections and no discernable pattern at Pratt Seamount (Rice et al., 2021a).

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, 2020c).

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., 2020a).

3.8.2.16.2 Abundance

There have been no new data regarding the number of Stejneger's beaked whales present in the GOA Study Area 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., 2020a).

3.8.2.16.3 Distribution

The occurrence of Stejneger's beaked whale in the GOA Study Area is considered likely year round. There have been no changes to the known distribution of Stejneger's beaked whales in the GOA Study Area since the 2016 GOA Final SEIS/OEIS. Stejneger's beaked whale echolocation clicks have been detected by passive acoustic monitoring primarily over the slope, with fewer detections farther offshore in the TMAA. Clicks were detected throughout the year over the slope with a peak in the number of detections in fall (Rice et al., 2021a; Rice et al., 2018b). Detections at two seamounts (Quinn and Pratt) farther offshore were sporadic throughout the year and few in number (Rice et al., 2021a).

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, 2020c).

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. NMFS has designated two Steller sea lion stocks in the North Pacific corresponding to two DPSs (Muto et al., 2020a); both populations are potentially present within the GOA Study Area. 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., 2020a). The Western U.S. stock is listed as depleted under the MMPA and endangered under the ESA (55 FR 49204). 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 GOA Study Area is located outside of Steller sea lion critical habitat.

The Eastern U.S. stock (or DPS) of Steller sea lions is currently listed as depleted under the MMPA. In recognition of their recovery, Steller sea lions in the Eastern U.S. DPS were delisted under the ESA in October 2013 (Muto et al., 2020a; 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., 2020a; 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., 2020a).

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 GOA, Central GOA, and Eastern GOA (Sweeney et al., 2017). Of these three groups, only Steller sea lions in the Eastern GOA and Central GOA groups are expected to occur within the TMAA, based on proximity of haulout and breeding sites located along the coastline. The range of the Western GOA group extends along the coast and into the Aleutian Islands and is inshore of the WMA. The primary habitat of Steller sea lions in Alaska is over the continental shelf, approximated as the 500 m isobath, and the nearshore boundary of the WMA is the 4,000 m isobath, indicating that the WMA and Steller sea lion preferred habitat do not overlap, and, as shown in Figure 3.8-2, the distance between Steller sea lion critical habitat and the WMA is about 20 NM or more.

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 GOA Study Area 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, 2020c).

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 and 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 abundance estimate for the California sea lion in the U.S. stock is 257,606 (Carretta et al., 2020b). As with other pinnipeds, the size of the U.S. stock is estimated from counts of pups at rookeries during each breeding season, and the total number of pups is used to estimate the species abundance (Carretta et al., 2020b; Laake et al., 2018).

The abundance of California sea lions in the GOA Study Area is not likely to have changed substantially 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., 2020a). 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 GOA (based on unpublished data collected by the Alaska Department of Fish and Game).

3.8.2.18.3 Distribution

Occurrence of the California sea lion in the GOA Study Area is considered rare and seasonal. California sea lions are only expected to occur over the continental shelf in the GOA, out to depths of 500 m, limiting their occurrence in the Study Area to the inshore portion of the TMAA. California sea lions breed on islands located off southern California; western Baja California, Mexico; and in the Gulf of California, Mexico (Carretta et al. 2021). Following the breeding season (May through July), males migrate north to nearshore waters off Washington, Oregon, and British Columbia, with some males traveling as far north as the GOA (Lowry & Forney, 2005; Maniscalco et al., 2004). Based on their migratory behavior, males would only be expected in the GOA in April and into May over the timeframe of the analysis in the SEIS/OEIS (April through October). Females are not expected to occur within the GOA and males would not be expected to occur within the WMA based on their preference for nearshore habitat closer to haulout sites.

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, 2020c).

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., 2020a). The Eastern Pacific stock occurs year round in the GOA Study Area, and pups from the California stock may also occur in the GOA 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 GOA Study Area 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., 2020a), 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 GOA. Nevertheless, the vast majority of fur seals in the GOA would be from the Eastern Pacific stock.

3.8.2.19.3 Distribution

Northern fur seal occurrence in the GOA Study Area is considered seasonal with the highest likelihood of occurrence between approximately March and June during the time when adults migrate through the GOA to breeding sites in the Bering Sea (Gelatt & Gentry, 2018). However, the occurrence and movement patterns of juveniles, yearlings, and pups (born the previous year) ensure that some northern fur seals are likely present in the GOA year round. The timing of adult male and female breeding migrations is staggered (Sterling et al., 2014). Adult males return in late spring and are at breeding sites in the Pribilof Islands (St. Paul and St. George), and Bogoslof Island in the Bering Sea between June and October. There are no breeding sites adjacent to the GOA Study Area (Muto et al., 2020b). Females migrate through the GOA in summer, arriving at breeding sites in August and departing in November (Sterling et al., 2014; Zeppelin et al., 2019). Overall, considering the asynchronous timing of migrations and occurrence, the abundance of northern fur seals in the GOA is expected to be greater in the first half of the year (January through June) compared to the second half.

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).

There are no rookeries or breeding sites for the species in or adjacent to the GOA Study Area. 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 GOA Study Area (Muto et al., 2020a).

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, 2020c).

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. 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). NMFS considers northern elephant seals in the GOA Study Area to be from the California Breeding Stock. Although elephant seals from Baja California, Mexico may migrate north as far as the GOA Study Area, females breeding in Mexico forage approximately 8° farther south than females from the California Breeding stock and are less likely to migrate into the GOA (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. An analysis of pup survey data from San Miguel, San Nicolas, and Santa Rosa islands (accounting for over 99 percent of elephant seal births) shows that pup mortality rates decreased from 7.1 percent in 2010 to between 2.7 and 3.6 percent in 2013. Based on the pup data, the population of elephant seals in the Channel Islands was estimated to have increased by 3.1 percent annually between 1989 and 2013 (Lowry et al., 2020). 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 seal occurrence in the GOA Study Area is considered seasonal; however, elephant seals are likely to occur in the GOA, with varying abundance, from March through October, encompassing the Navy's April through October training period. The highest abundance of elephant seals in the GOA is expected to be from July through September. There have been no changes to the known distribution of northern elephant seals since the 2016 GOA Final SEIS/OEIS.

Elephant seals make two annual migrations from breeding rookeries in California: a post-breeding migration and a post-molting migration. Both males and females in the California stock are in the Channel Islands during the breeding season from December to mid-March, with peak abundance around the end of January) (Le Boeuf et al., 2000; Le Boeuf & Laws, 1994). Adult females arrive in mid-December, reach peak abundance around the end of January, and have all returned to sea by early March. Adult males spend the entire period on shore (December through March), but younger males leave in mid-February. Post breeding, males and females distribute widely into the eastern North Pacific for a relatively short period to forage before returning to the Channel Islands to molt. Females that gave birth in early December return in mid-March to molt, a process that takes about one month. Adult females and juveniles of both sexes continue to return through May, with peak abundance in late April. Males return later than females and are on shore longer, hauling out from June to August. Elephant seals embark on a longer post-molting migration before returning the next year to breed. Females have departed the Channel Islands by mid-June and remain at sea until December, coincident with the eight-month gestation period. Males depart in September, returning to the Channel Islands in December for the next breeding season (Le Boeuf & Laws, 1994). While elephant seals have the potential to occur in the GOA Study Area over the entire period training activities could occur (April to October), abundance in the GOA will vary due to the different timing of male and female migrations between foraging areas in the North Pacific, including the GOA, and breeding and molting sites in the Channel Islands.

Northern elephant seal juveniles and females forage in the pelagic waters of the central and northern North Pacific. Males feed on pelagic prey but also supplement their diet with benthic prey and tend to forage in shallower waters closer to shore where benthic habitat is more accessible. Males may 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; however, their range is not continuous across the North Pacific (Robinson et al., 2012; Simmons et al., 2010; Stewart & Huber, 1993). Adult females mostly range west to about 173° W longitude and remain 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 latitudes (Le Boeuf et al., 2000; Robinson et al., 2012; Stewart & DeLong, 1995; Stewart et al., 1993). Robinson et al. (2012) tracked female elephant seals fitted with satellite tags and showed that foraging areas strongly correlated with the location of the stable boundary separating the sub-arctic and sub-tropical gyres, which fluctuates seasonally but remains between 40° N and 50° N latitude but is typically at or slightly north of 45° N latitude. The southern extent of the GOA Study Area is at approximately 50° N latitude.

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, 2020c).

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. 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 GOA Study Area: the North Kodiak, South Kodiak, Prince William Sound, and Cook Inlet/Shelikof Strait stocks (Carretta et al., 2020b; Muto et al., 2020a).

3.8.2.21.2 Abundance

The current statewide abundance estimate for Alaska harbor seals is 243,938 (Muto et al., 2020a). Abundance estimates for the four stocks considered in this SEIS/OEIS totaling over 108,000 seals 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., 2020a).

3.8.2.21.3 Distribution

Harbor seal occurrence in the GOA Study Area is considered rare year round, except for the nearshore portions of the TMAA that overlap with the continental shelf. While it is possible that harbor seals may travel farther offshore into the deeper waters of the GOA Study Area, the vast majority of harbor seals would remain closer to shore and over the continental shelf, which is estimated to terminate at the 500 m isobath for the acoustic impacts analysis. Harbor seals would not be expected in the deep offshore waters of the WMA.

Harbor seals prefer coastal habitat, frequently occupying bays, estuaries, and inlets, and are rarely found more than 20 km from shore. They spend much of their time hauled out along rocky shorelines (Baird, 2001; Harvey & Goley, 2011; Huber et al., 2001; Jefferson et al., 2014). Although they are distributed over a wide geographic range of coastal habitats, harbor seals are not considered migratory (Burns, 2009; Harvey & Goley, 2011; Jefferson et al., 2008). In a study investigating their site fidelity, 180 radio-tagged harbor seals in California 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, ice flows, and even peat banks in salt marshes (Burns, 2009; Gilbert & Guldager, 1998; Prescott, 1982; Schneider & Payne, 1983; Wilson, 1978). Considering their habitat preferences, harbor seals are unlikely to occur in the GOA Study Area outside of the nearshore portion of the TMAA.

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, 2020c).

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., 2020a). 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., 2020a).

3.8.2.22.3 Distribution

Ribbon seal occurrence in the GOA Study Area is considered 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 GOA, indicating that their summer distribution includes the GOA; however, the number of ribbon seals that could occur in the GOA Study Area 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, 2020c).

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 GOA Study Area, the northern sea otter is a species under the federal jurisdiction of USFWS within the Department of the Interior. Three stocks of sea otters are recognized by the USFWS: the Southwest Alaska stock, Southcentral Alaska stock, and the Southeast Alaska stock. The Southwest Alaska 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 Southcentral Alaska stock and the Southeast Alaska stock are also found along the GOA coast, but those populations are not ESA-listed.

The recovery plan for the Southwest Alaska DPS of 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 DPS, and it encompasses approximately 15,000 square kilometers of nearshore habitat, including around Kodiak Island and along the Alaska Peninsula, none of which is within or near the GOA Study Area. 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) reported Alaska Natives harvested of 1,380 northern sea otters 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 (Muto et al., 2020a), are based on disparate surveys covering a portion of each stock's geographic range in separate years. The Southeast Alaska stock surveys occurred between 2000 and 2008, the Southcentral Alaska stock surveys occurred between 2000 and 2010, and the Southwest Alaska stock surveys occurred between 2000 and 2014 (Lance et al., 2015; Muto et al., 2020a). The threatened Southwest Alaska stock is stable and may be increasing in number with an estimated abundance of 54,771 sea otters distributed from the GOA through the Aleutian Islands (Muto et al., 2020a). The Southcentral Alaska stock (18,297 sea otters) and Southeast Alaska stock (25,712 sea otters) also appear to be increasing in overall abundance (Muto et al., 2020a).

3.8.2.23.3 Distribution

Sea otters are not likely to occur in the TMAA or WMA. 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 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 expected to remain in waters shallower than 100 m, because they are primarily benthic foragers, and a depth of 100 m represents the upper limit of their foraging depth range (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 where shoals are located and where foraging may occur; however, there are no known offshore shoals or other shallow areas in the Study Area that would attract foraging sea otters. It is possible that vagrant individuals from the Southcentral Alaska stock or the Southeast Alaska stock could occur in the nearshore margins of the TMAA; however sea otters are not expected to occur in the deep offshore waters of the WMA. U.S. Fish and Wildlife Service (2011) 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 SEIS/OEIS, consists of activities that have been occurring in the TMAA for years and have been previously analyzed to assess 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). As part of the baseline for analysis in this SEIS/OEIS, it is important to recognize that Navy training events have been occurring in and around the TMAA since the mid-1990s without any indications of significant impact on the environment in general or marine mammals in particular. NMFS 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, 2011). The USFWS reaffirmed their determination with a letter of concurrence to the Navy on March 29, 2022.

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 the Proposed Action could impact marine mammals in the GOA Study Area. Refer to Section 3.0.3 (Resources and Issues Considered for Re-Evaluation in this Document), to review the approach to identifying resources requiring re-analysis under Alternative 1. 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, the proposed training activities in the TMAA do not include a SINKEX event and the explosive munitions used in that event. No longer including the SINKEX event as part of Proposed Action, eliminated the use of explosives detonated underwater. However, the Proposed Action retains activities involving the use of explosives detonating at or near the water's surface.[3] To facilitate the Navy's acoustic effect modeling, which only considers the impacts from explosives that detonate underwater, these activities have been conservatively modeled as if detonations occurred underwater, just below the surface, for purposes of quantitatively estimating potential effects on 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 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 GOA Study Area.

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 GOA Study Area 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).

[3] 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.

Vessel maneuvering activities in the WMA would introduce the risk of a ship strike, primarily for large cetaceans, in a region where training activities were not initially proposed in the 2020 GOA Draft SEIS/OEIS. However, the number of vessels and steaming hours in the Proposed Action is the same as the number proposed and analyzed in the 2020 GOA Draft EIS/OEIS. These same activities are now dispersed over the TMAA and WMA. Vessel maneuvering activities in the WMA would occur in deep offshore waters (greater than 4,000 m) located beyond the continental shelf and slope, where marine mammal occurrence and densities are generally lower. The probability of a ship strike in the WMA would be lower than the already low probability for a strike in the TMAA, because (1) fewer activities would take place in the WMA, (2) the vessel maneuvering activities that would occur in the WMA would be dispersed over a substantially larger area than the TMAA, and (3) the WMA does not overlap with habitat where most marine mammal species are expected to occur. Relocating some vessel maneuvering activities from the TMAA into the WMA would slightly reduce the probability of a ship strike in the TMAA, such that, when considered together, the probability of a ship strike would remain approximately the same as previously analyzed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS.

Based on the absence of any Navy vessel strikes associated with the Proposed Action in the GOA Study Area 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 GOA Study Area 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 GOA Study Area.

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, because, in addition to other standard safety measures employed when towing in-water devices, observers on the towing platform are tasked with ensuring that the platform avoids marine mammals and any other potential hazards to navigation. 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.

One type of military expended material, inert small-caliber projectiles, are aimed at and typically strike targets and travel relatively short distances, reducing the likelihood of striking a marine mammal at the water's surface. Furthermore, once an airborne projectile, particularly a small, high-velocity projectile, penetrates the water's surface its velocity is dramatically reduced due to the increased drag it encounters moving through water. The higher density of water and the design of standard projectiles intended to travel through air and not water causes the projectile's forward progress to halt completely within a few feet (Lee et al., 1997; May, 1952; Truscott et al., 2009). Projectiles impacting the water at shallow angles may also ricochet off the water's surface, tumble through the air, and only enter the water at greatly reduced velocities and kinetic energy (Truscott et al., 2009). As a result, marine mammals are extremely unlikely to be struck or disturbed by small-caliber munitions or even larger inert projectiles, which are subject to and respond similarly to the same physical forces as smaller projectiles. There have been no known instances of a seafloor device (such as an anchor) striking a marine mammal as it is being deployed or recovered. In addition, use of the PUTR, proposed in the 2016 GOA SEIS/OEIS is no longer a part of the Proposed Action.

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 procedural mitigation measures for applicable vessel movements, towed in-water devices, and during activities using non-explosive military expended materials. As an added precaution, for this SEIS/OEIS, the Navy developed new mitigation to issue pre-event awareness notification messages to alert ships and aircraft operating within the GOA Study Area to the possible presence of increased concentrations of large whales over the continental shelf and slope. Large whale species (including but not limited to fin whale, blue whale, humpback whale, gray whale, North Pacific right whale, sei whale, minke whale, and sperm whale) may be susceptible to ship strike, particularly while ships are traversing over the continental shelf and slope where densities of these species are high relative to other areas of the GOA Study Area. To maintain safety of navigation and to avoid interactions with these species, 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. These 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 the physical disturbance and strike stressor forward for 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 GOA Study Area, 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 (2020a); 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 GOA Study Area in this SEIS/OEIS include the following:

- Acoustic (sonar and other transducers, vessel noise, aircraft noise, weapons noise).
- Explosives (at or near the surface).

The Navy's quantitative acoustic effects analysis only analyzes impacts from sonar and other transducers and explosives, which are not used in the WMA. Therefore, the analysis of stressors from the use of sonar and other transducers and explosives presented in Section 3.8.3.1.2 (Impacts from Sonar and Other Transducers) and Section 3.8.3.2.2 (Impacts from Explosives) is only relevant to activities occurring in the TMAA, and, therefore, those sections reference the TMAA and not the GOA Study Area or the WMA. Vessel noise, aircraft noise, and weapons noise would occur in the WMA as well as the TMAA under Alternative 1, and the analysis of those other acoustic stressors is applicable to the entire GOA Study Area.

The majority of the changes in the quantitative modeling results for acoustic 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; Southall et al., 2021). 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 negative 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 responses (Section 3.8.3.1.1.5, Behavioral Reactions) range 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 organisms. 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. To validate decompression sickness observations in certain stranded cetaceans found coincident with naval activities, a study used rabbits as an experimental pathological model and found that rabbit mortalities during or immediately following decompression showed systematically distributed gas bubbles (microscopic and macroscopic), as well as emphysema and hemorrhages in multiple organs, similar to observations in the stranded cetacean mortalities (Velazquez-Wallraf et al., 2021). Similar findings were not found in almost half the rabbits that survived at least one hour after decompression, revealing individual variation has an essential role in this condition.

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), and reviewed in Fahlman et al. (2021) 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).

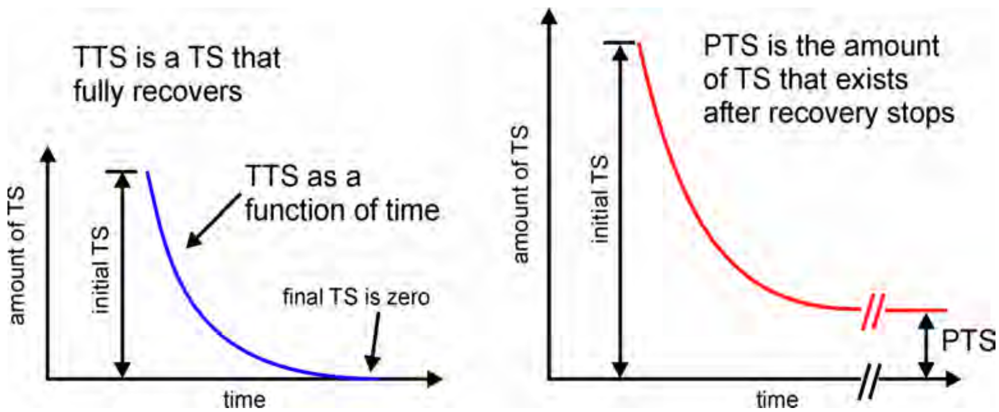
3.8.3.1.1.2 Hearing Loss

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 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 the amount of TTS that did not result 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) (Houser, 2021). 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., 2020c; Kastelein et al., 2019g; Kastelein et al., 2020g; 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 overestimate 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., 2019g), 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., 2019f)). 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 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 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 (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). Another study showed that echolocating animals (including odontocetes) might have anatomical specializations that might allow for conditioned hearing reduction and filtering of low-frequency ambient noise, including increased stiffness and control of middle ear structures and placement of inner ear structures (Ketten et al., 2021). 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.

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 airguns 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 of two species, bottlenose dolphins and beluga whales (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). Two high-frequency cetacean species have been studied for TTS due to non-impulsive sources: the harbor porpoise (Kastelein et al., 2020a; Kastelein et al., 2013a; Kastelein et al., 2015b; Kastelein et al., 2019d; Kastelein et al., 2020b; Kastelein et al., 2021a; Kastelein et al., 2020d; Kastelein et al., 2017a; Kastelein et al., 2019g; 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 and are summarized below.

- 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 overestimate 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. (2020d) 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., 2019e) 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.
- Additionally, Kastelein et al. (2019f) 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., 2020e). However, recovery patterns may be less gradual for higher-magnitude TTS (above 45 dB).
- 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.

- (Kastelein et al., 2021a) measured underwater, behavioral hearing thresholds at 0.5, 0.71, and 1 kHz in one harbor porpoise before and after exposure to one-sixth-octave band noise centered at 0.5 kHz. Maximum TTS was 8.9 dB (mean = 7.6 dB) at the 0.5 kHz hearing test frequency after a 205 dB SEL exposure. For the 0.71 and 1 kHz hearing test frequencies, no mean TTS > 6 dB was observed. However, at 0.71 kHz, maximum TTS of 6.5 dB (mean = 5.8 dB) was observed after a 205 dB SEL exposure. At 1 kHz, a maximum TTS of 6.3 dB (mean = 5.7 dB) occurred after 206 dB SEL exposures. All shifts < 5 dB recovered within 12 minutes, and shifts > 6 dB recovered within 60 minutes. These results are consistent with Phase III criteria.
- Kastelein et al. (2021c) measured behavioral, underwater hearing thresholds at 2, 2.8, and 4.2 kHz in two California sea lions before and after exposure to band-limited noise centered at 2 kHz. Sea lion hearing was also tested at 4.2, 5.6, 8 kHz before and after exposure to noise centered at 4 kHz. Maximum TTS was 24.1 dB (22.4 dB mean) at the 5.6 kHz test frequency after a 205-dB SEL exposure centered at 4 kHz. Threshold shifts greater than or equal to 6 dB occurred at 187, 181, and 187 dB SEL for 4.2, 5.6, and 8 kHz test frequencies respectively. After exposure to the 2-kHz noise, maximum TTS of 11.1 dB (10.5 dB mean) occurred for 203 dB SEL at the 2 kHz test frequency. Threshold shifts greater than or equal to 6 dB occurred at SELs of 192, 186, and 198 dB for test frequencies 2, 2.8, and 4.2 kHz respectively. These data suggest that one-half octave above the exposure frequency is the most sensitive to noise exposure. TTS between 6 and 10 dB recovered within 60 minutes, 10–15 dB of TTS recovered within 120 min, and TTS up to 24.1 dB recovered after 240 min.
- Kastelein et al. (2022c) measured underwater, behavioral hearing thresholds in two California sea lions at 8, 11.3, and 16 kHz before and after exposure to one-sixth-octave noise bands centered at 8 kHz. Hearing was also tested at 16, 22.4, and 32 kHz after exposure to one-sixth-octave noise bands centered at 16 kHz. The greatest TTS occurred at hearing test frequencies one-half octave above the center frequency of the fatiguing sound. For the 8 kHz exposure, maximum TTS was 20.2 dB (18 dB mean) immediately (1-4 minutes) after a 190 dB SEL re 1 µPa exposure. Mean TTS ≥ 6 dB was observed at 184 dB SEL and above for the 8 kHz hearing frequency, 178 dB SEL and above for the 16 kHz hearing frequency, and at 190 dB SEL for the 16 kHz hearing frequency. For the 16 kHz exposure frequency, maximum TTS was 19.7 dB (16.3 dB mean) immediately after a 207 dB SEL exposure. Mean TTS ≥ 6 dB was not observed at the 16 kHz hearing test frequency but was observed at 159 dB SEL and above for the 22.4 kHz hearing frequency, and at 165 dB SEL and above for the 32 kHz test frequency.
- Kastelein et al. (2022b) measured underwater behavioral hearing thresholds in two California sea lions at 0.6 0.85 and 1.2 kHz before and after exposure to a one-sixth-octave noise band centered at 0.6 kHz. Hearing tests were also conducted at 1, 1.4, and 2 kHz after exposure to a one-sixth-octave noise band centered at 1 kHz. For the 0.6 kHz exposure, the maximum TTS was 7.5 dB (6.7 dB mean) for a 210 dB SEL exposure at the hearing test frequency one-half octave above the center frequency of the fatiguing stimulus (0.85 kHz), which recovered after approximately 12 minutes. For the 1 kHz exposure, the maximum TTS was 10.6 dB (9.6 dB mean) after a 195 dB SEL exposure at the hearing test frequency one-half octave above the center frequency of the fatiguing stimulus (1.4 kHz). Mean TS greater than 6 dB (mean = 8.0, min = 7.2,

max = 8.5) was also observed after exposure to the 1 kHz fatiguing stimulus at 195 dB SEL for the 1 kHz hearing test frequency. For this exposure frequency, hearing recovered within 24 minutes.

- The results from the two sea lion studies described above (Kastelein et al., 2022b; Kastelein et al., 2021c; Kastelein et al., 2022c) suggest that the onset of TTS for otariids in water may be lower than currently assumed.

Threshold Shift due to Impulsive Sound Sources

Cetacean TTS data from impulsive sources are limited to three 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. Lucke et al. (2009) reported AEP-measured TTS of 7 to 20 dB in a harbor porpoise exposed to single impulses from a seismic airgun. Sills et al. (2020) reported TTS of 9.4 dB in a bearded seal exposed to a four-shot airgun impulse.

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 overestimate 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 airgun (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 airgun 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 airgun impulses. Either a single or double airgun arrangement was used. Maximum exposure peak pressure was 194/199 dB re 1 μPa for single/double airguns. 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 airguns. Kastelein et al. (2020f) 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 overestimated measured effects.
- Kastelein et al. (2019f) 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.
- Kastelein et al. (2020f) measured underwater, behavioral hearing thresholds in one harbor porpoise before and after exposure to airgun impulses (“shots”). Exposure conditions varied with regards to number of airguns, number of shots, light cues, and position of the dolphin relative to the airguns. Hearing test frequencies were 2, 4, and 8 kHz, and no TTS > 6 dB was observed.

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.Elmegaard et al. (2021) found that sonar sweeps did not elicit a startle response in captive harbor porpoises, but initial exposures induced bradycardia, whereas impulse exposures induced startle responses without a change in heart rate. The authors suggested that the parasympathetic cardiac dive response may override any transient sympathetic response, or that diving mammals may not have the cardiac startle response seen in terrestrial mammals in order to maintain volitional cardiovascular control at depth. Similarly, Thompson et al. (1998) observed a rapid but short-lived decrease in heart rates in harbor and grey seals exposed to seismic airguns (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. Yang et al. (2021) measured cortisol concentrations in two bottlenose dolphins and found significantly higher concentrations after exposure to 140 dB re 1 µPa impulsive noise playbacks. Two out of six tested indicators of immune system function underwent acoustic dose-dependent changes, suggesting that repeated exposures or sustained stress response to impulsive sounds may increase an affected individual’s susceptibility to pathogens. However, exposing dolphins to a different acoustic stressor yielded contrasting results. 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., 2014a; Williams et al., 2014b; 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.

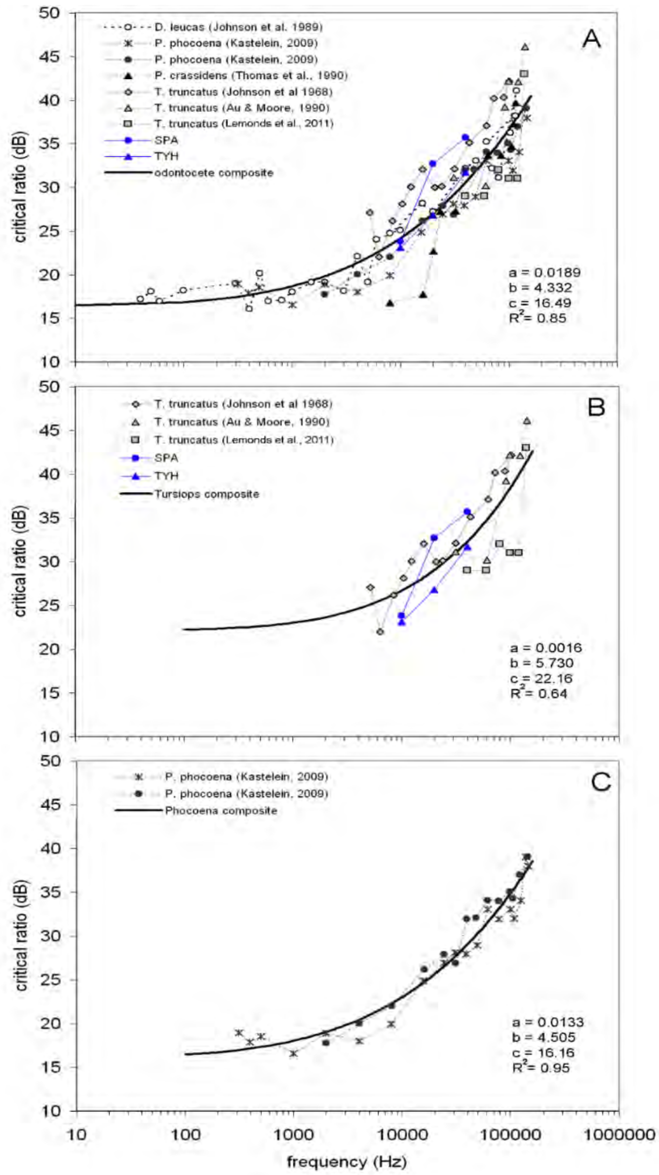
Collectively, these studies indicate the difficulty in teasing out factors that are dominant in exerting influence on the secretion of stress hormones, including the separate and additive effects of vessel presence and vessel noise. Nevertheless, although the reduced presence of the ships themselves 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).

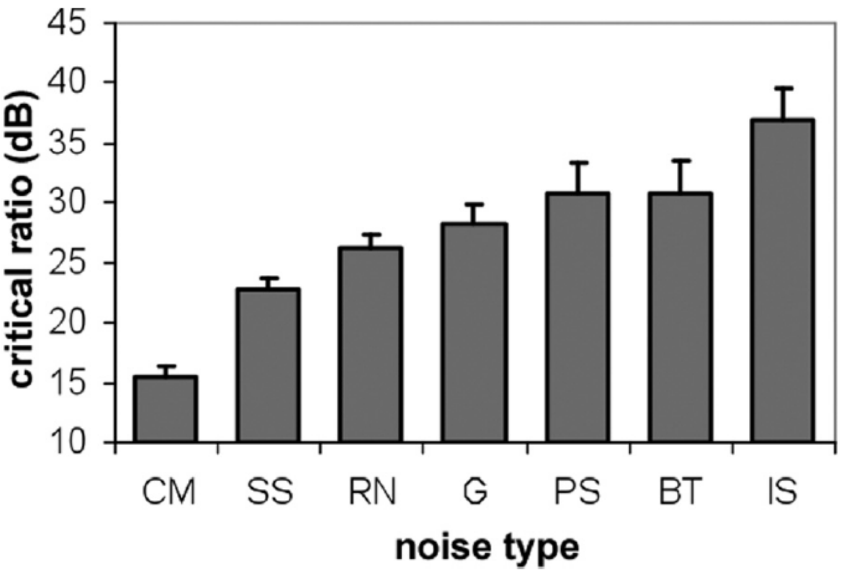
Critical ratios are the lowest signal-to-noise ratio in which detection under masking conditions occurs (Finneran & Branstetter, 2013; Johnson et al., 1989; Southall et al., 2000). When expressed in dB, critical ratios can easily be calculated by subtracting the noise level (in dB re 1 $\mu Pa^2/Hz$) 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., 2021; 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). For example, Kastelein et al. (2021b) showed that, for harbor porpoises, compared to continuous, constant amplitude (Gaussian) noise, up to 14.5 dB of masking release (from "dip listening") was observed in non-constant noise. The effect of masking is often modeled using constant-amplitude noise, whereas most Navy sources contain gaps, more like amplitude-modulated noise. 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). In other cases, increases in call amplitudes with ambient noise have been observed to stop increasing above a certain threshold, demonstrating the limitations of vocal compensation for increased noise (Fournet et al., 2021). 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 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 (e.g.,Kastelein et al., 2021b). 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, including echolocation clicks, particularly for delphinids and other mid-frequency cetaceans (Isojunno et al., 2021; von Benda-Beckmann et al., 2021). 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. Masking due to high-duty cycle sonar 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 (von Benda-Beckmann et al., 2021). These may include increases in vocalization amplitude (Lombard effect) and changes in frequency (Brumm & Slabbekoorn, 2005; Hotchkin & Parks, 2013; Isojunno et al., 2021) 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). When communication space of humpback whales was modeled in a pristine environment like the Colombian Pacific, the infrequent addition of ecotour boat noise could temporarily reduce the "very audible area" (> 10 dB signal to noise ratio) of their song's commonly used peak frequency (350 Hz) by 63 percent (Rey-Baquero et al., 2021). 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. (2014a) 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 motorboats 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. Pine et al. (2021) compared communication ranges of bottlenose dolphins in a busy gulf before and during a lockdown prohibiting access to all non-essential small watercraft, and found that the threefold decrease of ambient noise increased dolphin communication ranges nearshore (by 11 percent in one site) and even more in offshore habitats (20 percent), especially below 1 kHz.

Masking by Impulsive Sound

Potential masking from weapon noise is likely to be similar to masking studied for other impulsive sounds, such as airguns. 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 airgun noise at lower received levels (below 100 dB re: 1 μPa^2s cumulative SEL), but once the received level rose above 127 dB re 1 μPa^2s cumulative SEL the call rate began decreasing, and stopped altogether once received levels reached 170 dB re 1 μPa^{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 airgun sounds recorded within 1 km and 30 km of an airgun 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 airgun 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, while Southall et al. (2021) updated the behavioral response severity criteria laid out in Southall et al. (2007) and included recommendations on how to present and score behavioral responses in future work. 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; Jacobson et al., 2022; 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 composed 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^{2}s), 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., 2013b). 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. Changes in foraging duration during killer whale playbacks and mid-frequency sonar were positively correlated across multiple species in the Norwegian studies, including humpback whales, suggesting that tolerance of predation risk may play a role in sensitivity to sonar disturbance (Miller et al., 2022). 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. Building on this work, Durbach et al. (2021) used the same data and determined that individual minke whales tended to be in either a fast or slow movement behavior state while on the range, where whales tended to be in the slow state in baseline or before periods but transitioned into the fast state with more directed movement during sonar exposures. They also moved away from the area of sonar activity on the range, either to the north or east depending on where the activity was located; this explains the spatial redistribution found by Harris et al. (2019b). Minke whales were also more likely to stop calling when in the fast state, or when in the slow state during sonar activity (Durbach et al., 2021). 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; Jacobson et al., 2022; Miller et al., 2015; Moretti et al., 2014; 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; Siegal et al., 2022; 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., 2020b). 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 when utilizing 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; Jones-Todd et al., 2021; 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). When exposed to especially long durations of naval sonar (up to 13 consecutive hours, repeatedly over 8 days), Cuvier's beaked whale detection rates remained low even seven days after the exercise. In addition, a Mesoplodant beaked whale species was entirely displaced from the area during and at least 7 days after the sonar activity (Stanistreet et al., 2022). 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 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. Additionally, re-sightings up to seven years apart indicate a 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 farther 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 northern bottlenose whales, 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). Changes in foraging duration during killer whale playbacks and mid-frequency sonar were positively correlated across four species in the Norwegian studies, including long-finned pilot, sperm, and northern bottlenose whales, suggesting that tolerance of predation risk may play a role in sensitivity to sonar disturbance (Miller et al., 2022). 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; Curé et al., 2021; Miller, 2012; Miller et al., 2014). A close examination of 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 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. Other studies also demonstrate that higher SELs reduced sperm whale buzzing (i.e., foraging) (Isojunno et al., 2021). The time of day of the exposure and order effects (e.g., the SEL of the previous exposure) were also important covariates in determining the amount of non-foraging behavior (Isojunno et al., 2020), Duration of continuous sonar activity also appears to impact sperm whale displacement and foraging activity (Stanistreet et al., 2022). During long bouts of sonar lasting up to 13 consecutive hours, occurring repeatedly over an 8-day naval exercise (median and maximum SPL = 120 dB and 164 dB), sperm whales substantially reduced how often they produced clicks during sonar, indicating a decrease or cessation in foraging behavior. Few previous studies have shown sustained changes in sperm whales, but there was an absence of sperm whale clicks for 6 consecutive days of sonar activity. Curé et al. (2021) also found that sperm whales exposed to continuous and pulsed active sonar were more likely to produce low or medium severity responses with higher cumulative SEL. Specifically, the probability of observing a low severity response increased to 0.5 at approximately 173 dB SEL and observing a medium severity response reached a probability of 0.35 at cumulative SELs between 179 and 189 dB. 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, duration) 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. Durban et al. (2022) tested new methods of observing behavioral responses of groups of small delphinids to sonar, where the use of tags is challenging, and the response of the group is more salient than that of the individual. They tested the use of a land-based observation platform coupled with a drone and multiple acoustic recorders to observe the vocal behavior, group cohesion, group size, and group behavior before, during, and after a simulated sonar exposure. In a group of short-beaked common dolphins, the team found the number of whistles and sub-groups to increase during the exposure period, but the directivity of the tracked subgroup did not change by much.

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. In order to test an alternative acoustic deterrent, Hiley et al. (2021) exposed harbor porpoises to "startle sounds" with a lower broadband source SPL (176 dB re 1 uPa), SEL (169 dB re 1 uPa^{2}s) and duty cycle (0.6 percent) compared to popular acoustic deterrent devices on the market (10.5 kHz peak, 5-20 kHz range, 200 milliseconds each for 15 minutes). Noise was projected from a small vessel and avoidance responses were visually reported from land-based tracking stations. All porpoises travelled at least 1 km (> 3 km max) within 15 minutes of exposure, while no avoidance behaviors were observed during control conditions. During exposure, porpoises increased group cohesion and swim speed away from the transducer compared to control conditions. Around half of the groups studied returned to the study area 31 minutes after the exposure ended. Additionally, sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins & Schevill, 1975). Foraging minke whales exposed to an acoustic deterrent device (15 kHz tone, 198 dB root mean squared) increased their speed and dive durations, increased path predictability indicating straighter paths, and decreased reoxygenation rates (Boisseau et al., 2021). While path predictability had a strong relationship with received level, speed and dive duration were likely more influenced by the presence of the exposure signal instead of the received sound level. 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 farther 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). On the other hand, Elmegaard et al. (2021) found that sonar sweeps did not elicit a startle response in captive harbor porpoises, but initial exposures induced bradycardia, with subsequent habituation that was conserved for at least three years. 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 GOA Study Area 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; Matthews & Parks, 2021; 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 (Amrein et al., 2020; Au & Green, 2000; Currie et al., 2021; 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 airgun arrays, regardless of whether the airguns were active or not; this indicates that it was the presence of ships (rather than the active airguns) 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). Fin whales changed their direction of movement in the presence of whale watching vessels, with less linear movements than before the vessels were present, which could indicate some avoidance of the boats; in addition, their swim speeds while traveling increased after the boats left the area, possibly in response to the rapid speeds used by the boats when leaving (Santos-Carvallo et al., 2021). 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 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; Perez-Ortega et al., 2021; Puszka et al., 2021; 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. Toro et al. (2021) found bottlenose dolphin groups to decrease their surface activity in the presence of whale watching vessels and avoided the vessels more than ignoring or approaching them, 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 is difficult to decouple 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). One study's attempt to distinguish vessel noise from vessel presence conducted a noise exposure experiment which compared behavioral reactions of resting short-finned pilot whale mother-calf pairs during controlled approaches by a tour boat with two electric (136–140 dB) or petrol engines (139–150 dB) (Arranz et al., 2021). Approach speed (< 4 knots), distance of passes (60 m), and vessel features other than engine noise remained the same between the two experimental conditions. Behavioral data was collected via unmanned aerial vehicle and activity budgets were calculated from continuous focal follows. Mother pilot whales rested less and calves nursed less in response to both types of boat engines compared to control conditions (vessel > 300 m, stationary in neutral). However, they found no significant impact on whale behaviors when the boat approached with the quieter electric engine, while resting behavior decreased 29 percent and nursing decreased 81 percent when the louder petrol engine was installed in the same vessel.

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). The dive behavior of acoustically tagged killer whales was examined relative to the presence, distance, and speed of vessels and the presence of an active echosounder, as well as the sex of the tagged animal (Holt et al., 2021); all whales but particularly females were more likely to stop foraging and start traveling when vessels were within 400 m. These findings suggest females may not be able to meet energy requirements in the presence of close vessels, such as whale watching vessels in the Pacific Northwest, which could impact pregnancy and lactation. 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. (2014a) 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., 2014a).

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 and Brazilian waters decrease their call rates and change the frequency parameters of whistles in the presence of boats (Luís et al., 2014; Pellegrini et al., 2021), 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). Foraging Lahille's bottlenose dolphins in Brazil increase the duration of their whistles with increased speed or number of boats within 250 m; they also increase the frequency parameters of their whistles, especially when group size or calf presence increased (Pellegrini et al., 2021). 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 farther 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 haulouts occur during pupping season. Blundell & Pendleton (2015) found that the presence of any vessel reduces haulout time, but cruise ships and other large vessels in particular shorten haulout 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 haulout periods, and increased further when vessels approached and animals re-entered the water. Harbor seals responded more to vessels passing by haulout 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 haulout 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. Hauled-out wild Cape fur seals were exposed to low (60-64 dB re 20 µPa

RMS SPL), medium (64-70 dB), or high (70-80 dB) levels of vessel noise playbacks, depending on the individual's distance to the speaker (i.e., broadcast at 6 m, 3 m, or 1 m) (Martin et al., 2022). Although there were no behavioral differences between the low, medium, and high level exposure groups, mother-pup pairs spent less time nursing (15-31%) and more time awake (13-26%), vigilant (7-31%), and mobile (2-4%) during boat noise conditions compared to control conditions.

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 airgun 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 airgun 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. Similarly, Kuehne et al. (2020) measured the noise specific to Boeing EA-18G Growler takeoffs near the Naval Air Station Whidbey Island, and found that 10 aircraft had an average received level of 134 ± 3 dB re 1 µPa root mean square at 30 m underwater. However, authors made no direct observation of any species being affected by overflights, and at most, compared the measured in-air and underwater received levels with published audiograms or published behavioral response studies.

While aircraft noise can be audible to several species under the water's surface (Kuehne et al., 2020), 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 haulout 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 (Laborie et al., 2021; 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., 1985; 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 airguns 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-airgun 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 airguns, 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 airgun noise, and similar responses were observed in control trials with vessel movement but no airguns so some of the response was likely due to the presence of the vessel and not the received level of the airguns. When looking at the relationships between proximity, received level, and behavioral response, Dunlop et al. (2017) used responses to two different airguns 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 μPa^2s (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 airgun 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 farther 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 μPa^2s cumulative SEL, and ceased altogether at received levels over 170 dB re 1 μPa^2s 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 airgun 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 airgun 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 airguns 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 airgun 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 airgun impulsive sounds observed. In contrast, Atlantic spotted dolphins did show a significant, short-term avoidance response to airgun impulses within approximately 1 km of the source (Weir, 2008). The dolphins were observed at greater distances from the vessel when the airgun was in use, and when the airgun 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. Narwhals exposed to airguns in an Arctic fjord were even more sensitive (Heide-Jorgensen et al., 2021). Even though small and large airgun sources reached ambient noise levels around 3 and 10 km (airgun source levels = 231 and 241 dB re 1 μPa at 1 m), respectively, narwhals still changed their swimming direction away from the source and towards shore when seismic vessels were in line of sight over 11 km away. Swimming speed was context-dependent; whales usually increased speed in the presence of vessels but would reduce speed ("freeze") in response to closely approaching airgun pulses. Other behaviors, like feeding, also ceased when the active airgun noise was less than 10 km away, although received SELs were below 130 dB re 1 μPa^2 s for either airgun at this distance. Due to study research methods and criteria, even these long-distance reactions of narwhals may be conservatively estimating narwhals' range to behavioral response.

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 airgun, 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 airgun 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 similar study examining the presence and foraging activity of harbor porpoises between baseline (102-104 dB) and construction periods (155–161 dB) at two offshore windfarms using C-PODs found fewer porpoise (8-17 percent) and less foraging (41-62 percent) near piledriving, with more porpoises displaced up to 12 km away from pile driving and 4 km from construction vessels (Benhemma-Le Gall et al., 2021). 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. Swim speed, respiration rate, distance from the transducer, and jumping may also increase in response to pile driving sounds, as long as those sounds have higher frequencies present (i.e., above 6 kHz) (Kastelein et al., 2022a). 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 airgun 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 airgun 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, Hastie et al. (2021) studied how the number and severity of avoidance events may be an outcome of marine mammal cognition and risk assessment. Five captive grey seals were given the option to forage in a high- or low-density prey patch while continuously exposed to silence, pile driving or tidal turbine playbacks (148 dB re 1 µPa at 1 m). One prey patch was closer to the speaker, so had a higher received level in experimental exposures. Overall, seals avoided both anthropogenic noise playback conditions with higher received levels when the prey density was limited, but would forage successfully and for as long as control conditions when the prey density was higher, demonstrating that noise has the potential to impact seal foraging decisions if the level is high enough. Similarly, 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 non-startling 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 non-startling treatment did not react or habituated during the exposure period. The results of these studies 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 airguns had no significant impact on sea otters in California. During the multiple airgun 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 airgun vessel was 50 NM away, and success rate only decreased by 5 percent when the multiple airgun 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 airgun experiment, the airgun 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 airgun 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 airgun 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 airgun 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 airgun 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 farther 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). In 2020, 65 confirmed strandings, including multiple species of pinnipeds, large whales, and odontocetes, were reported by NMFS in the Gulf of Alaska (Savage, 2021). Although several mass strandings (strandings that involve two or more individuals of the same species, excluding a single mother-calf pair) have been associated with anthropogenic activities that introduced sound into the marine environment such as naval operations and seismic surveys, none of these have occurred in the GOA 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 conclusively linked to sonar exposure (Danil et al., 2021). 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. (2020) 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. (2020) 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. (2020), 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 (Wang et al., 2021), to behavioral reactions contributing to altered physiology (e.g., "gas and fat embolic syndrome") (Fahlman et al., 2021; 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; Joy et al., 2022; 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 (Jones-Todd et al., 2021; Joyce et al., 2019; McCarthy et al., 2011; Tyack et al., 2011). Jones-Todd et al. (2021) developed a discrete-space, continuous-time analysis to estimate animal occurrence and unique movement probability into and out of an area over time, in response to sonar. They argue that existing models in the field are inappropriate for estimating a whale’s exposure to sonar longitudinally and across multiple exercises; most models treat each day independently and don’t consider repeated exposures over longer periods. This model also allows for individual variation in movement data. Using seven tagged Blainville’s beaked whales’ telemetry data, the model showed transition rates across an area’s borders changing in response to sonar exposure, reflecting an avoidance response that lasted approximately three days after the end of the exposure. A study demonstrated that differences in squid distribution could be a substantial factor for beaked whales habitat preference in the Bahamas as well (Benoit-Bird et al., 2020). 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, 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, western gray 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., 2021; 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.

A review of over fifteen years of Population Consequences of Disturbance modelling data identified the most critical factors for determining long-term impacts to populations to be life-history traits, disturbance source characteristic, and environmental conditions (Keen et al., 2021). 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.

By integrating different sources of data (e.g., controlled exposure data, activity monitoring, telemetry tracking, and prey sampling) into a theoretical model to predict effects from sonar on a blue whale's daily energy intake, Pirotta et al. (2021) found that tagged blue whales' activity budgets, lunging rates, and ranging patterns caused variability in their predicted cost of 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. Pirotta et al. (2021) modeled the effects of more significant and widespread disturbances, and the resulting energy loss due to feeding disruption, on survival and reproductive success of Eastern North Pacific blue whales. The current Navy sonar regime off Southern California did not affect survival or reproductive success, whereas modeled reductions in prey, attributed to environmental changes, had the potential to severely affect reproductive success and survival.

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. The same research team reformulated the previous dynamic energy budget model to investigate the state-dependent life history strategies of female long-finned pilot whales and trade-offs between their body condition (I.e., ability to offset starvation during pregnancy and provide milk), prey availability, and decision to reproduce in situations with and without disturbance (Pirotta et al., 2020). In situations with disturbance, whale reproductive strategies resulted in lower fitness compared to the previous model, measured here as lifetime reproductive output. Hin et al. (2021) used the prior model for pilot whales to examine how lost foraging days affect individuals in a population at carrying capacity, where depletion of prey is dependent on whale density, and prey density limits the energy available for growth, reproduction, and survival. During a disturbance event, population decline was generally attributed to loss of lactating females and calves due to reduced body condition. The subsequent increase in prey density and per capita prey availability, however, resulted in improved body condition in the population overall and decreased age at first calf, suggesting that fitness markers may not indicate population effects.

McHuron et al. (2021) developed a state-dependent behavioral and life history model to predict the probability of Western gray whale mother-calf pair survival with or without acoustic disturbance and with or without prey availability on their summer foraging grounds. Pregnant mother movement, feeding behavior, fat mass and fetal length were input data for the model. Since prey availability was co-dependent on whales having access to prey-dense offshore areas by mid-July, nearshore seismic surveys had no impact on population fecundity or mother-calf survival. The results from this example indicate that Population Consequences of Disturbance researchers should consider "who, where, and when" whales are disturbed to properly evaluate acoustic impacts.

Murray et al. (2021) conducted a cumulative effects assessment on Northern and Southern resident killer whale populations and found that they were both highly sensitive to prey abundance. They were also impacted by the interaction of low prey abundance with vessel strike, vessel noise, and polychlorinated biphenyls contaminants, but more research is needed to validate the mechanisms of all non-prey variables. Even when eleven species of cetaceans' energetic costs associated with behavioral response to mid-frequency active sonar were modeled using data from feeding and metabolic rates, prey characteristics, and avoidance behavior, authors found that the short-term energetic cost was influenced more by lost foraging opportunities than increased locomotor effort during avoidance (Czapanskiy et al., 2021). Additionally, the model found that mysticetes incurred more energetic cost that odontocetes, even during mild behavioral responses to sonar.

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. 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. In another modeling study, harbor porpoise movement and foraging behavior were modeled for periods with seismic activity and found the seasonality of the activity to be an important predictor of impact (Gallagher et al., 2021). Seismic activity in May had a much smaller impact on harbor porpoise health and reproduction, due to the porpoises having greater energy stores that time of year and females having already weaned their calves. In contrast, seismic surveys in September had a much greater impact due to lower energy reserves at that time, while females were lactating and possibly pregnant as well.

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 by 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.

Dunlop et al. (2021) modeled migrating humpback whale mother-calf pairs in response to seismic surveys using both a forwards and backward approach. While a typical forwards approach can determine if a stressor would have population-level consequences, authors demonstrated that working backwards through a Population Consequences of Disturbance model can be used to assess the worst-case scenario for an interaction of a target species and stressor. This method may be useful for future management goals when appropriate data becomes available to fully support the model.

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). Another model analyzed the effect of a number of disturbances on two bottlenose dolphin populations in Australia over five years (Reed et al., 2020), and results indicated that habitat/noise disturbance had little overall impact on population abundances in either location, even in the most extreme impact scenarios modeled.

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 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).

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, 2020c) 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).

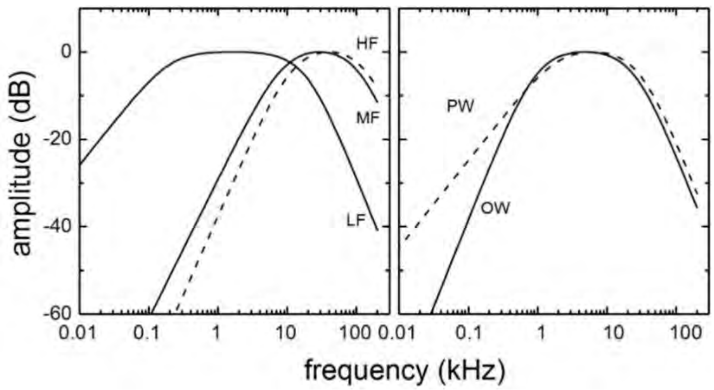
Criteria and Thresholds Used to Estimate Impacts from Sonar and Other Transducers

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 NMFS 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).

The Navy and NMFS are assessing new auditory research published since the development of the Phase III auditory criteria and is summarized in the background section above in this chapter. Notably, emergent research with sea lions (Kastelein et al., 2022b; Kastelein et al., 2021c; Kastelein et al., 2022c) suggests that otariids may be significantly more susceptible to auditory effects than assumed in this analysis. Development of new criteria is an iterative process which validates and incorporates new data along with results of previous investigations and studies. The Navy is working with NMFS to assess how these new studies, as well as other ongoing and future studies, should inform updates to auditory criteria and thresholds.

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.



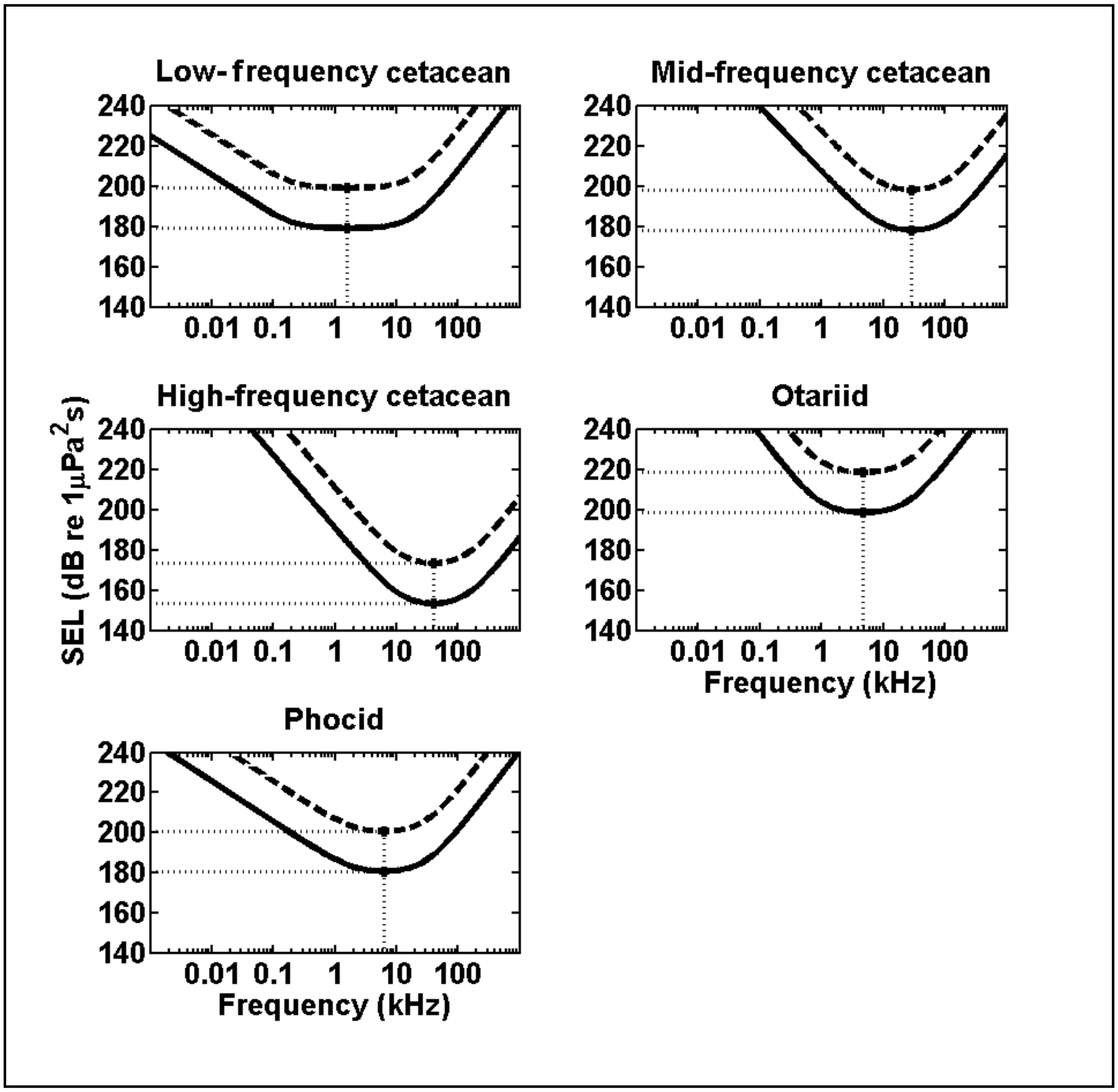
Source: For parameters used to generate the functions and more information on weighting function derivation, see the *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* technical report (U.S. Department of the Navy (2017a))

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 are those with possible immediate consequences to growth, survivability, or reproduction: long-term or permanent abandonment of area; prolonged separation of females and dependent offspring; panic, flight, or stampede; and stranding; and responses affecting animals in vulnerable life stages (e.g., calf, pup, or cub). These responses are 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.

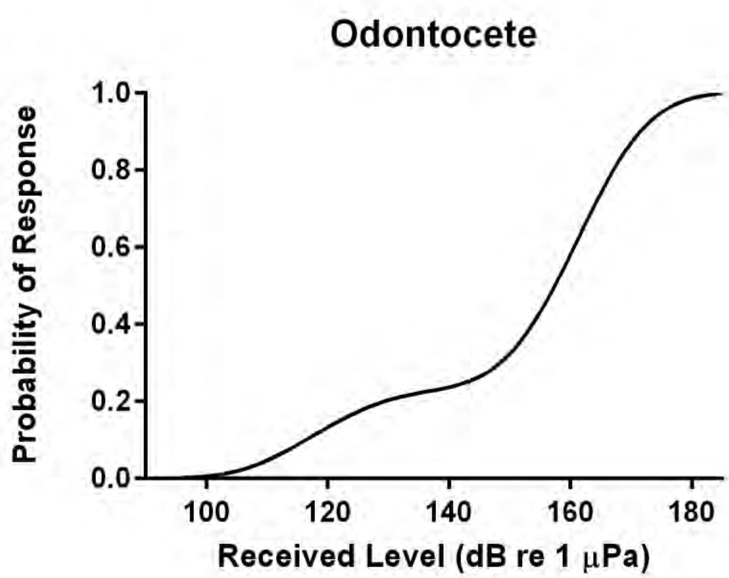


Figure 3.8-8: Behavioral Response Function for Odontocetes

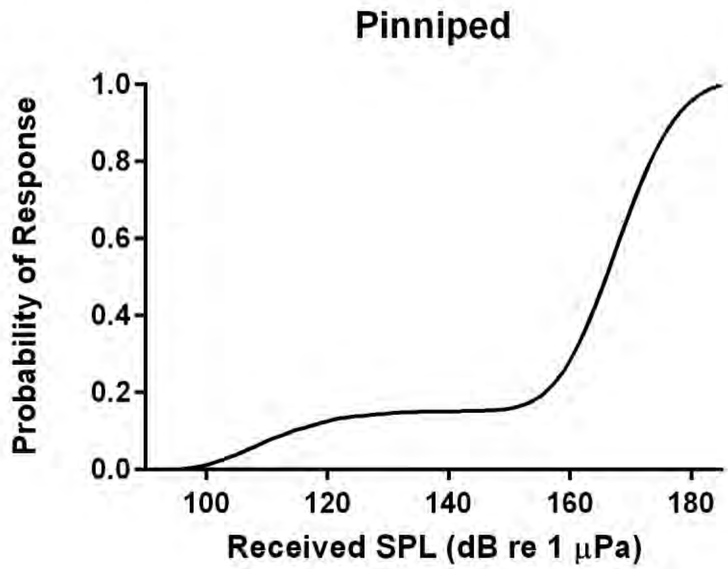


Figure 3.8-9: Behavioral Response Function for Pinnipeds

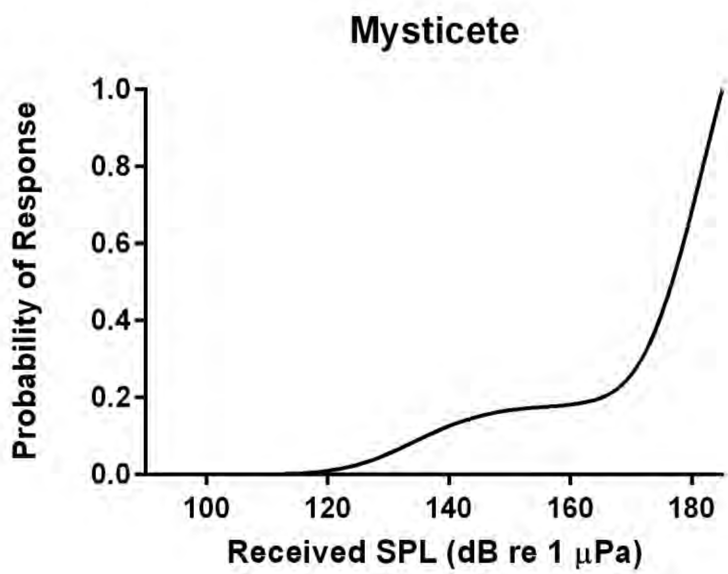


Figure 3.8-10: Behavioral Response Function for Mysticetes

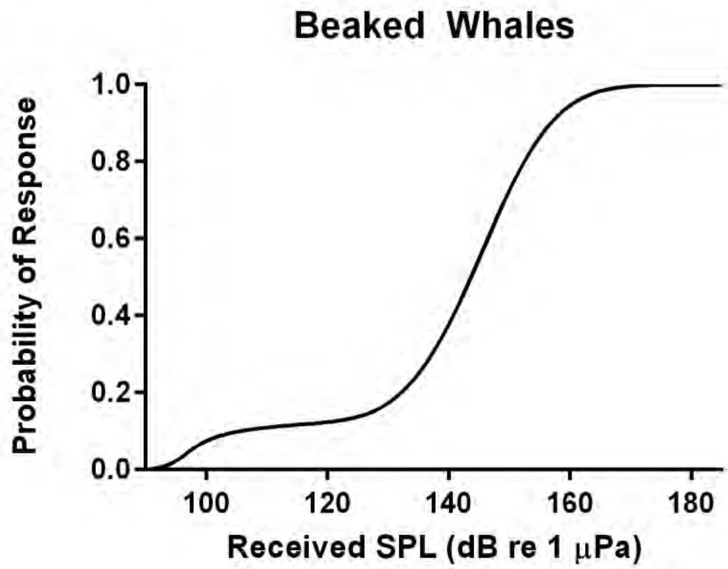


Figure 3.8-11: Behavioral Response Function for Beaked Whales

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).

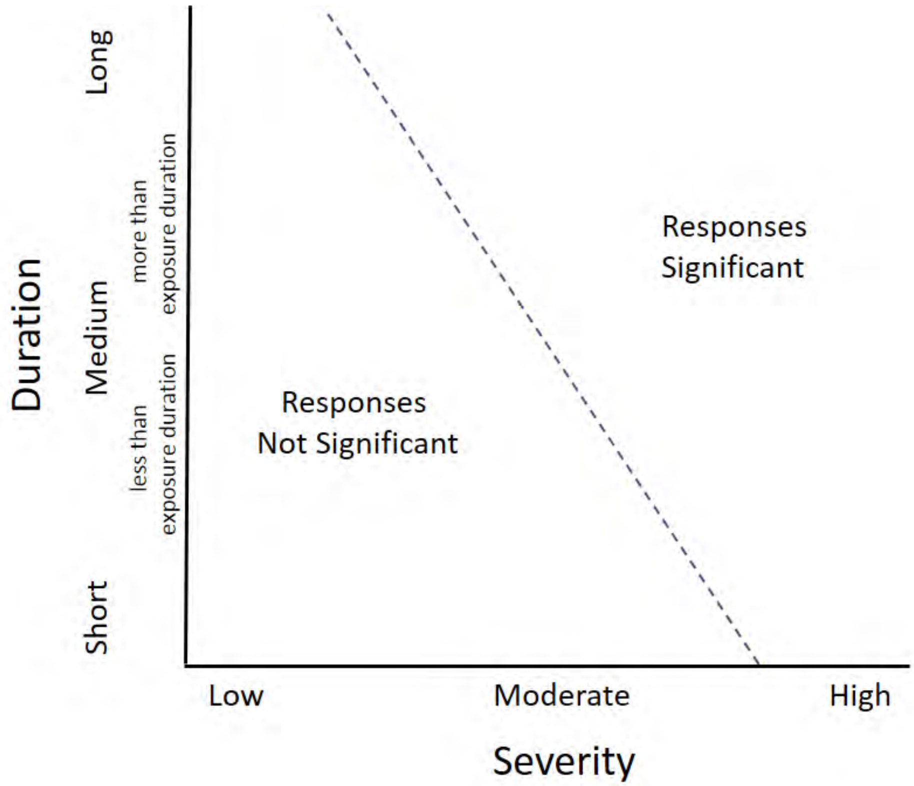


Figure 3.8-12: Relative Likelihood of a Response Being Significant Based on the Duration and Severity of Behavioral Reactions

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). For the Proposed Action, the Navy Acoustic Effects Model did not predict PTS for nearly all species due to sonar. Thus, mitigation was only assessed to reduce PTS for one species, the Dall's porpoise, in the results presented below.

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 Phase III quantitative analysis assumes a lower overall mitigation effectiveness for sonar activities in the GOA compared to Phase II by conservatively assuming sonar use would occur in times of reduced visibility (e.g., at night or in poor conditions).

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 duration (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 Table 3.8-4 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 Gulf of Alaska 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 GOA 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 Gulf of Alaska 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 GOA 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 Gulf of Alaska 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 GOA 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 Gulf of Alaska 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 Gulf of Alaska 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 Gulf of Alaska 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 in the GOA Study Area, and the use of active sonar would no longer 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.

3.8.3.1.2.4 Impacts from Sonar and Other Transducers Under Alternative 1

Sonars would be used during activities in the TMAA, but not the WMA. 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 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 impacts from sonar and other transducers on marine mammals is provided here and supplants the results of previous analyses. The updated analysis is based on available new literature, adjusted sound exposure criteria, new acoustic effects modeling, and updated marine mammal density estimates.

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 near 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.

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. Behavioral response functions predict moderate responses, and the Navy assumes that a subset of those responses may have the potential to be significant. 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* and *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 (Dunlop et al., 2013a). Mysticetes disturbed while migrating could pause their migration or route around the disturbance. While mysticetes' reaction to sonar can vary based on the individual, species, and context (Section 3.8.3.1.1.5, Behavioral Reactions to Sonar and Other Transducers, Mysticetes), whales 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 (Wensveen et al., 2017). 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 after the event subsides. Because the action would occur over a relatively short timeframe (21 days) in the TMAA, it is possible that some individual marine mammals may be exposed to sonar on multiple days. 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 farther 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 farther 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 has requested 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 is consulting 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 Gulf of Alaska 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

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). Although no impacts to the Western North Pacific stock are predicted, NMFS conservatively proposes to authorize take by Level B harassment of one group of Western North Pacific humpback whales. 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 pre-event awareness notification messages to alert ships and aircraft operating within the TMAA to the possible presence of increased concentrations of large whale species, including humpback whales, over the continental shelf and slope where densities may be high relative to other areas of the TMAA. This mitigation area fully overlaps the humpback whale critical habitat within the TMAA. 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 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 critical habitat for the ESA-listed Mexico and Western North Pacific DPSs 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 has requested 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 is consulting 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 critical habitat for humpback whales.

Table 3.8-12: Estimated Impacts on Individual Humpback Whale Stocks Within the Gulf of Alaska 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

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 has requested 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 is consulting 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 Gulf of Alaska 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

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 has requested 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 is consulting 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 Gulf of Alaska 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

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 summer. 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 has requested 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 is consulting 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 Gulf of Alaska 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

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 has requested 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 Gulf of Alaska 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

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; however, NMFS conservatively proposes to authorize take by Level B harassment of one group of Eastern North Pacific gray whale. 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 pre-event awareness notification messages to alert ships and aircraft operating within the TMAA to the possible presence of increased concentrations of large whale species, including gray whales, over the continental shelf and slope where densities may be high relative to other areas of the TMAA. 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. 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. 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 is consulting 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. Because the action would occur over a relatively short timeframe (21 days) in the TMAA, it is possible that some individual marine mammals may be exposed to sonar on multiple days. 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 farther 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 farther 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 farther ranges. Sounds from mid-frequency sonar could mask killer whale vocalizations, making them more difficult to detect, especially at farther 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 has requested 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 is consulting 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 Gulf of Alaska 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

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 has requested 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 Gulf of Alaska 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 Alaska Resident	0	0	0
AT1 Transient	0	0	0
Eastern North Pacific Offshore	64	17	0
Eastern North Pacific Gulf of Alaska, Aleutian Island, & Bering Sea Transient	119	24	0

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 occurrence of Pacific white-sided dolphin in the TMAA is considered 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 has requested 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 Gulf of Alaska 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

Harbor Porpoises

Harbor porpoises may be exposed to sounds from sonar and other transducers associated with training activities April through October. The occurrence of harbor porpoise in the TMAA is considered likely year round in relatively shallow, nearshore habitat extending 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).

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. Dall's porpoise occurrence in the TMAA is considered 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. Unlike harbor porpoises, however, Dall's porpoises are known to occasionally approach vessels to bow ride. Dall's porpoises typically travel in small groups and exhibit a distinctive rooster tail splash, which may contribute to sightability if present in the mitigation zone. Thus, mitigation is assessed to be effective in reducing some PTS exposures predicted by the Navy's Acoustic Effects Model that are not otherwise assumed to be reduced by avoidance of injurious exposures.

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 relies 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 has requested 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 Gulf of Alaska 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

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 has requested 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 Gulf of Alaska 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

Table 3.8-22: Estimated Impacts on Individual Cuvier's Beaked Whale Stocks Within the Gulf of Alaska 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

Table 3.8-23: Estimated Impacts on Individual Stejneger's Beaked Whale Stocks Within the Gulf of Alaska 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

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 farther 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 farther ranges. Sounds from mid-frequency sonar could mask killer whale vocalizations making them more difficult to detect, especially at farther 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. Steller sea lion occurrence in the TMAA is considered likely year round in relatively shallow waters over the continental shelf. 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 in the Western U.S. stock. The Navy is consulting 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. California sea lion occurrence in the TMAA is considered rare with the highest likelihood of occurrence in April and 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). Very recent literature provides some evidence to suggest that the current onset of TTS for California sea lions in water may be lower than previously estimated (Kastelein et al., 2021c). However, even with this new information, considering the low sea lion density in the TMAA, impact ranges, 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 has requested 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 Gulf of Alaska 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	2,972	31	0
California	60	1	0

Northern Elephant Seals

Northern elephant seals may be exposed to sounds from sonar and other transducers associated with training activities April through October. Northern elephant seal occurrence in the TMAA is considered seasonal with the highest likelihood of occurrence from 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 has requested 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 Gulf of Alaska 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

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 farther 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 ribbon 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 GOA 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); however, sea otters would not be expected in the WMA.

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 but is not likely to adversely affect ESA-listed northern sea otters or northern sea otter critical habitat. The Navy has consulted 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 in the GOA Study Area. 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 GOA Study Area 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 GOA Study Area. 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 under the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. In addition to the TMAA, the area in which activities involving vessel maneuvers could occur has expanded since the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS to include the WMA. Expansion of the GOA Study Area to include the WMA does constitute a change to the affected environment; however, no additional marine mammal species occur in the WMA that were not analyzed previously in the TMAA, and the activities proposed for the WMA are the same activities that have been occurring in the TMAA.

Activities proposed under Alternative 1 for this SEIS/OEIS remain consistent with the activities analyzed under Alternative 1 in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS and the analysis in those documents remains applicable. As noted in Section 3.8.3 (Environmental Consequences), the addition of the WMA to the GOA Study Area would not increase the number of vessels nor the amount of vessel activity compared to prior analyses. Because the existing baseline conditions have not changed appreciably, and no new Navy training activities are being proposed in this SEIS/OEIS, a detailed re-analysis of impacts from vessel noise on 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 could propagate into 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 mechanism for impacting prey species and would not remove humpback whale prey or reduce the quality, abundance, or accessibility of prey to humpback whales.

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 is consulting with NMFS as required by section 7(a)(2) of the ESA. Vessel noise during training activities would have no effect on the critical habitat for humpback whales.

Pursuant to the ESA, vessel noise during training activities as described under Alternative 1 may affect but is not likely to adversely affect northern sea otters or northern sea otter critical habitat. The Navy has consulted 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 in the GOA Study Area. 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 GOA Study Area 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. In addition to U.S. Navy, aircraft, other sources of aircraft noise in the GOA Study Area include aircraft overflights of commercial aircraft and other military aircraft.

Aircraft produce different types of airborne noise depending on the type of aircraft and engine. Fixed-wing aircraft use either turbofan or turbojet engines. An infrequent type of aircraft noise is the sonic boom, produced when a fixed-wing aircraft exceeds the speed of sound. Rotary-wing aircraft produce low-frequency sound and vibration from rotor blades (Pepper et al., 2003). The different types of aircraft noise may or may not elicit a behavioral reaction from a marine mammal. 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 GOA Study Area, but the likelihood of a behavioral reaction would depend on several factors, including the type of aircraft, the altitude of the aircraft, the duration of the exposure, and the animal's proximity to the surface. The greater the distance between the aircraft and the animal, the lower the noise level the animal would be exposed to. The noise level will also be reduced further as the sound propagates across the air-water interface. 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 and would take place in the same locations in the TMAA analyzed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. Expansion of the GOA Study Area to include the WMA does constitute a change to the affected environment; however, no additional marine mammal species occur in the WMA that were not analyzed previously in the TMAA, and the activities proposed for the WMA are the same activities that have been occurring in the TMAA.

Activities proposed under Alternative 1 for this SEIS/OEIS remain consistent with the activities analyzed under Alternative 1 in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS and the analysis in those documents remains applicable. Because the existing baseline conditions have not changed appreciably, with respect to marine mammals, and no new Navy training activities are being proposed in the GOA Study Area in this SEIS/OEIS, a detailed re-analysis of impacts from aircraft noise on marine mammals is not warranted.

Sound from naval aircraft would overlap 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 near the water's surface and in close proximity to a low-flying aircraft, noise from aircraft presents no plausible route of impact to prey species and would not remove humpback whale prey or reduce the quality, abundance, or accessibility of prey to humpback whales.

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 is consulting with NMFS as required by section 7(a)(2) of the ESA. Aircraft noise during training activities would have no effect on the critical habitat for humpback whales.

Pursuant to the ESA, aircraft noise during training activities as described under Alternative 1 may affect but is not likely to adversely affect northern sea otters or northern sea otter critical habitat. The Navy has consulted 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 in the GOA Study Area. 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 addition to the TMAA, the area in which activities involving weapon noise could occur has expanded since the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS to include the WMA; although, only non-explosive munitions would be used in the WMA. 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).

Activities proposed under Alternative 1 for this SEIS/OEIS remain consistent with the activities analyzed under Alternative 1 in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS and the analysis in those documents remains applicable. Because the existing baseline conditions have not changed appreciably, and no new Navy training activities are proposed in the GOA Study Area in this SEIS/OEIS, a detailed re-analysis of the alternatives with respect to marine mammals is not warranted. Expansion of the GOA Study Area to include the WMA does constitute a change to the affected environment; however, no additional marine mammal species occur in the WMA that were not analyzed previously in the TMAA, and the activities proposed for the WMA are the same activities that have been occurring in the TMAA.

The Navy will implement mitigation measures to avoid or reduce potential impacts from weapon firing noise during large-caliber gunnery activities in the TMAA and WMA, as discussed in Section 5.3.2.2 (Weapon Firing Noise).

Weapon noise from non-explosive gunnery firing could overlap critical habitat for the ESA-listed Western North Pacific and Mexico DPSs of humpback whales in the TMAA, although implementation of the Continental Shelf and Slope Mitigation Areas would limit any potential overlap of weapon noise from the firing of explosive munitions with the critical habitat in the TMAA, as described in Chapter 5 (Mitigation). No humpback whale critical habitat overlaps with the WMA.

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 whale prey or reduce the quality, abundance, or accessibility of prey to humpback whales.

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 is consulting with NMFS as required by section 7(a)(2) of the ESA. Weapon noise during training activities would have no effect on the critical habitat for humpback whales.

Pursuant to the ESA, weapon noise during training activities as described under Alternative 1 may affect but is not likely to adversely affect northern sea otters or northern sea otter critical habitat. The Navy has consulted 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). Section 3.8.3.2.1 (Background) discusses what is currently known about explosive effects on 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). There is no known incidence of mortality or injury to marine mammals due to Navy training events involving explosives in the TMAA.

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 airguns. 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 airguns.

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 airguns 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-airgun 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 at or near the surface (within 10 m above the 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 at 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, 2020c) 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

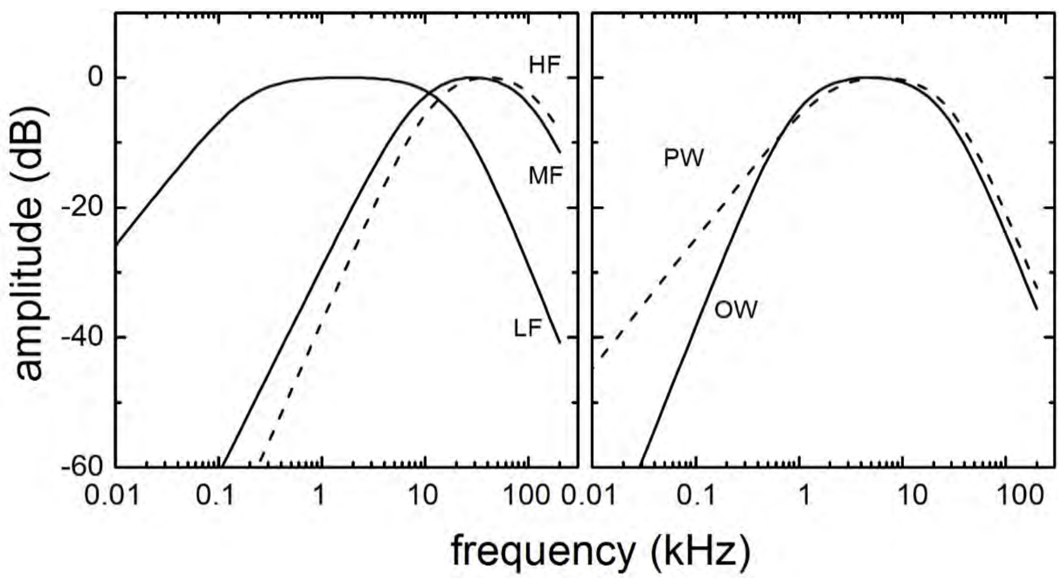
Impact Category	*Impact Threshold*	*Threshold for Farthest Range to Effect*[2]
Mortality[1]	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s	$103\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
Injury[1]	$65.8M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s	$47.5M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ 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.



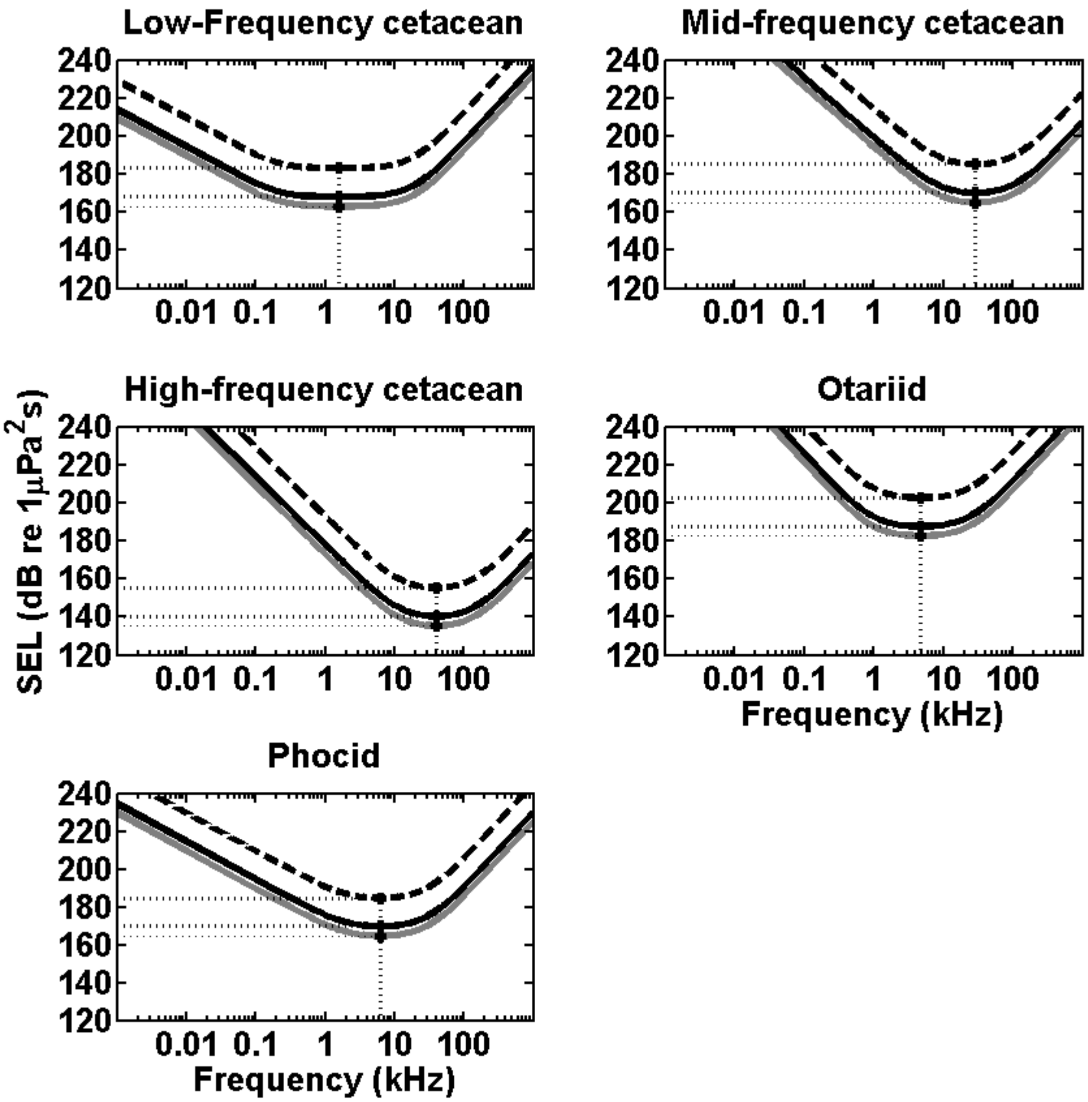
Source: See U.S. Department of the Navy (2017a) for parameters used to generate the functions and more information on weighting function derivation.
Notes: MF = mid-frequency cetacean, HF = high-frequency cetacean, LF = low-frequency cetacean, PW = phocid (in-water), and OW = otariid and other non-phocid 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 airgun. 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. This growth rate is supported by the limited data from marine mammals (Finneran, 2015; Southall et al., 2019c). 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).

The Navy and NMFS are assessing new auditory research published since the development of the Phase III auditory criteria and is summarized in the background section above in this chapter. Notably, emergent research with sea lions (Kastelein et al., 2021c; Kastelein et al., 2022c) suggests that otariids may be significantly more susceptible to auditory effects than assumed in this analysis. Development of new criteria is an iterative process which validates and incorporates new data along with results of previous investigations and studies. The Navy is working with NMFS to assess how these new studies, as well as other ongoing and future studies, should inform updates to auditory criteria and thresholds.



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 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 to prohibit the use of explosives below 10,000 ft. altitude (including at the water surface) in the Continental Shelf and Slope Mitigation Area. The mitigation area is designed to help avoid or reduce impacts during biologically important life processes, such as foraging and migration, throughout the entire continental shelf and slope. The benefits of the mitigation area 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.

No underwater detonations are proposed in this action, but marine mammals could be exposed to detonations at or near the water surface. The Navy Acoustic Effects Model cannot account for the highly non-linear effects of cavitation and surface blow off for shallow underwater explosions, nor can it estimate the explosive energy entering the water from a low-altitude detonation. Thus, for this analysis, sources detonating at or near (within 10 m) the surface are modeled as if detonating completely underwater at a depth of 0.1 m, with all energy reflected into the water rather than released into the air. Therefore, the amount of explosive and acoustic energy entering the water, and consequently the estimated ranges to effects, are likely to be overestimated.

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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.

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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.

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]	Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	*Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	*Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	***Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	***Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	*Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	*Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	***Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	***Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	***Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	***Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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]	***Modeled 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. No underwater explosions are proposed in this action. The model assumes that all explosive energy from detonations at or above (within 10 m) the water surface is released underwater, likely overestimating ranges to effect.
[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 in the GOA Study Area, and the use of explosives would no longer 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.

3.8.3.2.2.4 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 at or near the surface would occur beyond the continental shelf and slope at depths greater than 4,000 m in the deeper waters of the TMAA. Detonations would not occur in the WMA. 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 and would be operated within the same location as analyzed under the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, except that explosives would not be used below 10,000 ft. altitude (including at the water surface) in the Continental Shelf and Slope Mitigation

Area. 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.

Presentation of Estimated Impacts from the Quantitative Analysis

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).

Training activities involving explosions for this SEIS/OEIS only occur in the TMAA and would not occur in the WMA. 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 between April and October in the TMAA. 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 one 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, the Navy will not use explosives below 10,000 ft. altitude (including at the water surface) in the Continental Shelf and Slope Mitigation Area, which fully 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 has requested 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 is consulting 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 Gulf of Alaska 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

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 DPSs (Western North Pacific stock) 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). Although no impacts to the Western North Pacific stock are predicted, NMFS conservatively proposes to authorize take by Level B harassment of one group of Western North Pacific humpback whale. As described in Section 3.8.2.3 (Humpback Whale [*Megaptera novaeangliae*]), critical habitat for the ESA-listed Western North Pacific and Mexico DPS of humpback whales (NMFS designated units 5 and 8) overlaps the northwestern portion of the TMAA over the continental shelf. In addition to procedural mitigation, the Navy will prohibit the use of explosives below 10,000 ft. altitude (including at the water surface) in the Continental Shelf and Slope Mitigation Area, which fully overlaps the humpback whale critical habitat in 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 stocks would not be expected.

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. Explosives would not be used at or near the surface in humpback whale critical habitat, nor within the range to effects on prey items within critical habitat. 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 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.

Because explosives would not be used at or near the surface in critical habitat, there would be minimal change in the overall quantity or availability of prey items within the habitat due to explosive use off the shelf and slope in the TMAA. Although some individual prey items may be killed in areas outside of critical habitat, long-term consequences for fish and invertebrate populations and the effect on overall quantity, quality, and availability of prey items in critical habitat 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 has requested 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 critical habitat. The Navy is consulting 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 Gulf of Alaska 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

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), including the Continental Shelf and Slope Mitigation Area, 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 has requested 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 is consulting 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 Gulf of Alaska 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

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), including the Continental Shelf and Slope Mitigation Area, 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 has requested 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 is consulting 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 Gulf of Alaska 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

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 summer. 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), including the Continental Shelf and Slope Mitigation Area, 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 has requested 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 is consulting 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 Gulf of Alaska 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

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), including the Continental Shelf and Slope Mitigation Area, 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 has requested 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 Gulf of Alaska 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

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 occurrence 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. Although no impacts to the Eastern North Pacific stock are predicted, NMFS conservatively proposes to authorize take by Level B harassment of one group of Eastern North Pacific gray whale. 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 the Continental Shelf and Slope Mitigation Area, which will further help avoid the already low potential for impacts from explosives on gray whales. The Navy will prohibit the use of explosives below 10,000 ft. altitude (including at the water surface) in the Continental Shelf and Slope Mitigation Area, which fully 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), including the Continental Shelf and Slope Mitigation Area, 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 is consulting 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), including the Continental Shelf and Slope Mitigation Area, 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. Pacific white-sided dolphin occurrence in the TMAA is considered 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), including the Continental Shelf and Slope Mitigation Area, 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. Harbor porpoise occurrence in the TMAA is considered likely year round in nearshore habitat extending to the shelf break. Because harbor porpoises are not expected to be present in deep waters beyond the continental shelf, implementation of the Continental Shelf and Slope Mitigation Area would further reduce any risk of exposure to explosive stressors. 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. Dall's porpoises occurrence in the TMAA is considered 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 overpredicted 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), including the Continental Shelf and Slope Mitigation Area which would prohibit the use of explosives over the shelf and slope where Dall's porpoise densities are highest, long-term consequences for the species or stock would not be expected. Refer to the *U.S. Navy Marine Species Density Database Phase III Technical Report for the Gulf of Alaska Temporary Maritime Activities Area* for information on Dall's porpoise densities (U.S. Department of the Navy, 2020c).

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 has requested 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 Gulf of Alaska 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

Beaked Whales

Beaked whales may be exposed to sound or energy from explosions associated with training activities April through October. Beaked whales within the 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), including the Continental Shelf and Slope Mitigation Area, 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 has requested 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 Gulf of Alaska 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

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. Steller sea lion occurrence in the TMAA would be likely year round in nearshore habitat over the continental shelf. 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. Because Steller sea lions are not expected to be present in deep waters beyond the continental slope, implementation of the Continental Shelf and Slope Mitigation Area would further reduce any risk of exposure. 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), including the Continental Shelf and Slope Mitigation Area, 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 in the Western U.S. stock. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

California Sea Lions

California sea lions may be exposed to sound or energy from explosions associated with training activities April through October. California sea lion occurrence in the TMAA is considered rare with the highest likelihood of occurrence in April and May. California sea lions are not expected to be present in deep waters beyond the continental shelf, but implementation of the Continental Shelf and Slope Mitigation Area would further reduce any risk of exposure. 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), including the Continental Shelf and Slope Mitigation Area, 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), including the Continental Shelf and Slope Mitigation Area, 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. Northern elephant seal occurrence in the TMAA is considered seasonal with the highest likelihood of occurrence from July through September. 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), including the Continental Shelf and Slope Mitigation Area, 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 has requested 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 Gulf of Alaska 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

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 and not in the TMAA. Harbor seals that venture farther from shore and into the TMAA would predominantly remain in waters over the continental shelf. Thus, implementation of the Continental Shelf and Slope Mitigation Area would further reduce any risk of exposure. 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), including the Continental Shelf and Slope Mitigation Area, 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), including the Continental Shelf and Slope Mitigation Area, 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 GOA 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 farther offshore than the nearshore areas that sea otters inhabit. Because sea otters are not expected to be present in deep waters offshore, implementation of the Continental Shelf and Slope Mitigation Area would further reduce any risk of exposure. 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), including the Continental Shelf and Slope Mitigation Area, 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 but is not likely to adversely affect ESA-listed northern sea otters or northern sea otter critical habitat. The Navy has consulted 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 impacts on habitat or prey due to the introduction of explosives by-products, metals, and chemicals into the marine environment. Analysis of the potential impacts on sediment and water quality (in the TMAA) are discussed in Section 3.3 (Water Resources) of the 2016 GOA Final SEIS/OEIS. The same analysis is applicable to sediments and water quality in the WMA where the only materials expended would be non-explosives munitions composed almost entirely of metals. These munitions would sink to the seafloor in depths greater than 4,000 m and corrode slowly over time. Refer to Section 3.2 (Expended Materials) in the 2011 Final EIS/OEIS for a detailed discussion on the potential impacts from metals and other expended materials on sediments.

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 GOA Study Area the concentration of unexploded ordnance, explosives byproducts, metals, and other chemicals on the seafloor would be orders of magnitude less than that of more widely used Navy operating areas and ranges and, to an even greater degree, less than that of an extensively studied World War II-era munitions dump site. The series of studies at the munitions dump site located off Hawaii revealed that slightly elevated concentrations of munitions degradation products were detectable only in sediments adjacent (within a few feet) of the degrading munition, and that there was no detectable uptake of chemicals 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 GOA Study Area. 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 activities in the GOA Study Area would be negligible and would have no long-term effect on habitat.

Secondary stressors from training activities were analyzed for potential indirect impacts on marine mammal prey availability. Acoustic stressors (i.e., sonar and other transducers) and explosions occurring at the water's surface could impact other marine species in the food web, including prey species that marine mammals feed on, indirectly impacting marine mammals. If their prey is less accessible, marine mammals may need to forage for longer periods, travel to alternate locations, or temporarily abandon foraging efforts (National Oceanic and Atmospheric Administration, 2015c).

The potential impacts from explosions at the surface differ depending on the type of prey species in the area of the detonation, proximity of prey to the detonation site, and the net explosive weight of the munition. Sound propagation from acoustic stressors may affect certain species, including some fishes that marine mammals prey on, but most potential prey are not sensitive to acoustic stressors and would not be impacted at the population level, as described in Section 3.6 (Fishes) of this SEIS/OEIS and Section 3.5 (Marine Plants and Invertebrates) in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS.

Commercial fisheries that harvest the same species that marine mammals prey upon and competition between marine mammals and other species for the same prey have a greater and more widespread effect on the availability of prey than Navy training activities. Navy training activities using explosives in the TMAA have the potential to disturb prey species and injure individual fishes or invertebrates in the immediate vicinity of an explosive detonation; however, commercial fisheries in Alaska waters removed over 3 billion pounds of fish and invertebrates in 2020 (see Section 3.12, Socioeconomics and Environmental Justice). While only some of the harvested species are also prey for marine mammals, the potential temporary disturbance of marine mammal prey by certain Navy training activities would have a negligible effect on the availability of prey by comparison.

The critical habitat for humpback whales (see Figure 3.8-2) occurs on the continental shelf and does not overlap with the continental the slope or deeper waters of the GOA Study Area where Navy training activities predominantly occur (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). The Navy created the Continental Shelf and Slope Mitigation Area, which prohibits the use of explosives below 10,000 ft. altitude (including at the water surface) on the continental shelf and slope inside the TMAA. The WMA does not overlap with the continental shelf and slope. The Continental Shelf and Slope Mitigation Area fully encompasses the portions of the biologically important habitat identified by Ferguson et al. (2015) for North Pacific right whale feeding and gray whale migration overlapping the TMAA and the portion of humpback whale critical habitat that overlaps the TMAA (Figure 3.8-2). Thus, there is no overlap of activities that use explosives with important habitat on the shelf and slope for multiple marine mammal species.

Based on the analysis presented in this section and in the 2011 GOA Final EIS/OEIS (and reaffirmed in the 2016 GOA Final SEIS/OEIS), indirect effects (secondary stressors) on marine mammals would be discountable, negligible, or insignificant. There would also be no impacts on humpback whale critical habitat from secondary stressors. This determination is supported by authorizations pursuant to the MMPA reached by NMFS in all other Navy study areas analyzed in the Pacific and Atlantic for Navy activities similar to those proposed for the GOA Study Area.

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 SEIS/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 GOA Study Area 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 overpredict 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 detrimental 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

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 Navy has funded monitoring and research since 2006 in and beyond Navy ranges and occurring in many cases before, during, and after Navy training and testing events. The results have been included as part of the Navy's analyses of impacts on marine mammals as well as the analyses by NMFS in their MMPA authorization (National Marine Fisheries Service, 2017c) and 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 GOA Study Area and includes all the marine mammal taxonomic groups present in the GOA Study Area, many of the same species, and some of the same populations as they seasonally migrate from other range complexes, this compendium of Navy reporting is directly applicable to the analysis of impacts in the GOA Study Area. In addition, subsequent research and monitoring has continued to broaden, both in number and geographic scope, the sample size of observations used to expand our understanding of the occurrence, distribution, and the general condition 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 impacts on marine mammals presented in this SEIS/OEIS.

The Navy has been funding marine mammal monitoring in the GOA since 2009, including funding line surveys in 2009, 2013, and 2021 to improve our knowledge of marine mammal distribution in the GOA and to better estimate marine mammal abundances and densities. Line-transect surveys have also included passive acoustic monitoring to compliment visual observations. Since 2011, the Navy has funded research in the TMAA that has included collecting passive acoustic data from an unmanned glider, collecting data at five static sites equipped with buoy-mounted passive acoustic hydrophones, and analyzing and maintaining the data, which has allowed the Navy to characterize ambient sound levels in the TMAA and detect vocalizing marine mammals (Crance et al., 2022; Klinck et al., 2016; Rice et al., 2021a; Rice et al., 2018b; Rice et al., 2020; Rone et al., 2015; Rone et al., 2014; Rone et al., 2017; Wiggins et al., 2017; Wiggins & Hildebrand, 2018). The Navy summarizes the result of marine species monitoring in annual reports that are available to the public and can be downloaded from Navy and NMFS websites[4]. These reports provide a record of marine mammal observations made during Navy training activities in the TMAA and other Navy range complexes in the Pacific (U.S. Department of the Navy, 2018a, 2019, 2020a, 2021).

Monitoring during Navy training activities in the Pacific for more than three decades indicates that while the Navy's proposed training activities in the TMAA would 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 population level. Therefore, based on the best available science, including the results of Navy-funded research in the TMAA, long-term consequences for marine mammal populations are unlikely to result from Navy training activities in the GOA Study Area. This conclusion is based on the analysis provided in Section 3.8.3 (Environmental Consequences) and on the result of monitoring conducted in the GOA and TMAA summarized in the Navy's marine species monitoring reports as well as the results of monitoring in other areas where the Navy trains in the Pacific.

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, 2011), where they remain valid. The Navy has consulted under section 7 of the ESA with USFWS for the ESA-listed sea otter and is consulting with NMFS for the remaining ESA-listed marine mammals that may be affected by the Proposed Action (National Marine Fisheries Service, 2017a; U.S. Fish and Wildlife Service, 2011). As noted in this SEIS/OEIS previously, there are no new Navy training activities in the GOA Study Area that have not been previously considered in the TMAA or elsewhere where Navy trains. Furthermore, although there are slight differences in species occurrence and distribution between the TMAA and WMA for some ESA-listed species, the inclusion of the WMA does not change the effects determinations

[4] 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).

in this analysis, and the determinations are applicable to the entire GOA Study Area. There have been no new ESA-listed marine mammal species in the GOA Study Area. New critical habitat was proposed for ESA-listed humpback whales along the Pacific coast of the United States (84 FR 54354; 9 October 2019) and designated (86 FR 21082; 15 April 2021), 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 has also determined that Navy activities in the TMAA may affect humpback whale critical habitat. The Navy has consulted with USFWS as required by section 7(a)(2) of the ESA and received a Letter of Concurrence from USFWS concurring with the Navy's determination of effects for northern sea other and northern sea otter critical habitat. Consultation with NMFS for the other ESA-listed marine mammal species is ongoing. NMFS plans on issuing a Biological Opinion in the fall of 2022.

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 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 the 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 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,[5] the Navy has determined that weapon noise, vessel noise, aircraft noise, the use of in-water electromagnetic devices, in-air electromagnetic devices, vessel strike, in-water devices, seafloor devices, wires and cables, decelerators/parachutes, and military expended materials are not expected to result in mortality or Level A or Level B harassment of any marine mammals.

[5] 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).

3.8.6.1 Summary of Science in the Temporary Maritime Activities Area by the Navy Related to Potential Effects on Marine Mammals

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 been surveyed for decades, it cannot be conclusively determined if the sperm whale population in the West Coast region is increasing, decreasing, or has remained static Moore & Barlow, 2017). Additional types of information other than the status and trends in species' abundance must therefore be considered when assessing the potential impacts of Navy activities on marine mammal populations.

Since 2006, the Navy, non-Navy marine mammal scientists, and research groups and academic institutions have conducted scientific monitoring and research in the Atlantic and Pacific where the Navy has been, and proposes to continue, testing and training. The Navy and NMFS have conducted three rounds of analysis of impacts on marine mammals from Navy at-sea training and testing activities in multiple Navy range complexes in the Pacific (see for example 83 FR 66846, December 27, 2018); two rounds of analysis have been conducted for Navy training activities in the GOA, and the analysis in this SEIS/OEIS represents the third round of analysis. Data collected from Navy monitoring and Navy-sponsored scientific research are reported annually to NMFS[6] and contribute to the analysis of potential impacts on marine mammals from anthropogenic stressors. The data collected by the Navy and Navy-sponsored researchers provide information relevant to species distribution, habitat use, and evaluation of potential responses to Navy activities. The Navy continues to fund behavioral response studies specifically designed to determine the effects of sonar (e.g., mid-frequency surface ship anti-submarine warfare sonar) on marine mammals.

The Navy and NMFS work collaboratively to identify research needs and allocate funding with the intention of focusing resources where they will be most effective. As a result, the majority of the Navy's monitoring and research efforts have been conducted in locations outside of the TMAA (e.g., in the SOCAL Range Complex, off Hawaii, and in the Northwest Training Range Complex) where the Navy trains (and tests) continuously throughout the year and with greater intensity than in the TMAA. However, the results of research and monitoring efforts in other areas of the Pacific are relevant to the GOA Study Area, because in many cases the marine mammals occurring in the GOA are part of the same trans-boundary populations that occur in other parts of the Pacific. For example, the Hawaii DPS of humpback whales, gray whales in the Eastern North Pacific stock, and elephant seals occur in other Navy range complexes where research and monitoring has occurred more frequently, and individuals from those same stocks migrate into the GOA where they may encounter similar stressors from Navy training activities that are fundamentally the same as activities conducted in SOCAL, Hawaii, and in the Pacific Northwest. The results of new research on marine mammal habitat use has become available since the 2016 GOA Final SEIS/OEIS, but this research was carried out in 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; Mate et al., 2018b, 2019b; Mate et al., 2019c; National Oceanic and Atmospheric Administration, 2019b; Palacios

[6] 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).

et al., 2020b; Pirotta et al., 2018b; Rice et al., 2021b; Rockwood et al., 2017; Santora et al., 2017). Nevertheless, the results are informative and were cited throughout Section 3.8 (Marine Mammals) to support the analysis of potential impacts on marine mammals in the GOA Study Area.

Marine mammal research funded by the Navy in the TMAA and GOA since 2009 has included three types of monitoring methods: 1) Passive Acoustic Monitoring, which includes stationary, moored passive acoustic recorders and non-stationary (mobile) autonomous gliders (Klinck et al., 2016; Rice et al., 2021a; Rice et al., 2018b; Rice et al., 2019, 2020; Wiggins et al., 2017; Wiggins & Hildebrand, 2018); 2) visual surveys (systematic line-transect surveys with NMFS) (Crance et al., 2022; Rone et al., 2015; Rone et al., 2009; Rone et al., 2014; Rone et al., 2017); and 3) satellite telemetry of tagged marine mammals (Irvine et al., 2020; Mate et al., 2018a, 2019a; Mate et al., 2017; Mate et al., 2018b, 2018c, 2019b; Mate et al., 2019c, 2020; Palacios et al., 2021; Palacios et al., 2019; Palacios et al., 2020a; Palacios et al., 2020b; Palacios et al., 2020c) and fishes (Seitz & Courtney, 2021; Seitz & Courtney, 2022). These three different methods of data collection funded by the Navy in the GOA focus on increasing our understanding of marine mammal occurrence in the GOA. Over the 7-year period of the previous Final Rule issued by NMFS, Navy-funded research has produced 21 technical reports on marine mammal occurrence in the GOA and 2 reports on the movements of fishes. As noted throughout this SEIS/OEIS, the training activities the Navy is proposing for the GOA Study Area in this SEIS/OEIS are similar if not identical to activities that have been occurring in the GOA for decades and equivalent to training activities analyzed in the 2016 GOA Final SEIS/OEIS and 2011 Final GOA EIS/OEIS (U.S. Department of the Navy, 2011a, 2016a). Training in the GOA Study Area, in comparison to other Navy areas, occurs less frequently (and only from April through October) and is in general smaller in scope.

Since 2006, the Navy has been submitting exercise reports and monitoring reports describing what training (and testing) activities have occurred and any sightings of marine mammals 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 to focus 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 2020 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, 2021).

These reporting, monitoring, and research efforts from locations across the Pacific and the Atlantic have added to our understanding of the behavior and habitat use of marine mammals inhabiting the GOA Study Area. In addition, subsequent research and monitoring has continued to broaden, both in number and geographic scope, the sample size of observations used to expand our understanding of the occurrence, distribution, and the general condition 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. The collective record of data and information includes many of the same Navy training activities proposed for the GOA Study Area and all marine mammal taxonomic families present in the GOA Study Area. Many of the same species, and some of the same populations, migrate seasonally from other range complexes into the GOA Study Area, such that the compendium of Navy monitoring and reporting is directly applicable to the marine mammals occurring in the GOA Study Area.

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3.9 Birds

Gulf of Alaska Navy Training Activities

Final Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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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, 2011) 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 (e.g., EA-6B aircraft and Oliver Hazard Perry Class Frigate, and their associated systems, have been replaced with the EA-18G aircraft, Littoral Combat Ship, and Constellation Class Frigate), and use of the Portable Underwater Tracking Range (PUTR) is no longer proposed. Consistent with the previous analysis for Alternative 1, the sinking exercise activity is not part of the Proposed Action for this SEIS/OEIS. The Final SEIS/OEIS has been updated to include the addition of the Continental Shelf and Slope Mitigation Area (see Section 2.1.1 [Gulf of Alaska Temporary Maritime Activities Area]) and the addition of the Western Maneuver Area (WMA) to the area previously analyzed (the Temporary Maritime Activities Area [TMAA]) (see Section 2.1.2 [Western Maneuver Area]). Together, the TMAA and WMA comprise the GOA Study Area.

The purpose of this SEIS/OEIS section is to provide any new or changed information since the 2016 GOA Final SEIS/OEIS that is relevant to the analysis of potential impacts on birds associated with the Proposed Action in the GOA Study Area, beyond May 2022. This section analyzes proposed Navy training activities in the GOA Study Area and incorporates the analysis of impacts from the 2022 Supplement to this SEIS/OEIS prepared to address proposed activities occurring in the Navy's Western Maneuver Area (WMA).

This section also documents the continued interagency cooperation with U.S. Fish and Wildlife Service (USFWS) set forth in section 7(a)(2) of the Endangered Species Act (ESA) (16 United States Code part 1536).

- On March 24, 2010, the USFWS issued a Letter of Concurrence to the Navy for the "may affect, not likely to adversely affect" determination on short-tailed albatross (*Phoebastria albatrus*) (consultation #2010-0075). 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. Given that the precautionary measures were established to avoid interactions with short-tailed albatross, and that the probability of encounter between activities and the species over the entire TMAA was low, the USFWS concurred with the determination that the Navy training activities in the GOA during the two, 21-day periods from April through October were not likely to adversely affect the endangered short-tailed albatross (U.S. Fish and Wildlife Service, 2010).
- On July 23, 2014, the USFWS sent an email to the Navy stating that reinitiation of consultation for those proposed activities 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 TMAA. The correspondence between the Navy and USFWS in 2014 was based on the Navy's preferred Alternative 2 (which carried forward the activity levels that were authorized in the 2011 GOA Final SEIS/OEIS) and the 2010 and 2011 consultations. After going through the National Environmental Policy Act (NEPA) process and considering all impacts of the project, the Navy (in 2017) ultimately selected Alternative 1, which reduced the activity levels authorized in 2011 in half, as documented in the Navy's 2017 Record of Decision (ROD). This alternative also removed the SINKEX activity from the Proposed Action. Therefore, although the Navy's proposed activities are consistent with the 2017 ROD, there has been a significant reduction of activities associated with the Proposed Action since USFWS's last review of the Navy's project in 2010, 2011, and 2014.

- On May 26, 2021, the Navy requested reinitiation of ESA consultation based on changes in the Proposed Action from that presented in the prior consultations and improved understanding of the distribution of short-tailed albatross in the GOA Study Area. The reinitiation includes those activities that involve acoustic, explosive, physical disturbance and strike, entanglement, and ingestion stressors for the short-tailed albatross.
- On February 4, 2022, the Navy provided additional consultation documentation to USFWS.
- On March 29, 2022, the Navy received a Letter of Concurrence from the USFWS concurring with the Navy's determination that the Proposed Action may affect but is not likely to adversely affect short-tailed albatross.

Marine birds in the GOA Study Area 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 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 GOA Study Area, 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. These descriptions are generally applicable to the entire GOA Study Area, and marine bird species present in the TMAA also known to occur within the WMA, as described in the sub-sections below. The GOA 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 GOA 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

All bird species analyzed in this section have the potential to occur in the WMA and TMAA portions of the GOA Study Area. Certain bird species that prefer more shallow, nearshore habitat would be less likely to occur or would occur in lower densities in the WMA than in the TMAA. Similarly, birds that prefer habitat farther from shore would be less abundant in the nearshore portion of the TMAA. The analysis of impacts on birds is focused on stressors from sonar and other transducers and explosives, which are only used in the TMAA and not the WMA. Analysis of other acoustic stressors, specifically noise from vessels, aircraft, and weapons firing, is applicable to the WMA as well as the TMAA.

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 GOA Study Area, with any relevant updates to the affected environment since the completion of the 2016 GOA Final SEIS/OEIS. Table 3.9-1 lists representative bird species in the GOA Study Area.

Table 3.9-1: Representative Bird Species Within the GOA Study Area

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*
	Red-faced Cormorant[2]	*Phalacrocorax urile*
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*
	Aleutian Tern[2]	*Onychoprion aleuticus*
	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 GOA Study Area (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*
	Kittlitz's Murrelet[2]	*Brachyramphus brevirostris*
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*
	Red-throated Loon[2]	*Gavia stellata*

[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 storm petrel (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 GOA Study Area 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. While not discussed specifically in the 2011 GOA Final EIS/OEIS, the descriptions of habitat in the TMAA are also generally applicable to the WMA as well. 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 habitat in the GOA Study Area is mostly over deep ocean waters beyond the continental shelf and slope, the GOA Study Area is used predominantly by species that occur in the region seasonally and are not land-based outside of the nesting season.

Since the previous analyses conducted in 2011 and 2016, the USFWS has released an updated draft list of Birds of Conservation Concern (BCC) released in 2019, 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, 2019). The USFWS maintains this list to implement and promote proactive management for species that do not warrant ESA listing status. Bird taxa considered in the draft 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 draft 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 GOA Study Area (short-tailed albatross, 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 GOA Study Area.

One important source for determining long-term trends and occurrence information included the North Pacific Pelagic Seabird Database, a database maintained by the U.S. Geological Survey (USGS) that includes more than 460,000 survey transects that were designed and conducted by numerous partners primarily to census seabirds at sea (Drew & Piatt, 2015). 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 GOA Study Area and are not analyzed in detail in this SEIS/OEIS (see Section 3.9.2.1.1 [Species Unlikely to Occur within the Gulf of Alaska Study Area]). As part of the Navy's literature review, the status of the eskimo curlew was reconfirmed (extinct). In addition, on October 1, 2014, the USFWS announced their determination that listing the yellow-billed loon was not warranted (79 FR 59195). 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 for known occurrences within the GOA Study Area).

[1] Marbled murrelets in inland waters of Alaska and pelagic environments in the GOA are not ESA listed.

3.9.2.1.1 Species Unlikely to Occur within the Gulf of Alaska Study Area

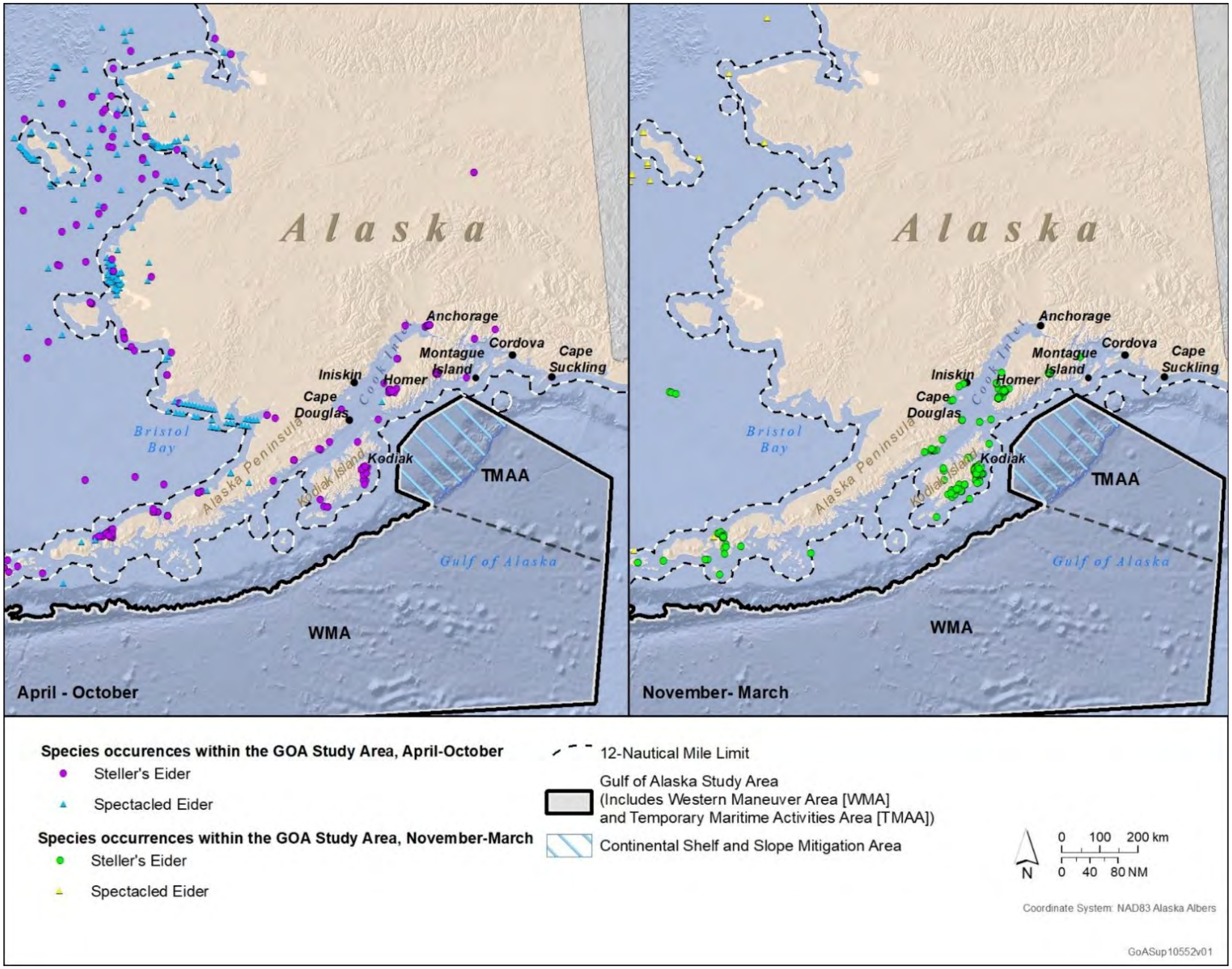
Previous Navy NEPA documents concerning activities within GOA addressed potential impacts on the Steller's eider and spectacled eider. Because this SEIS/OEIS addresses training activities within the GOA Study Area, the Navy conducted a literature review for these species' occurrences in relation to the spatial extent of the GOA Study Area and the potential for seasonal occurrence within the GOA Study Area and, in particular, when activities that introduce acoustic and explosive stressors 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 GOA Study Area.

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 2019, the USFWS concluded a 5-year status review of Steller's eider and recommended no change in the status of the species. 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. As described in the 2011 GOA Final EIS/OEIS and 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 and outside the WMA. 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 GOA Study Area.

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 GOA Study Area. Based on this review of records, no Steller's eider observations are reported within the GOA Study Area, 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. Activities within the WMA are also seasonally restricted. 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 for potential impacts in the GOA Study Area.



Sources: North Pacific Pelagic Seabird Database (Drew & Piatt, 2015) and eBird (2020)

Figure 3.9-1: ESA-Listed Bird Species Seasonal Distributions

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 overlaps with the GOA Study Area. On August 31, 2020, the USFWS announced a 5-year review of the status of spectacled eider (85 FR 53840).

Spectacled eiders are not expected to occur in the GOA Study Area 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 (Larned & Tiplady, 1999).

In support of this SEIS/OEIS, the Navy examined records of the USGS Alaska Science Center to determine which pelagic species overlap with the GOA Study Area. Based on this review of records, no spectacled eider observations are reported within the GOA Study Area. One record is reported from the North Pacific Pelagic Seabird Database 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 GOA Study Area 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). Radar studies have demonstrated that 95 percent of the migratory movements occur at less than 10,000 ft. (3,050 meters [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. Guilford et al. (2022) determined that albatross species can dive deeper than previously thought, using improved methods to measure diving depth. Black-browed albatross (*Thalassarche melanophris*), for example, were shown to dive as deep as 19 m, and for as long as 52 seconds. Previous literature presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS suggest that albatross species are limited to shallower dives, mostly within 2 m of the surface. Bentley et al. (2021) notes that these longer duration dives have implications for bycatch risk in commercial fisheries. For other species groups, 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.

There are three general feeding strategies for seabirds—surface feeding, pursuit diving, and plunge diving. Many of the seabird species found in the GOA Study Area 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 GOA Study Area, 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 GOA Study Area. 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 (*Puffinus tenuirostris*), the most frequently reported bird species in the North Pacific Pelagic Seabird 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 GOA Study Area, 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., 2020; 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. 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. 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 nine wild Atlantic puffins 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.

While electrophysiological techniques provide insight into hearing abilities, auditory sensitivity is more accurately obtained using behavioral techniques. Crowell (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.

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. Data on short-tailed albatross vocalization does not exist. Vocalizations recorded from the Laysan albatross and black-footed albatross 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.

3.9.2.1.5.2 Underwater Hearing in Seabirds

Albatross species make relatively shallow dives while foraging. Due to plunge diving and surface dipping 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.

Two studies have tested the ability of a single individual diving bird, a great cormorant, 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 et al. (2020), 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 (ear canal) 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 a study that is currently ongoing on underwater hearing sensitivity in three species of auk, which will help the Navy refine its assessment of potential impacts from training activities on seabirds, including auks and other seabirds of interest such as the ESA-listed marbled murrelet (Hansen et al., 2020; Mooney et al., 2020; Navy, 2022).

Additional scientific information published since 2011 supplements and reinforces the information presented on birds in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. New information reviewed and described in this section is consistent with and does not alter the analysis and conclusions presented in those previous EIS/OEISs. As such, the description of bird hearing capabilities presented in the 2016 GOA Final SEIS/OEIS remains 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 GOA Study Area. Recent literature is available that improves understanding of climate change and potential impacts in the GOA and surrounding areas.

Specific to birds in the Alaska area, Goyert et al. (2018), analyzed the population dynamics of five species of marine birds (black-legged kittiwake [*Rissa tridactyla*], red-legged kittiwake), common murre, thick-legged murre [*Uria lomvia*], and tufted puffin [*Fratercula cirrhata*]), and predicted that some species may be more sensitive to environmental changes (Goyert et al., 2018). 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 changes in a suite of climate variables. Analyzing seasonal and annual spatial projections from three climate models for two physical climate variables (seawater temperature and sea ice concentration) and three forage variables (biomass of 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 regions 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, 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.

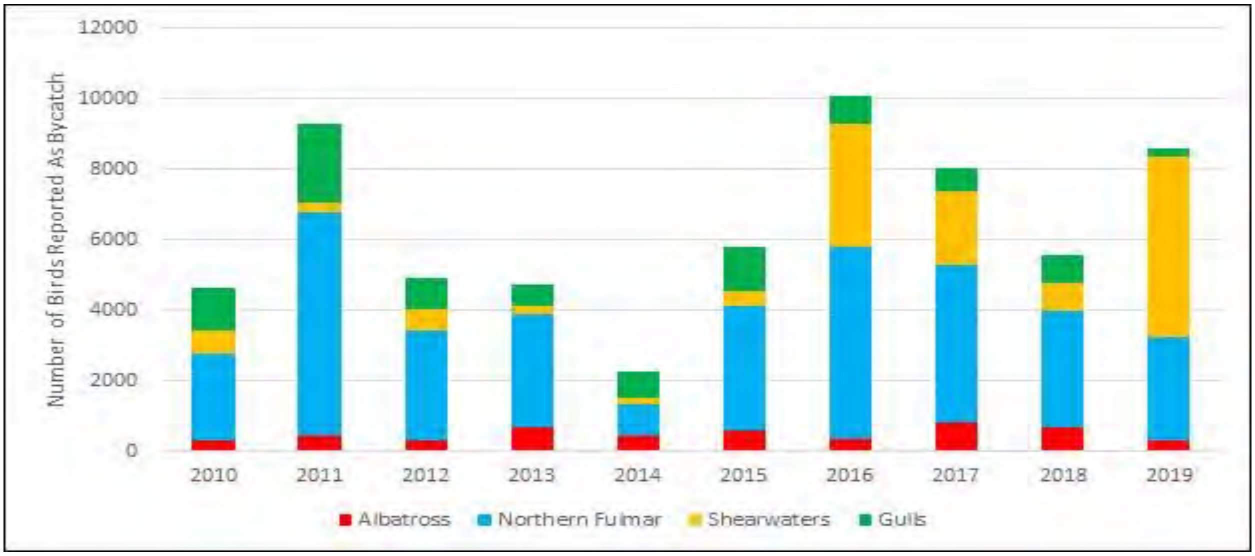
Recently reported bird die-offs are also notable for the description of the existing conditions in the GOA Study Area and surrounding regions. For example, seabird mortality events in the Bering Sea and GOA appear to be due to starvation (Jones et al., 2019; Walsh et al., 2018). Thompson et al. (2019) analyzed both of forage fish and determined that size and condition were negatively correlated to increasing sea surface temperatures and periodic Pacific Decadal Oscillation, described as Pacific climate variability that includes a longer period of extreme temperatures, either being warm or cool in the interior North Pacific and cool or warm along the Pacific Coast (National Oceanic and Atmospheric Administration, 2021). 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.

Increasing ocean water temperatures over the past few years have resulted in a warmer than normal "blob" of water off the west coast of North America that extends into the GOA (Peterson et al., 2014a). The warmer ocean temperatures shortened the upwelling season in 2013 by six weeks. Ocean upwelling is related to marine ecosystem productivity. High water temperatures lead to low entrainment of nutrients and, therefore, decreasing biological productivity (Peterson et al., 2014b). Low biological productivity may impact short-tailed albatross prey abundance.

Climate change may result in prey base changes that affect seabird foraging and habitat (U.S. Fish and Wildlife Service, 2020b). A global analysis of seabird response to forage fish depletion in 16 seabird species found a generally stable pattern of breeding success when prey abundance remained above a certain threshold, but breeding success was negatively impacted when prey abundance was below that threshold (Cury et al., 2011). The threshold approximated one-third of the maximum prey biomass observed in long-term studies. This study and subsequent studies suggest that many seabird species are resilient to some level of prey depletion but that catastrophic population crashes can occur when resources become limiting (d'Entremont et al., 2022; Evans et al., 2021; Fayet et al., 2021; Scopel et al., 2019).

Commercial Industries

The most significant commercial activity impacting seabirds within the GOA Study Area and GOA 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 (Krieger & Eich, 2020). Impacts from bycatch 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 (*Fulmarus glacialis*, 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 to 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). Reports of short-tailed albatross bycatch are infrequent. In 2014, 11 short-tailed albatross were reported as bycatch in 2014 (Krieger & Eich, 2020), and two instances of bycatch were reported in 2020. The 2020 bycatch events were reported from the Bering Sea outside of the GOA Study Area (National Marine Fisheries Service, 2020).

Shearwaters. In 2019, shearwaters accounted for the majority (58 percent) of all bycatch in waters off of Alaska. Estimated shearwater bycatch (5,103 birds) was more than 5 times greater than the 2010 through 2018 average (957 birds per year) (Krieger & Eich, 2020). 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); andWalsh 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 (Krieger & Eich, 2020).

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 was listed as endangered throughout its range under the ESA in 2000 (65 FR 46643). There is no designated critical habitat under the ESA for the short-tailed albatross. The recovery plan for this species was completed in 2008 (U.S. Fish and Wildlife Service, 2008b). Since then, the USFWS has completed status reviews in 2014 and 2020 (U.S. Fish and Wildlife Service, 2014, 2020a).

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. 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) (U.S. Fish and Wildlife Service, 2008b) have remained persistent since the consultation in 2010. 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. There has been no reported short-tailed albatross bycatch in Alaska fisheries since 2014 (11 short-tailed albatross reported as bycatch in 2014) (National Marine Fisheries Service, 2020).

3.9.2.2.2 Abundance

Since the publication of the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, new information is available regarding the abundance of the short-tailed albatross in waters off of Alaska. As reported in the 2020 USFWS five-year review, the current short-tailed albatross population consists of

7,365 individuals, with an estimated annual population growth rate of 8.9 percent (three-year running average). The current growth rate is supported by an estimated 1,011 breeding pairs. The distribution of short-tailed albatross breeding pairs is approximately 84 percent on Torishima Island, approximately 16 percent in the Senkaku Islands, and less than 1 percent in the Ogasawara Islands (U.S. Fish and Wildlife Service, 2020a).

3.9.2.2.3 Distribution

New information is available pertaining to the distribution of the short-tailed albatrosses within the GOA Study Area since previous consultations between the Navy and USFWS. The most recent USFWS status review for the short-tailed albatross (U.S. Fish and Wildlife Service, 2020a) provides the most up-to-date distributions in offshore waters of the North Pacific and Arctic. Distribution of short-tailed albatross can be reported from two different survey methods—at sea observations, typically line transect methods from ships; and tagging data, typically reported in pelagic birds using Global Positioning System (GPS) transmitters. The results of ship-based surveys, conducted since 2006, report a total of 199 short-tailed albatross at-sea from March to October. Short-tailed albatross were primarily observed near and over deep water canyons in the GOA, Aleutian Islands, and Bering Sea. In the GOA, short-tailed albatrosses were primarily observed over the outer continental shelf and slope. Within the TMAA, short-tailed albatross observations account for approximately 15 percent of the total records of offshore surveys as reported in the 2020 USFWS status review. The Navy also examined records of the U.S. Geological Survey Alaska Science Center to determine which pelagic species overlap with the TMAA where explosive and acoustic stressors would occur. Based on this review of geographically relevant records, 30 short-tailed albatross observations were reported between 1998 and 2018 (Drew & Piatt, 2015; U.S. Fish and Wildlife Service, 2020a) (Figure 3.9-3).

In addition to the records provided by the U.S. Geological Survey Alaska Science Center, the Navy also reviewed recent satellite telemetry data of tagged short-tailed albatross within the GOA. Suryan and Kuletz (2018) collected tracking data over a 14-year period (2002-2015) with a total of 99 short-tailed albatrosses tracked. Most short-tailed albatrosses were captured at the main breeding colony on Torishima Island, Japan, with six albatrosses tagged on summer feeding grounds in the Aleutian Islands. Short-tailed albatross occur in the highest densities at the outer continental shelf-slope regions, which brings them close to shore in the Aleutian Archipelago, much farther offshore in the Bering Sea, and intermediate distances from shore in the GOA (Suryan & Kuletz, 2018). 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 and eventually aligning with adult distributions.

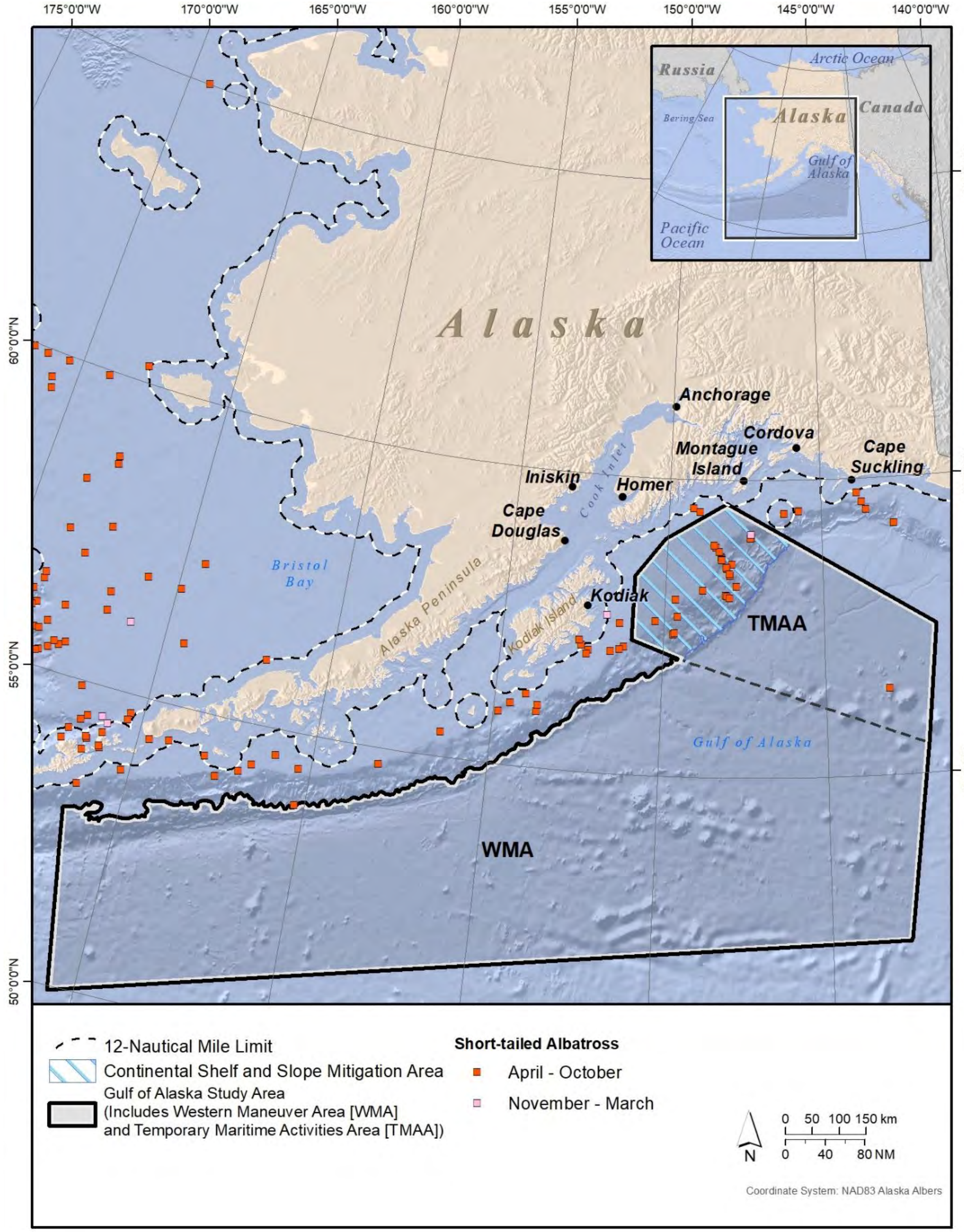


Figure 3.9-3: Visual Observations of Short-Tailed Albatrosses Within the GOA Study Area (2006–2019)

Figure 3.9-4 shows satellite tracking locations of 99 short-tailed albatrosses tagged at nesting colonies (Torishima Island and Mukojima Island, Japan) and on summer feeding grounds in the Aleutian Islands (6 of the 99 albatrosses) reported by Suryan and Kuletz (2018). These location data span the years 2002 through 2015 and occur throughout and beyond the GOA Study Area. Figure 3.9-5 shows individual short-tailed albatross satellite data reported by yearly occurrence within the TMAA. Only the years with location data inside the TMAA are shown in the figure.

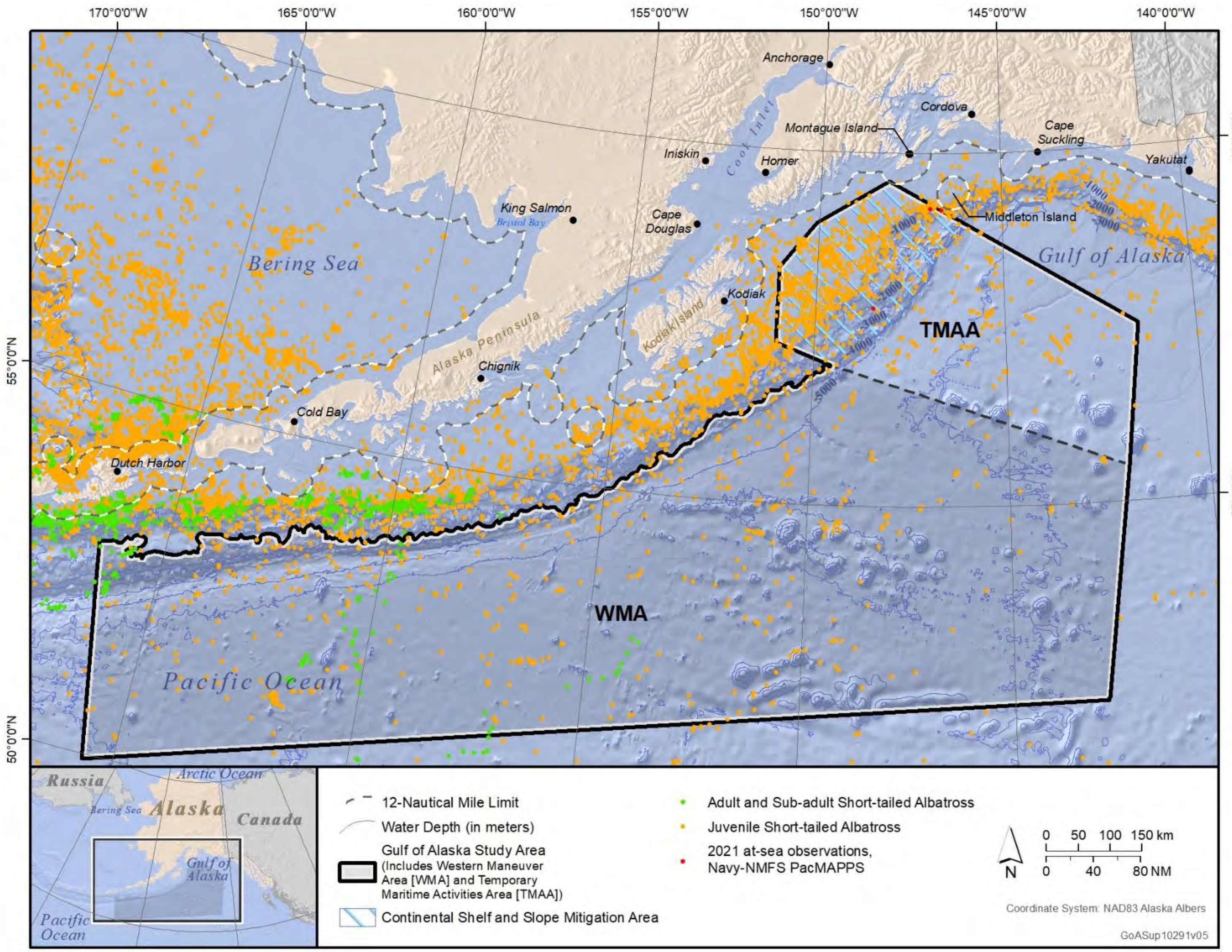


Figure 3.9-4: Short-Tailed Albatross Satellite Tracking in the GOA Study Area, April-October (2002–2015)

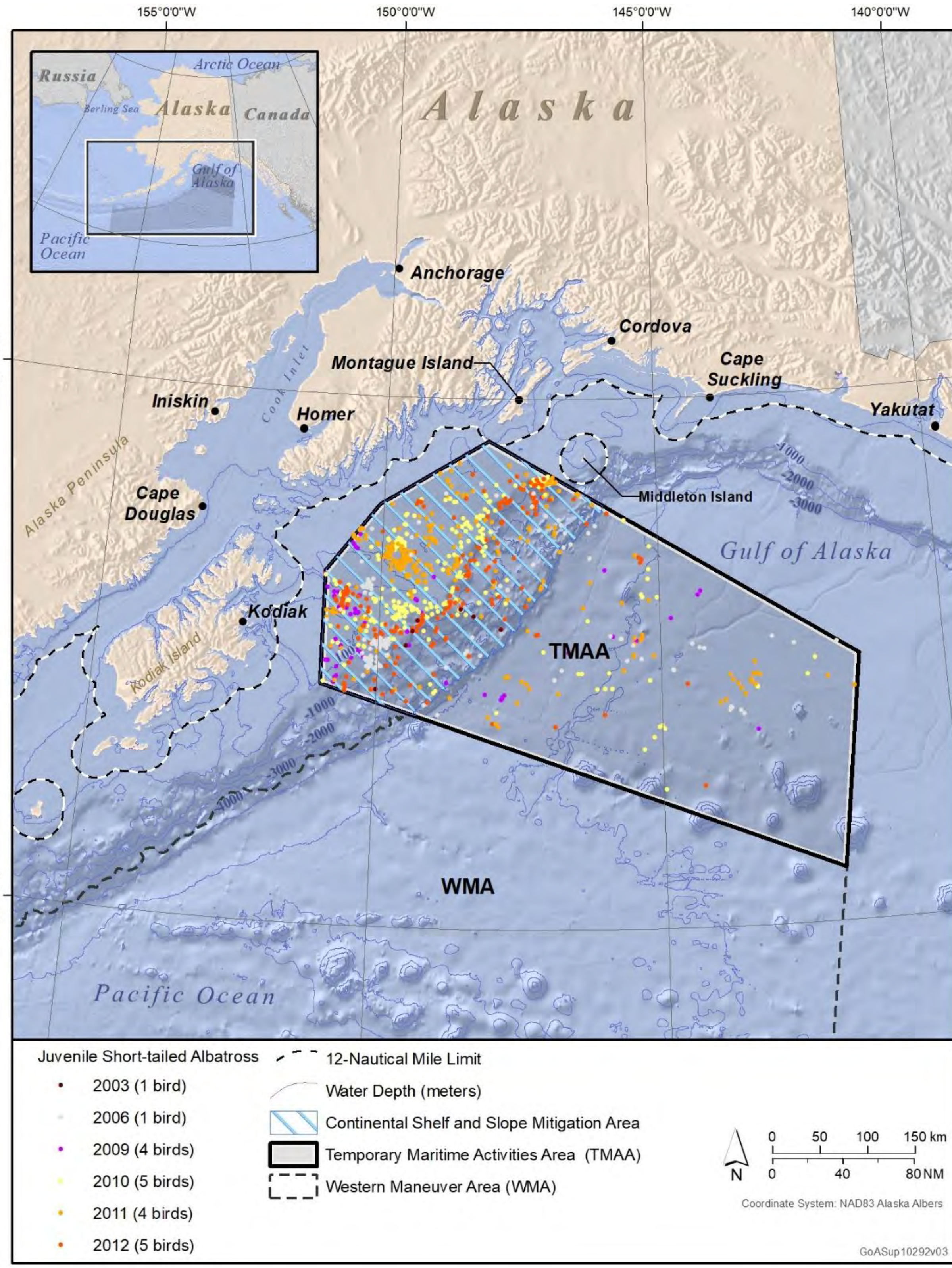


Figure 3.9-5: Short-Tailed Albatross Satellite Tracking Data Within the TMAA, April–October (2002–2015)

All of the locations reported by Suryan and Kuletz (2018) within the TMAA are from juveniles, with most locations occurring over the continental shelf and shelf break.

Sea-ice retreat in the Arctic may potentially open new foraging habitat or provide a new migration corridor between the Pacific and Atlantic Oceans. A juvenile short-tailed albatross was recently sighted in the Arctic (Chukchi Sea) and evidence from other species (e.g., northern gannet [*Morus bassanus*], ancient murrelet [*Synthliboramphus antiquus*]) indicates some bird species might use ice-free portions of the Arctic as a migration or population dispersion route (Kuletz et al., 2014; U.S. Geological Survey, 2006, 2016a).

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 and, in particular, short-tailed albatross. 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 GOA Study Area, 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, 2016b). 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 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, and specifically short-tailed albatross, within the TMAA include the following:

- Acoustic (sonar and other transducers, vessel noise, aircraft noise, weapons noise)
- Explosives (explosive shock wave and sound, explosive fragments)[2]

Since sonar and other transducers and explosives are not used in the WMA, the only stressors analyzed in this section with the potential to impact seabirds in the WMA are the acoustic stressors: vessel noise, aircraft noise (or disturbance), and weapons noise. 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, and the potential for vessel and aircraft strike on seabirds. Based on the review of these stressors, the Navy determined that no additional information was available that would change the conclusions of the analysis presented in the 2011 GOA Final EIS/OEIS and updated in the 2016 GOA Final SEIS/OEIS. However, Navy did discuss potential impacts from these additional stressors during consultation pursuant to the ESA on short-tailed albatross with the USFWS.

The analysis of potential impacts of stressors on seabirds within the GOA Study Area includes consideration of the standard operating procedures and mitigation measures (see Chapter 5, Mitigation) 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 GOA Study Area. Additional information about mitigation for birds is presented in Chapter 5 (Mitigation) of this SEIS/OEIS, which includes the addition of the Continental Shelf and Slope

[2] 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. 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. 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.

Mitigation Area, an area within the TMAA where explosives would not be used. This mitigation area covers the shelf and slope habitat where many seabird species, including the short-tailed albatross, aggregate to forage. Explosives would continue to be used in the TMAA in deeper waters beyond the continental slope, which, for the purposes of this analysis, occur at depths greater than 4,000 m. Neither explosives nor sonar and other transducers would be used in the WMA. In addition to explosive stressors and acoustic stressors from sonar and other transducers, which occur exclusively within the TMAA, other acoustic stressors, specifically vessel noise, aircraft noise, and weapons noise, and other non-explosive stressors were addressed during the Navy's consultation with USFWS for the entire GOA Study Area. After reviewing the Navy's analysis, the USFWS issued a Letter of Concurrence on March 29, 2022 concurring with the Navy's determination that the Proposed Action may affect but is not likely to affect short-tailed albatross.

The Navy has determined that the wide distribution of short-tailed albatross within the GOA Study Area, the dispersed occurrence of Navy training activities, and the addition of the Continental Shelf and Slope Mitigation Area in the TMAA do not present new risks to short-tailed albatross than what was analyzed previously. Accordingly, this SEIS/OEIS will analyze in detail only the potential impacts from acoustic stressors (sonar and other transducers, vessel noise, aircraft noise, weapons noise) and explosive stressors (explosive shock wave and sound, explosive fragments).

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 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 within the Study Area may include (1) pelagic seabird species such albatrosses, petrels, alcids, jaegers, and some terns that forage over the ocean and nest on coastlines and oceanic islands within the GOA or other locations in the Pacific; (2) waterfowl species such as grebes, scoters, ducks, and loons that nest and forage along the coast and inland habitats and come to the coastal areas during non-breeding season; (3) shorebird species such as sandpipers that, like other nearshore species, may transit through the GOA Study Area during annual fall and spring migration periods; and (4) birds that are typically found inland, such as songbirds, that may be present flying in large numbers over open ocean areas during annual migrations.

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; Saunders et al., 2000).

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 (*Melopsittacus undulatus*), 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, 2017) 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 GOA Study Area. 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. Sorensen et al. (2020) demonstrated that Gentoo penguins (*Pygoscelis papua*) react to noise bursts (0.2–6 kHz) by exposing seven individuals while underwater in a pool. Individual penguins received levels of 100, 105, 110, 115, and 120 dB re 1 µPa, but a dose-response relationship between behavioral responses and SPL could not be established from the data. Variability both within and between individuals was observed. For example, one individual exhibited no response and a strong response to two different 120 dB exposures, and another individual exhibited no response and a strong response to two different 110 dB exposures. A third individual did not show any responses to levels below 120 dB but exhibited strong reactions to two exposures of 120 dB. Five out of eight exposures resulted in strong behavioral reactions to the 120 dB noise burst. The data suggest that Gentoo penguins, a species adapted for pursuing prey underwater, are likely to react to received levels of 120 dB re 1 µPa and higher.

The effect of fishing net pingers on bird bycatch has also been examined. Fewer common murres 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.

Behavioral Reactions to Aircraft

Behavioral reactions of birds to aircraft overflights can include (1) scanning and alerting behavior such as head turning; (2) agitated behavior such as increased calling, pacing, or wing-flapping, and (3) protective/escape behavior such as fighting, flying, diving, or swimming away (Brown, 2001; Hoang, 2013). 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 (absence of noise) suggest that the visual presence of aircraft is likely to be an important component of disturbance (Brown, 1990); responses to acoustic playbacks suggest that the noise type and level above background is related to the level of disturbance (Brown, 2001). Therefore, the effects of acoustic and visual components of aircraft disturbance cannot be disentangled.

Research conducted on land at breeding and nesting colony sites shows that most severe behavioral reactions (e.g., flushing) result from low-altitude overflights, but habituation and absence of behavioral responses have also been observed (Conomy et al., 1998; Hoang, 2013). Colonial waterbirds including black skimmers and least, gull-billed, and common terns 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(Brown, 1990), and herring gulls (*Larus argentatus*) significantly increased aggressive interactions and flights over the colony during overflights with received SPLs of 101–116 dBA re 20 µPa (Burger, 1981). Raptors responded minimally to jet (110 dBA re 20 µPa) overflights, and flights at greater than 1,640 ft. (500 m) 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, and there were no demonstrated impacts of military activity on 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*) increased agonistic behavior and reduced courtship behavior up to one to two hours after low-altitude military jet overflights (Goudie & Jones, 2004). Kuehne et al. (2020) measured the noise specific to Boeing EA-18G Growler takeoffs near the Naval Air Station Whidbey Island, but made no direct observation of any bird species being affected by low-altitude overflights. 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. Herring gulls exposed to supersonic plane overflights, however, were observed to have increased agonistic interactions that resulted in broken eggs and lower mean clutch size (Burger, 1981; Hoang, 2013). Breeding status can also influence the severity of behavioral responses, where individuals engaged in early-stage egg-laying are more susceptible to aircraft disturbance (Hoang, 2013). For example, common murres in California exhibited a higher proportion of flushing responses after overflights that occurred before the mean egg-laying date as compared to after (Rojek et al., 2007).

In general, low-altitude helicopter overflights are most likely to disturb birds, and the most severe behavioral reactions to aircraft overflights at nesting sites can result in broken eggs or chicks exposed to predation (Brown, 2001; Hoang, 2013). Research on bird behavioral reactions to aircraft at sea is lacking.

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. No sonar or other transducers would be used in the WMA. 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; Hansen et al., 2017; Johansen et al., 2016) suggests 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. Short-tailed albatross 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.

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 temporary and permanent threshold shift 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 (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 estimated impact level presented below to predict ranges to effects. This is a change in methodology from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS.

There are no published studies specific to sonar and its effects on short-tailed albatross. In order to estimate auditory impacts, 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 $\mu Pa^2 s$ in air. To translate this into an estimate of 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, 2017)]. The results of the analysis determined a cumulative SEL estimated impact level for auditory injury of 220 dB re 1 $\mu Pa^2 s$. 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 as a reasonable level to estimate potential impact. The USFWS also used this estimated impact level to assess impacts to short-tailed albatross in its 2016 Biological Opinion for the Navy's Northwest Training and Testing Study Area (U.S. Fish and Wildlife Service, 2016), which was reaffirmed in the 2018 and 2020 Biological Opinions (U.S. Fish and Wildlife Service, 2018, 2021).

3.9.3.1.2.2 Impact Ranges for Sonar and Other Transducers

Based on the sound source level, source depth, angle of the vertical beam pattern, and a maximum dive depth of 2 m, the short-tailed albatross would not receive SELs from sonar that meet or exceed the estimated 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 calculated for representative acoustic bins MF1, MF4, and MF5.

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 in the GOA Study Area, and the use of active sonar or other transducers would no longer 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.

3.9.3.1.2.4 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. 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 2-2 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 estimated impact level, and new acoustic effects modeling.

Short-tailed albatross forage in offshore, open ocean waters and are present within the TMAA (see Section 3.9.2.2.3, Distribution). 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 proposed 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 the estimated impact level for auditory injury in birds (described in Section 3.9.3.1.2.1, Methods for Analyzing Impacts from Sonar and Other Transducers) 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). This analysis concludes that the short-tailed albatross would not receive SELs from sonar that would result in 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.

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. 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 occur. Effects of sonar and other transducers on short-tailed albatross are therefore considered insignificant[3].

Pursuant to the ESA, noise produced by sonar and other transducers during training activities as described under Alternative 1 may affect but is not likely to adversely affect the ESA-listed short-tailed albatross. The Navy has consulted 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

[3] This conclusion is consistent with the USFWS's determination for sonar use in the Northwest Training and Testing Study Area Biological Opinion (U.S. Fish and Wildlife Service, 2021), which re-affirmed the determination for sonar in the 2016 and 2018 Biological Opinions (U.S. Fish and Wildlife Service, 2016, 2018). Considering similar sonar use is proposed in this SEIS/OEIS, prior conclusions reached in the 2010 and 2011 USFWS consultations for activities occurring in the TMAA remain unchanged - exposures to sonar and other transducers are unlikely to occur.

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 in the GOA Study Area. 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 in the GOA Study Area, including the TMAA and WMA. 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 Study Area 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. Although sound levels may increase or decrease as a result of changes to platforms and systems, the overall potential impacts on birds from vessel noise is not expected to change. While the revised GOA Study Area is larger than the area analyzed in the 2020 GOA Draft SEIS/OEIS, no new or increased levels of training activities would occur, and no increases in vessel numbers or underway steaming hours, would occur. Increases and decreases shown in Table 2-2 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.

In addition to standard operating procedures, the Navy developed mitigation measures to avoid or reduce potential impacts of vessel movement (and therefore noise) on ESA-listed short-tailed albatross. A 200 yard (yd.) mitigation zone surrounding vessels will be implemented for large-bodied seabirds such as the short-tailed albatross. Additional information about mitigation for birds is presented in Chapter 5 (Mitigation) of this 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 GOA Study Area. Noise from Navy vessels is similar to or less than 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 but is not likely to adversely affect the ESA-listed short-tailed albatross. The Navy has consulted 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 noise produced by vessels during training activities described under Alternative 1 and would not result in a significant adverse effect on populations of seabirds, shorebirds, and other birds protected under the MBTA.

3.9.3.1.4 Impacts from Aircraft Disturbance

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 are detailed in Section 3.9.3.1.1.5 (Behavioral Reactions), and since visual and acoustic components of disturbance cannot be distinguished, this section analyzes all potential impacts due to aircraft overflights. 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 Disturbance Under the No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not occur in the GOA Study Area. 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 Disturbance Under Alternative 1

Birds may be exposed to noise from aircraft overflights in the GOA Study Area including both the TMAA and WMA. 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 Study Area involve maneuvers by various types of fixed, rotary-wing, and tilt-rotor aircraft (collectively referred to as aircraft). Most exposure to aircraft overflights would be temporary and intermittent because there are no airbases or fixed ranges within the Study Area for which aircraft would be concentrated. However, some aircraft flights 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 Study Area at any given time (see Section 3.9.2.2.2, Abundance, and Section 3.9.2.2.3, Distribution, and Figure 3.9-1), it is unlikely that albatross would be disturbed by aircraft. Therefore, any potential adverse effects on short-tailed albatross from aircraft, including auditory masking, physiological stress, or changes in behavior, would be insignificant.

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. Although sound levels may increase or decrease as a result of changes to platforms and systems, the overall potential impacts on birds from aircraft disturbance is not expected to change. While the revised GOA Study Area is larger than the area analyzed in the 2020 GOA Draft SEIS/OEIS, no new or increased levels of training activities would occur, and no increases in aircraft events would occur. Because the existing conditions have not changed appreciably, and no new Navy training activities are proposed in the Study Area 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 2-2 for proposed activities under Alternative 1 do not change the impact conclusions presented in the 2016 GOA Final SEIS/OEIS.

Pursuant to the ESA, aircraft disturbance during training activities as described under Alternative 1 may affect but is not likely to adversely affect the ESA-listed short-tailed albatross. The Navy has consulted 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 disturbance 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. 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 in the GOA Study Area. 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). All proposed activities involving weapons noise would occur in the TMAA, except for the Surface-to-Surface Gunnery Exercise (non-explosive practice munitions only), which could also occur in the WMA.

In general, weapons noise consists of impulsive sounds (such as those discussed under Section 3.0.4.2, Explosive Stressors) generated in close vicinity to or at the water surface. 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 weapons noise is therefore extremely unlikely to affect birds underwater, and no acoustic impacts to birds are expected as a result of underwater weapons noise. Conversely, in-air weapons 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 weapons 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 weapons 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 weapons 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). In addition to behavioral disturbance, 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). Therefore, 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 to avoid or reduce potential impacts of all large-caliber weapon firing noise on ESA-listed short-tailed albatross. For large-caliber gunnery activities, a 70 yd. mitigation zone within 30 degrees of the firing line from the weapon's muzzle will be implemented for seabirds, as outlined in Table 5-3. 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 2-2 for details) and 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. Although sound levels may increase or decrease as a result of changes to platforms and systems, the overall potential impacts on birds from weapons noise is not expected to change. While the revised GOA Study Area is larger than the area analyzed in the 2020 GOA Draft SEIS/OEIS, no new or increased levels of training activities would occur. Because the existing conditions have not changed appreciably, and no new Navy training activities are proposed in the GOA Study Area 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, weapons noise produced during training activities as described under Alternative 1 may affect but is not likely to adversely affect the ESA-listed short-tailed albatross. The Navy has consulted 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

Explosives (at or near the surface) could be used beyond (seaward of) the 4,000 m depth contour in the TMAA portion of the GOA Study Area. Explosives (up to 10,000 ft. altitude) would not be used over the continental shelf or slope in the TMAA. Explosives would not be used anywhere in the WMA.

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 analysis of 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. The current analysis reflects that explosives (Bombing Exercise, Gunnery Exercise) actually occur (explode) "in-air" at or above the water surface (within 10 m).

Due to adjusted sound exposure impact level estimates 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.

(Danil & St Leger, 2011)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). (Yelverton & Richmond, 1981)

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 dynamic pressure impulse exposures below 5 psi-ms would not be expected to result in injuries. Dynamic pressure impulse is a different measure than overpressure impulse, and it is relevant to displacement caused by blast wind pressure or blast throw.

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 dynamic pressure impulse, similar to the results of the displacement injury study.

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 (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 2-2 for details), with one exception. Consistent with the previous analyses for Alternative 1, the SINKEX 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 estimated impact level, new acoustic effects modeling, and new mitigation procedures, 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 in-air explosions near the water surface 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 explosives safety calculator developed by the Department of Defense Explosives Safety Board (Blast Effects Computer – Open Version 1.0 available at https://denix.osd.mil/ddes/ddes-technical-papers/). 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 estimated impact levels for in-air explosions near the water surface are reported in Table 3.9-2. The estimated impact levels 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 metrics for injury and mortality using peak pressure (dB peak) and dynamic pressure impulse (Pa-s). There were insufficient data to correct for the mass of the bird using the data in Damon et al. (1974); therefore, the lowest values associated with any or no injury and severe injury were applied.

The estimated impact levels 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 estimated onset levels 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 3.9-2 presents the auditory and non-auditory estimated impact levels 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 estimated level 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 estimated level 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^2s cumulative SEL plus a spectral correction factor of 15 dB to account for low-frequency energy in an impulsive exposure as an estimate of onset of auditory injury in birds due to impulsive sources in air. To convert this to an underwater estimated impact level, 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 (2017). That data suggests a 36 dB impedance value for birds underwater. The resulting in-water level estimated to result in auditory injury is 212 dB re 1 μPa^2 s SEL. The estimated impact levels presented in Table 3.9-2 were developed in support of the Northwest Training and Testing consultations (U.S. Fish and Wildlife Service, 2016).

Table 3.9-2: Explosive Effects Onset Estimates 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)*	*Potential serious injury (including 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 (overpressure or dynamic pressure) = Pa-s (pascal seconds)

[1]Threshold based on methods of the Hydroacoustic Science Panel (Science Applications International Corporation, 2011), consistent with the analysis in the 2015 BO.

[2]Underwater injury and mortality overpressure impulse thresholds (Yelverton et al., 1973) are adjusted to consider typical mass of bird species, based on the relationships between injury and mass for fish (Yelverton & Richmond, 1981).

[3]Dual metrics from observations of in-air explosive injuries to birds in Damon et al. (1974): peak pressure and dynamic pressure (no overpressure) impulse. 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

Table 3.9-3 and Table 3.9-4 provide impulse ranges to injury for the short-tailed albatross. These ranges to effect are based on the estimated impact levels presented in Table 3.9-2 (see Section 3.9.3.2.2.1, Methods for Analyzing Impacts from Explosives). Detonations conducted during Navy activities that may affect short-tailed albatross would occur at or near the surface. Underwater effects of above-water explosions are modeled in the Navy Acoustic Effects Model as if they occur fully underwater since there is currently no means to model underwater impacts from in-air detonations. Therefore, these underwater ranges are likely overestimated. 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.

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 in the GOA Study Area, and the use of explosives would no longer 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.

Table 3.9-3: Underwater Ranges to Effects for Surface Explosives

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 [> 5–10]	0.1	11	17	8
E9 [> 100–250]	0.1	15	30	16
E10 [> 250–500]	0.1	17	35	18
E12 [> 650–1000]	0.1	20	40	21

[1]The farthest range predicted for either peak pressure or dynamic pressure impulse is shown. For these charge sizes and effect thresholds, the ranges predicted for peak pressure and dynamic pressure impulse thresholds are similar.
Note: NEW = net explosive weight

Table 3.9-4: In-Air Ranges to Effects for Surface Explosives

Source Bin (lb. NEW)	Range to Effects for Explosives: Short-tailed Albatross[1]		
	Range to Auditory Injury (meters)	Range to Non-Auditory Injury (meters)	Range to Mortality (meters)
E5 [> 5–10]	48	9	6
E9 [> 100–250]	139	28	19
E10 [> 250–500]	175	35	24
E12 [> 650–1000]	220	44	33

[1] The farthest range predicted for either peak pressure or dynamic pressure impulse is shown. For these charge sizes and effect thresholds, the ranges predicted for peak pressure and dynamic pressure impulse thresholds are similar.
Note: NEW = net explosive weight

3.9.3.2.2.4 Impacts from Explosives Under Alternative 1

Training activities under Alternative 1 would use surface or near-surface detonations and explosive ordnance. 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 with one exception. Consistent with the previous analyses for Alternative 1, the SINKEX 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 estimated impact levels for sound exposure, and new acoustic effects modeling.

Short-tailed albatross pelagic range overlaps with areas that include in-air explosive detonations as part of training activities in the TMAA. No explosives would occur in the WMA. The Navy will not detonate explosives below 10,000 ft. altitude (including the water surface) in the Continental Shelf and Slope Mitigation Area during training (see Chapter 5, Mitigation; and Figure 5-1, Mitigation Areas). Short-tailed albatross could potentially occur anywhere in the TMAA but are most likely to occur within the Continental Shelf and Slope Mitigation Area portion of the TMAA (Figure 3.9-5). The use of explosives is typically dispersed in space and time.

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 3.9-3). 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.

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, and long-term consequences for populations would not be expected.

Additionally, for all explosive bombs and explosive large-caliber gunnery, procedural mitigation will be implemented within a 600 yd. mitigation zone around the target for large-bodied seabirds such as short-tailed albatross. Additional information about mitigation for birds is presented in Chapter 5 (Mitigation) of this SEIS/OEIS. Implementation of the Continental Shelf and Slope Mitigation Area and the procedural mitigation outlined above would further reduce the already low potential for impacts on individual short-tailed albatrosses.

Pursuant to the ESA, the use of explosives during training activities as described under Alternative 1 may affect but is not likely to adversely affect the ESA-listed short-tailed albatross. The Navy has consulted 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 & Bełdowski, 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 et al., 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 on 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 GOA Study Area 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 explosions at or near the surface within the TMAA 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 explosions at or near the surface would be temporary, and no lasting impact on prey availability or the pelagic food web would be expected. Indirect impacts of in-air 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 GOA Study Area, (4) the dispersed spatial and temporal nature of the training activities that may have temporary water or air quality impacts, and (5) the addition of the

Continental Shelf and Slope Mitigation Area within the TMAA. 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 but is not likely to adversely affect the short-tailed albatross. The Navy has consulted 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 stressors resulting from 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, new information on existing environmental conditions since the analysis in the 2016 GOA Final SEIS/OEIS has been incorporated into the analysis in this SEIS/OEIS. However, this new information does not significantly change the environmental baseline of the analyses in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. While the addition of the WMA as part of the GOA Study Area expands the affected environment, the activities occurring in the WMA would not use sonar and other transducers or explosives and would only involve vessel and aircraft maneuvering and weapons noise (see Chapter 2, Description of Proposed Action and Alternatives). Other acoustic stressors, specifically noise from vessels, aircraft, and weapons firing would occur in the WMA and could disturb seabirds in the WMA. However, no new activities are being proposed in this SEIS/OEIS that were not previously analyzed, and activities proposed to occur in the WMA are the same activities that have been occurring in the TMAA for decades. These same activities have been relocated to the more expansive WMA. The number of vessel steaming hours, aircraft operations, and weapons firing events in the Proposed Action is the same as the number proposed and analyzed in the 2020 GOA Draft EIS/OEIS. Vessel and aircraft maneuvering activities and weapons noise in the WMA would occur in deep offshore waters at depths greater than 4,000 m and located beyond the continental shelf and slope, where seabirds, including short-tailed albatross, are less likely to congregate. The probability of disturbance by aircraft, vessel, or weapons noise in the WMA would be lower than the already low probability for disturbance in the TMAA, because (1) fewer activities would take place in the WMA, (2) the vessel or aircraft maneuvering activities and weapons noise that would occur in the WMA would be dispersed over a substantially larger area than the TMAA, and (3) the WMA is located farther offshore than the shelf and slope habitat preferred by many seabird species, including short-tailed albatross. Relocating some vessel and aircraft maneuvering activities from the TMAA into the WMA would slightly reduce the probability of a disturbance in the TMAA, such that, when considered together, the probability of disturbing or otherwise impacting a seabird would remain approximately the same as previously analyzed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS.

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/OEIS (Steller's eider and spectacled eider) were not included in this previous consultation. The Navy has determined that the Proposed Action will have no effect on the Steller's eider and the spectacled eider.

As provided in 50 CFR sections 402.16(a)–(d), reinitiation of consultation is required if the following occurs: (a) the amount or extent of incidental take is exceeded; (b) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (c) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not previously considered; or (d) a new species is listed or critical habitat designated that may be affected by the action.

For GOA training activities analyzed in the 2010 Letter of Concurrence for the short-tailed albatross, the following triggers under section 402.16 have been met:

- **Section 402.16(b):** The 2021 Biological Assessment incorporates new information on species hearing criteria, sound propagation calculations, species presence and distribution, and provides the updated analysis resulting from these improvements;
- **Section 402.16(c)**: There has been a reduction in the Proposed Action from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS in that the exercise is reduced to one annual event and the sinking of a target vessel (SINKEX) is no longer being planned, in addition to changes in the platforms and systems used as part of the remaining activities.

Pursuant to the ESA, the Navy has determined that the continuation of the Navy's activities in the GOA Study Area may affect the short-tailed albatross. The Navy has consulted with USFWS as required by section 7(a)(2) of the ESA and received a Letter of Concurrence from USFWS concurring with the Navy's determination of effects for short-tailed albatross.

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3.11 Socioeconomic Resources and Environmental Justice

Gulf of Alaska Navy Training Activities

Final Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

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3.11 Socioeconomic Resources and Environmental Justice

3.11.1 Affected Environment

Concerns regarding socioeconomic resources (including commercial shipping, commercial and recreational fishing, and tourism) and environmental justice remain the same as those issues previously identified in the 2011 Gulf of Alaska (GOA) Final Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) and 2016 GOA Final Supplemental Environmental Impact Statement (SEIS)/OEIS. Further, the Navy's standard operating procedures to prevent or reduce socioeconomic impacts on local communities—as described in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS—remain applicable in this SEIS/OEIS. Socioeconomic resources were analyzed in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS for training activities occurring in the Temporary Maritime Activities Area (TMAA), which is located beyond 12 nautical miles (NM) from shore and outside of the U.S. Territorial Sea in the GOA. The Study Area for this SEIS/OEIS was expanded to include a limited number of activities in the Western Maneuver Area (WMA), as well as the same activities in the TMAA analyzed previously. The Proposed Action is to conduct an annual exercise, historically referred to as Northern Edge, over a maximum time period of 21 consecutive days during the months of April through 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 (e.g., EA-6B aircraft has been replaced with the EA-18G aircraft). Additionally, the use of the Portable Underwater Tracking Range is no longer proposed, and the Sinking Exercise, originally proposed in the 2011 GOA Final EIS/OEIS, is not part of the Proposed Action in this SEIS/OEIS. Refer to Chapter 2 (Description of Proposed Action and Alternatives) for a more detailed description of the GOA Study Area and the alternatives considered and eliminated from further consideration.

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 Socioeconomic Resources

Following a review of recent literature, the Navy has determined that the existing conditions with respect to military, commercial, and general aviation air traffic and 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 a Navy exercise commences, the military and the local Federal Aviation Administration (FAA) 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

Notice to Mariners (NTMs) issued by the U.S. Coast Guard (USCG) and Notices to Airmen issued by the FAA. 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 via the U.S. Department of Homeland Security Navigation Center, Local NTMs[1] which are published weekly and downloadable as PDF documents.

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). All three ports are located in inland waters north of the TMAA and would not be impacted by activities in the WMA. The port of Dutch Harbor, located on Amaknak Island in the Aleutians, is the only major port located in proximity to the WMA. The western boundary of the WMA is approximately at the same longitude as Dutch Harbor (see Figure 2-1). Vessel traffic at ports, harbors, and terminals in the Cook Inlet area are likely to increase over the next 40 to 50 years as several port expansion projects are completed and economic activity increases (Bureau of Ocean Energy Management, 2016).

Commercially used waterways are controlled by the use of directional shipping lanes for large vessels (e.g., cargo, container ships, and tankers). The most heavily used commercial ports and waterways in Alaska can be visualized using signals broadcast mainly by larger commercial vessels through the Automatic Identification System. The locations for all participating vessels were plotted from April to October 2014 to create a map of relative vessel traffic density (Figure 3.11-1). While the data do not include every vessel or encompass all possible shipping routes, the visualization highlights the use and importance of nearshore coastal routes to conduct commerce and for transportation and shows that deeper offshore waters in the GOA Study Area are not heavily used. Vessel traffic extending west along the GOA Study Area and the Aleutian Islands to Dutch Harbor would most commonly follow the route of the Alaska Marine Highway System and use inland and nearshore waterways along the coastline. Commercial fishing vessels predominantly approach Dutch Harbor from the Bering Sea to the north; however, vessel traffic approaching from the south appears to be concentrated north of the WMA (Figure 3.11-1).

In 2020 there were 5,139 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, 2022). This is a significant reduction in vessel traffic from 2017 when 7,934 vessel transits were recorded at these same ports. (U.S. Army Corps of Engineers, 2018a). The Port of Anchorage is the third-largest port in Alaska and is designated as a U.S. Department of Defense National Strategic Port. This port provides services to approximately 75 percent of the total population of Alaska (Bureau of Ocean Energy Management, 2016). The port of Unalaska, which includes Dutch Harbor, is located inshore of the western boundary of the WMA. In addition to other commodities, the port processed over 800,000 short tons of fish and shellfish in 2020 and reported 907 vessel transits (inbound and outbound) (U.S. Army Corps of Engineers, 2022). Ships that travel from major ports to the lower 48 states and Hawaii, as well as marine traffic between coastal ports, enter the GOA Study Area briefly.

[1] See http://www.navcen.uscg.gov/?pageName=lnmDistrict&region=17.

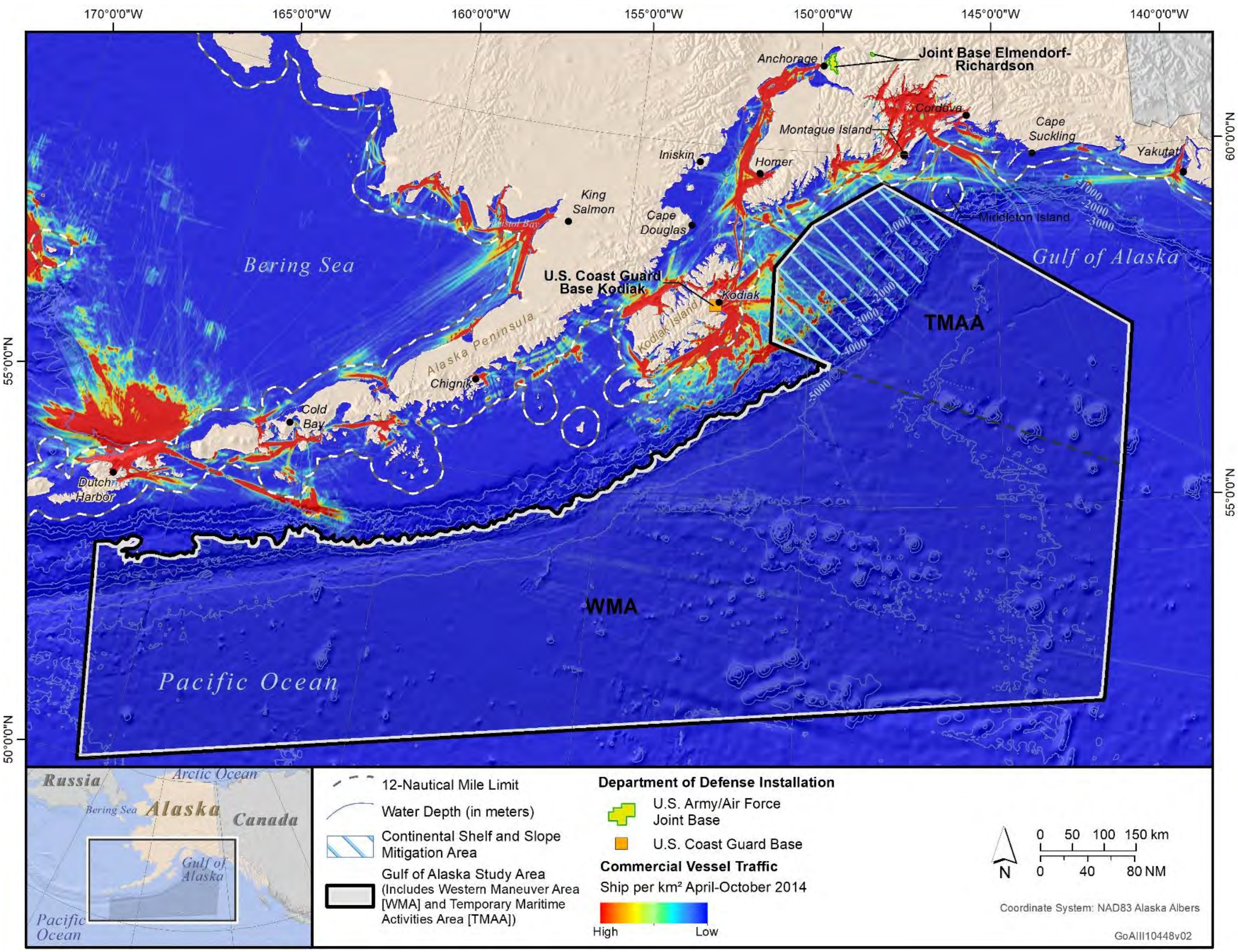

Figure 3.11-1: Density of Commercial Vessel Traffic in Proximity to the Gulf of Alaska Study Area

While the Navy does not publish daily NTMs, USCG District 17, Alaska (Juneau and Anchorage) communicates any active Navy training activity to vessels through broadcast NTMs on very high frequency-FM Channel 16 and accessible through the U.S Coast Guard Navigation Center District 17 Broadcast Notice to Mariners website[2] (U.S. Coast Guard, 2022).

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). In federal waters off the state of Alaska, groundfish are managed under a fishery management plan (North Pacific Fishery Management Council, 2020). Commercial fishing regions, as defined by the Alaska Department of Fish and Game (ADFG), which are closest to or overlap the GOA Study Area are presented in Figure 3.11-2. Groundfish harvest in the GOA Study Area (TMAA and WMA) is very limited (Alaska Department of Fish and Game, 2022b), with low catches in the WMA likely due to its location in deep offshore waters (greater than 4,000 meter [m]) beyond the continental shelf and slope.

Landings data from 2020 show that walleye pollock had the greatest harvest and highest value, with 3.23 billion pounds landed (86 percent of the total) and a total value of $419 million (67 percent of value) (Figure 3.11-3 and Figure 3.11-4) (National Marine Fisheries Service, 2022b). Pacific cod had the second-highest harvest and value in 2020, with 380 million pounds harvested and a value of $118 million (Figure 3.11-3 and Figure 3.11-4). Combined, these two species accounted for over 97 percent of the total groundfish harvest in the GOA in 2020 (National Marine Fisheries Service, 2022b).

Several groundfish species' seasons are open year round, while others vary throughout the year depending on the region (Alaska Department of Fish and Game, 2020a). However, the areas of highest harvest for groundfish within the GOA Study Area occur on the continental shelf in the TMAA, with very limited catch effort occurring in the WMA due to the deep offshore waters beyond the continental shelf and slope (see Figure 3.11-2) (Alaska Department of Fish and Game, 2020a, 2020b; National Marine Fisheries Service, 2020c). As described in Chapter 5 (Mitigation), the Navy is adding the Continental Shelf and Slope Mitigation Area within the TMAA, which would prohibit the use of explosives from the sea surface up to 10,000 feet altitude during training over the entire continental shelf and slope out to the 4,000 m depth contour to protect marine species and biologically important habitat.

[2] https://www.navcen.uscg.gov/bnmmessages/DistrictSearchV1.php?d=17&i=2

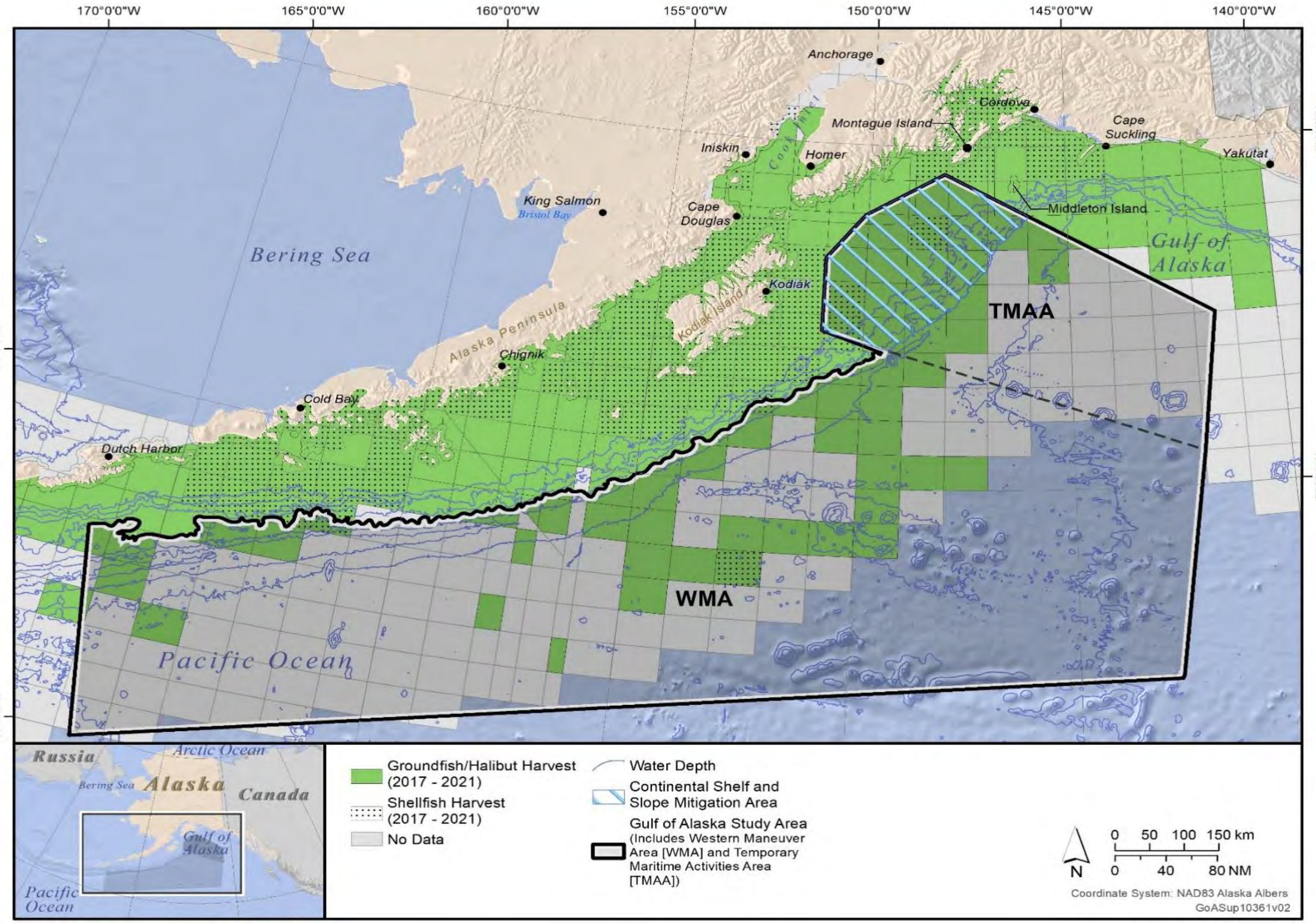

Figure 3.11-2: Commercial Groundfish/Halibut and Shellfish Harvest in the Gulf of Alaska Study Area, 2017–2021

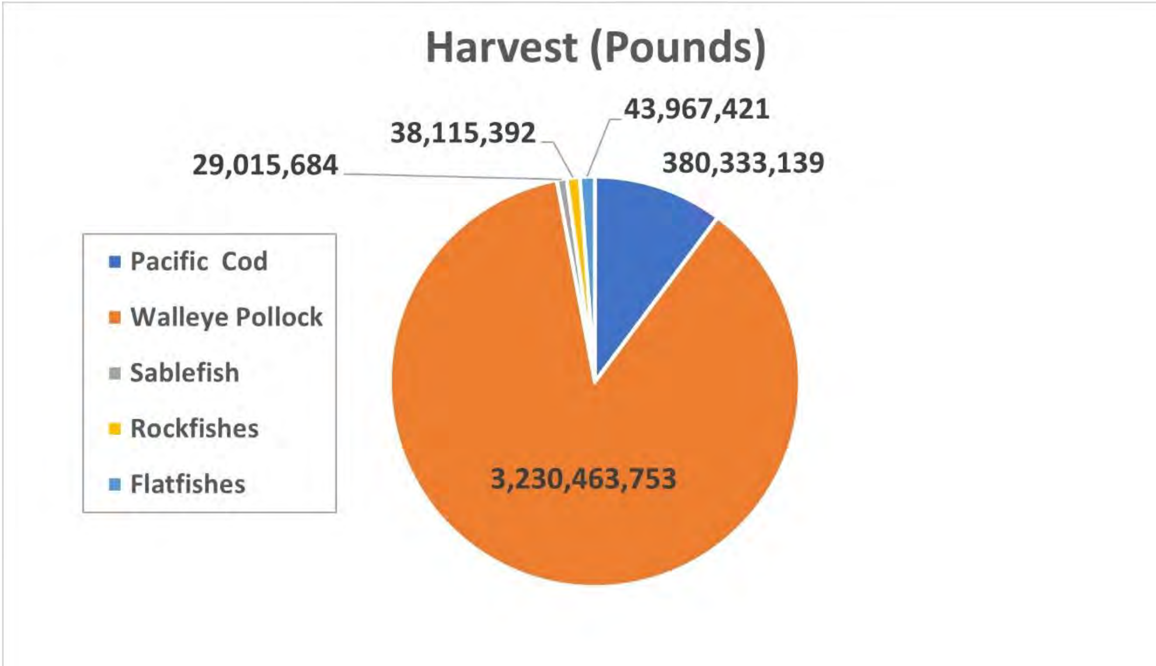

Figure 3.11-3: Commercial Groundfish Harvest by Species in Alaska State Waters in 2020

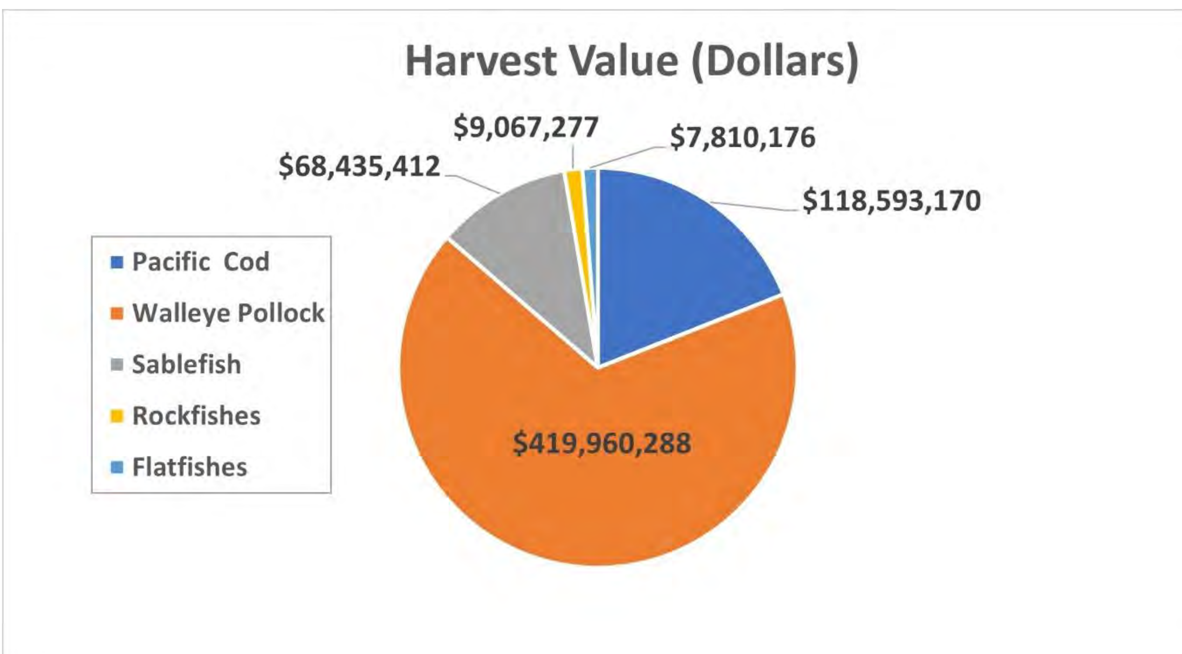

Figure 3.11-4: Commercial Groundfish Harvest Value by Species in Alaska State Waters in 2020

Salmon

In federal waters off the state of Alaska, salmon fisheries are managed under a fishery management plan (North Pacific Fishery Management Council et al., 2021). There is no overlap of the commercial salmon fishery management areas and the GOA Study Area (Figure 3.11-5). There is no science-based evidence that trends in salmon harvests (National Marine Fisheries Service, 2020d) have been positively or negatively correlated with historically biennial Navy training activities in the TMAA. Commercial 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, 2020a). Commercial and recreational fishing of salmonids is concentrated in on-shelf environments near the coast, and only a small northwest portion of the GOA Project Area is located on-shelf.

Across Alaska, trends in commercial harvest and the ability to meet escapement (i.e., are not harvested and return to fresh water to spawn) 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 an increase in 2019 being driven by large runs to Bristol Bay (Brehmer, 2021). However, 2020 and 2021 showed substantial decreases in sockeye salmon numbers, with the Copper River fishery closing early due to low counts and catches (Brehmer, 2021). 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 (Alaska Department of Fish and Game, 2019a). Despite these restrictions, meeting escapement goals has been challenging and has led to listing of several Alaskan stocks as “stocks of concern” (Munro, 2018, 2019).

Due to their abundance and the biennial life history of pink salmon, over the past five years, pink and sockeye salmon have alternated as the salmonid accounting for the greatest proportion of annual Alaska salmon harvest, with sockeye salmon catch being highest in 2016 and 2018, and pink salmon catch being highest in 2017 and 2019 (Figure 3.11-6). Despite pink salmon having the highest catch in 2017 and 2019, sockeye salmon consistently had the highest value (Figure 3.11-7). Coho, sockeye, and chum salmon harvests have fluctuated but have been relatively stable over the past five years, while Chinook salmon show a slightly downward trend (National Marine Fisheries Service, 2022c).

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 recent years (Munro, 2019).

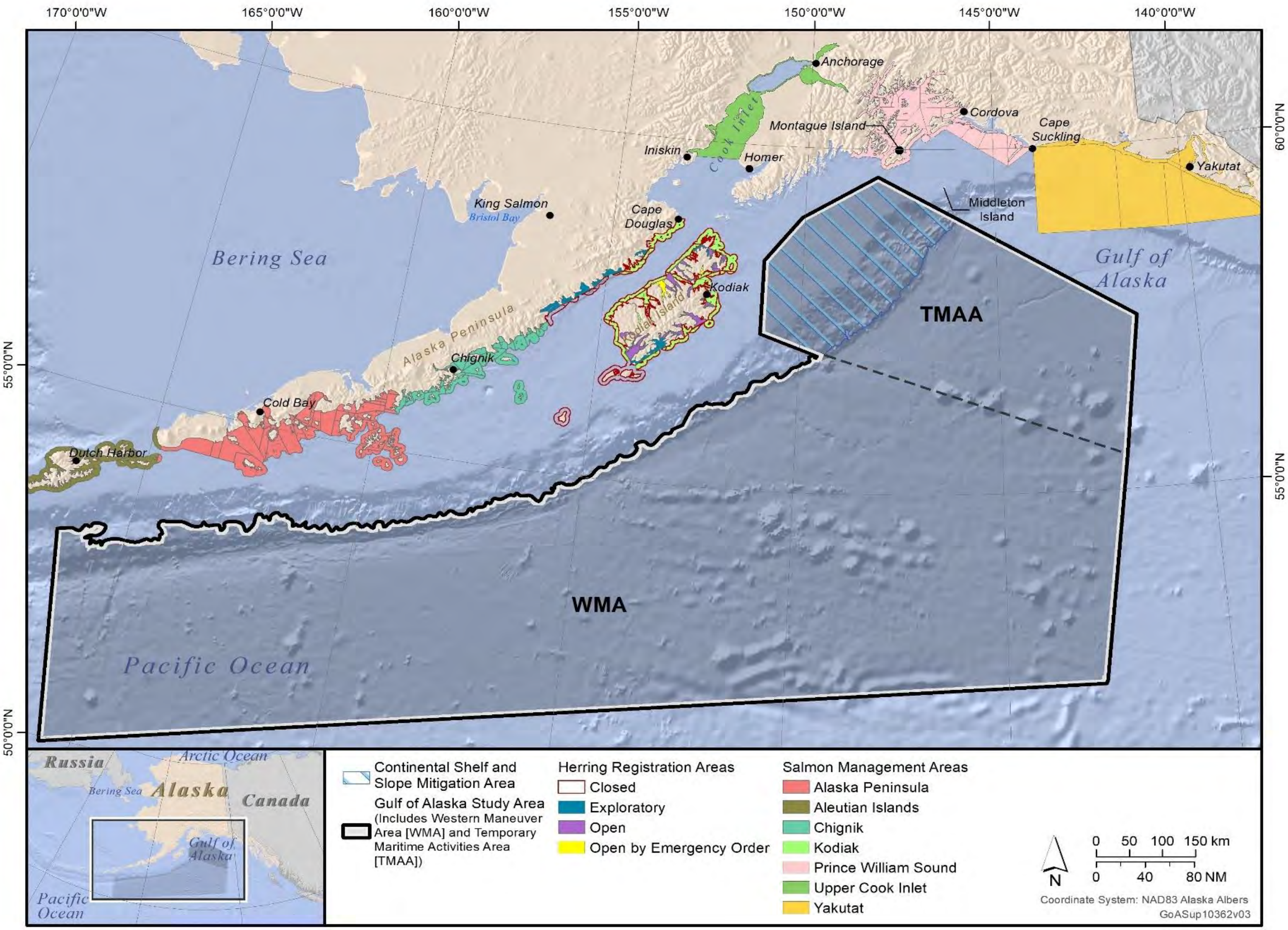

Figure 3.11-5: Commercial Salmon and Herring Fishery Management Areas in the Gulf of Alaska Study Area

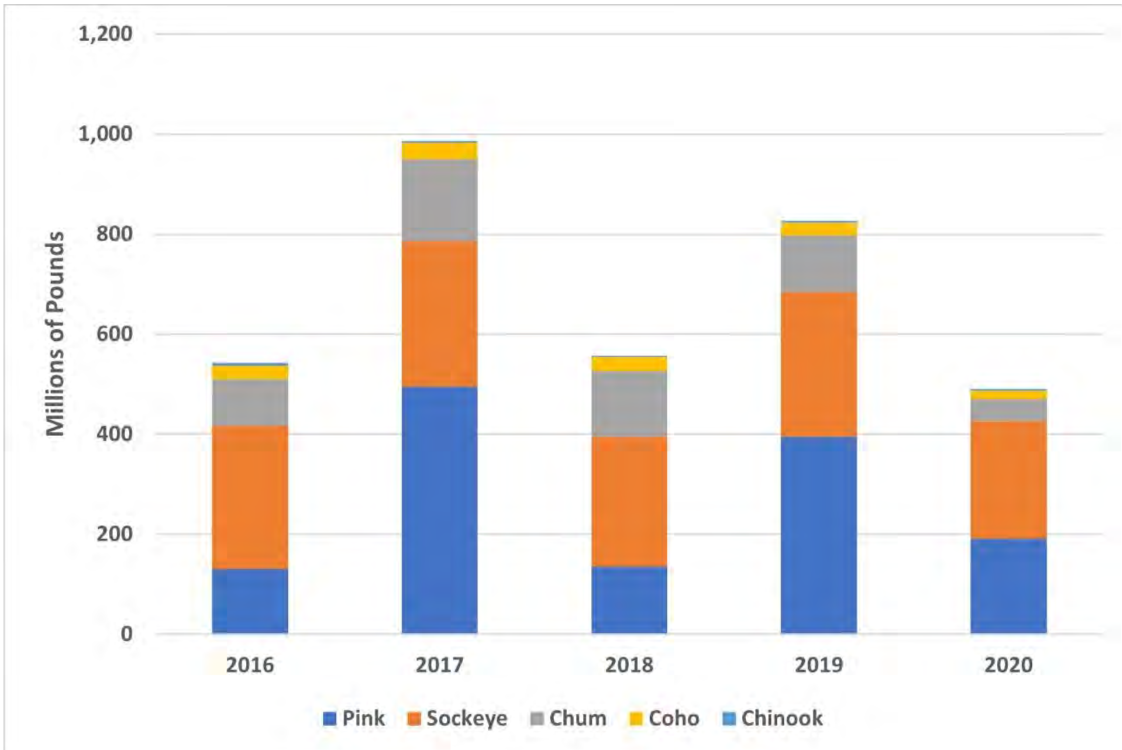

Figure 3.11-6: Commercial Salmon Harvest by Species in Alaska State Waters, 2016–2020

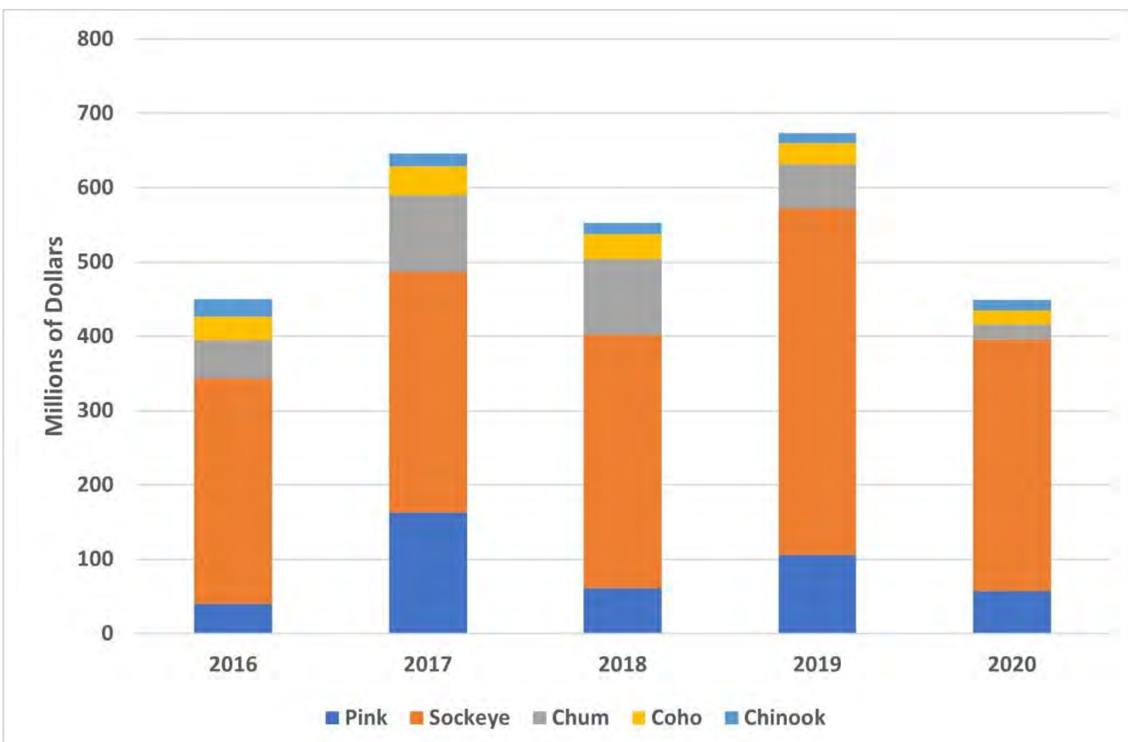

Figure 3.11-7: Commercial Salmon Harvest Value by Species in Alaska State Waters, 2016–2020

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 GOA Study Area (Alaska Department of Fish and Game, 2016). There is no overlap of the commercial herring fishery management areas and the GOA Study Area (see Figure 3.11-5).

Shellfish

According to the ADFG, crabs, shrimp, clams, scallops, octopuses, and squids are commercially harvested in the GOA under the term “shellfish”, “miscellaneous shellfish”, and “marine invertebrates.” However, for this analysis, with the exception of crab that are analyzed separately (see ”Crab” section below), all other shellfish species are combined into one group, referred to as “shellfish.” Overlap of the commercial shellfish fisheries with the GOA Study Area is presented in Figure 3.11-2.

Panaeid shrimp had the largest total harvest between 2016 and 2020 (Figure 3.11-8). Squid species in the family Loliginidae also had high total shellfish harvest between 2016 and 2018, but had no data reported in 2019 and 2020 (Figure 3.11-8). In contrast to total harvest, squid species was a very small portion of the total shellfish value (Figure 3.11-9). Pacific geoducks represented the largest portion of the harvest value, with penaeid shrimps also making up a significant portion of the overall value (National Marine Fisheries Service, 2022d).

In federal waters off the state of Alaska, weathervane scallops are managed under a fishery management plan (North Pacific Fishery Management Council, 2014) and 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). Since scallop harvest takes place in shallow waters, there is very little overlap of scallop harvesting with the training activities in the GOA Study Area. In addition, these seasons 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, 2020a).

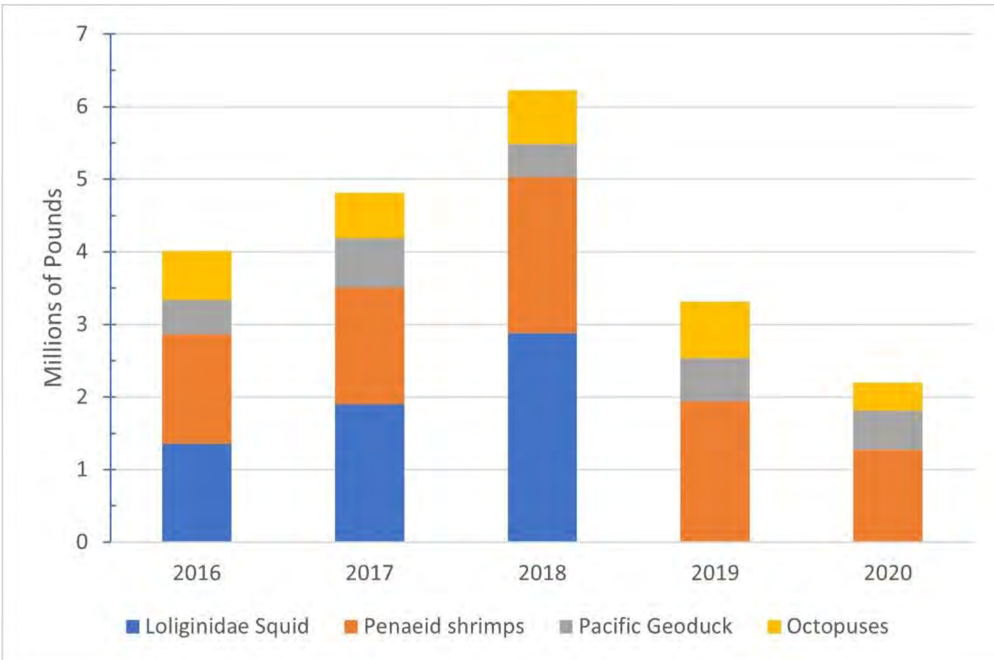

Figure 3.11-8: Commercial Shellfish Harvest by Species in Alaska State Waters, 2016–2020

Figure 3.11-9: Commercial Shellfish Harvest Value by Species in Alaska State Waters, 2016–2020

Crab

Crab are defined as shellfish by the ADFG; however, for this analysis, crab are analyzed separately from all other non-crab shellfish due to their commercial importance in the GOA (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). From 2017–2020, overall crab harvest in Alaska (all species combined) increased (Figure 3.11-10) (Alaska Department of Fish and Game, 2019b; National Marine Fisheries Service, 2020b, 2022a). As shown in Figure 3.11-10, 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 generally had the highest value (Figure 3.11-11) (National Marine Fisheries Service, 2022a). From 2017–2020, the Dungeness crab fishery has been steadily increasing in both harvest and value (Figure 3.11-10 and Figure 3.11-11). 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 the ADFG (Denning, 2020) and showed the highest total harvest in 2020 (National Marine Fisheries Service, 2022a). 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; 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, 2020c).

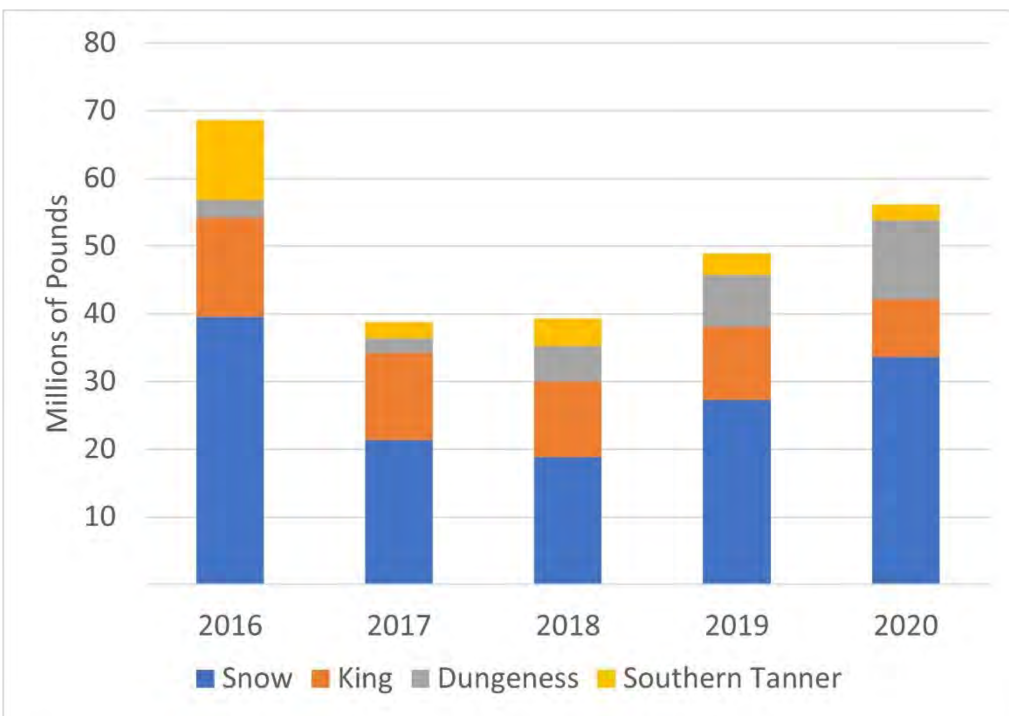

Figure 3.11-10: Commercial Crab Harvest by Species in Alaska State Waters, 2016–2020

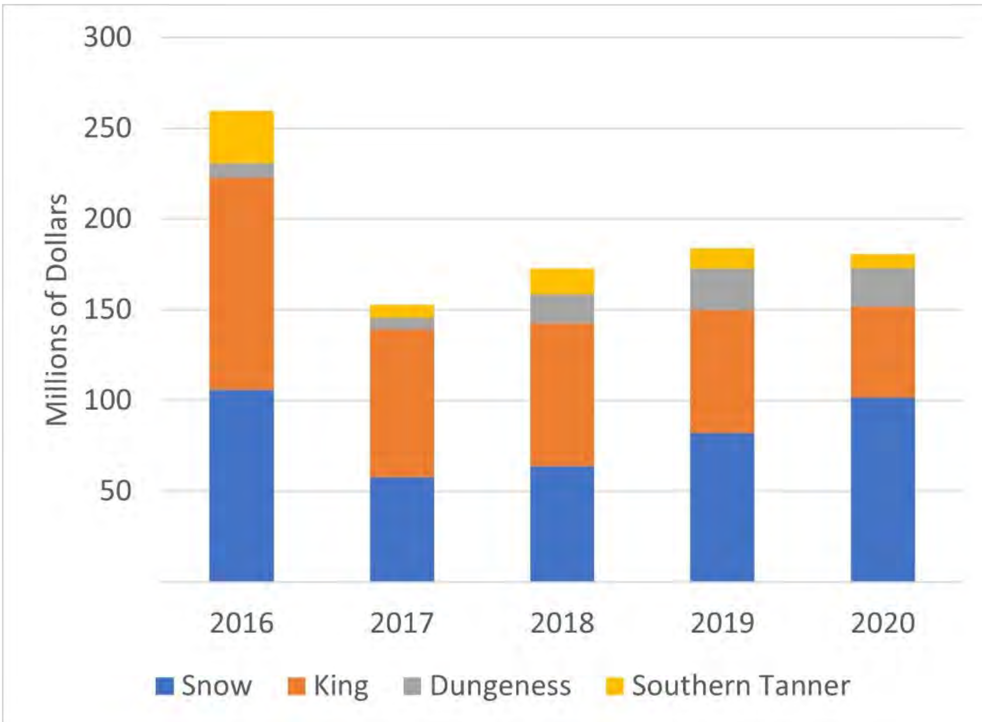

Figure 3.11-11: Commercial Crab Harvest Value by Species in Alaska State Waters, 2016–2020

Commercial crab harvest has very little overlap with the GOA Study Area (see Figure 3.11-2). The Kodiak region is the only commercial fishing region close to or overlapping the TMAA (Alaska Department of Fish and Game, 2020a). 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, 2020a) and has some overlap with the April 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, 2020a) and does not overlap with the proposed window for training activities (Alaska Department of Fish and Game, 2020a).

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 coronavirus pandemic (COVID-19) 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 GOA 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 3.11-12, there was an overall downward trend in recreational catch of salmon species caught by pound, as well as other than salmon caught from 2010 through 2018. 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). However, in 2019, the most recent year data were available, the downward trend of recreational fish catch reversed, as shown in Figure 3.11-12 (Alaska Department of Fish and Game, 2022a). Despite the stricter fishery management and previous downward trend of recreational fishing catch, Alaska state income from recreational fishing has been stable since the release of the 2011 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2011; Alaska Department of Commerce, 2018). In addition, only a small northwest portion of the GOA Study Area is located in an on-shelf environment. Recreational and commercial fishing of salmonids is concentrated in on-shelf, estuarine, and river environments near the coast or inland.

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).

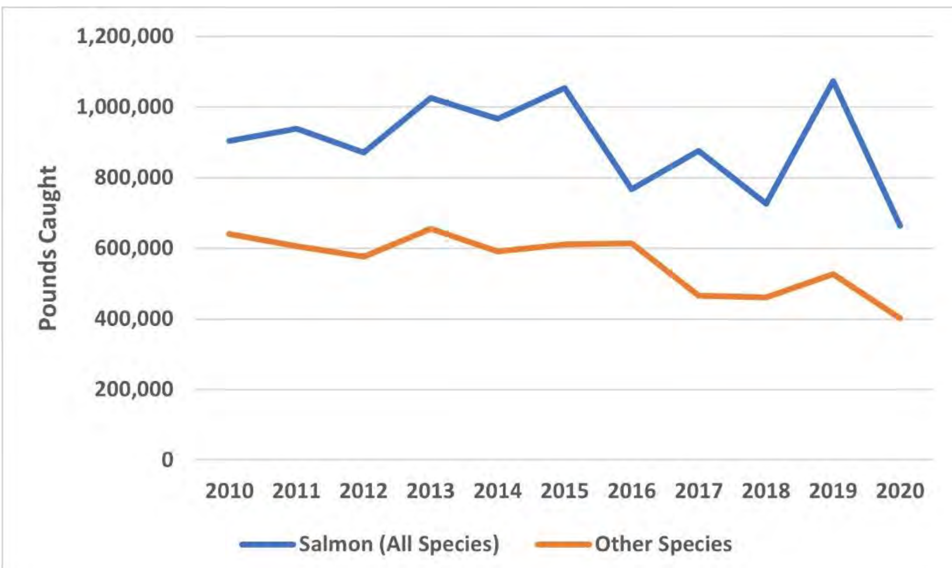

Figure 3.11-12: Total Catch of Ocean Salmon and Other Fish Species in Southcentral Alaska State Waters, 2010–2020

However, because of the COVID-19 pandemic, the cruise industry came to a virtual halt in 2020 and 2021. The Centers for Disease Control and Prevention restricted all non-essential maritime traffic in the GOA. As such, the cruise industry in Alaska experienced a stark reduction in business, and the volume of maritime traffic from tourism in the GOA decreased in 2020 and 2021 (State of Alaska, 2021). The Governor of Alaska stated that an estimated 3 billion dollars in gross state product is lost for each year that cruises cannot operate in Alaska (Dunleavy, 2021). However, in May 2021 Congress passed H.R. 1318, the Alaska Tourism Recovery Act, that allowed cruises to continue between Alaska and the lower 48 since July 2021.

A pillar of the tourism industry in Alaska is the whale watching industry. In 2019, the Alaskan whale watching industry catered to over half of a million passengers and supported the employment of over 1,000 direct and indirect jobs (McDowell Group, 2020). However, the COVID-19 pandemic dramatically reduced tourism, resulting in a sharp decline in the whale watching industry in Alaska during the 2020 and 2021 seasons as compared to 2019. Whale watching companies rely on tourists from cruises, which did not occur in 2020 (National Marine Fisheries Service, 2021). With the Alaska Tourism Recovery Act allowing cruises to resume as of July 2021, the whale watching industry may be able to begin recovering from the effects of the COVID-19 pandemic.

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 GOA Study Area (Figure 3.11-1), 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 Environmental Justice

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 mainland 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, and the maneuvering activities proposed for the WMA are the same as those conducted in the TMAA and would have been conducted in the TMAA if they had not been moved into the WMA. Furthermore, the WMA is located farther from shore than the TMAA, beyond the continental shelf and slope, and in waters deeper than 4,000 m. As noted in Section 3.11.1 (Affected Environment), the types of activities and numbers of events in the Proposed Action are largely the same as in the previous documents (Alternative 1 in both the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS). As described in Chapter 2 (Description of Proposed Action and Alternatives), there have been changes in the platforms and systems used as part of those activities, and, notably, neither the Sinking Exercise nor the use of the Portable Underwater Training Range are part of the Proposed Action. Based on the similarities between this and past proposed actions, the analysis of potential impacts on environmental justice presented in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS remains valid, and consistent with the conclusions from those analyses, the Proposed Action in this SEIS/OEIS would not disproportionately affect any minority populations or low-income populations

3.11.1.3 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 GOA Study Area 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.

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 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, 2013). The 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 issued by the FAA, 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. Pre-exercise public engagement was carried forward by the Navy leading up to Northern Edge training in 2021. The meetings were hosted between September 2019 and April 2021. Due to the COVID-19 pandemic, most events were hosted virtually in 2020 and 2021; however, this did not impact the Navy's ability to alert the public of its upcoming training activities.

3.11.2 Environmental Consequences

The Navy conducted a review of new literature, to include laws, regulations, and publications pertaining to socioeconomic resources 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 generally consistent with the proposed actions from the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, with two notable exceptions: the Sinking Exercise and the use of the Portable Underwater Training Range are not part of the Proposed Action in this SEIS/OEIS. This SEIS/OEIS analyzes the impacts on socioeconomic resources and environmental justice from the No Action Alternative and Alternative 1 (the Preferred Alternative).

3.11.2.1 No Action Alternative

Under the No Action Alternative, proposed Navy training activities would not be conducted in the GOA Study Area. The impacts associated with Navy training activities would not be introduced into the marine environment. Therefore, existing environmental conditions would remain unchanged after cessation of ongoing Navy training activities. Furthermore, because Navy training activities have not been found to directly impact commercial fishing or other socioeconomic industries, such as recreational fishing or cruising, cessation of ongoing Navy training activities would have a negligible effect on socioeconomic resources. With respect to environmental justice, because ongoing Navy training activities do not have any direct effect on environmental justice, cessation of those activities would not disproportionately impact minority or low income populations.

3.11.2.2 Alternative 1

3.11.2.2.1 Socioeconomic Resources

Alternative 1 for this SEIS/OEIS remains generally consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, with the exceptions noted above.

No adverse impacts on socioeconomic resources, including commercial shipping, commercial and recreational fishing, and tourism, would occur as a result of the proposed training activities under Alternative 1. 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 GOA Study Area would have a significant effect on socioeconomic resources in the region.

As described in Section 3.11.1.1.1 (Commercial Shipping) the highest densities of commercial vessel traffic do not overlap with the GOA Study Area. While commercial vessels do transit the offshore areas of the GOA Study Area, conflicts with Navy vessels or aircraft are unlikely given the short 21-day duration of Navy activities and the limited use of the Study Area by commercial vessels. Should an interaction occur, it would be resolved through communications between the Navy vessel and commercial vessel, minimizing any economic costs that might be incurred through a delay, for example.

As described in Section 3.11.1.1.3 (Tourism and Recreation), the majority of coastal and marine tourism activities occur in relatively shallow waters over the continental shelf and do not depend on access to deep offshore waters, which includes the vast majority of the GOA Study Area and all of the WMA. Smaller vessels supporting tourism in Alaska would most likely follow the Alaska Marine Highway System linking small towns and ports along the GOA coast and through the Aleutian Islands, including Dutch Harbor, and would generally avoid rougher seas farther offshore. The proposed training activities in the GOA Study Area would be unlikely to occur in the same place and at the same time as marine tourism and recreational activities. Therefore, no impacts on tourism and recreation are anticipated.

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 overlap with this timeframe are typically longer than (at least double) the 21-day training period (Alaska Department of Fish and Game, 2020a). In addition, a large portion of the GOA Study Area is located far enough offshore (>12 NM) that overlap with preferred or frequented commercial and recreational fishing areas would be minimal. More specifically, conflicts or interactions between Navy activities in the GOA Study Area and commercial and recreational fishers are unlikely for the following reasons: (1) the largest commercial fishery in Alaska state waters, the groundfish fishery, is mostly open year-round, and the seasons in regions that overlap or are adjacent to the TMAA portion of the GOA Study Area that are not year round are more than double the length of the 21-day duration of proposed training activities (Alaska Department of Fish and Game, 2020a); (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, 2020a), and the only crab season that overlaps with the April–October timeframe for training activities is the Dungeness crab season, which occurs from July–December. The Dungeness crab fishery is a relatively shallow water, on-shelf, coastal fishery and is considered healthy (Denning, 2020); (3) general areas of effort for the weathervane scallop fishery do not overlap with the TMAA, and only a small portion of the Prince William Sound exploratory scallop fishing area overlaps with 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, estuaries, and rivers (<12 NM) and outside of the GOA Study Area.

In addition, aircraft and vessel maneuvering activities originally planned for the TMAA would now be more widely distributed within both the GOA Study Area with the addition of the WMA to achieve more realistic training scenarios. Only approximately 30 percent of maneuvering activities would occur in the WMA annually, and they would occur in deep (greater than 4,000 m) offshore waters located beyond the continental shelf and slope. These maneuvering activities are the same activities proposed for the TMAA and analyzed in the 2020 Draft SEIS/OEIS.

The establishment of the Continental Shelf and Slope Mitigation Area under Alternative 1 would prohibit the use of explosives from the sea surface to 10,000 feet altitude over the continental shelf and slope within the TMAA. The mitigation area would extend seaward to the 4,000 m depth contour, which is used to define the termination of the continental slope. Socioeconomic resources occurring in waters over the continental shelf and slope in the TMAA, such as commercial fishing, would no longer be impacted by training activities using explosives. Other training activities that do not use explosives would continue to be conducted as planned in the Continental Shelf and Slope Mitigation Area; however, any impacts on socioeconomic resources previously anticipated from the use of explosives in the TMAA would not occur. Impacts from training activities in the Continental Shelf and Slope Mitigation Area would either remain the same as previously analyzed or would be reduced. Therefore, no significant impacts are expected to occur to socioeconomic resources under Alternative 1 and a detailed re-analysis of this alternative with respect to socioeconomic resources is not warranted.

3.11.2.2.2 Environmental Justice

Alternative 1 for this SEIS/OEIS remains generally consistent with the description of Alternative 1 in the 2011 GOA Final EIS/OEIS and the 2016 GOA Final SEIS/OEIS, with the two exceptions noted above: the Sinking Exercise and the use of the Portable Underwater Training Range are not part of the Proposed Action in this SEIS/OEIS. The existing baseline conditions have not changed appreciably since the previous analyses. Furthermore, no new Navy training activities are proposed in the TMAA in this SEIS/OEIS, and all maneuvering activities moved into the WMA would occur more the 12 NM offshore and far from population centers. Therefore, a detailed re-analysis of this alternative with respect to environmental justice is not warranted.

3.11.3 Conclusion

3.11.3.1 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 for the analysis in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS. No new Navy training activities are being proposed in this SEIS/OEIS that would significantly impact socioeconomic resources in the GOA Study Area, and neither the Sinking Exercise nor the Portable Underwater Training Range, which were analyzed previously, are part of the

Proposed Action is this SEIS/OEIS. Therefore, the conclusion that there would be no significant impacts on socioeconomic resources under 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 impacts of the Proposed Action under Alternative 1 on socioeconomic resources for both the NEPA and EO 12114 regulations, please refer to Table 3.12-1 in the 2011 GOA Final EIS/OEIS.

The establishment of the Continental Shelf and Slope Mitigation Area as part of the Proposed Action would prohibit the use of explosives from the sea surface to 10,000 feet altitude over the continental shelf and slope within the TMAA. Socioeconomic resources, such as commercial fishing, would no longer be impacted by potential conflicts with training activities using explosives over the shelf and slope, and impacts on socioeconomic resources would either remain the same or would be reduced compared with past analyses in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS.

3.11.3.2 Environmental Justice

As described above, there is new no information on existing environmental conditions that significantly changes the affected environment for environmental justice. The geographic location of the GOA Study Area, including the WMA, is far offshore (greater than 12 NM from shore) with no population centers in close proximity. Significant socioeconomic impacts are not anticipated due to the Proposed Action; therefore, there would be no disproportionately high and adverse human health or environmental effects on any minority populations and low-income populations. The 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 Alternative 1 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

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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, 2019b). This analysis incorporates by reference the 2011 GOA Final EIS/OEIS (U.S. Department of the Navy, 2011) and the 2016 GOA Final SEIS/OEIS (U.S. Department of the Navy, 2016), and 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 Study Area. In general, the GOA Study Area includes those areas previously identified in Chapter 3 (Affected Environment and Environmental Consequences). The geographic boundaries for cumulative impacts analysis for marine mammals were expanded to include activities outside the GOA Study Area that might impact migratory marine mammals. Primary considerations from outside the GOA Study Area 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 GOA Study Area. 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 4-1.

Table 4-1: 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, 2021).		O	O	O
Cook Inlet Planning Area, Oil and Gas Lease Sale 244	Cook Inlet, Alaska	The Bureau of Ocean Energy Management released a Final EIS in 2016 for the lease sale of 244 outer continental shelf blocks. Following the Final EIS, in 2017 there were bids over $3 million for the blocks; the Cook Inlet lease blocks sale occurred in 2017 (Bureau of Ocean Energy Management, 2017a). The production of oil and gas in the Cook Inlet could have cumulative effects on marine mammals, fishes, sea turtles, and socioeconomic resources and environmental justice.		C	O	O

Table 4-1: 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*
Yakutat Alaska Wave Energy Project	Yakutat, Alaska	This project is underway and is monitored by the University of Alaska Fairbanks, Bureau of Ocean Energy Management (BOEM), and other regulating entities for both environmental impacts and the potential to further spread wave and tidal energy to remote communities in Alaska (Bureau of Ocean Energy Management, 2021b). This project could have cumulative effects on air quality, sediments and water quality, fishes, marine mammals, and socioeconomic resources and environmental justice.	Upon completion, this project would reduce the amount of diesel used by the city to generate electricity.		C	O

Table 4-1: 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 GOA 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). In addition to this EIS, the National Marine Fisheries Service (NMFS) also releases annual Alaska groundfish harvest specifications for more relevant catch limits (National Marine Fisheries Service, 2021). Operations carried out under this EIS and subsequent annual specifications 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 GOA 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

Table 4-1: 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*
Cook Inlet Beluga Whale Subsistence Harvest Final EIS	Cook Inlet, Alaska	A 2015 SEIS was published with the intention to specify Beluga whale subsistent 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, 2008). However, because the population of the Cook Inlet Beluga Whale has continued to decline and remained below the 350 individuals threshold—even with harvest control—subsistence harvesting has not been allowed (Marine Mammal Commission, 2021). Operations carried out under this SEIS could have cumulative effects on sediments and water quality, marine mammals, and socioeconomic resources and environmental justice.	The 2015 SEIS defines the number of Belugas that may be harvested by local tribes, setting a limit that NMFS determines will not pose a long-term threat to the species. Furthermore, no subsistent harvests are allowed until the Cook Inlet Beluga Whale population has passed the 350 individuals threshold.	O	O	O
Final EIS for Essential Fish Habitat Identification and Conservation in Alaska	GOA Study Area	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

Table 4-1: 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*
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 changes in the GOA Study Area on resources affected by the oil spill (Matkin et al., 2018). 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 effects on air quality, marine mammals, birds, and socioeconomic resources and environmental justice.	The NMFS take authorization 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 4-1: 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 (BSEE), 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 are multiple active leases in Alaskan waters permitted by the BSEE (Bureau of Safety and Environmental Enforcement, 2022). Activities carried out under the leases permitted by the BSEE could have cumulative effects on sediments and water quality, marine habitats, marine vegetation, marine invertebrates, fishes, marine mammals, and birds.		O	O	O

Table 4-1: 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	GOA Study Area, and open ocean areas	There are currently scientific research permits and General Authorizations for research issued by various agencies for work in the northern Pacific. For example, the Navy funds the University of Alaska Fairbanks to conduct Chinook salmon studies, while the BOEM funds the University of Alaska Fairbanks to conduct steelhead research. In addition, NMFS has issued permits for cetacean work in the North Pacific, as well as research studies on salmonids. As of May 2022, BOEM has no active survey permits in the Alaskan region. Currently, there is one pending permit with BOEM for 3D Marine Geohazard which would be permitted to Hilcorp Alaska LLC. However, no dates are projected for when the permit would begin if approved (Bureau of Ocean Energy Management, 2021a).This research could have cumulative effects 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 GOA Study Area.	O	O	O

Table 4-1: 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	GOA Study Area, 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 GOA, 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 GOA Study Area.	O	O	O

Table 4-1: 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*
Exxon Valdez Oil Spill Trustee Council	GOA	The Exxon Valdez Oil Spill 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, 2019a). 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, 2019b).	O	O	O
Alaska Marine Conservation Council	Northeast Pacific	This council has several 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, 2020).	The projects enacted by this council help to collect data, pass litigation, and promote healthy fishing practices in the Northeast Pacific.	O	O	O

Table 4-1: 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 Acidification Program (OAP) – GOA	GOA 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 Oceanic and Atmospheric Administration, 2021). 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	GOA	The North Pacific Research Board has three main hypotheses guiding research and monitoring programs for their GOA Project, centered around producing peer-reviewed research. 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 4-1: 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						
Joint Pacific Alaska Range Complex Final EIS/OEIS	Military Land Ranges, Maritime Training Areas, and Airspace Based in Alaska	This FEIS/OEIS was led by the U.S. Departments of the Army and Air Force to modernize and enhance JPARC in Alaska and to best support the military exercises in and near Alaska. JPARC provides a realistic training environment and allows the Services to train for full spectrum engagements, ranging from individual skills to complex, large-scale joint engagements. Training exercises under the JPARC EIS/OEIS overlap with the Northern Edge training described in Chapter 2 (Description of the Proposed Action) and the JPARC FEIS/OEIS (U.S. Department of Army & Air Force, 2013). The activities carried out under this Final EIS/OEIS, including construction and training, could have cumulative effects on all resource categories analyzed in this document.		C/O	O	O
Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar Final SEIS/OEIS	Western and Central North Pacific and Eastern Indian Oceans	The Navy released a Record of Decision regarding the Final SEIS/OEIS for SURTASS LFA Sonar in 2019 to continue to train with low-frequency sonar with its surveillance ships. (U.S. Department of the Navy, 2019a)The training occurs outside of GOA Study Area (84 FR 40397). 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

Table 4-1: 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 4-1: 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 construction and pile driving in the Gulf of Alaska coastal waters	Kodiak, Sitka, Ketchikan, Valdez, Cordova, Juneau, Petersburg, and Seward, Alaska	Project activities include rock socket drilling, vibratory hammering, pile cutting or clipping, power washing, and pile driving using an impact driver. The USCG-proposed activities may result in the incidental taking of marine mammals, specifically sea otters.	USCG has proposed six mitigation measures to reduce sea otter disturbance from acoustic stimuli to ensure that the USCG's activities will have the least practicable adverse impact on the species, their habitat, and the availability of this species for subsistence uses; and requirements for monitoring and reporting.			C

Table 4-1: 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 GOA	GOA	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 4-1: 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	GOA Study Area, and open ocean areas	Commercial and recreational fishing constitutes an important and widespread use of the ocean resources throughout the GOA Study Area. 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 GOA Study Area 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
Maritime Traffic	GOA Study Area, and open ocean areas	In previous years, cruises and other marine tourism constituted a significant portion of Alaska's maritime traffic. Since the beginning of the coronavirus pandemic (COVID-19), the CDC has restricted all non-essential maritime traffic in the GOA. As such, the cruise industry in Alaska has seen a stark reduction and the volume of maritime traffic from tourism in the GOA has decreased in 2020 and 2021 (State of Alaska, 2021). However, in May of 2021 Congress passed H.R. 1318, the Alaska Tourism Recovery Act, that would		O	O	O

Table 4-1: 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*
		allow for cruises to continue between Alaska and the lower 48 beginning July of 2021. (State of Alaska, 2021)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. This ferry service was closed temporarily following the beginning of the coronavirus pandemic (COVID-19) and has since reopened under restrictions set by the Center for Disease Control (Alaska Marine Highway System, 2021). This temporary closure and restricted operations resulted in overall lower maritime traffic. 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.				

Table 4-1: 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 Arm	The Knik Arm Crossing is a proposed project that would include construction of a 2-mile toll bridge servicing the Municipality of Anchorage and the Matanuska-Susitna Borough (State of Alaska Department of Natural Resources, n.d.). 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. In April of 2022, the Alaska Department of Transportation & Public Facilities announced that it was continuing to pursue the project and should have the right-of-way complete sometime within the year. In their announcement, they addressed the project’s history, the new landscape in the wake of the pandemic, and their desire to continue pursuing this project (Alaska Department of Transportation & Public Facilities, 2022).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.				C/X

Table 4-1: 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 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). Construction related to this project could potentially have cumulative effects on sediments and water quality, fishes, marine mammals, socioeconomic resources and environmental justice, and safety.			C	C
Hilcorp Alaska and Harvest Alaska Oil and Gas Activities	Cook Inlet	Hilcorp Alaska and Harvest Alaska have requested a Letter of Authorization for unintentional take of marine mammals from NMFS in 2021 to facilitate the beginning of oil and gas activities in the Cook Inlet(Hilcorp Alaska LLC & Harvest Alaska LLC, 2021). Oil and gas activities include exploration, development, and production activities. If granted, the authorization would expire in June of 2024 (Hilcorp Alaska LLC & Harvest Alaska LLC, 2021). Activities described above could have cumulative effects on marine mammals, fishes, and socioeconomic resources and environmental justice.			C/O	C/O

Table 4-1: 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 Expansion	Port of Alaska	The Port of Alaska is aiming to complete its new petroleum and cement terminal by fall of 2021 (Brehmer, 2020); however, at the time this document was prepared in June 2022 there is still no confirmation that this project is complete. 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	C/O
Shoreline Development	Northern coastline of GOA	Shoreline development adjacent to the TMAA portion of the Study Area 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 entire GOA Study Area 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

Table 4-1: 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	GOA Study Area, 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 may have a cumulative impact 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 GOA. 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 4-1: 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	GOA Study Area, 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 4-1: 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	GOA Study Area, 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 4-1: 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	GOA Study Area, 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). The State of Alaska has released a report stating the impacts of the 2020 and 2021 cruise ship season cancelation due to the coronavirus pandemic (COVID-19) (State of Alaska, 2021). The economic effects of the pandemic are not isolated to the cruise industry alone and will have effects on all tourism-related industries in Alaska. The Alaska Tourism Recovery Act S.593 was approved in May 2021 and will facilitate the return of the cruise industry beginning July 2021. Marine tourism is essential to Alaska's growing economy, and even with a temporary reduction due to the coronavirus pandemic (COVID-19) it still 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

Table 4-1: 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 Nome Modification	Bering Sea	In March 2020 a Final Integrated Feasibility Report and EA, and 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, 2020). Modification and an increased threshold of operational activities 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/O
Alaska Deep-Draft Arctic Port System Study	Bering Sea and GOA	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). This project has been temporarily suspended for several years but has not been officially canceled (U.S. Army Corps of Engineers, 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.				C

Table 4-1: 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***
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). At the time this document is being prepared in June of 2022, the EPA has just proposed to block this project by prohibiting the mines use of certain water ways under the Clean Water Act Section 404(c) (U.S. Environmental Protection Agency, 2022). If this proposition is approved, this project would likely be rejected from moving forward. However, if this project is not blocked, this project could have cumulative effects on air quality, sediments and water quality, and socioeconomic resources and environmental justice.		X	X	C/O

Table 4-1: 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*
Oil Spills	GOA Study Area, and open ocean areas	Oil and other hydrocarbon spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species (Marine Mammal Commission, 2011), sea turtles, birds, and fishes. Marine mammals, sea turtles, and fishes can be affected directly by contact or ingestion of oil, indirectly by activities during the containment and cleanup phases, and through long-term impacts on prey and habitat. The Exxon Valdez oil spill is an example of a historic oil spill near the GOA Study Area that may have direct and indirect long-term effects and cumulative population-level impacts if it affects the development or mortality rate of several life stages of marine life. Spills can also occur at the site of the well if drilling procedures are not maintained or executed properly. Past and potential future oil spills from sources such as oil rigs, oil wells, and oil tankers could have cumulative effects on fishes, sea turtles, marine mammals, and birds.		X	X	X
The Effects of Climate Change on the Marine Environment	GOA Study Area, and open ocean areas	While the exact effects of climate change over time are unknown, there are several effects on marine environments that have been documented due to anthropogenic emissions and steady global temperature rise. The global mean sea level has risen by 0.19 m over the period from 1901 to 2010, based on tide gauge records and (more recently) satellite data with an accelerated nature in more recent		X	X	X

Table 4-1: 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*
		decades (Rhein et al., 2013). Oceanic heatwaves in the GOA were studied by Suryan et al. (2021) who found varied but largely negative effects on all trophic levels of marine species including planktonic, forage fish, bird, and mammal species during and post-heatwaves. Additional potential consequences of climate change on biological resources in the GOA include changes to primary productivity and prey base; 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. Increased ocean acidification and storm severity are also attributed to climate change—both phenomena could have direct and indirect effects on marine life in and around the GOA Study Area. Overall, climate change could have meaningful impacts on all resources analyzed in this SEIS/OEIS.				

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, WMA = Western Maneuver Area; FR = Federal Register, CDC = Center for Disease Control, BOEM = Bureau of Ocean Energy Management, JPARC = Joint Pacific Alaska Range Complex.

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 GOA Study Area 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, the addition of the WMA would not result in 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 Endangered Species Act (ESA)-listed fish species, groundfish species, or Essential Fish Habitat in the GOA Study Area. However, the addition of the Continental Shelf and Slope Mitigation Area would reduce Navy training-related stressors on some ESA-listed fish species and habitats designated as EFH. 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 GOA Study Area. 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 GOA Study Area 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, 2017b; 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 federally and state managed sport and commercial fish, non-managed fish, and 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 (refer to Section 3.6.2.1.4 [General Threats] 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 affect Alaskan fisheries productivity (Johnson, 2016).

Many of the cumulative stressors identified in Section 4.4.9 (Birds) for birds also apply to fishes. The aggregate impacts of past, present, and reasonably foreseeable future actions, including those summarized in Table 4-1: Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis, 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 (National Marine Fisheries Service, 2017a). 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 (as discussed in Table 4-1) 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 Study Area.

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 GOA Study Area. No impacts on leatherback sea turtles were predicted. No other sea turtle species are expected to occur in the GOA Study Area. 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 GOA Study Area may add to stressors on sea turtles in the GOA Study Area; however, the Proposed Action would not contribute significantly to the cumulative impacts on sea turtles in the GOA Study Area, 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 2011 GOA Final EIS/OEIS and summarized in the 2016 GOA Final SEIS/OEIS described the potential for impacts on marine mammals from the various stressors related to Navy training activities. The analysis has been updated in Section 3.8 (Marine Mammals) of this SEIS/OEIS. As discussed in Section 3.8.3 (Environmental Consequences), there are no substantial changes to the activities analyzed in the 2016 GOA Final SEIS/OEIS that would change the overall conclusions that populations of marine mammals would not be significantly impacted by training activities in the TMAA. The addition of the WMA to the GOA Study Area is a change to the affected environment, but the mainly vessel and aircraft maneuvering activities proposed for the WMA would not significantly impact marine mammals or marine mammal populations based on the analysis of similar activities conducted in the TMAA. No activities using sonar and other transducers or explosives would be conducted in the WMA. The activities that would be conducted in the WMA are the same activities that would have been conducted in the TMAA and were analyzed for potential impacts in the 2011 GOA Final EIS/OEIS and summarized in the 2016 GOA Final SEIS/OEIS and in this SEIS/OEIS. The consistent conclusion of the analyses in all three documents is that vessel and aircraft maneuvering activities and the infrequent use of non-explosives munitions in the GOA Study Area would have no significant impacts on marine mammals or marine mammal populations.

The current analysis has incorporated new, applicable marine mammal research, the Navy's most recent (at time of the analysis) thresholds and criteria, and updated 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 this 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 activities (National Marine Fisheries Service, 2017c) and that none of the other stressors analyzed in the 2011 GOA Final EIS/OEIS would result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Marine Fisheries Service, 2017b). 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.

NMFS specifically incorporated the impacts from other past and ongoing anthropogenic activities identified by Navy (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, 2017c). The 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, 2017b). NMFS concluded that Navy training 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 since the 2016 GOA Final SEIS/OEIS that would necessitate changes to the conclusions reached by Navy and NMFS (as a cooperating agency) that significant impacts on marine mammals are not anticipated as a result of training activities in the GOA Study Area.

It has long been understood that the cumulative effects of stressors on marine organisms in general and marine mammal populations in particular are extremely difficult to predict (National Academies of Sciences Engineering and Medicine, 2017). Scientists and resource managers recognize that predicting trends in marine mammal populations is challenging and depends on coordinated, long-term efforts to measure abundance and track fluctuating distributions. Therefore, the focus of assessing populations has often been on indicators of adverse impacts, including health and other population-related 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 activities; see in particular Section 3.8.4 (Summary of Monitoring and Observations During Navy Activities) in the 2016 GOA Final SEIS/OEIS and updated information in Section 3.8.6.1 (Summary of Science in the Temporary Maritime Activities

Area by the Navy Related to Potential Effects on Marine Mammals) in this SEIS/OEIS. Since the 2016 analyses, neither the present nor the reasonably foreseeable actions change the assessment that the Navy's contribution to any cumulative impacts on marine mammal populations would be negligible.

The U.S. Fish and Wildlife Service has jurisdiction over the northern sea otter. The current training activities and reasonably foreseeable activities in the GOA Study Area have the potential to result in impacts on sea otters; however, the potential for impacts is limited by the lack of overlap between sea otter habitat and the GOA Study Area. Sea otters prefer shallow coastal waters with depths less than 40 m or within 400 m from shore. Sea otters are primarily benthic foragers, and a depth of 100 m represents the upper limit of their foraging depth range (Bodkin, 2015; Bodkin et al., 2004; Coletti et al., 2011; Thometz et al., 2014; Tinker et al., 2019). The majority of the TMAA and all of the WMA is located in deep offshore waters beyond the continental slope where depths exceed 4,000 m. The Navy's proposed activities, specifically those conducted over the continental shelf, have the potential to contribute to cumulative behavioral impacts on sea otters, but the relative contribution of these impacts would be negligible considering the unlikely occurrence of sea otters in the GOA Study Area and the short duration (a maximum of 21 days) over which Navy training activities would occur. Furthermore, the Navy's proposed Continental Shelf and Slope Mitigation Area excludes the use of explosives below 10,000 feet altitude (including at the water surface) over the continental shelf and slope. While no impacts on sea otters from the use of explosives in the TMAA were predicted by the Navy's acoustic effects model, eliminating the future use of explosives in the mitigation area would add additional protection for sea otters in the portion of the GOA Study Area where they are most likely to occur, if only on rare occasion.

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, 2017b, 2017c), and the reasons summarized above from previous analyses in the 2011 GOA Final EIS/OEIS and 2016 GOA Final SEIS/OEIS, the incremental contribution of the Proposed Action to cumulative impacts on marine mammals would be negligible.

Furthermore, under Alternative 1, the Navy will implement the Continental Shelf and Slope Mitigation Area prohibiting the use of explosives below 10,000 feet altitude (including at the water surface) over the continental shelf and slope in the TMAA. Explosives are not used in the WMA, and the WMA does not overlap with the continental shelf and slope. The mitigation area is designed to help avoid or reduce impacts during biologically important life processes, such as foraging and migration, used by several marine mammals species. The benefits of the mitigation area are discussed qualitatively in terms of the context of impact avoidance or reduction in Section 3.8 (Marine Mammals) and described in more detail in Chapter 5 (Mitigation). Therefore, a more in-depth 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 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 or the wider GOA Study Area. 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 GOA Study Area are threatened by continued overfishing, pollution, shipping, and oil and gas development (Bureau of Ocean Energy Management, 2017b; 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. Commercial ships may also attract pelagic birds with artificial lighting, which may increase the potential for vessel strikes of birds, especially at night. Therefore, the aggregate impacts of past, present, and reasonably foreseeable future actions may have a significant effect on birds. Section 3.9 (Birds) includes descriptions of anthropogenic and natural threats to seabirds that may occur within the GOA Study Area.

It is likely that distant shipping and aircraft noise (which is more pervasive and continuous) and sound associated with in-air 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 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. Furthermore, under Alternative 1, the Navy will implement the Continental Shelf and Slope Mitigation Area prohibiting the use of explosives below 10,000 feet altitude (including at the water surface) over the continental shelf and slope in the TMAA. Explosives are not used in the WMA, and the WMA does not overlap with the continental shelf and slope. The mitigation area is designed to help avoid or reduce impacts during biologically important life processes, such as foraging and migration, used by several marine mammals species. The benefits of the mitigation area are discussed qualitatively in terms of the context of impact avoidance or reduction in Section 3.8 (Marine Mammals) and described in more detail in Chapter 5 (Mitigation). Therefore, a more in-depth analysis of cumulative impacts on birds within the GOA Study Area is not warranted.

4.4.5 Socioeconomic Resources and Environmental Justice

As stated in the 2011 GOA Final EIS/OEIS and summarized in the 2016 GOA Final SEIS/OEIS, the Proposed Action has the potential to limit accessibility to areas where commercial and recreational fishing and some tourism activities take place. Within the GOA Study Area, these would primarily be shallower areas over the continental shelf and slope within the TMAA. Parts of the GOA Study Area that are farther offshore, including the entire WMA and the remaining portion of the TMAA, are not expected to be used by fishers or for tourism activities as frequently due to their distance from shore and water depths exceeding 4,000 meters. Limiting accessibility to the shelf and slope areas in the TMAA to facilitate Navy training activities are not expected to significantly impact fishing and tourism activities, because restrictions would be temporary and of short duration (hours), and Navy activities would take place over a maximum of 21 days.

To ensure and maintain public safety, access to waters within exclusion areas would be limited during military training activities. The limitations on accessing portions of the GOA Study Area designated as restricted areas and warning areas would be the same 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 Code of Federal Regulations 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.

In 2020, there were 5,139 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, 2022). This is a significant reduction in vessel traffic from 2017 when 7,934 vessel transits were recorded at these same ports. (U.S. Army Corps of Engineers, 2018). The reduction in vessel transits is attributable to the impact of the worldwide economic shutdowns due to the coronavirus pandemic and major restrictions on international shipping. The city of Unalaska, which includes Dutch Harbor, is located inshore of the western boundary of the WMA. In addition to other commodities, the port processed over 800,000 short tons of fish and shellfish in 2020 and reported 907 vessel transits (inbound and outbound) (U.S. Army Corps of Engineers, 2022). The total for all commodities passing through the port was 1,241 short tons, down from 1,437 in 2019 and a recent peak of 1,817 short tons in 2017 (U.S. Army Corps of Engineers, 2022). Increases in international shipping in 2021 and 2022 are anticipated as the pandemic is brought under control and the world recovers from the economic disruptions.

With few exceptions, harvest and catch from the commercial fisheries off Alaska have remained relatively consistent and the GOA supports one of the most sustainable fisheries in the world (National Marine Fisheries Service, 2020). These trends suggest that the volume and value of fisheries off of Alaska will likely remain consistent in coming years (Fissel et al., 2019). The addition of the Continental Shelf and Slope Mitigation Area within the TMAA portion of the GOA Study Area will further reduce potential impacts to commercial and recreational fishing by prohibiting the use of explosives below 10,000 feet altitude (including at the water surface) over the continental shelf and slope in the TMAA. Explosives are not used in the WMA, and the WMA does not overlap with the continental shelf and slope.

Waterways traversing and adjacent to the GOA Study Area are heavily traveled by commercial, recreational, and other vessels, including military and USCG vessels, with the majority of vessel traffic occurring shoreward of the Study Area. Several important commercial ports are located inshore of the GOA Study Area, such as Dutch Harbor, and Kodiak, and vessels from these ports may need to enter or cross the Study Area to deliver goods. Commercial vessel traffic also has the potential to limit access by the public to waterways used for the transport of goods and products, which would limit access by recreational boaters and tourism related businesses (e.g., whale watching vessels) to those waterways.

Several commercial airways cross over the GOA, mainly connecting Ted Stevens Anchorage International Airport in Anchorage, Alaska to other airports in the continental United States. There are also numerous smaller commercial and general aviation airports along Alaska's southern coast that service coastal communities and communities located farther inland. Airborne noise generated by commercial and private aircraft traversing the Southern Alaskan Coast and accessing these airports may disturb, or otherwise impact the enjoyment of, tourist activities in the GOA.

Cumulative impacts due to intermittent and short-term limits on accessibility to areas within the GOA Study Area, physical disturbances and interactions, airborne acoustics that disturb people on the ground or on the water, and secondary impacts (e.g., to tourism) resulting from effects on marine species populations as a result of the Proposed Action are not anticipated to be significant. No cumulative impacts on commercial transportation and shipping are anticipated because major shipping routes and airways are well-defined, and Navy training activities would largely avoid those areas to avoid disruptions to commerce and Navy training activities. The Navy would continue to reduce or avoid impacts on commercial and recreational fishing and tourism-related activities by continuing to notify the public of upcoming activities that may limit accessibility to certain areas of the GOA Study Area. The USCG would continue to issue Notices to Mariners and the FAA would continue to issue Notices to Airmen in advance of planned Navy training 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 short term and intermittent and have no long-term, cumulative impacts. Airborne acoustics from aircraft activities in the GOA Study Area would mainly occur far offshore and at high altitudes but could potentially disturb participants in recreational and tourism activities in the GOA. Disturbances, if they were to occur, would be brief (seconds) and discrete and are not expected to have long-term negative impacts on the enjoyment of the region or the Alaska maritime economy. Therefore, further analysis of cumulative impacts on socioeconomic resources is not warranted.

The analyses 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 demonstrate that the Proposed Action would not contribute significantly to impacts on environmental justice. As shown in the previous analyses and in Section 3.11 (Socioeconomic Resources and Environmental Justice), in general, due to the distance from any population centers regardless of social or economic status, the Proposed Action is not expected to disproportionately impact low income and minority populations or children. Other projects proposed to occur within or near the GOA Study Area may add to cumulative impacts on environmental justice in the GOA Study Area; however, the Proposed Action would not contribute significantly to the cumulative impacts on environmental justice in the GOA Study Area. 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 GOA Study Area 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 harassment 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 a further review of cumulative impacts.

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5 Mitigation

Gulf of Alaska Navy Training Activities
Final Supplemental Environmental Impact Statement/
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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 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 Study Area, which includes the Temporary Maritime Activities Area (TMAA) and Western Maneuvering Area (WMA). 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 biological or cultural resources. The Navy developed mitigation measures that would be implemented under Alternative 1 for those stressors, and considered the benefits of the mitigation in its 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 Study Area, such as seabirds listed under the Migratory Bird Treaty Act.

5.1.2 Compliance Initiatives

Compliance initiatives, including mitigation requirement dissemination, monitoring, research, and reporting are 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 mitigation areas). 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, National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service (USFWS) 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 Study Area 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, including marine mammals, sea turtles, diving sea birds, and fishes. 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.

Projects sponsored by the U.S. Navy's Marine Species Monitoring Program primarily focus on marine mammals, sea turtles, and fishes. For example, the Navy is sponsoring ongoing projects using acoustic tagging technologies to characterize the distribution of ESA-listed salmonids in Washington and Alaska, and using pop-up satellite technologies and genetic studies to provide critical information on Chinook salmon spatial and temporal distribution in the Gulf of Alaska and along the Washington coast. 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, 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 Study Area 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 worked collaboratively with the appropriate regulatory agencies, such as NMFS and the USFWS, to develop and refine its mitigation, which was finalized through the consultation and permitting processes. The mitigation development process involved 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 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, 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 provided input on the effectiveness and practicality of mitigation implementation. Navy Senior Leadership reviewed and approved all mitigation measures included in this Final 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 included in this Final SEIS/OEIS represents 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 is 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 Study Area. 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).

The Navy has been conducting a Lookout Effectiveness Study in association with the University of St. Andrews for several years to assess the ability of shipboard Lookouts to observe marine mammals while conducting hull-mounted sonar training activities at sea. The University of St. Andrews' report was provided to NMFS on April 1, 2022 as required by existing ESA authorizations. Following a review and discussion period with NMFS, the study was publicly posted on the U.S. Navy's Marine Species Monitoring Program website in July 2022. The Navy and NMFS determined that the Lookout Effectiveness Study results would not alter the acoustic effects quantitative analysis of potential impacts on marine mammals due to the Proposed Action. It was concluded that the acoustic effects quantitative analyses included in this Final SEIS/OEIS and in the regulatory consultation documents did not underestimate the number or extent of marine mammal takes due to the conservative approach already taken by the Navy in its quantitative analysis process. The Navy is currently working with NMFS to determine how and to what extent the study's results should be incorporated into future environmental analyses. The Navy is also working internally and with NMFS through the adaptive management process to determine if there are additional measures that would be practical to implement that would improve effectiveness of Lookouts, such as through enhanced personnel training.

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 where the Navy will implement additional mitigation measures (i.e., geographic mitigation, in addition to procedural mitigation). The Navy completed an assessment of the Study Area 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 also assessed mitigation recommendations received through public comments on the 2020 GOA Draft SEIS/OEIS, and mitigation identified by regulatory agencies during the consultation and permitting processes. The Navy's biological effectiveness and operational assessments of mitigation areas developed for this Final 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 was 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 in the Study Area 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 Study Area, 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);

- o 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);
- o 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);
- o 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);
- o 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
- o 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 5-1.

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. The most recent product was 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 Navy-wide 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 is provided in Section 5.1.2.1 (Protective Measures Assessment Protocol) and Section 5.1.2.2 (Monitoring, Research, and Reporting Initiatives).

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 Navy-wide environmental compliance as intended.

Table 5-1: 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.

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 Navy-wide 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 5-2.

Table 5-2: 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).

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.

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 Study Area, 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 (m). 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. 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 5-2 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.

Table 5-3: 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 large-bodied seabirds (such as albatross); if observed, relocate or delay the start of weapon firing. • During the activity: – Observe the mitigation zone for marine mammals, sea turtles, and large-bodied seabirds (such as albatross); if observed, cease weapon firing. • Commencement/recommencement conditions after a marine mammal, sea turtle, or large-bodied seabird (such as albatross) sighting before or during the activity: – The Navy will allow a sighted marine mammal, sea turtle, or large-bodied seabird (such as albatross) 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 large-bodied seabirds to protect ESA-listed short-tailed albatross.

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 Study Area.

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 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 Large-Caliber Projectiles

The Navy will continue to implement procedural mitigation during explosive large-caliber gunnery activities, as outlined in Table 5-4. Mitigation for explosive medium-caliber gunnery was included in the 2020 Draft SEIS/OEIS. However, after revalidating its training requirements during the development of this Final SEIS/OEIS, the Navy has reconfirmed that explosive gunnery events would only involve explosive large-caliber projectiles and would not involve explosive medium-caliber projectiles. For this reason, mitigation for explosive medium-caliber projectiles is not needed and has been removed from this chapter as well as from the discussions of mitigation throughout this Final SEIS/OEIS and associated consultation documents.

In the 2016 GOA Final SEIS/OEIS, the explosive gunnery mitigation zone for marine mammals and sea turtles was based on net explosive weight and the associated average range to PTS. When developing this SEIS/OEIS, the Navy identified an opportunity to increase the marine mammal and sea turtle mitigation zone size by 400 yd. to enhance protections to the maximum extent practicable, which is reflected in Table 5-4. The Navy also identified an opportunity to develop new mitigation for large-bodied seabirds to protect ESA-listed short-tailed albatross. The mitigation zones are based on the largest areas within which it is practical to implement mitigation for this activity.

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 5-4: Procedural Mitigation for Explosive Large-Caliber Projectiles

Procedural Mitigation Description
Stressor or Activity • Gunnery activities using explosive 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   – 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 zone:
  – 600 yd. for large-bodied seabirds (such as albatross) around the intended impact location
  – 1,000 yd. for marine mammals and sea turtles 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, sea turtles, and large-bodied seabirds (such as albatross); if observed, relocate or delay the start of firing.
• During the activity:
  – Observe the mitigation zone for marine mammals, sea turtles, and large-bodied seabirds (such as albatross); if observed, cease firing.
• Commencement/recommencement conditions after a marine mammal, sea turtle, or large-bodied seabird (such as albatross) sighting, as applicable before or during the activity:
  – The Navy will allow a sighted marine mammal, sea turtle, or large-bodied seabird (such as albatross) 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 30 minutes; 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. These events are conducted from surface combatants, and Lookouts 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. 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. 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 species 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 marine species, 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.

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. mitigation zone extends beyond the ranges to 50 percent non-auditory injury and 50 percent mortality for sea turtles and marine mammals for bin E5. The mitigation zone extends 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 zone also extends 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.

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, sea turtles, and seabirds. 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. 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 the activity area and 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 a larger area 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. This 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 large-caliber projectiles beyond what is detailed in Table 5-4 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 for explosive bombs, as outlined in Table 5-5. In the 2016 GOA Final SEIS/OEIS, the marine mammal and sea turtle 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 for marine mammals and sea turtles under the Proposed Action. The Navy also identified an opportunity to develop new mitigation for large-bodied seabirds to protect ESA-listed short-tailed albatross.

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 species 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.

Table 5-5: Procedural Mitigation for Explosive Bombs

Procedural Mitigation Description
Stressor or Activity • Explosive bombs
Resource Protection Focus • Marine mammals • Sea turtles • Seabirds (short-tailed albatross)
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: – 600 yd. for large-bodied seabirds (such as albatross) around the intended impact location – 2,500 yd. for marine mammals and sea turtles 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, sea turtles, and large-bodied seabirds (such as albatross); 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, sea turtles, and large-bodied seabirds (such as albatross); if observed, cease bomb deployment. • Commencement/recommencement conditions after a marine mammal, sea turtle, or large-bodied seabird (such as albatross) sighting, as applicable before or during the activity: – The Navy will allow a sighted marine mammal, sea turtle, or large-bodied seabird (such as albatross) 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.

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 zones developed for this SEIS/OEIS is based on the largest areas within which it is practical for the Navy to implement mitigation. It is not practical to increase the mitigation zones 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 zones 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 zones would increase safety risks due to the presence of observation vessels within the vicinity of the intended explosive bomb detonation location.

Increasing the mitigation zones 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 5-5 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 during vessel movements, as outlined in Table 5-6. The Navy will continue to implement the same marine mammal mitigation zone sizes for vessel movement that were included in the 2016 GOA Final SEIS/OEIS. The marine mammal mitigation zone sizes are 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 newly captured that mitigation in the 2020 GOA Draft SEIS/OEIS. A mitigation zone size is not specified for sea turtles to allow flexibility based on vessel type and mission requirements. The Navy also identified an opportunity to develop new mitigation for large-bodied seabirds to protect ESA-listed short-tailed albatross. 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, sea turtles, and large-bodied seabirds throughout the mitigation zones while vessels are underway. 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.

Additional information has been added to Table 5-6 for this Final SEIS/OEIS to more clearly describe the Navy's vessel movement mitigation procedures. The Navy is clarifying that the number of Lookouts required for underway vessels will align with the number of Lookouts required on surface ships as specified in the Surface Ship Navigation Department Organization and Regulations Manual (U.S. Department of the Navy, 2021). Navy Lookouts have always observed for objects to include marine mammals and sea turtles in the direct path of the vessel and waters surrounding the vessel, and will continue to do so under the Proposed Action. When vessels are underway, there are typically additional personnel who have eyes on the water (continuously or periodically) while performing their regular duties, such as assisting with navigation or safety protocols, which could help increase the likelihood of detecting marine mammals and sea turtles.

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 U.S. 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.

Table 5-6: 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 • Seabirds (short-tailed albatross)
Number of Lookouts and Observation Platform • 1 or more Lookouts on underway vessels[1] • If additional watch personnel are positioned on underway vessels, those personnel (e.g., persons assisting with navigation or safety) will support observing for applicable marine species while performing their regular duties.
Mitigation Requirements • Mitigation zones: – 500 yd. for whales around the vessel – 200 yd. for other marine mammals (except those intentionally swimming alongside or choosing to swim alongside vessels, such as for bow-riding or wake-riding) around the vessel – 200 yd. for large-bodied seabirds (such as albatross) around the vessel – Within the vicinity of the vessel for sea turtles • When underway: – Observe the direct path of the vessel and waters surrounding the vessel for marine mammals, large-bodied seabirds (such as albatross), and sea turtles. – If a marine mammal, large-bodied seabird (such as albatross), or sea turtle is observed in the direct path of the vessel, maneuver the vessel as necessary to maintain the appropriate mitigation zone distance. – If a marine mammal, large-bodied seabird (such as albatross), or sea turtle is observed in waters surrounding the vessel, maintain situational awareness of that animal's position. Based on the animal's course and speed relative to the vessel's path, maneuver the vessel as necessary to ensure that the appropriate mitigation zone distance from the animal continues to be maintained. • Additional requirements: – If a marine mammal or sea turtle vessel strike occurs, the Navy will follow established incident reporting procedures. – If a large-bodied seabird (such as albatross) vessel strike occurs, the Navy will notify the USFWS Alaska Regional Office.

[1] Underway vessels will maintain at least one Lookout. For ship classes required to maintain more than one Lookout, the specific requirement is subject to change over time in accordance with Navy navigation instruction.

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 part 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 5-6 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 5-7. 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 5-7.

Table 5-7: 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. for marine mammals (except those intentionally swimming alongside or choosing to swim alongside towing vessels, such as for bow-riding or wake-riding) around the towed in-water device – Within the vicinity of the towed in-water device for 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.

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.

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 5-7 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 5-8. 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.

The Navy identified an opportunity to develop new mitigation for large-bodied seabirds to protect ESA-listed short-tailed albatross. Although there is a low likelihood that short-tailed albatross will be exposed to these activities in the Study Area, the mitigation will help the Navy further avoid or reduce potential impacts on this ESA-listed bird species, as well as other large-bodied seabirds that occur in the Study Area.

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, sea turtles, and seabirds 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, sea turtles, and seabirds. 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.

Table 5-8: 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, sea turtles, and large-bodied seabirds (such as albatross); if observed, relocate or delay the start of firing.
• During the activity:
  – Observe the mitigation zone for marine mammals, sea turtles, and large-bodied seabirds (such as albatross); if observed, cease firing.
• Commencement/recommencement conditions after a marine mammal, sea turtle, or large-bodied seabird (such as albatross) sighting before or during the activity:
  – The Navy will allow a sighted marine mammal, sea turtle, or large-bodied seabird (such as albatross) 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.

5.3.4.4 Non-Explosive Bombs

The Navy will continue to implement procedural mitigation to avoid or reduce the potential for strike from non-explosive bombs, as outlined in Table 5-9.

The mitigation is a continuation from the 2016 GOA Final SEIS/OEIS for marine mammals and sea turtles. 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.

Table 5-9: Procedural Mitigation for Non-Explosive Bombs

Procedural Mitigation Description
Stressor or Activity • Non-explosive bombs
Resource Protection Focus • Marine mammals • Sea turtles • Seabirds (short-tailed albatross)
Number of Lookouts and Observation Platform • 1 Lookout positioned in an aircraft
Mitigation Requirements • Mitigation zone: – 600 yd. for large-bodied seabirds (such as albatross) around the intended target – 1,000 yd. for marine mammals and sea turtles 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, sea turtles, and large-bodied seabirds (such as albatross); if observed, relocate or delay the start of bomb deployment. • During the activity (e.g., during approach of the target): – Observe the mitigation zone for marine mammals, sea turtles, and large-bodied seabirds (such as albatross); if observed, cease bomb deployment. • Commencement/recommencement conditions after a marine mammal, sea turtle, or large-bodied seabird (such as albatross) sighting prior to or during the activity: – The Navy will allow a sighted marine mammal, sea turtle, or large-bodied seabird (such as albatross) 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.

The Navy identified an opportunity to develop new mitigation for large-bodied seabirds to protect ESA-listed short-tailed albatross. 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 large-bodied seabirds that occur in the TMAA.

Activities involving non-explosive bombing involve aircraft deploying munitions from a relatively steady altitude of approximately 1,500 ft. at a surface target located beneath the aircraft. Due to the mitigation zone sizes, proximity to the observation platform, and the good vantage point from an aircraft, Lookouts will be able to observe the entire mitigation zones during approach of the target. 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 detailed in Table 5-10, shown in Figure 5-1, and described in the sections below, the Navy developed mitigation areas to avoid or reduce potential impacts on marine mammals, ESA-listed fish, fishery resources, and ESA-listed short-tailed albatross from active sonar, explosives, or physical disturbance and strike stressors in particularly important habitat areas.

Table 5-10: Mitigation Areas

Mitigation Area Description
Stressor or Activity • Sonar • Explosives • Physical disturbance and strikes
Resource Protection Focus • Marine mammals (including ESA-listed fin, blue, humpback, gray, North Pacific right, sei, and sperm whale) • Fish (including ESA-listed Chinook salmon, coho, chum, green sturgeon, sockeye, steelhead) • Seabirds (including ESA-listed short-tailed albatross) • 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 during training. • Continental Shelf and Slope Mitigation Area – During training, the Navy will not detonate explosives below 10,000 ft. altitude (including at the water surface) in the Continental Shelf and Slope Mitigation Area, which extends over the continental shelf and slope out to the 4,000 m depth contour within the Temporary Maritime Activities Area. • 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 pre-event awareness messages to alert ships and aircraft participating in training activities within the TMAA to the possible presence of concentrations of large whales on the continental shelf and slope. Occurrences of large whales may be higher over the continental shelf and slope relative to other areas of the TMAA. Large whale species in the TMAA include, but are not limited to, fin whale, blue whale, humpback whale, gray whale, North Pacific right whale, sei whale, and sperm whale. To maintain safety of navigation and to avoid interactions with these species, 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. Additionally, ships and aircraft will use the information from the awareness 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, U.S. Third Fleet 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, use of explosives detonated below 10,000 ft.) in its annual activity reports to NMFS.

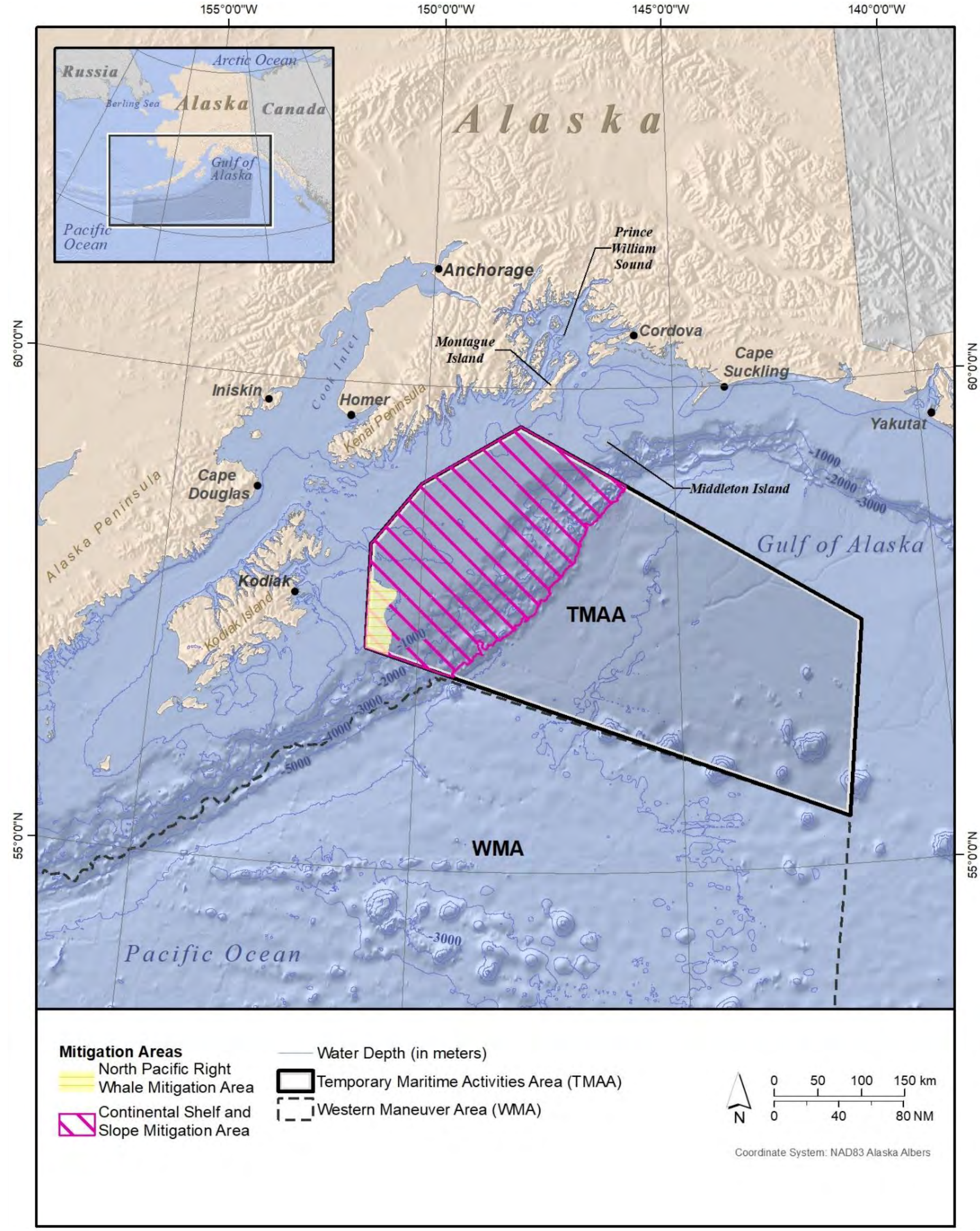

Figure 5-1: Mitigation Areas

The Navy will continue to implement the following geographic mitigation measures that were included in the 2016 GOA Final SEIS/OEIS, and therefore were also included in the 2020 GOA Draft SEIS/OEIS:

- Requirements to 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.
- Requirements to not detonate explosives in the Portlock Bank Mitigation Area and from June 1 to September 30 within the North Pacific Right Whale Mitigation Area. For this Final SEIS/OEIS, the Navy expanded the geographic extent and seasonality of this mitigation requirement to include the entire continental shelf and slope in a mitigation area now called the Continental Shelf and Slope Mitigation Area, as further described below.
- Requirements for the TMAA boundaries to be located outside of the 1993 NMFS-designated Steller sea lion critical habitat.

During development of the 2020 GOA Draft SEIS/OEIS, based on its initial analysis of the best available science and potential mitigation suggested by scoping comments, the Navy identified the following opportunity to increase its geographic mitigation over what was included in the 2016 GOA Final SEIS/OEIS:

- Requirements to issue pre-event awareness messages to alert ships and aircraft operating within the TMAA to the possible presence of relatively higher concentrations of large whale species (including, but not limited to, fin whale, blue whale, humpback whale, gray whale, North Pacific right whale, sei whale, minke whale, and sperm whale) on the continental shelf and slope.

During development of this Final SEIS/OEIS, based on its ongoing analysis of the best available science, potential mitigation suggested by comments on the 2020 GOA Draft SEIS/OEIS, and during the MMPA and ESA consultation processes, the Navy identified the following additional opportunity to increase its geographic mitigation over what was included in the 2020 GOA Draft SEIS/OEIS:

- Requirements to not detonate explosives below 10,000 ft. altitude (including at the water surface) within the Continental Shelf and Slope Mitigation Area. Previously, the Navy's explosive restrictions applied only within two smaller areas located on the continental shelf: in the Portlock Bank Mitigation Area, and from June 1 to September 30 within the North Pacific Right Whale Mitigation Area. The Continental Shelf and Slope Mitigation Area requirements will apply over the entire continental shelf and slope out to the 4,000 m depth contour, instead of only within Portlock Bank and seasonally within the North Pacific Right Whale Mitigation Area. The mitigation will apply to explosives detonated up to 10,000 ft. altitude for enhanced protections of ESA-listed short-tailed albatross.

5.4.1 Resource Descriptions for the Habitats Considered

The boundary of the WMA was configured to avoid overlap and potential impacts on critical habitats, biologically important areas, marine mammal migration routes, and primary fishing grounds. Therefore, the Navy focused its mitigation area analysis on habitat areas within the TMAA. 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-designated critical habitat for humpback whales; foraging, maturation, and migration habitats for ESA-listed salmonids; a fishery area important for Alaska Native tribes; and foraging habitat for ESA-listed short-tailed albatross. 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 5-2.

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 GOA 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 GOA 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 GOA 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 GOA, 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.

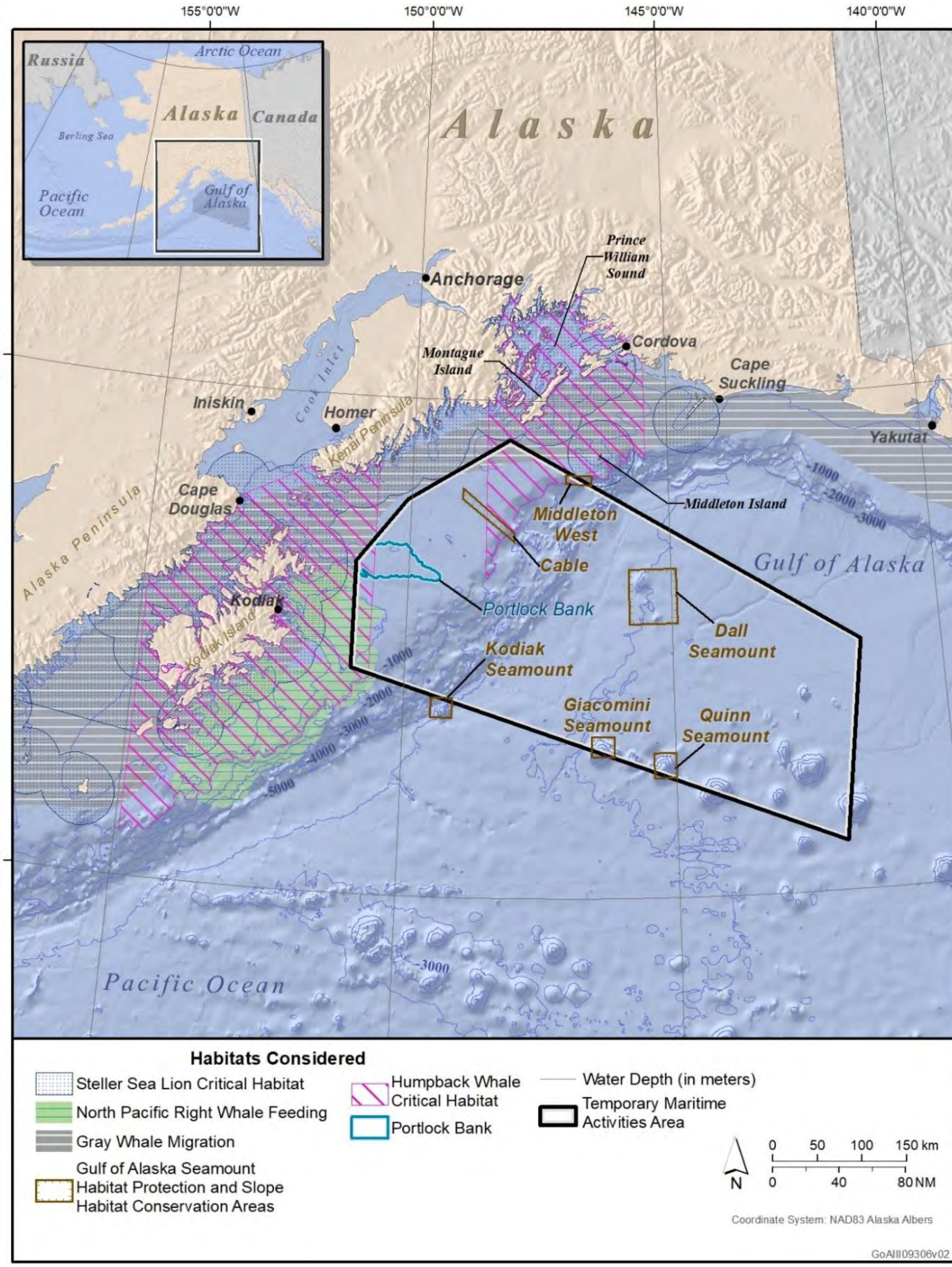

Figure 5-2: Habitats Considered

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), NMFS proposed critical habitat in 2019 for humpback whales in feeding areas that overlap the TMAA (84 FR 54354). NMFS issued a final rule in April 2021 to designate critical habitat for the Western North Pacific Distinct Population Segment (DPS) and Mexico DPS of humpback whales in two areas that overlap the TMAA, as shown in Figure 5-2 (86 FR 21082). 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 boundaries of the critical habitat were 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 (i.e., June through September) in locations 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 critical habitat also 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 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 habitat designated by NMFS in 2021; 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 GOA (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. 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 GOA, 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 5-2. 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; therefore, that habitat can be considered particularly important to gray whales 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 DPS, which is listed as endangered under the ESA, and Eastern DPS, 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).

NMFS-designated critical habitat for the Western DPS (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 5-10 and Section 5.4.2.3 (Temporary Maritime Activities Area). In the GOA, 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 DPS and Eastern DPS 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 Birds and Fish

The continental shelf and slope provide important foraging habitat for ESA-listed short-tailed albatross and important migration, maturation, and foraging habitats for ESA-listed salmonids. As described in Section 3.9 (Birds) of the GOA Final SEIS/OEIS, adult short-tailed albatross forage over both oceanic and neritic habitats across the North Pacific, concentrating along biologically productive shelf-break areas, while 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). Surveys conducted since 2006 showed that in the GOA, short-tailed albatross were primarily observed over the continental shelf break and slope (U.S. Fish and Wildlife Service, 2020).

As described in Section 3.6 (Fish) of the GOA Final SEIS/OEIS, Chinook salmon from West Coast Evolutionarily Significant Units tend to be primarily distributed along the continental shelf in southeast Alaskan waters during their marine residence, remaining in coastal water throughout their ocean life (Seitz & Courtney, 2022; Sharma, 2009). The vast majority of juvenile Chinook salmon in the GOA 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 GOA, though they are distributed more widely throughout the GOA than juveniles (Echave et al., 2012; National Marine Fisheries Service, 2017). Instead of an even distribution in GOA waters, Chinook salmon tend to be much more associated with on-shelf habitats than other Pacific salmonids, such as chum, sockeye, and pink salmon. Echave et al. (2012) found that 95 percent of sampled juvenile Chinook salmon distribution occurred within shallower (18–447 m) waters. Similarly, recent juvenile salmon trawl studies found that juvenile Chinook salmon occurred infrequently in offshore GOA waters (Beamish & Riddell, 2020). Recent pop-up satellite archival tag studies by Seitz and Courtney (2022) lend further support to the distribution summaries of Echave et al. (2012) and NMFS (2017), that show large, immature Chinook salmon are not broadly distributed throughout the GOA, but instead prefer on-shelf habitats.

In the GOA, 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). 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). 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).

Within the GOA, juvenile chum salmon are distributed throughout the inner and middle shelf along the coastline between July and September (Echave et al., 2012), but 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. Exclusive Economic Zone (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., 2007).

The distribution of juvenile sockeye salmon in the GOA 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 (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). Sockeye juveniles are found at the shallowest depths of any salmonids (generally top 5 m of the water column) (Walker et al., 2007).

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 other Pacific salmonids (Quinn & Myers, 2005). 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). Steelhead kelts tend to occur over the continental slope, where upwelling creates productive habitats (Seitz & Courtney, 2021).

The ESA-listed Southern DPS green sturgeon have been confirmed to occur from Graves Harbor, Alaska, to Monterey Bay, California (73 FR 52300). The few observations of green sturgeon in Alaskan waters have occurred in on-shelf, coastal, nearshore, and estuarine habitats (Environmental Protection Information Center et al., 2001; Huff et al., 2020). 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., 2015). They are rarely found deeper than 200 m (Huff et al., 2012). Primarily a demersal fish species, green sturgeon regularly occur over flat, sandy substrate (Payne et al., 2015), but they can also be found near complex hard-bottom habitats (Huff et al., 2012) on the continental shelf.

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 GOA. The North Pacific Fishery Management Council established several Habitat Areas of Particular Concern that are within or partially overlapping the TMAA, including the following GOA Seamount Habitat Protection Areas and GOA 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 GOA 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 Alaska Native 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 the continental shelf and slope are particularly important habitat for ESA-listed short-tailed albatross foraging, and Chinook salmon, coho, chum, sockeye, and steelhead foraging, maturation, and migration. Habitat Areas of Particular Concern and Portlock Bank constitute particularly important fishery habitats for Alaska Native tribes and commercial fisheries within the TMAA. For additional information about fisheries, seabirds, socioeconomic resources, and cultural resources, see Section 3.6 (Fishes) and Section 3.9 (Birds) 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

The Navy developed the North Pacific Right Whale Mitigation Area to fully 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. Mitigation requirements to not use surface ship hull-mounted MF1 mid-frequency active sonar 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.

5.4.2.2 Continental Shelf and Slope Mitigation Area

Per the MMPA and ESA consultations under the 2016 GOA Final SEIS/OEIS, the Navy previously restricted the number of explosives that could be used on the continental shelf to six detonations annually. The Navy also restricted explosive use within the North Pacific Right Whale Mitigation Area (from June 1 to September 30), and within Portlock Bank. As described in the 2020 GOA Draft SEIS/OEIS, these previous restrictions were designed to avoid or reduce potential impacts on North Pacific right whales, Portlock Bank fishery resources, and other marine species (e.g., marine mammals, ESA-listed fish and seabird species) that inhabit the highly productive waters of Portlock Bank and the continental shelf.

For this SEIS/OEIS, the Navy is expanding its geographic mitigation requirements for explosives. The Navy will prohibit all use of explosives detonated below 10,000 ft. altitude (including at the water surface) over the continental shelf and slope out to the 4,000 m depth contour in an area called the Continental Shelf and Slope Mitigation Area (see Figure 5-1). The Navy developed this expanded mitigation area in order to avoid potential impacts from explosives within key habitat areas for additional ESA-listed species, including humpback whales, gray whales, short-tailed albatross, and salmonids. The expanded mitigation area will prevent marine species from being exposed to detonations throughout the highly productive waters of the continental shelf and slope, including near Portlock Bank and off Kodiak Island. The Navy developed the boundaries of the Continental Shelf and Slope Mitigation Area to overlap or encompass the following habitat areas to the maximum extent practical:

- Biologically important North Pacific right whale feeding habitat identified by Ferguson et al. (2015).
- Biologically important gray whale migration habitat identified by Ferguson et al. (2015).
- NMFS-designated critical habitat for humpback whale feeding.
- Migration, maturation, and foraging habitat for juvenile, immature, or maturing adult salmonids (Chinook salmon, coho, chum, green sturgeon, sockeye, and steelhead).
- The mitigation will be particularly beneficial to surface-oriented fishes and those that occur in the top tens of meters of the water column, such as coho, chum, sockeye, and steelhead, which otherwise would have had a higher potential of being exposed to and affected by detonations at or near the surface.
- Essential fish habitats, including for numerous salmon, groundfish, and shellfish species.
- Important fishery habitats for Alaska Native Tribes at Portlock Bank
- Foraging habitat for ESA-listed short-tailed albatross.

In addition, the mitigation could also benefit other marine species that inhabit the continental shelf and slope. For example, fin whales were found to feed in association with high density of zooplankton near the Kodiak Archipelago (Witteveen et al., 2014). Passive acoustic data have recorded high level of fin whale calls on the continental slope and shelf, which is consistent with fin whale sighting records, which have typically occurred along the slope and shelf (Rice et al., 2021; Rone et al., 2017; Zerbini et al., 2006). Sea otter habitat (including designated critical habitat) is located well inshore of the TMAA (within the 100 m isobath) and therefore outside of the mitigation area. Although it is very unlikely that sea otters would have spatial and temporal overlap with the Navy's activities inside the TMAA, the mitigation area would prevent sea otters from being exposed to explosives should the rare individual venture offshore during the training period.

5.4.2.3 Temporary Maritime Activities Area

To accomplish the mitigation to conduct the Proposed Action outside of Steller sea lion critical habitat, the Navy adjusted the boundaries of the TMAA so it is situated outside of the critical habitat designated by NMFS in 1993 (58 FR 45269). Within the Study Area, sonar and explosives are only conducted within the TMAA; therefore, this mitigation will continue to help the Navy avoid the potential for Steller sea lions from the Western DPS to be exposed to active sonar and explosives within their critical habitat for reproduction and foraging.

Mitigation to issue pre-event awareness messages will alert ships and aircraft operating within the TMAA to the possible presence of increased concentrations of large whales on the continental shelf and slope. This mitigation will further help avoid or reduce potential impacts from vessel strikes and training activities on large whale species, including, but not limited to, fin whale, blue whale, humpback whale, gray whale, North Pacific right whale, sei whale, minke whale, and sperm whale within areas of relatively higher animal concentrations; the biologically important gray whale migration habitat identified by Ferguson et al. (2015); and the NMFS-designated critical habitat for humpback whale feeding.

5.4.3 Operational Assessment

The Study Area provides valuable access to sea space and airspace conditions analogous to areas where the Navy operates or may need to operate in the future. Northern Edge is a U.S. Indo-Pacific Command sponsored exercise, led by Headquarters Pacific Air Forces. The Navy has participated in this or its predecessor exercises for decades, and, although naval warships and planes play a vital role in Northern Edge, the Navy does not determine the specific dates for conducting each exercise. U.S. Indo-Pacific Command determines exercise dates based on a number of factors, to include weather conditions, safety of personnel and equipment, effectiveness of training, availability of forces, deployment schedules, maintenance periods, other exercise schedules within the Pacific region, as well as important environmental considerations. It has been determined that conducting the exercise during the months of November through March would not support safe completion of training objectives, due to weather and oceanic conditions, and therefore would not meet the purpose and need addressed in this SEIS/OEIS.

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 Study Area 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 also allows appropriate distance limitations to support Air Force aircraft reaching the Study Area without needing to refuel to conduct training at sea with the carrier strike group. Therefore, the Study Area as currently sited is dependent on these location-specific factors to satisfy criteria for safety, practicality, and mission requirements.

Navy training schedules are generally 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 Study Area is largely scheduled to accommodate weather conditions for safety of personnel and to achieve optimum operational parameters. Storms and high sea states in the GOA 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 Study Area. 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 Study Area 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, during past events, the Navy has not typically conducted 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 and other areas throughout the continental shelf experience relatively high levels of commercial and recreational vessel and aircraft traffic, which can present sea space and airspace conflicts. For these reasons, it is practical for the Navy to not use surface ship hull-mounted MF1 mid-frequency active sonar seasonally within the North Pacific Right Whale Mitigation Area, and to not use explosives below 10,000 ft. altitude (including at the water surface) in the Continental Shelf and Slope Mitigation Area.

Restrictions beyond what is identified in Table 5-10 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 (Birds and Fish), 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 Study Area 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 GOA; 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 Study Area 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 Study Area. Certain measures would restrict or prohibit Navy training throughout most of the Study Area 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 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 and does not include other types of underwater detonations), the Navy considered further limiting the number, size, locations, and time of day for in-air explosives detonated at or near the surface of the water. 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 (Birds and Fish), 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 on 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. Palmer et al. (2022) stated that manual annotation or verification is nearly always used to confirm automated detector outputs prior to near-real-time conservation measures due to limitations in automatic detector capabilities. The Navy does not currently have the capability to perform data processing 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 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 Study Area, 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 U.S. 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 5-11 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).

Table 5-11: Summary of Mitigation Requirements

Stressor, Activity, or Mitigation Category	Summary of Procedural Mitigation Requirements*		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 (June 1 – September 30)	Continental Shelf and Slope Mitigation Area	Temporary Maritime Activities Area	Marine Mammals	Sea Turtles	Large-Bodied Seabirds	Fishery Resources	
Other	—	—	—	—	• TMAA to remain out of Steller sea lion CH	X	—	—	—	—
Environmental Awareness and Education	—	• Applicable personnel take assigned Afloat Environmental Compliance Training modules	—	—	• Issue pre-event large whale awareness messages	X	X	X	—	• Large whale 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 (marine mammals, sea turtles) • 200 yd. shut down for non-HM MFAS and HFAS (marine mammals, sea turtles)	• No HM MFAS in bin MF1	—	—	X	X	—	—	—
Weapon Firing Noise	1	• 30° on sides of firing line out to 70 yd. from the weapon muzzle (marine mammals, sea turtles, large-bodied seabirds)	—	—	—	X	X	X	—	• Seabird mitigation
Explosive Lg-Cal Projectiles	1	• 600 yd. (large-bodied seabirds) • 1,000 yd. (marine mammals, sea turtles)	—	• No explosives detonated below 10,000 ft. altitude	—	X	X	X	X	• Increased mitigation zone size • Post-event observations • Additional participants support Lookout observations • Seabird mitigation • Expanded mitigation area applicable to explosives use
Explosive Bombs	1	• 600 yd. (large-bodied seabirds) • 2,500 yd. (marine mammals, sea turtles)	—	• No explosives detonated below 10,000 ft. altitude	—	X	X	X	X	• Post-event observations • Additional participants support Lookout observations • Seabird mitigation • Expanded mitigation area applicable to explosives use
Vessel Movement	1 or more	• 500 yd. (whales) • 200 yd. (other marine mammals, large-bodied seabirds) • Vicinity (sea turtles)	—	—	—	X	X	X	—	• Sea turtle mitigation • Seabird 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. (marine mammals, sea turtles, large-bodied seabirds)	—	—	—	X	X	X	—	• Seabird mitigation
Non-Explosive Bombs	1	• 600 yd. (large-bodied seabirds) • 1,000 yd. (marine mammals, sea turtles)	—	—	—	X	X	X	—	• Seabird mitigation

*Procedural Mitigation will be implemented within the Temporary Maritime Activities Area and Western Maneuvering Area wherever applicable activities are conducted.

Notes: — = No mitigation or mitigation is not applicable, X = Mitigation is applicable, CH = critical habitat, ft. = foot, 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

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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 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) 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 agency correspondence is provided in Appendix E (Correspondence). The Navy is in consultation with the National Marine Fisheries Service (NMFS) and completed consultation with U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act. Likewise, the Navy submitted an application and addendums to NMFS for Marine Mammal Protection Act authorizations supported by this SEIS/OEIS. Consultation with the USFWS was completed in April 2022. Consultation documentation is included in Appendix E (Correspondence) and on the website (www.goaeis.com).

Table 6-1: Summary of Environmental Compliance for the Proposed Action

Statutes, Regulations, Executive Orders, International Standards, and Guidance	*Status of Compliance*
Statutes and Regulations	
Coastal Zone Management Act (16 U.S.C. sections 1451-1464)	Alaska currently does not have an approved Coastal Management Program, and the Navy has no requirements to prepare and submit a Consistency Determination.
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. In accordance with 50 CFR part 402, the Navy developed a biological assessment to reinitiate the informal consultation with the USFWS 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 and northern sea otter) or critical habitat in a manner or to an extent not previously considered in the 2016 GOA Final SEIS/OEIS. The Navy has consulted with the USFWS for the Proposed Action described in the 2022 Final SEIS/OEIS. The USFWS issued a Letter of Concurrence on April 12, 2022. 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: Summary of Environmental Compliance for the Proposed Action (continued)

Statutes, Regulations, Executive Orders, International Standards, and Guidance	*Status of Compliance*
Endangered Species Act (ESA) (16 U.S.C. sections 1531 et seq.) (continued)	In accordance with 50 CFR section 402, the Navy requested reinitiation of formal consultation with NMFS. A BO may be issued by NMFS, and the Navy will adhere to any BO terms and conditions listed therein.
Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. parts 1801–1882)	The Navy consulted with NMFS pursuant to 50 CFR section 600.920(1). The Navy will continue to implement the conservation recommendation of coordinating with other research activities within the GOA to avoid displacement or effects. On 25 July 2022, NMFS concurred with the Navy's approach to offset adverse effects to Essential Fish Habitat and concluded consultation.
Marine Mammal Protection Act (16 U.S.C. sections 1431 et seq.)	This SEIS/OEIS updated 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 maximum 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 Navy sent correspondence to the Alaska SHPO informing them that the proposed activities were occurring outside of 12 nautical miles from shore and beyond the SHPO's jurisdiction under the National Historic Preservation Act. On June 30, 2021, the Navy received a response from the Alaska SHPO stating they had no objections to the Navy's determination that Section 106 compliance is not necessary for the Proposed Action. (refer to Appendix E for correspondence from the Alaska SHPO).
National Marine Sanctuaries Act (16 U.S.C. section 1431-1445c-1)	The GOA Study Area 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. parts 1301–1315)	In accordance with the State's regulations, the Proposed Action is consistent with regulations concerning the Submerged Lands Act.
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 invited federally recognized tribal governments to initiate government-to-government consultation; however, no federally recognized tribes have requested government-to-government consultation for the SEIS/OEIS.
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 13834, *Efficient Federal Operations* (revoked in part by EO 13990)	This Executive Order has been revoked in part by EO 13990, *Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis.* The Proposed Action is consistent with the part of the federal government's order that is not revoked 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.

Table 6-1: Summary of Environmental Compliance for the Proposed Action (continued)

Statutes, Regulations, Executive Orders, International Standards, and Guidance	***Status of Compliance***
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*).
EO 13990, *Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis*	This EO revokes EO 13783, *On Promoting Energy Independence and Economic Growth*; EO 13792, *Review of Designations Under the Antiquities Act*; and revokes in part, EO 13834, *Efficient Federal Operations*. The Proposed Action is consistent with the policy's goals to "empower our workers and communities; promote and protect our public health and the environment; and conserve our national treasures and monuments" (EO 13990).
EO 14008, *Tackling the Climate Crisis at Home and Abroad*	This EO amends EO 12898, *Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations*. The Proposed Action is consistent with the policy "that climate considerations shall be an essential element of United States foreign policy and national security" (EO 14008).

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.

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 near the Temporary Maritime Activities Area (TMAA) and the Western Maneuver Area (WMA), collectively referred to as the GOA Study Area, 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 6-2 provides information on the individual MPA regulations and the Navy activities that occur in these areas.

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 GOA Study Area. Figure 6-1 shows MPAs near the GOA Study Area.

Table 6-2: Marine Protected Areas Near the Gulf of Alaska Study Area

Marine Protected Area	Location Within the GOA Study Area	Protection Focus	Regulations Applicable to Navy Activities	Navy Proposed Activities and Potential Impacts
Alaska Maritime National Wildlife Refuge (NWR)	Borders the GOA 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 NWR	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 NWR	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)	GOA	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 Area	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

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 NMFS, regional Fishery Management Councils, and other federal agencies to identify and protect important marine, estuarine, and anadromous fish habitat. The GOA Study Area 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 GOA Study Area 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 nine Alaska Seamount Habitat Protection Areas that occur within the GOA Study Area (Figure 6-1). These areas have restrictions prohibiting bottom trawling. Additionally, there are two GOA Slope Habitat Conservation Areas, including Middleton Island West and Cable that occur within the GOA Study Area (71 Federal Register 36703) (Figure 6-1). These areas have restrictions prohibiting the use of bottom contact fishing gear and anchorages. The restrictions of the Habitat Protection Area are not applicable to the type of activities planned as part of the Navy's Proposed Action.

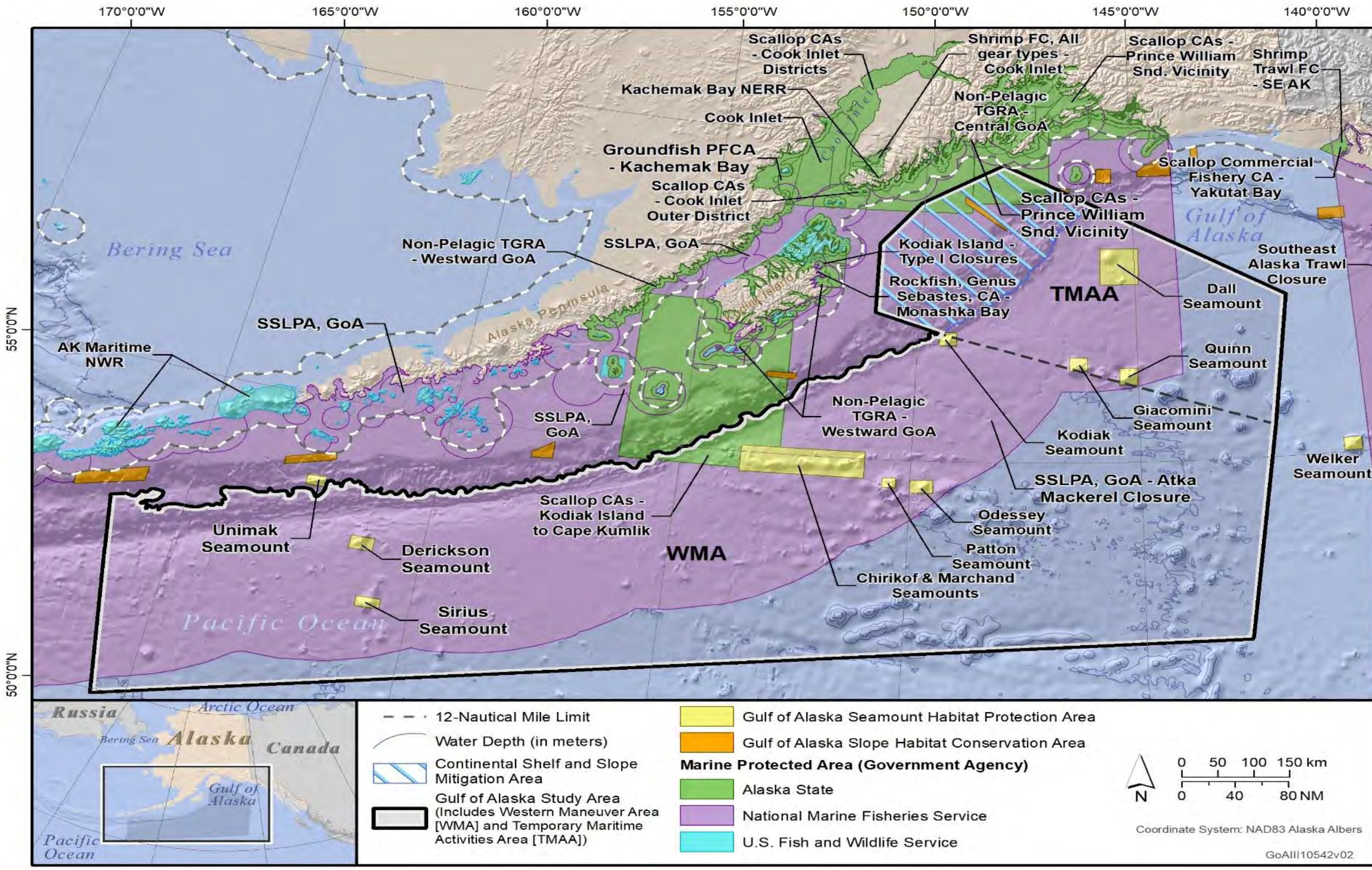

Figure 6-1: Map of Marine Protected Areas in the Gulf of Alaska Study Area

6.1.3 Government-to-Government Consultation with Federally Recognized Alaska Native Tribes

The Navy will continue government-to-government communications 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 11010.14A, *Policy for Consultation with Federally-Recognized American Indian and Alaska Native Tribes* (April 10, 2021); 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. Although there are tribal rights and protected resources in and near the Study Area, after reaching out to tribal chairpersons, presidents, or chiefs of Alaska Native federally recognized tribes, the Navy concluded that there would be no potential to affect the resources as a result of the Proposed Action. Tribal letters were mailed February 6, 2020, via certified mail to 24 tribal chairpersons, presidents, or chiefs of Alaska Native federally recognized tribes. Invitations to government-to-government consultation for continuation of U.S. Navy GOA TMAA were sent to the 24 tribal chairpersons, presidents, or chiefs of Alaska Native federally recognized tribes on December 3, 2020, via certified mail. Tribal letters, including enclosures of a fact sheet booklet and a CD-ROM of all volumes of the 2020 GOA Draft SEIS/OEIS, were mailed December 16, 2020, via certified mail to 24 tribal chairpersons, presidents, or chiefs of Alaska Native federally recognized tribes. Tribal letters were mailed February 3, 2022, via certified mail to 42 tribal chairpersons, presidents, or chiefs of Alaska Native federally recognized tribes to inform them of the Navy's intent to prepare a Supplement to the December 2020 GOA Draft SEIS/OEIS, which would address a change in the Study Area and the addition of a new Continental Shelf and Slope Mitigation Area. With the release of the Supplement, tribal letters were mailed March 16, 2022, via certified mail to 42 tribal chairpersons, presidents, or chiefs of Alaska Native federally recognized tribes. Additional Alaska Native federally recognized tribes were included for the Supplement mailings to cover the expanded Study Area, the Western Maneuver Area, that the Navy may use for vessel and aircraft maneuvering purposes during exercises. The Navy has not received any requests by federally recognized tribes for government-to-government consultation for the SEIS/OEIS.

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 includes an analysis on 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 included 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 part 4332). This analysis has not changed since the analysis included in the 2016 GOA Final SEIS/OEIS. There were no irreversible or irretrievable commitment of resources as a result of implementation of the Proposed Action. 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* (U.S. 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 (U.S. Department of Defense, 2018). The Navy consumes approximately 26 percent of the total DoD share (U.S. 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. 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, 2010). 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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U.S. Department of the Navy

Andrea Balla-Holden (Commander, U.S. Pacific Fleet)
B.S., Fisheries
Years of experience: 31

Anna Bausher (Naval Facilities Engineering Command, Northwest)
B.A., Environmental Studies: Environmental Policy and Planning
Years of experience: 7

Victoria Bowman (Naval Information Warfare Center Pacific)
B.A., Psychology
Years of experience: 11

Cassie DePietro (Naval Undersea Warfare Center, Division Newport)
M.S., Applied Mathematics
Years of experience: 4

Jessica Desrochers (Naval Undersea Warfare Center, Division Newport)
M.S., Applied Mathematics
Years of experience: 5

Joseph Fayton (Naval Undersea Warfare Center, Division Newport)
Ph.D., Mathematics
Years of experience: 7

Dave Grant (Naval Facilities Engineering Command Northwest)
M.A., Anthropology (Nautical Archaeology)
Years of experience: 35

Elizabeth Henderson (Naval Information Warfare Center Pacific)
Ph.D., Biological Oceanography
M.Sc., Wildlife and Fisheries Sciences
B.A., Psychobiology
Years of experience: 23

Peter Hulton (Naval Undersea Warfare Center, Division Newport)
B.S., Mechanical Engineering
Years of experience: 40

Chris Hunt (Naval Facilities Engineering Command Northwest)
M.S., Environmental Science
B.S., Biology
Years of experience: 23

Keith Jenkins (Naval Information Warfare Center Pacific)
M.S., Fisheries Oceanography
B.S., Marine Biology
Years of experience: 20

Danielle Kitchen (Chief of Naval Operations)
M.E.M, Coastal Environmental Management
Years of experience: 13

Kimberly Kler (Chief of Naval Operations)
B.S., Environmental Policy Analysis and Planning
Years of experience: 27

Arnold Kostenbader (Commander Pacific Fleet)
B.S., Business
Years of experience: 19

Sarah Kotecki (Naval Information Warfare Center Pacific)
B.S., Civil and Environmental Engineering
Years of experience: 21

Cindi Kunz (Naval Facilities Engineering Command Northwest)
M.S., Wildlife Science
B.S., Wildlife Science
Years of experience: 37

Dayv Lowry (Naval Facilities Engineering Command, Northwest)
Ph.D., Marine Biology
B.S., Marine Biology
Years of experience: 16

Cameron Martin (Naval Information Warfare Center Pacific)
B.S., Environmental Science
Years of experience: 9

John Mosher (U.S. Pacific Fleet, Environmental Readiness Division)
B.S., Geology
Years of experience: 32

Danielle Page-Pattison (NAVFAC NW)
M.A., *Anthropology* (emphasis is Archaeology)
Years of experience: 30

Jennie Shield (Naval Information Warfare Center Pacific)
B.A., International Studies
Years of experience: 17

Stephanie Sleeman (Naval Facilities Engineering Command Northwest)
M.E.S., Environmental Science
B.A., Environmental Policy and Planning; Minor, Marine Science
Years of experience: 15

Jennifer Steele (Naval Facilities Engineering Command Northwest)

M.S., Coastal and Oceanographic Engineering
M. Cert., Environmental Policy and Management
B.S., Marine Sciences
Years of Experience: 10

Christina Wertman (Naval Undersea Warfare Center, Division Newport, Newport RI)
Ph.D. Oceanography
Years of experience: 2

Contractors

Alyssa W. Accomando (National Marine Mammal Foundation)
Ph.D., Neuroscience
B.S., Neuroscience
Years of experience: 5

Andy Clodfelter (AECOM)
B.S., Biology
Years of experience: 21

Conrad Erkelens (ManTech International)
M.A., Anthropology
B.A., Anthropology
Years of experience: 23

Matthew Hahn (ManTech International)
M.B.A., Project Management
B.A., General Business
Years of experience: 29

Danny Heilprin (ManTech International)
M.S., Marine Science
B.A., Aquatic Biology
Years of experience: 35

Taylor Houston (ManTech International)
M.B.A., Project Management
B.S., Natural Resource Management
Years of experience: 22

Sarah Rider (G2 Software Systems)
M.E.M., Coastal Environmental Management
B.S., Marine Science
Years of experience: 15

Marya Samuelson (ManTech International)
M.B.A., Project Management
B.A., Environmental Science
Years of experience: 9

Allison Turner (ManTech International)
M.E.S.M., Environmental Science & Management
B.A., Social Science emphasis in Environment
Years of experience: 20

Karen Waller (ManTech International)

M.B.A., Environmental Management
B.S., Public Affairs
Years of experience: 34

Lawrence Wolski (ManTech International)
M.S., Marine Sciences
B.S., Biology
Years of experience: 24

Ryan Wright-Zinniger (ManTech International)
B.S., Environmental Studies
Years of experience: 2

Maria Zapetis (National Marine Mammal Foundation)
Ph.D., Brain and Behavior, Psychology
M.A., Brain and Behavior, Psychology
B.A., Biology
Years of experience: 3

Mike Zickel (ManTech International)
M.S., Marine Estuarine Environmental Sciences
B.S., Physics
Years of experience: 22