The Mariana Islands Training and Testing

Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement
United States Department of the Navy

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Mariana Islands Training and Testing Activities Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement

Volume 1

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FOREWORD

The Draft Mariana Islands Training and Testing (MITT) Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (SEIS/OEIS) was released on February 1, 2019 for public review and comment through April 17, 2019. Changes in this Final SEIS/OEIS reflect responses to all substantive comments made on the Draft SEIS/OEIS during the public comment period as well as refinements to the Proposed Action made by the Navy. Public comments are summarized, and their corresponding responses are provided, in Appendix K (Public Comments and Responses) of the Final SEIS/OEIS.

While most sections in the Final SEIS/OEIS were changed in some manner between the draft and final versions, many of those changes were not substantive and entailed minor modifications to improve clarity. Substantive changes made to sections between the Draft SEIS/OEIS and Final SEIS/OEIS are summarized below.

- Chapter 2 (Description of Proposed Action and Alternatives):

  Information on standard operating procedures for amphibious assaults and amphibious raids was added. Standard operating procedures for these activities are designed primarily for safety of personnel and equipment but will also benefit shallow coral reefs, hard bottom, and other substrates.

  Added Table 2.3-1 which provides the differences between major training exercises and smaller integrated/coordinated anti-submarine exercises based on scale, duration, and sonar hours for the purposes of exercise reporting requirements.

- Section 3.0 (Introduction to Affected Environment and Environmental Consequences):

  Additional information regarding the surface area of the seafloor that has the potential to be impacted by the use of military expended materials proposed under the SEIS/OEIS was added to *Table 3.0-18 (Impact Area of Proposed Military Expended Materials)*. The amount of military expended materials that would result from activities proposed in this SEIS/OEIS would decrease from the amount analyzed in the 2015 MITT Final EIS/OEIS. Therefore, the area of the seafloor potentially impacted by military expended materials residing on the seafloor is expected to be less. In addition, updated information was added to *Section 3.0.4.1.4.1 (Muzzle Blast from Naval Gunfire)*, including a new figure that depicts 5-inch deck gun variants on two classes of Navy surface ships, to enhance the discussion of weapon firing noise. Additional information was provided in *Section 3.0.4.1.2 (Vessel Noise)* to differentiate between Navy ships and non-Navy ships in terms of their radiated ship noise. Finally, *Section 3.0.4.4.7 (Personnel Disturbance)* presented a new stressor to account for the potential for physical impacts on the nearshore seafloor from personnel involved in training or testing activities.

- Section 3.2 (Sediments and Water Quality):

  Additional information regarding water quality criteria and screening levels in waters surrounding Guam and the Commonwealth of the Northern Mariana Islands (CNMI) was provided, including water quality standards and classifications set by Guam and the CNMI. In addition, a summary of research conducted at other sites with expended munitions and other military expended materials was included.

- Section 3.4 (Marine Mammals):

  Updates including the best available science and discussions of newly published journal articles were included in this section. In addition, an error was identified in the explosive range to effects tables and was corrected. There is no change to the explosives being proposed. Lastly, an expanded discussion of beaked whale strandings was added in *Section 3.4.2.1.1.6 (Stranding)* to include the history of their routine occurrence in the Mariana Islands based on concern expressed in public comments on the Draft SEIS/OEIS.

- Section 3.5 (Sea Turtles):

  Updates including the best available science and discussions of newly published journal articles were included in this section. In addition, an error was identified in the explosive range to effects tables and was corrected. There is no change to the explosives being proposed. This section was also updated to include an analysis on potential impacts on sea turtles resulting from multiple stressors (*Section 3.5.3, Summary of Potential Impacts on Sea Turtles*).

- Section 3.6 (Birds):

  An analysis of potential impacts on birds from multiple stressors (*Section 3.6.3, Summary of Potential Impacts on Marine Birds*) was included in this section.

- Section 3.8 (Marine Invertebrates):

  Background information and analysis on hydrothermal vents, to the extent that data were available, was included in this section. In addition, a coral reef map (*Figure 3.8-1: Percent Coral Cover and Habitat Types Around Farallon de Medinilla*) was added. Updated information from the National Oceanic and Atmospheric Administration's coral condition report for CNMI and Guam was incorporated.

- Section 3.9 (Fishes):

  Updates including the best available science and discussions of newly published journal articles were included in this section. In addition, an error was identified in the explosive range to effects tables and was corrected. There is no change to the explosives being proposed.

- Section 3.10 (Terrestrial Species and Habitats):

  Clarifications on when periodic surveys of Farallon de Medinilla occur and on training activity type descriptions on the island were included in this section.

- Section 3.11 (Cultural Resources):

  Cultural practices and beliefs shared by participants at the National Historic Preservation Act Section 106 consultation meetings were added to this section. Minor corrections and edits were made, where applicable.

- Section 3.12 (Socioeconomic Resources):

  A more in-depth analysis of environmental justice issues, particularly issues associated with traditional fishing practices, was added to this section. Changes included information on the importance of coral reefs to fishers, citing National Oceanic and Atmospheric Administration publications that report on surveys of fishers. The most recent available economic data on GDP growth for Guam and CNMI, visitation, and fisheries landings were added to the section. Data on the number of Notices to Mariners issued by the U.S. Coast Guard on behalf of the Navy and announcing restrictions on access to waters around Farallon de Medinilla and beneath warning areas were updated. Lastly, information was provided on bioaccumulation risk to fisheries due to munitions constituents in the secondary impact discussion.

- Chapter 5 (Mitigation):

  The Navy worked with the National Marine Fisheries Service during the Endangered Species Act consultation process to develop new procedural mitigation for manta rays and enhance existing procedural mitigation for marine mammals, sea turtles, and hammerhead sharks during explosive mine neutralization activities involving Navy divers. In addition, updates to mitigation area measures were also included as a result of consultations under the Marine Mammal Protection Act and Endangered Species Act, as detailed in Appendix I (Geographic Mitigation Assessment).

- Appendix I (Geographic Mitigation Assessment):

  The boundaries of the proposed geographic mitigation areas were updated using bathymetry as the physical feature defining the areas. The list of mitigation areas considered but not carried forward was expanded to include other areas suggested by commenters and the rationale for not proposing those areas as geographic mitigation areas.

  The Navy developed new mitigation for the Final SEIS/OEIS in consultation with NMFS to limit surface ship hull-mounted MF1 mid-frequency active sonar to a maximum combined total of 20 hours from December 1 to April 30 in the Marpi Reef Geographic Mitigation Area and Chalan Kanoa Reef Mitigation Area.

- Appendix K (Public Comment Responses):

  This Appendix was added since the release of the Draft SEIS/OEIS and includes an explanation of the public comment process for the Draft SEIS/OEIS, a list of agencies and organizations that provided comments, and a table containing the comments received and the Navy’s responses.

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FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT/ OVERSEAS ENVIRONMENTAL IMPACT STATEMENT FOR MARIANA ISLANDS TRAINING AND TESTING

Lead Agency:	United States Department of the Navy
Cooperating Agency:	National Marine Fisheries Service United States Coast Guard
Title of the Proposed Action:	Mariana Islands Training and Testing Final Supplemental Environmental Impact Statement/ Overseas Environmental Impact Statement

Abstract

The United States Department of the Navy (Navy) prepared this Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (SEIS/OEIS) in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code section 4321 et seq.); the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations sections 1500 et seq.); Navy Procedures for Implementing NEPA (32 Code of Federal Regulations section 775); and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*. This SEIS/OEIS evaluates the potential environmental impacts of conducting training and testing activities after August 2020 at sea and on Farallon de Medinilla within the Mariana Islands Training and Testing (MITT) Study Area (Study Area). The Study Area is the same as was analyzed in the 2015 MITT Final EIS/OEIS and is composed of three components: (1) the Mariana Islands Range Complex, (2) additional areas on the high seas, and (3) a transit corridor between the Mariana Islands Range Complex and the Hawaii Range Complex. Three alternatives were analyzed in this SEIS/OEIS:

- The No Action Alternative represents no military readiness activities at sea or on Farallon de Medinilla associated with the Proposed Action within the Study Area. Other military activities not associated with this Proposed Action would continue to occur.
- Alternative 1 consists of an adjustment from the level of training and testing activities analyzed in the 2015 MITT Final EIS/OEIS, accounting for changes in the types and tempo (increases or decreases) of activities necessary to meet current and future military readiness requirements beyond 2020.
- Alternative 2 (Preferred Alternative) includes the same type of training and testing activities that would occur under Alternative 1 and had been analyzed in the 2015 MITT FEIS/OEIS. Alternative 2 also considers an increase in tempo of some training and testing activities, including additional Fleet exercises and associated unit-level activities, should unanticipated emergent world events require increased readiness levels.

Resources evaluated include sediments and water quality, air quality, marine habitats, marine mammals, sea turtles, marine birds, marine vegetation, marine invertebrates, fishes, terrestrial species and habitats, cultural resources, socioeconomic resources and environmental justice, and public health and safety.

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Executive Summary

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ES Executive Summary

ES.1 Introduction

The United States (U.S.) Department of the Navy (Navy) prepared the supplement to the May 2015 Mariana Islands Training and Testing (MITT) Final Environmental Impact Statement/Overseas EIS (EIS/OEIS) (U.S. Department of the Navy, 2015) pursuant to Council on Environmental Quality (CEQ) Regulations. The Supplemental EIS (SEIS)/OEIS considered ongoing and future activities conducted at sea and on Farallon de Medinilla (FDM), updated training and testing requirements, incorporated new information from an updated acoustic effects model, updated marine mammal density data, and incorporated evolving and emergent best available science. The SEIS/OEIS also supports the issuance of federal regulatory permits and authorizations under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) by using the most current and best available science and analytical methods to reassess potential environmental impacts on the species applicable to those regulations. The Navy consulted with the National Marine Fisheries Service (NMFS) to renew these authorizations. While the Study Area remains unchanged from the 2015 MITT Final EIS/OEIS, the SEIS/OEIS focuses only on the at-sea and FDM portion of that area.

The 2015 MITT Final EIS/OEIS also analyzed training and testing activities conducted at existing Mariana Islands Range Complex (MIRC) land-based training areas located on Guam, Saipan, Tinian, and Rota. In accordance with 40 Code of Federal Regulations (CFR) Section 1502.9, the Navy will continue to rely on the 2015 MITT Final EIS/OEIS and the 2015 U.S. Fish and Wildlife Service consultation for land-based activities because there are no changes that are relevant to environmental concerns or that would have a bearing on the land-based activities or their impacts.

ES.2 Purpose of and Need for Proposed Training and Testing Activities

The Navy and NMFS (as a cooperating agency) have coordinated from the outset and developed this document to meet each agency’s distinct National Environmental Policy Act (NEPA) obligations and support the decision making of both agencies. The Navy’s purpose of the Proposed Action is to conduct training and testing activities to ensure that the Navy, other U.S. military services, and the U.S. Coast Guard meet their respective missions, which, for the Navy under Title 10 United States Code (U.S.C.) Section 8062, is to maintain, train, and equip combat-ready military forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. The respective missions are achieved in part by training and testing within the Study Area in accordance with established military readiness requirements. NMFS’s purpose is to evaluate the Navy's Proposed Action pursuant to NMFS’s authority under the MMPA, and to make a determination whether to issue incidental take regulations and Letters of Authorization, including any conditions needed to meet the statutory mandates of the MMPA.

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

In the SEIS/OEIS, the Navy reanalyzed at-sea and FDM training and testing activities that could potentially impact natural resources, such as marine mammals, sea turtles, and other marine resources. Since the completion of the 2015 MITT Final EIS/OEIS, new information has become available and is incorporated in the analysis, in addition to proposed changes in training and testing requirements. The range of alternatives in the SEIS/OEIS includes the No Action Alternative and two action alternatives. The Navy analyzed 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 the SEIS/OEIS. The document is being prepared in coordination with the U.S. Coast Guard as a cooperating agency, as its at-sea and FDM training and testing activities in the Study Area are included in the Proposed Action.

The National Oceanic Atmospheric Administration's NMFS is serving as a cooperating agency because the scope of the Proposed Action and alternatives involves activities that have the potential to impact protected resources under their jurisdiction by law, including marine mammals, threatened and endangered species, and Essential Fish Habitat. The National Oceanic Atmospheric Administration's authorities and special expertise are based on their statutory responsibilities under the MMPA of 1972, as amended (16 U.S.C. 1361 et seq.), the ESA of 1973 (16 U.S.C. 1531 et seq.), and the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.). In addition, NMFS, in accordance with 40 CFR 1506.3 and 1505.2, may adopt the SEIS/OEIS and issue a separate Record of Decision associated with its decision to grant or deny the Navy's request for an incidental take authorization pursuant to Section 101(a)(5)(A) of the MMPA.

In accordance with CEQ regulations (40 CFR 1505.2), the Navy will issue a Record of Decision that provides the rationale for choosing one of the alternatives.

ES.4 Proposed Action and Alternatives

The Navy proposes to continue military readiness training and testing activities throughout the Study Area (Figure ES.4-1), primarily in the existing MIRC. The proposed training and testing activities associated with the Proposed Action are to be conducted at sea (including the transit corridor between the MIRC and the Hawaii Range Complex, and select Navy pierside and harbor locations) and on FDM. These proposed activities are generally consistent with those at-sea and FDM activities analyzed in the 2015 MITT Final EIS/OEIS. To achieve and maintain Fleet readiness through this SEIS/OEIS, the Navy

- analyzes at-sea and FDM activities necessary to meet readiness requirements beyond 2020 and into the reasonably foreseeable future, including any changes to those activities previously analyzed, and reflects the most up-to-date compilation of training and testing activities deemed necessary to accomplish military readiness requirements;
- adjusts types and tempo (increases or decreases) of training and testing events from the 2015 MITT Final EIS/OEIS to the level needed to meet readiness requirements beyond 2020 and into the reasonably foreseeable future;
- presents the results of the evaluation of relevant new information, which was incorporated into revised analyses where appropriate (each resource area analyzed within the 2015 MITT Final EIS/OEIS was evaluated to determine the need for reanalysis within the SEIS/OEIS);
- updates the environmental impact analyses in previous documents to account for changes to tempo of activity, renaming or combining related types of activities, acknowledging discontinuation of some activities assessed in 2015, and assessing new activities, such as those involving high-energy lasers, to enable the Navy to adopt new technology and new capabilities;
- updates environmental analyses with the best available science and most current acoustic analysis methods to evaluate the potential effects of training and testing on the marine environment; and
- supports reauthorization of incidental takes of marine mammals under the MMPA and incidental takes of threatened and endangered marine species under the ESA.

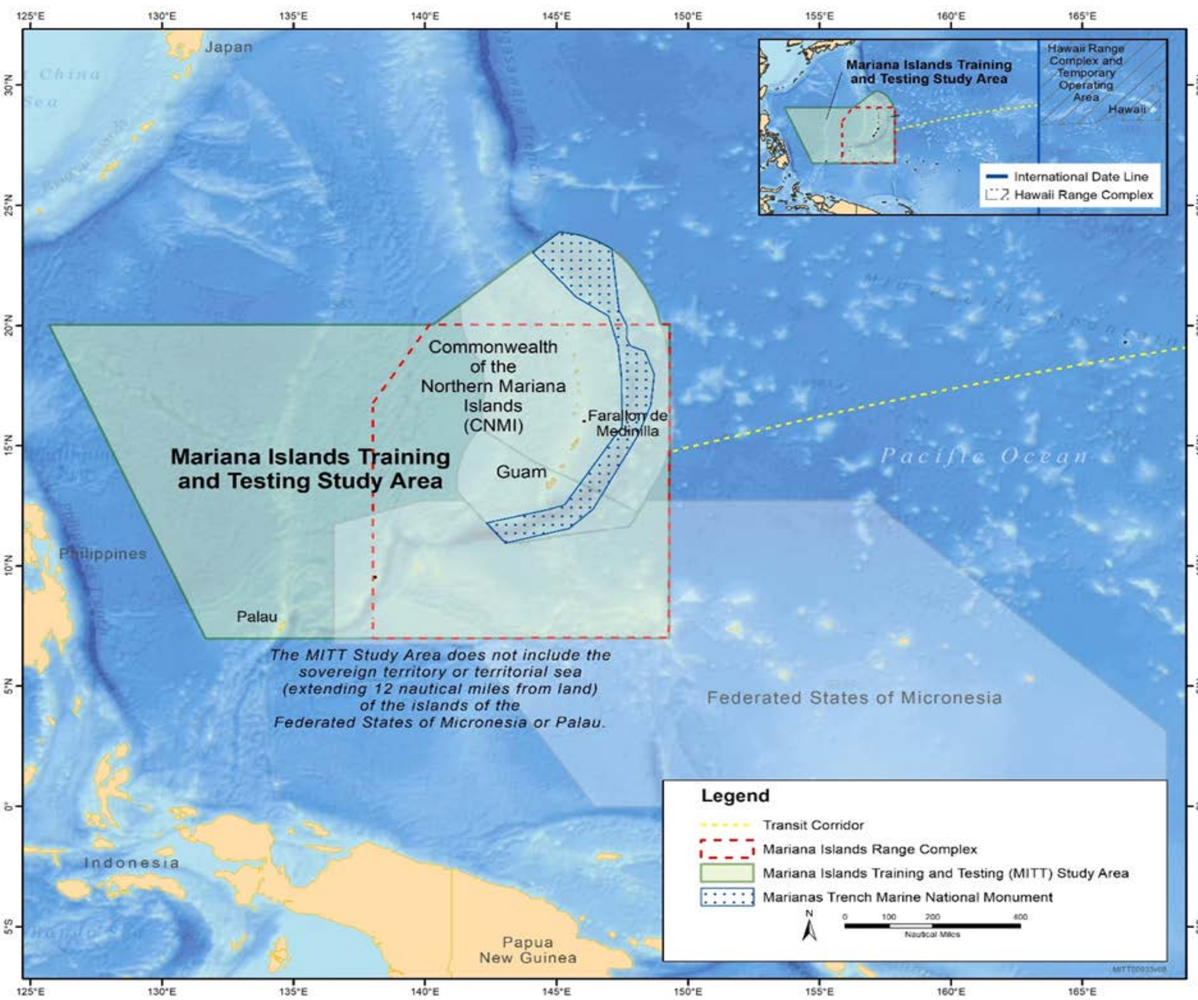

Figure ES.4-1: Mariana Islands Training and Testing Study Area

ES.4.1 No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the MITT Study Area. Other military activities not associated with this Proposed Action would continue to occur. For FDM, the lease agreement between the U.S. government and the Commonwealth of the Northern Mariana Islands would remain in place, and the island would continue to be maintained as a Navy range, although strike warfare would no longer continue on the island. For NMFS, denial of an application for an incidental take authorization constitutes the NMFS No Action Alternative, which is consistent with NMFS' statutory obligation under the MMPA to grant or deny requests for take incidental to specified activities. The resulting environmental effects from taking no action will be compared with the effects of the action alternatives.

Cessation of proposed Navy at-sea training and testing activities would mean that the Navy would not meet its statutory requirements and would be unable to properly defend itself and the United States from enemy forces, unable to successfully detect enemy submarines, and unable to safely and effectively use its weapons systems or defensive countermeasures due to a lack of training of forces and testing of systems that replicate the conditions to which Naval forces must operate while executing the range of military operations required to further national security objectives. Navy personnel would essentially not obtain the unique skills or be prepared to safely and effectively use sensors, weapons, and technologies in realistic scenarios required to accomplish the overall mission. Consequently, the No Action Alternative of not conducting the proposed live, at-sea training and testing activities in the Study Area is inherently unreasonable because it does not meet the purpose of and need for the Proposed Action.

ES.4.2 Alternative 1

This alternative consists of an adjustment from the level of training and testing activities analyzed in the 2015 MITT Final EIS/OEIS, accounting for changes in the types and tempo (increases or decreases) of activities necessary to meet current and future military readiness requirements beyond 2020.

- **Adjustments to Tempo of Training and Testing Activities.** This alternative includes changes to training and testing requirements necessary to accommodate current and future training and testing requirements at sea and on FDM, including new at-sea activities as well as activities subject to previous analysis that are currently ongoing and have historically occurred in the Study Area.

Alternative 1 reflects a level of training and testing activities to be conducted at sea and on FDM, with adjustments from the 2015 MITT Final EIS/OEIS that account for changes in the types and tempo of activities necessary to meet current and future military readiness requirements beyond 2020. Alternative 1 reflects a representative year of training and testing to account for the typical fluctuation of training cycles, testing programs, and deployment schedules that generally limit the maximum level of training and testing from occurring for the reasonably foreseeable future.

ES.4.3 Alternative 2 (Preferred Alternative)

Alternative 2 includes the same type of training and testing activities that would occur under Alternative 1. Alternative 2 also includes an increase in tempo of some training and testing activities, including additional Fleet exercises and associated unit-level activities, should unanticipated emergent world events require increased readiness levels. Alternative 2 includes additional electronic warfare activities for Naval Air Systems Command and additional electronic warfare, anti-submarine warfare, and surface warfare activities for Naval Sea Systems Command. Alternative 2 reflects the maximum number of training activities that could occur within a given year, and assumes the maximum number of Fleet exercises would occur annually. This alternative allows for the greatest flexibility for the Navy to maintain readiness when considering potential changes in the national security environment, fluctuations in training and deployment schedules, and anticipated in-theater demands.

ES.5 Summary of Environmental Effects

Environmental effects which might result from implementing the Navy's Proposed Action have been analyzed in the SEIS/OEIS. Physical resources (e.g., air quality, sediments, and water quality) considered for re-evaluation in the SEIS/OEIS are the same as those that were analyzed in the 2015 MITT Final EIS/OEIS. Biological resources considered include marine habitats, marine mammals, sea turtles, marine birds, marine vegetation, marine invertebrates, fishes, and terrestrial species and habitats. Human resources considered in the SEIS/OEIS include cultural resources, socioeconomic resources and environmental justice, and public health and safety.

As stated previously, the SEIS/OEIS is an update to the 2015 MITT Final EIS/OEIS. New information specifically addressed in the SEIS/OEIS includes updates to military readiness requirements, an updated acoustic effects model, updated marine mammal density data, and evolving and emergent best available science.[1] As the science regarding the potential impacts of acoustics (sonar and explosives) on marine species has evolved since the 2015 MITT Final EIS/OEIS (new research available, updated criteria and thresholds), the acoustic analysis contained in the supplement is a complete update and does not rely on the 2015 MITT Final EIS/OEIS analysis. Analysis associated with activities that result in non-acoustic impacts is updated as necessary in the SEIS/OEIS to reflect new science and refers to the 2015 MITT Final EIS/OEIS analysis when appropriate.

Table ES.5-1 lists the potential environmental impacts of the Proposed Action. All sections of the 2015 MITT Final EIS/OEIS were reviewed to determine whether there was relevant best available science that would require updates to the analysis and incorporation into the SEIS/OEIS. To the extent there was updated or new and relevant best available science, it is reflected in each of the sections in Chapter 3 (Affected Environment and Environmental Consequences). The Navy also reassessed effects determinations for marine species. Predicted acoustic exposures are reduced 25 percent under Alternative 1 and would decrease 17 percent under Alternative 2, when compared to the impacts predicted in the 2015 MITT Final EIS/OEIS.

[1] The 2015 MITT Final EIS/OEIS used a new modeling system known as the Navy Acoustic Effects Model, developed by the Navy in cooperation with the National Marine Fisheries Service, and marine mammal density information that was the best available information at the time. In the SEIS/OEIS, the Navy Acoustic Effects Model has been refined, marine mammal density estimates have been updated, NMFS has published new criteria, and criteria used in the acoustic model have been revised.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2

Resource Category	Summary of Impacts
Section 3.1 Sediments and Water Quality	The Navy considered all stressors that could potentially impact sediments and water quality as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative:** • Under the No Action Alternative, proposed training and testing activities would not occur in the MITT Study Area. Discontinuing training and testing would result in fewer explosives and explosives byproducts, metals, chemicals, and other materials within the marine environment where training and testing activities have historically occurred. Discontinuing training and testing activities would reduce the potential for impacts on sediments and water quality from training and testing activities. **Alternative 1:** • Explosives and explosives byproducts: The number of explosive munitions used during at-sea training and testing activities and on FDM would increase compared to the number analyzed in the 2015 MITT Final EIS/OEIS. In addition, all munitions would be dropped on the same existing impact areas on FDM. The analysis shows that the proposed increase in ordnance use on FDM would be less than 1 percent compared to levels analyzed previously. The small increase in at-sea activities and on FDM would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS. Furthermore, chemical, physical, or biological changes in sediment or water quality would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS. Guam, CNMI, and federal standards or guidelines would not be violated. • Metals: Under Alternative 1, the number of sources of metals that would be expended during training and testing would increase compared to the 2015 MITT Final EIS/OEIS. There is no new information that changes the basis of the conclusions presented for the potential impacts of metals on sediments and water quality. Chemical, physical, or biological changes to sediments or water quality in the Study Area would not be detectable beyond the vicinity of the corroding metals and any impacts would be short term and localized. Therefore, increases in training and testing activities proposed under Alternative 1 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS. • Chemicals other than explosives: Under Alternative 1, fewer items that would expend chemicals other than explosives (e.g., solid-fuel propellants in missiles and rockets, Otto Fuel II torpedo propellant and combustion byproducts, polychlorinated biphenyls [PCBs] in target vessels used during sinking exercises, and other chemicals associated with expended materials) would be used during training and testing activities compared to the number of items proposed in the 2015 MITT Final EIS/OEIS. Some testing activities that would introduce chemicals other than explosives into the environment would increase, while others would decrease. The changes in the number of activities that introduce chemicals other than explosives proposed under Alternative 1 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.1 Sediments and Water Quality (continued)	• <u>Other materials expended</u>: Under Alternative 1, the number of proposed training and testing activities that would introduce other materials, such as marine markers and flares, chaff, towed and stationary targets, and miscellaneous components, would increase over levels analyzed previously in the 2015 MITT Final EIS/OEIS. These materials and components are made mainly of nonreactive or slowly reactive materials (e.g., glass, carbon fibers, and plastics), or they break down or decompose into benign byproducts (e.g., rubber, steel, iron, and concrete). Increases in training and testing activities under Alternative 1 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS. **<u>Alternative 2 (Preferred Alternative)</u>:** • <u>Explosives and explosives byproducts</u>: Activities proposed under Alternative 2 would increase the number of explosive munitions used during at-sea training and testing activities and on FDM as compared to Alternative 1 and the number analyzed in the 2015 MITT Final EIS/OEIS. As noted under Alternative 1, all munitions would be dropped on the same existing impact areas on FDM under Alternative 2. The small increase of at-sea ordnance and ordnance dropped on FDM under Alternative 2 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS. Therefore, under Alternative 2, impacts on sediments and water quality from the use of explosives and generating explosives byproducts would be negligible. • <u>Metals</u>: Under Alternative 2, the number of sources of metals expended would increase as compared to the 2015 MITT Final EIS/OEIS and Alternative 1. However, these increases would have no appreciable change on the impact conclusions for metals under Alternative 1 and the 2015 MITT Final EIS/OEIS. • <u>Chemicals other than explosives</u>: Under Alternative 2, the number of sources that would generate chemicals other than explosives would increase as compared to Alternative 1. Impacts from chemicals other than explosives under Alternative 2 would be similar to impacts described under Alternative 1 despite a small increase in expended materials. • <u>Other materials expended</u>: The number of proposed training and testing activities that would introduce other expended materials would increase over levels analyzed previously in the 2015 MITT Final EIS/OEIS and as compared to Alternative 1; however, these increases would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.2 Air Quality	The Navy considered all stressors that could potentially impact air quality as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative**: • Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Implementation of the No Action Alternative would mean that emissions associated with proposed training and testing activities would no longer be produced; however, there would be no measurable change in air quality conditions. **Alternative 1**: • Criteria air pollutants: The amount of air pollutants emitted within territorial waters and subsequently transported ashore would be minor because pollutants would be emitted over large areas (i.e., 501,873 NM^2) mostly beyond 3 NM and would be substantially dispersed during transport. Increased emissions under Alternative 1 would not affect the NAAQS attainment status of the relevant air quality control regions nor impact the general public because criteria air pollutants are below *de minimis* thresholds. **Alternative 2 (Preferred Alternative):** • Criteria air pollutants: Under Alternative 2, the numbers of training and testing activities would increase over what is proposed under Alternative 1. Increased emissions however would not affect the NAAQS attainment status of the relevant air quality control regions nor impact the general public because criteria air pollutants are below *de minimis* thresholds.
Section 3.3 Marine Habitats	The Navy considered all stressors that could potentially impact marine habitats as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative:** • Under the No Action Alternative, proposed training and testing activities would not occur in the MITT Study Area. Discontinuing training and testing activities would result in fewer explosive and physical disturbance and strike stressors within the marine environment where training and testing activities have historically occurred. Therefore, discontinuing training and testing activities would reduce the potential for explosive or physical disturbance and strike stressor impacts on marine habitat, but would not measurably improve the overall distribution or abundance of marine habitat.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.3 Marine Habitats (continued)	**Alternative 1**: • Explosives: Most of the explosive military expended materials would detonate at or near the water surface. Training and testing activities that include bottom-laid in-water explosions under Alternative 1 would affect marine habitat structure in the Study Area, but these activities would occur in an area that has been previously disturbed and impacts would be localized. Mitigation measures would help the Navy avoid or reduce impacts on seafloor resources (including shallow-water coral reefs, live hard bottom, artificial reefs, and submerged cultural resources) from explosives during applicable activities. • Physical Disturbance and Strike: Vessel and in-water device strikes, military expended materials, seafloor devices, and personnel disturbance (walking, standing, or swimming in the nearshore waters during amphibious activities such as raids and assaults) could disturb bottom substrates. However, the impact of physical disturbance and strike stressors on marine habitats would remain inconsequential because (1) vessel and in-water activities that could come into contact with marine substrates would be located in previously disturbed areas (i.e., nearshore shallow waters), (2) military expended materials could be colonized by benthic organisms, and (3) seafloor devices would be used predominantly in previously disturbed areas and therefore would not be expected to affect marine substrates. **Alternative 2 (Preferred Alternative)**: • Explosives: The number of explosives are proposed to be the same as under Alternative 1 and increase compared to the 2015 MITT Final EIS/OEIS. However, proposed increases would have no appreciable change on the impact conclusions as described under Alternative 1. • Physical Disturbance and Strike: Proposed increases in some physical disturbance and strike stressors, such as military expended materials, could increase the impact risk on marine habitats but would have no appreciable change on the impact conclusions as described under Alternative 1, or impact conclusions presented in the 2015 MITT Final EIS/OEIS.
Section 3.4 Marine Mammals	The Navy considered all stressors that could potentially impact marine mammals as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative**: • Under the No Action Alternative, proposed training and testing activities would not occur in the MITT Study Area. Discontinuing training and testing activities would result in fewer stressors that potentially affect marine mammals. Therefore, discontinuing training and testing activities would reduce the potential for stressor impacts on marine mammals, but would not measurably improve the overall habitat, distribution, or abundance of marine mammals.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.4 Marine Mammals (continued)	**Alternative 1:** • Acoustics: Navy training and testing activities have the potential to expose marine mammals to multiple acoustic stressors. Exposures to sound-producing activities present risks to marine mammals that could include temporary or permanent hearing threshold shift, auditory masking, physiological stress, or behavioral responses. Individual animals would typically experience only a small number of behavioral responses or temporary hearing threshold shifts per year due to exposure to acoustic stressors, and these are very unlikely to lead to any costs or long-term consequences for individuals or populations. • Explosives: Explosions in the water or near the water's surface present a risk to marine mammals located in proximity to the explosion because the resulting shock waves could cause injury or result in the death of an animal. There are, however, no mortalities predicted by the analysis. If a marine mammal is farther from an explosion, the impulsive, broadband sounds introduced into the marine environment may cause a temporary or permanent threshold shift, auditory masking, physiological stress, or behavioral responses. Population-level effects on marine mammals are unlikely because most estimated impacts from explosions are behavioral responses or temporary threshold shifts, and the number of marine mammals potentially impacted by explosives are small compared to each species' respective abundance. • Energy: Navy training and testing activities have the potential to expose marine mammals to electromagnetic fields or high-energy lasers as energy stressors. The likelihood and magnitude of energy impacts depend on the proximity of marine mammals to energy stressors. Based on the relatively weak strength of the electromagnetic field created by some Navy activities, a marine mammal would have to be in close proximity for there to be any effect. Impacts on marine mammal migrating behaviors and navigational patterns are not anticipated. Statistical probability analyses with conservative assumptions (tending to overestimation of exposures) demonstrate with a high level of certainty that a marine mammal would not be struck by a high-energy laser. These activities are temporary and localized in nature, and may result in short-term and minor impacts on individual marine mammals, but would not result in long-term impacts on marine mammal populations. • Physical Disturbance and Strike: Marine mammals would potentially be exposed to multiple physical disturbance and strike stressors associated with Navy training and testing activities. Historical data indicate no occurrence of vessel strikes with marine mammals in the MITT Study Area over the last 10 years during any training and testing activities. Since the Navy does not anticipate a substantive change in the level of vessel use compared to the last decade, the potential for striking a marine mammal is not expected. Physical disturbance of individual marine mammals due to vessel movement and in-water devices may occur, but any stress response or avoidance behavior would not be severe enough to have long-term fitness consequences on individual marine mammals. The use of in-water devices during Navy activities involves multiple types of vehicles or towed devices traveling on the water surface, through the water column, or along the seafloor, all of which have

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.4 Marine Mammals (continued)	the potential to physically disturb or strike marine mammals. No recorded or reported instances of marine mammal strikes have resulted from in-water devices; therefore, impacts on individuals or long-term consequences to marine mammal populations are not anticipated. Potential impacts from military expended materials and seafloor devices are determined through statistical probability analyses. Analyses suggest a very low potential for marine mammals to be struck by these items. Long-term consequences on marine mammal populations from physical disturbance and strike associated with the use of vessels, in-water devices, military expended materials, and seafloor devices during training and testing activities are not anticipated. • <u>Entanglement</u>: Marine mammals could be exposed to multiple entanglement sources associated with Navy training and testing activities. The potential for impacts is dependent on the probability that a marine mammal would encounter an expended material, as well as the physical properties of the expended materials and the likelihood that a marine mammal could become entangled in the item. Physical characteristics of cables, wires, and decelerators/parachutes suggest that it is not likely a marine mammal would become entangled in these items. While it may be possible for a marine mammal to become entangled in cables or wires, the sparse distribution of these items throughout the Study Area indicates a very low potential for encounter. Furthermore, fiber optic cables used during mine warfare activities are easily abraded and have a low breaking strength, which reduces the risk of entanglement should a cable be encountered. Short-term impacts on individual marine mammals and long-term impacts on marine mammal populations from entanglement are not anticipated. • <u>Ingestion</u>: Navy training and testing activities have the potential to expose marine mammals to ingestion impacts from multiple sources. The potential for impacts relies heavily on feeding behaviors of marine mammals that occur in the Study Area, the physical properties of the expended items, the feasibility that a marine mammal could ingest the items, and the likelihood that a marine mammal would encounter an item. Marine mammals that forage along the water surface or within the water column are less likely to encounter ingestion stressors as they sink through the water column to the seafloor. Most expended materials that would remain floating or suspended within the water column are typically too small to pose a risk of intestinal blockage to any marine mammal that encounters it. Bottom-feeding marine mammals would be more likely to encounter expended materials that have already sunk to the floor. In the unlikely event that a marine mammal encounters and ingests expended material, the individual might be negatively affected if the material becomes lodged in the digestive tract. The likelihood that a marine mammal would ingest a military expended item associated with training and testing activities is considered low. Long-term consequences to marine mammal populations from expended materials associated with training and testing activities are not anticipated. • <u>Secondary</u>: Marine mammals would be exposed to secondary stressors associated with training and testing activities in the Study Area. In-water explosions have the potential to injure or kill prey species that marine mammals feed on; however, impacts would not substantially impact prey availability. Explosion byproducts are not considered as indirect stressors to

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.4 Marine Mammals (continued)	marine mammals while mixed in marine sediments or water. Explosion byproducts and unexploded munitions would have no lasting or meaningful effect on water quality and would therefore not constitute a secondary indirect stressor for marine mammals. Metals are introduced into the water and sediments from targets, munitions, and other expended materials. Evidence from a number of studies indicate metal contamination is localized and ephemeral, and bioaccumulation resulting from munitions was not observed in the studies specifically designed to look for bioaccumulation. Therefore, it is unlikely that impacts on marine mammal prey availability would occur. Several training and testing activities introduce explosive byproducts into the marine environment that are potentially harmful in concentration; however, rapid dilution would occur and toxic concentrations would not likely be encountered. Furthermore, there is no evidence of acute toxicity or chronic accumulation of chemicals introduced by Navy activities that would alter water quality to an extent that would result in overall habitat degradation for marine mammals. Transmission of diseases and parasites are not considered likely from the Navy's trained marine mammals because strict protocols are in place to prevent such impacts on wild populations. Secondary stressors from training and testing activities in the Study Area are not expected to have short-term impacts on individual marine mammals or long-term impacts on marine mammal populations. **Alternative 2 (Preferred Alternative):** • Acoustics: Potential impacts on marine mammals would be similar to those discussed for training and testing activities under Alternative 1. The only difference in sonar and other transducer use between Alternatives 1 and 2 is that the number of sonar hours used would be greater under Alternative 2. Potential impacts resulting from vessel noise would be similar to those discussed for activities under Alternative 1. The only difference in weapons noise impacts between Alternatives 1 and 2 is that the number of munitions used would be greater under Alternative 2. While the types of expected impacts on any individual marine mammal would remain the same, more animals could be affected. • Explosives: The locations and number of events involving explosives that could impact marine mammals would increase under Alternative 2 compared to Alternative 1 and the 2015 MITT Final EIS/OEIS. However, this increase would have no appreciable change on the impact conclusions described under Alternative 1. • Energy: The locations, number of events, and potential effects associated with energy stressors would be the same under Alternatives 1 and 2. Under Alternative 2, the use of high-energy lasers would increase as compared to Alternative 1. There would be no change regarding the impact conclusions for energy stressors under Alternative 1 and the 2015 MITT Final EIS/OEIS. • Physical Disturbance and Strike: Under Alternative 2, potential physical disturbance and strike impacts on marine mammals associated with training and testing activities would be similar to those discussed for activities under Alternative 1. There

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.4 Marine Mammals (continued)	would be a small increase in vessel and in-water device use in the Study Area. However, the difference would not result in substantive changes to the potential for or types of impacts on marine mammals. • Entanglement: There would be an increase in the number of military expended materials associated with Alternative 2 activities. However, the increase is negligible, and the potential impacts from wires and cables and decelerators/parachutes under Alternative 2 would be similar to that of Alternative 1. • Ingestion: Under Alternative 2, the locations and types of military expended materials used would be the same as those of Alternative 1. There would be an increase in the number of some items expended. However, the increase in the total number of items expended would not be expected to result in substantive changes to the type or degree of impacts on marine mammals. • Secondary: Impacts from secondary stressors on marine mammals resulting from Alternative 2 activities would be the same as those described under Alternative 1. Secondary stressors from training and testing activities in the Study Area are not expected to have short-term impacts on individual marine mammals or long-term impacts on marine mammal populations.
Section 3.5 Sea Turtles	The 2015 MITT Final EIS/OEIS analyzed potential impacts of at-sea training and testing activities, as well as amphibious landings on training beaches on Guam and within the CNMI, which may support sea turtle nesting. Activities on Guam, Rota, and Tinian are not proposed to change; therefore, the SEIS/OEIS only addresses potential stressors on sea turtles for training and testing activities at sea. The Navy considered all stressors that could potentially impact sea turtles as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative:** • Under the No Action Alternative, proposed training and testing activities would not occur in the MITT Study Area. Discontinuing the training and testing activities would result in fewer stressors that potentially affect sea turtles within the marine environment where training and testing have historically occurred. Therefore, discontinuing training and testing activities would reduce the potential for stressor impacts on sea turtles, but would not measurably improve the status of sea turtle populations. **Alternative 1:** • Acoustics: Navy training and testing activities have the potential to expose sea turtles to multiple acoustic stressors. Exposures to sound-producing activities present risks to sea turtles that could include temporary or permanent hearing threshold shift, auditory masking, physiological stress, or behavioral responses. Individual sea turtles would typically

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	**Summary of Impacts**
Section 3.5 Sea Turtles (continued)	experience only a small number of behavioral responses or temporary hearing threshold shifts per year due to exposure to acoustic stressors, and these are very unlikely to lead to any costs or long-term consequences for individuals or populations. • Explosives: Explosions in the water or near the water's surface present a risk to sea turtles located near the explosion because the resulting shock waves can cause injury or result in the death of an animal. If a sea turtle is farther from an explosion, the impulsive, broadband sounds introduced into the marine environment may cause a temporary or permanent threshold shift, auditory masking, physiological stress, or behavioral responses. Due to the low numbers of sea turtles anticipated to be in locations where explosives at sea are expended, impacts are unlikely to occur. Lower-NEW explosives were analyzed for potential impacts on sea turtles within nearshore habitats of Guam. Potential impacts resulting from these activity types are anticipated to be few, if any, due to the fact that other stressor types occur before nearshore explosives occur (such as small vessel movements and other activities on or above the water) that would likely induce sea turtles to leave the area. • Energy: In-water electromagnetic devices are not expected to result in population-level impacts for sea turtles due to the low intensity, localized potential impact area, and short duration of use. The use of high-energy lasers associated with training and testing activities is not expected to impact sea turtles as a result of the very low probability of a strike by a high-energy laser. • Physical Disturbance and Strike: Sea turtles would potentially be exposed to multiple physical disturbance and strike stressors associated with Navy training and testing activities. The potential for impacts relies heavily on the probability that sea turtles would be in close proximity to an activity (e.g., a vessel or an expended non-explosive munition). Green sea turtles and hawksbill sea turtles occur inside or within proximity to port locations where vessel movements would be most frequent. Use of vessels and in-water devices, military expended materials, and seafloor devices may cause short-term disturbance to an individual turtle within the Study Area. However, due to the low numbers of sea turtles anticipated to be in locations where these items are expended, impacts are unlikely to occur. • Entanglement: Sea turtles could be exposed to multiple entanglement sources associated with Navy training and testing activities. The potential for impacts is dependent on the probability that a sea turtle would encounter an expended material, the physical properties of the expended materials, and the likelihood that a sea turtle could become entangled in the item. Physical characteristics of cables, wires, and decelerators/parachutes suggest it is unlikely a sea turtle would become entangled in these items. While it may be possible for a sea turtle to become entangled in cables or wires, the sparse distribution of these items throughout the Study Area indicates a very low potential for encounter. Furthermore, fiber optic cables used during mine warfare activities are easily abraded and have a low breaking strength, which reduces the risk of entanglement should a cable be encountered.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.5 Sea Turtles (continued)	• Ingestion: Navy training and testing activities have the potential to expose sea turtles to ingestion impacts from multiple sources. The potential for impacts relies heavily on feeding behaviors of different sea turtle species that occur in the Study Area, the physical properties of the expended items, the feasibility that a sea turtle could ingest the items, and the likelihood that a sea turtle would encounter an item. Sea turtles that forage along the water surface or within the water column are less likely to encounter ingestion stressors as they sink through the water column to the seafloor. Most expended materials that would remain floating or suspended within the water column are typically too small to pose a risk of intestinal blockage to any sea turtle that encounters it. Bottom-feeding sea turtles would be more likely to encounter expended materials that have already sunk to the sea floor if the floor is within the dive depth of a particular sea turtle species. In the unlikely event that a sea turtle encounters and ingests expended material, the individual might be negatively affected if the material becomes lodged in the digestive tract. The likelihood that a sea turtle would ingest a military expended item associated with training and testing activities is considered low. • Secondary: Sea turtles would be exposed to secondary stressors associated with training and testing activities in the Study Area. In-water explosions have the potential to injure or kill prey species that some sea turtle species feed on; however, impacts would not substantially impact prey availability. Metals are introduced into the water and sediments from targets, munitions, and other expended materials. Evidence from several studies indicate metal contamination is localized and ephemeral, and bioaccumulation resulting from munitions was not observed in the studies specifically designed to look for bioaccumulation. Therefore, it is unlikely that impacts on sea turtle prey availability would occur. Furthermore, there is no evidence of acute toxicity or chronic accumulation of chemicals introduced by Navy activities that would alter water quality to an extent that would result in overall habitat degradation for sea turtles. **Alternative 2 (Preferred Alternative):** • Acoustics: Potential impacts on sea turtles would be similar to those discussed for training and testing activities under Alternative 1. The only difference in sonar and other transducer use between Alternatives 1 and 2 is that the number of sonar hours used would be greater under Alternative 2. Potential impacts resulting from vessel noise would be similar to those discussed for activities under Alternative 1. The only difference in weapons noise impacts between Alternatives 1 and 2 is that the number of munitions used would be greater under Alternative 2. While the types of expected impacts on any individual sea turtle would remain the same, more animals could be affected. • Explosives: The locations and number of events involving explosives would increase under Alternative 2 compared to Alternative 1 and the 2015 MITT Final EIS/OEIS. However, this increase would have no appreciable change on the impact conclusions described under Alternative 1.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.5 Sea Turtles (continued)	• <u>Energy</u>: The locations, number of events, and potential effects associated with energy stressors would be the same under Alternatives 1 and 2. Under Alternative 2, the use of high-energy lasers would increase as compared to Alternative 1. There would be no change regarding the impact conclusions described under Alternative 1 and the 2015 MITT Final EIS/OEIS. • <u>Physical Disturbance and Strike</u>: Under Alternative 2, potential physical disturbance and strike impacts on sea turtles associated with training and testing activities would be similar to Alternative 1. There would be a small increase in vessel and in-water device use in the Study Area. However, the difference would not result in substantive changes to the potential for or types of impacts on sea turtles. • <u>Entanglement</u>: There would be an increase in the number of military expended materials associated with Alternative 2 activities. However, the increase is negligible and the potential impacts from wires and cables and decelerators/parachutes under Alternative 2 would be similar to Alternative 1. • <u>Ingestion</u>: Under Alternative 2, the locations and types of military expended materials used would be the same as Alternative 1. There would be an increase in the number of some items expended. However, the increase in the total number of items expended would not be expected to result in substantive changes to the type or degree of impacts on sea turtles. • <u>Secondary</u>: Impacts from secondary stressors on sea turtles resulting from Alternative 2 activities would be nearly identical to Alternative 1.
Section 3.6 Marine Birds	The Navy considered all stressors that could potentially impact marine birds as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **<u>No Action Alternative</u>:** • Under the No Action Alternative, proposed training and testing activities would not occur in the MITT Study Area. Discontinuing training and testing activities would result in fewer stressors that potentially affect marine birds. Therefore, discontinuing training and testing activities would reduce the potential for stressor impacts on marine birds, but would not measurably improve the status of marine bird populations. **<u>Alternative 1</u>:** • <u>Acoustics</u>: Navy training and testing activities have the potential to expose marine birds to multiple acoustic stressors, such as sonar and other transducers, vessel noise, aircraft noise, and weapons noise. Birds are less susceptible to both temporary or permanent hearing threshold shifts relative to other marine species because birds have adaptions to protect the middle

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.6 Marine Birds (continued)	ear and tympanum from pressure changes during diving that may affect hearing. Therefore, 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. In-air noise was analyzed for potential impacts on birds in at-sea areas and on FDM. Training and testing activities on FDM would not significantly impact populations of marine birds on the island. This conclusion is based on statistical analysis of periodic population counts of masked, brown, and red-footed boobies by the Navy from 1998 through 2016, and the relatively small increases in the number of events, munitions, and NEW expended on FDM proposed under Alternative 1 compared to what was analyzed in the 2015 MITT Final EIS/OEIS. • Explosives: Explosions in the water or near the water's surface present a risk to marine birds located near the explosion because the resulting shock waves can cause injury or result in the death of an animal. Potential exposure to stressors associated with ordnance use would increase under Alternative 1 compared to the 2015 MITT Final EIS/OEIS. Factors that limit the potential for additional adverse impacts, however, include maintaining the same ordnance type and targeting restrictions included in the 2015 MITT Final EIS/OEIS and 2015 USFWS Biological Opinion. All ordnance expended on FDM would target existing impact zones, with the same ordnance restrictions imposed on all FDM activities and with the same avoidance and minimization measures in place. • Physical Disturbance and Strike: Navy training and testing activities have the potential to expose marine birds to multiple physical disturbance and strike stressors. In at-sea environments, the risk for marine birds is low because of the wide dispersal of training and testing activities throughout the Study Area. On FDM, where intensive military training and testing activities occur on an island that supports important marine bird rookery locations, the Navy analyzed munitions use and wildfires for potential impacts on marine birds. Factors that limit the potential for additional adverse impacts from physical disturbance and strike, however, include maintaining the same ordnance type and targeting restrictions included in the 2015 MITT Final EIS/OEIS. All ordnance expended on FDM would target existing impact zones, with the same ordnance restrictions imposed on all FDM activities and with the same avoidance and minimization measures in place. Recent relocation of target positions from the cliff to inland portions within impact zones further reduces potential impacts on marine bird rookeries on FDM. • Secondary: Marine birds would be exposed to multiple secondary stressors associated with training and testing activities in the Study Area. In-water explosions have the potential to injure or kill prey species that marine bird species feed on; however, impacts would not substantially impact prey availability. Metals are introduced into the water and sediments from targets, munitions, and other expended materials. Evidence from several studies indicate metal contamination is localized and ephemeral, and bioaccumulation resulting from munitions was not observed in the studies specifically designed to look for bioaccumulation. Therefore, it is unlikely that impacts on marine bird prey availability would occur. Furthermore, there is

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.6 Marine Birds (continued)	no evidence of acute toxicity or chronic accumulation of chemicals introduced by Navy activities that would alter water quality to an extent that would result in overall habitat degradation for marine birds. **Alternative 2 (Preferred Alternative):** • Acoustics: Potential impacts on marine birds would be similar to those discussed for training and testing activities under Alternative 1. The only difference in sonar and other transducer use between Alternatives 1 and 2 is that the number of sonar hours used would be greater under Alternative 2. Potential impacts resulting from vessel noise would be similar to those under Alternative 1. The only difference in weapons noise impacts between Alternatives 1 and 2 is that the number of munitions used would be greater under Alternative 2. While the types of expected impacts on any individual marine bird would remain the same, more animals could be affected. • Explosives: The locations and number of events involving explosives that could impact marine birds would increase under Alternative 2 compared to Alternative 1 and the 2015 MITT Final EIS/OEIS. However, this increase would not have no appreciable change on the impact conclusions described under Alternative 1. • Physical Disturbance and Strike: Under Alternative 2, potential physical disturbance and strike impacts on marine birds associated with training and testing activities would be similar to those discussed for activities under Alternative 1. There would be a small increase in vessel and in-water device use in the Study Area. However, the difference would not result in substantive changes to the potential for or types of impacts on marine birds. • Secondary: Impacts from secondary stressors on marine birds resulting from Alternative 2 activities would be nearly identical to those described under Alternative 1.
Section 3.7 Marine Vegetation	The Navy considered all stressors that could potentially impact marine vegetation as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative:** • Under the No Action Alternative, proposed training and testing activities would not occur in the MITT Study Area. Discontinuing training and testing activities would result in fewer stressors that potentially affect marine vegetation within the marine environment. Therefore, discontinuing training and testing activities would reduce the potential for stressor impacts on marine vegetation, but would not measurably improve the status of populations or subpopulations. **Alternative 1:** • Explosives: Explosives could affect vegetation by destroying or removing marine vegetation; however, the use of explosives

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.7 Marine Vegetation (continued)	is not expected to impact the long-term survival, annual reproductive success, and lifetime reproductive success of marine vegetation. • Physical Disturbance and Strike: Physical disturbance and strike could affect vegetation by destroying individuals or damaging parts of individuals; however, physical disturbance and strike impacts on marine vegetation under Alternative 1 would be negligible. • Secondary: Stressors from Navy training and testing activities could pose secondary or indirect impacts on marine vegetation via habitat, sediment, or water quality. Potential impacts on marine vegetation exposed to secondary stressors could occur indirectly through sediments and water quality. Explosive ordnance could loosen the soil on FDM and runoff from surface drainage areas containing soil, and explosive byproducts could contaminate sediments and the surrounding ocean water. **Alternative 2 (Preferred Alternative):** • Explosives: The locations and number of events involving explosives that could impact marine vegetation would increase under Alternative 2 compared to Alternative 1 and the 2015 MITT Final EIS/OEIS. However, this increase would have no appreciable change on the impact conclusions described under Alternative 1. • Physical Disturbance and Strike: Although impacts from physical disturbance and strike under Alternative 2 would increase slightly compared to those of Alternative 1 because of a small increase in proposed activities, physical disturbance and strike impacts on marine vegetation under Alternative 2 would also be negligible. • Secondary: Impacts from secondary stressors under Alternative 2 would increase slightly compared to those of Alternative 1 because of a small increase in activities and expended materials, but the difference would not result in substantive changes to the marine environment.
Section 3.8 Marine Invertebrates	The Navy considered all stressors that could potentially impact marine invertebrates as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative:** • Under the No Action Alternative, proposed training and testing activities would not occur in the MITT Study Area. Discontinuing training and testing activities would result in fewer stressors that potentially affect marine invertebrates within the marine environment. Therefore, discontinuing training and testing activities would reduce the potential for stressor impacts on marine invertebrates, but would not measurably improve the status of invertebrate populations or subpopulations.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.8 Marine Invertebrates (continued)	<u>Alternative 1</u>: • <u>Acoustics</u>: Marine invertebrates throughout the Study Area may be exposed to non-impulse sounds generated by low-, mid-, and high-frequency sonar and other acoustic sources, vessel noise, and aircraft noise during training and testing activities. Acoustic impacts on marine invertebrates under Alternative 1 would be inconsequential because most marine invertebrates would not be close enough to intense sound sources. Any marine invertebrate capable of sensing sound may alter its behavior and become disoriented due to masking of relevant environmental sounds if exposed to non-impulsive sound, although it is unknown if responses to non-impulsive sounds occur. Continuous noise, such as from vessels, may also contribute to masking of relevant environmental sounds. Because the distance over which most marine invertebrates are expected to detect any sound is limited and vessels would be in transit, any sound exposures with the potential to cause masking or behavioral responses would last only minutes. Furthermore, invertebrate species have their best sensitivity to sound below 1 kilohertz and would not be capable of detecting the majority of sonars and other acoustic sources used in the Study Area. Therefore, non-impulsive sounds associated with Alternative 1 are not expected to impact the majority of marine invertebrates or cause more than a short-term behavioral disturbance (e.g., change in orientation or swim speeds) to those capable of detecting nearby sound. No population-level impacts on the survival, growth, recruitment, or reproduction of populations are expected under Alternative 1. • <u>Explosives</u>: Most explosions at the water surface would not injure benthic marine invertebrates because of the great water depth in areas where most explosives would be used. Explosions would likely kill or injure nearby marine invertebrates. Effects could include physical disturbance, fragmentation, or mortality to sessile organisms and pelagic larvae. If corals are present in areas overlapping with other training and testing activities using explosives, sessile shallow-water corals, hard-bottom, and deep-water corals, as well as eggs, sperm, early embryonic stages, and planula larvae of corals could be impacted. Consequences of exposure to an explosive shock wave could include breakage, injury, or mortality. Many corals and hard bottom invertebrates are sessile, fragile, and particularly vulnerable. No long-term impacts are expected because exposures to explosive shock waves are brief, limited in number, and spread over a large area. Explosives may impact individuals and groups of marine invertebrates, but are unlikely to impact populations or subpopulations. Therefore, impacts on marine invertebrates under Alternative 1 from explosives would be negligible. • <u>Energy</u>: High-energy lasers are designed to disable surface targets, rendering them immobile. The primary concern is the potential for an invertebrate to be struck with the laser beam at or near the water's surface, where extended exposure could result in injury or death. Little information exists about marine invertebrates' susceptibility to electromagnetic fields. Most corals are thought to use water temperature, day length, lunar cycles, and tidal fluctuations as cues for spawning. Magnetic fields are not known to influence coral spawning or larval settlement. Most marine invertebrates are not susceptible to laser exposure because they occur beneath the sea surface. Under Alternative 1, the number of proposed

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.8 Marine Invertebrates (continued)	training and testing activities involving the use of in-water electromagnetic devices would decrease in comparison to the 2015 MITT Final EIS/OEIS. The activities would occur in the same locations and in a similar manner as were analyzed previously. Therefore, impacts on marine invertebrates under Alternative 1 from in-water electromagnetic devices would be negligible. • <u>Physical Disturbance and Strike</u>: The impact of physical disturbance and strike stressors on marine invertebrates is likely to cause injury or mortality to individuals, such as corals on nearshore reefs, but impacts on populations would be negligible because (1) the area exposed to the stressor is extremely small (localized) relative to most marine invertebrates' ranges, and (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one event. Activities involving vessels and in-water devices, military expended materials, seafloor devices, and personnel disturbance are not expected to yield behavioral changes or lasting effects on the survival, growth, recruitment, or reproduction of invertebrate species at the population level. However, the combined consequences of all physical disturbance and strike stressors could degrade habitat quality at some locations, to some degree. Combat swimmers and Marines may be required to walk through nearshore areas and reefs, potentially damaging coral species. These activities could cause injury or mortality to individuals, but impacts on marine invertebrate populations, including ESA-listed corals, are unlikely. Therefore, under Alternative 1, impacts on marine invertebrates from the use of vessels and in-water devices, military expended materials, and seafloor devices would be negligible. • <u>Entanglement</u>: Entanglement stressors that may impact marine invertebrates include (1) fiber optic cables and guidance wires, and (2) decelerators/parachutes. The impact of fiber optic cables, guidance wires, and decelerators/parachutes on marine invertebrates is not likely to cause injury or mortality to individuals, and impacts would be negligible because (1) the area exposed to the stressor is extremely small (localized) relative to most marine invertebrates' ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, and (3) marine invertebrates are not particularly susceptible to entanglement stressors. Activities involving cables, guidance wires, and decelerators/parachutes are not expected to yield behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels. Therefore, impacts on marine invertebrates from entanglement stressors under Alternative 1 would be negligible. • <u>Ingestion</u>: Most military expended materials and fragments of military expended materials are too large to be ingested by marine invertebrates. The potential for marine invertebrates to encounter fragments of ingestible size increases as the materials degrade into smaller fragments. The increase in military expended materials, primarily from small-caliber projectiles, would not represent an ingestion risk for marine invertebrates. Only a small fraction would be of ingestible size, or become ingestible after degradation; while those may impact individual marine invertebrates, such as ESA-listed corals,

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.8 Marine Invertebrates (continued)	they are unlikely to impact populations. Therefore, impacts on marine invertebrates from ingestion of military expended materials under Alternative 1 would be negligible. • Secondary: Potential impacts on marine invertebrates exposed to stressors could occur indirectly through sediments and water quality. Stressors from Navy training and testing activities could pose secondary or indirect impacts on marine invertebrates via habitat, sediment, or water quality. Components of these stressors that could pose indirect impacts include (1) explosives and byproducts; (2) metals; (3) chemicals; and (4) other materials such as targets, chaff, and plastics. Impacts on marine invertebrates, including zooplankton, eggs, and larvae, are likely within a very small radius of the ordnance (1–6 ft. [0.3–1.8 m]). These impacts may continue as the ordnance degrades over months to decades. Because most ordnance is deployed as projectiles, multiple unexploded or low-order detonations would accumulate on spatial scales of 1 to 6 ft. (0.3 to 1.8 m.); therefore, potential impacts are likely to remain local and widely separated. Given these conditions, the possibility of population-level impacts on marine invertebrates is negligible. Concentrations of metals in water are extremely unlikely to be high enough to cause injury or mortality to marine invertebrates; therefore, indirect impacts of metals via water are likely to be negligible and not detectable. Marine invertebrates could be indirectly impacted by chemicals from plastics but, absent bioaccumulation, these impacts would be limited to direct contact with the material because relatively few military expended materials contain plastics. Therefore, population-level impacts on marine invertebrates attributable to Navy-expended materials are likely to be negligible and not detectable. **Alternative 2 (Preferred Alternative):** • Acoustics: Under Alternative 2, increases in the number of sonar hours would have no appreciable change on the impact conclusions described for acoustic stressors under Alternative 1 and the 2015 MITT Final EIS/OEIS. Therefore, acoustic impacts on marine invertebrates under Alternative 2 would be negligible. • Explosives: Under Alternative 2, increases in the number of underwater explosives would have no appreciable change on the impact conclusions described for explosive stressors under Alternative 1 and the 2015 MITT Final EIS/OEIS. Therefore, impacts on marine invertebrates under Alternative 2 from explosives would be negligible. • Energy: The locations, number of events, and potential effects would be the same under Alternatives 1 and 2. Therefore, impacts on marine invertebrates under Alternative 2 from in-water electromagnetic devices would be negligible. • Physical Disturbance and Strike: Impacts on marine invertebrates would be inconsequential for the same reasons as Alternative 1, and there would have no appreciable change on the impact conclusions described for physical disturbance and strike stressors under Alternative 1 and in the 2015 MITT Final EIS/OEIS. Therefore, under Alternative 2, impacts on marine invertebrates from the use of vessels and in-water devices, military expended materials, and seafloor devices would be negligible.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.8 Marine Invertebrates (continued)	• Entanglement: Training and testing activities involving fiber optic cables, guidance wires, and decelerators/parachutes are not expected to yield behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of invertebrate species at individual or population levels for the same reasons as Alternative 1. Therefore, impacts on marine invertebrates from entanglement stressors under Alternative 2 would be negligible. • Ingestion: Under Alternative 2, the combined number of ingestion stressors would increase compared to Alternative 1. However, these increases would have no appreciable change on the impact analysis or conclusions described under Alternative 1 and in the 2015 MITT Final EIS/OEIS. Therefore, impacts on marine invertebrates from ingestion of military expended materials under Alternative 2 would be negligible. • Secondary: Impacts from secondary stressors on invertebrates resulting from activities under Alternative 2 would be nearly identical to those described under Alternative 1.
Section 3.9 Fishes	The Navy considered all stressors that could potentially impact fishes as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative:** • Under the No Action Alternative, proposed training and testing activities would not occur in the MITT Study Area. Discontinuing training and testing activities would result in fewer stressors that potentially affect fishes. Therefore, discontinuing training and testing activities would reduce the potential for stressor impacts on fishes, but would not measurably improve the status of fish populations or subpopulations. **Alternative 1:** • Acoustics: The use of sonar and other transducers, vessel noise, aircraft noise, and weapons noise could impact fishes in the Study Area. Some sonars and other transducers, vessel noise, and weapons noise could result in hearing loss, masking, physiological stress, or behavioral reactions. Aircraft noise would not likely result in impacts other than brief, mild behavioral responses in fishes close to the surface. Most impacts, such as masking or behavioral reactions, are expected to be temporary and infrequent, as most activities involving acoustic stressors would be at low levels of noise, 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. • Explosives: The use of explosives could result in impacts on fishes within the Study Area. Sound and energy from explosions are capable of causing mortality, injury, hearing loss, masking, physiological stress, or behavioral responses. The time scale of individual explosions is very limited, and training and testing activities involving explosions are dispersed in space and

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.9 Fishes (continued)	time. Therefore, repeated exposure of individual fishes is unlikely. Most effects such as hearing loss or behavioral responses are expected to be short term and localized. 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. • Energy: The use of in-water electromagnetic devices may elicit brief behavioral or physiological stress responses only in those exposed fishes with sensitivities to the electromagnetic spectrum. This behavioral impact is expected to be temporary and minor. Similar to regular vessel traffic, in-water electromagnetic fields would be continuously moving and cover only a small spatial area during use; thus, population-level impacts are unlikely. • Physical Disturbance and Strike: Impacts on fishes from vessel strikes, in-water device strikes, military expended material strikes, and seafloor device strikes are highly unlikely because most fishes are highly mobile and have sensory capabilities that enable the detection and avoidance of vessels, expended materials, or objects in the water column or on the seafloor. Exceptions include a few large, slow-moving species such as manta rays, ocean sunfish, and whale sharks that occur near the surface. Long-term consequences from vessel strikes for individuals and fish populations are not expected. • Entanglement: Fishes could be exposed to multiple entanglement stressors associated with Navy training and testing activities. The potential for impacts is dependent on the physical properties of the expended materials and the likelihood a fish would encounter a potential entanglement stressor and become entangled in it. Physical characteristics of wires and cables, and decelerators/parachutes, combined with the sparse distribution of these items throughout the Study Area, indicates a very low potential for fishes to encounter and become entangled in them. Population-level impacts are unlikely because of the low numbers of fishes potentially impacted by entanglement stressors. • Ingestion: The likelihood that expended items would cause a potential impact on a given fish species depends on the size and feeding habits of the fish, the rate at which the fish encounters the item, and the composition of the item. Military expended materials from munitions present an ingestion risk to fishes that forage in the water column and on the seafloor. Military expended materials other than munitions present an ingestion risk for fishes foraging at or near the surface while these materials are buoyant, and on the seafloor when the materials sink. Population-level impacts are unlikely because of the low numbers of fishes potentially impacted by ingestion stressors. • Secondary: Effects on sediment or water quality would be minor, temporary, and localized and could have short-term, small-scale secondary effects on fishes; however, there would be no persistent or large-scale effects on the growth, survival, distribution, or populations of fishes.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.9 Fishes (continued)	**<u>Alternative 2 (Preferred Alternative)</u>:** • <u>Acoustics</u>: Although the number of training and testing activities under Alternative 2 would increase relative to Alternative 1, acoustic impacts are not expected to be meaningfully different from those described under Alternative 1. Therefore, impacts associated with training and testing activities are the same as Alternative 1. • <u>Explosives</u>: Although activities under Alternative 2 increase relative to Alternative 1, impacts from explosives are not expected to be meaningfully different from those described under Alternative 1. Therefore, impacts associated with training and testing activities are the same as Alternative 1. • <u>Energy</u>: Although activities under Alternative 2 increase relative to Alternative 1, impacts from energy stressors are not expected to be meaningfully different from those described under Alternative 1. Therefore, impacts associated with training and testing activities are the same as Alternative 1. • <u>Physical Disturbance and Strike</u>: Although impacts from physical disturbance and strike under Alternative 2 would increase slightly compared to those of Alternative 1 because of a small increase in proposed activities, physical disturbance and strike impacts on marine fishes under Alternative 2 would also be negligible. • <u>Entanglement</u>: Although activities under Alternative 2 increase relative to Alternative 1, impacts from entanglement stressors are not expected to be meaningfully different from those described under Alternative 1. Therefore, impacts associated with training and testing activities are the same as Alternative 1. • <u>Ingestion</u>: Although activities under Alternative 2 increase relative to Alternative 1, impacts from ingestion stressors are not expected to be meaningfully different from those described under Alternative 1. Therefore, impacts associated with training and testing activities are the same as Alternative 1. • <u>Secondary</u>: Impacts from secondary stressors under Alternative 2 would increase slightly compared to those of Alternative 1 due to a small increase in activities and expended materials; however, the difference would not result in substantive changes. Therefore, impacts from secondary stressors associated with training and testing activities are the same as Alternative 1.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.10 Terrestrial Species and Habitats	The Navy considered all stressors that could potentially impact terrestrial species and habitats as a result of the Proposed Action. The SEIS/OEIS addresses potential impacts on terrestrial species and habitats on FDM. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative:** • Under the No Action Alternative, the proposed training and testing activities would not occur in the MITT Study Area. For FDM, the lease agreement between the U.S. government and the Commonwealth of the Northern Mariana Islands would remain in place, and the island would continue to be maintained as a Navy range. **Alternative 1:** • Acoustics: Navy training activities have the potential to expose terrestrial wildlife on FDM to multiple acoustic stressors. Sources of noise from weapons firing that may be heard by wildlife on FDM include close-in weapons firing from vessels, helicopters, close-combat surface firing from fixed-wing aircraft, and surface firing, with the largest increase in munitions use resulting from small arms, medium-caliber explosives, and mortar and grenade use during Direct Action training activities. These training events would occur within the Northern Special Use Area and fire into the impact areas towards the south; therefore, more megapodes and bats (along with other wildlife species) would be exposed to more weapons firing noise under Alternative 1 because of the increased number of small-caliber rounds, medium-caliber explosives, and grenades and mortars fired into impact areas from the Northern Special Use Area. The weapons-firing noise would likely be masked somewhat by natural sounds on FDM, such as waves and winds. The impulsive sound caused by weapon firings would have limited potential to mask important biological sound because the duration of the impulse is brief, even when multiple shots are fired in series. • Explosives: There would be a small increase in the number of explosions on FDM, which would increase the number of exposures to percussive force. The types of explosive munitions used on FDM include explosive bombs, missiles, rockets, explosive grenades and mortars, medium-caliber projectiles, and large-caliber projectiles. The number of explosive bombs would not change compared to the 2015 MITT Final EIS/OEIS, while the increases in NEW would be from the increased number of smaller NEW munitions. Although more ordnance would be used on FDM under Alternative 1, all of the ordnance would target impact zones, with the same avoidance and minimization measures in place as analyzed previously in 2015. • Physical Disturbance and Strike: Navy training activities have the potential to impact terrestrial species and habitats through direct strike, habitat disturbance, and potential wildfires ignited by training activities on FDM. Factors that limit the potential for additional adverse impacts from physical disturbance and strike, however, include maintaining the same ordnance type and targeting restrictions included in the 2015 MITT Final EIS/OEIS. All ordnance expended on FDM would

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.10 Terrestrial Species and Habitats (continued)	target existing impact zones, with the same ordnance restrictions imposed on FDM activities and with the same avoidance and minimization measures in place. • Secondary: The Navy analyzed the potential for invasive species introduction, establishment, and spread on FDM as part of the analysis for secondary stressors. Of the two training activity types that would increase on FDM under Alternative 1, only Direct Action training activities present potential introduction pathways for invasive species. Introduction pathways that originate on Guam and end on FDM present a potential hazard for brown treesnake dispersal. The Direct Action training activities, which are proposed to increase, would still be subject to biosecurity measures. The potential introduction of invasive species to FDM from additional transits during Direct Action training activities is unlikely; therefore, there would be no appreciable increase in risk. **Alternative 2 (Preferred Alternative):** • Acoustics: Potential impacts on terrestrial species and habitats would be similar to those discussed under Alternative 1. Under Alternative 2, there would be an increase in the amount of ordnance expended compared to Alternative 1. As with Alternative 1, these training events would occur within the Northern Special Use Area and fire into the impact areas towards the south; therefore, more megapodes and bats (along with other wildlife species) would be exposed to more weapons firing noise under Alternative 2 because of the increased number of small-caliber rounds, medium-caliber explosives, and grenades and mortars fired into impact areas from the Northern Special Use Area. The weapons-firing noise would likely be masked somewhat by natural sounds on FDM, such as waves and winds. Additionally, the impulsive sound caused by weapon firings would have limited potential to mask important biological sound because the duration of the impulse is brief, even when multiple shots are fired in series, and the short duration of an exercise expending munitions on FDM. • Explosives: Under Alternative 2, there would be an increase in the number of events using FDM as a training location or target, with a corresponding increase in the number of munitions items expended on FDM (see Table 3.6-2) compared to what was analyzed previously in the 2015 MITT Final EIS/OEIS and under Alternative 1. However, factors that limit the potential for additional adverse impacts would include maintaining the same ordnance type and targeting restrictions consistent with Alternative 1. • Physical Disturbance and Strike: Under Alternative 2, potential physical disturbance and strike impacts on terrestrial species and habitats would be similar to those discussed under Alternative 1. All ordnance expended on FDM would target existing impact zones, with the same ordnance restrictions imposed on FDM activities and with the same avoidance and minimization measures in place. Recent relocation of target positions from the cliff to inland portions within impact zones further reduces potential impacts on terrestrial species and wildlife on FDM.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.10 Terrestrial Species and Habitats (continued)	• Secondary: Impacts from secondary stressors on terrestrial species and habitats on FDM resulting from Alternative 2 activities would be nearly identical to those from Alternative 1.
Section 3.11 Cultural Resources	The Navy considered all stressors that could potentially impact cultural resources as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative:** • Under the No Action Alternative, the proposed training and testing activities would not occur in the MITT Study Area. Discontinuing training and testing activities would result in fewer stressors that potentially affect cultural resources. Therefore, discontinuing training and testing activities would reduce the potential for stressor impacts on cultural resources. **Alternative 1:** • Explosives: Explosive stressors resulting from underwater explosions creating shock waves and cratering of the seafloor would not result in adverse effects to known submerged cultural resources because of the great water depth in areas where most explosives would be used. In accordance with Section 402 of the NHPA, no known World Heritage Sites would be affected. Therefore, no submerged cultural resources are expected to be impacted. • Physical Disturbance and Strike: Physical disturbance and strike stressors resulting from in-water devices, military expended materials, and seafloor devices during training and testing activities would not result in adverse effects on known submerged cultural resources because of the deep water and the implementation of standard operating procedures. Devices are also designed so they do not come in contact with the sea floor. In accordance with Section 402 of the NHPA, no known World Heritage Sites would be affected. Therefore, no submerged cultural resources are expected to be affected. • Measures to avoid and protect submerged historic properties would continue to be implemented according to the mitigation measures and procedures identified and described in the 2009 MIRC Programmatic Agreement. While the MIRC Programmatic Agreement expired in December 2019, the Navy initiated an NHPA Section 106 consultation in January 2019 with an eye toward developing new updated Programmatic Agreements. The interim PAs took effect after the expiration of the 2009 MIRC PA and serve as a continuation of the DoD's compliance under Section 106 of the NHPA for MITT activities. The interim PA with the CNMI Historic Preservation Officer (HPO) expires September 10, 2020, while the interim PA with the Guam HPO expires June 30, 2020.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.11 Cultural Resources (continued)	**Alternative 2 (Preferred Alternative):** • Explosives: Explosive ordnance would continue to occur in the same areas and would have no appreciable change on the impact analysis or conclusions described under Alternative 1 and in the 2015 MITT Final EIS/OEIS. Therefore, potential effects would the same as under Alternative 1. • Physical Disturbance and Strike: Under Alternative 2, increases as compared to Alternative 1 would have no appreciable change on the impact conclusions described under Alternative 1 and in the 2015 MITT Final EIS/OEIS. Therefore, potential effects would be the same as under Alternative 1.
Section 3.12 Socioeconomic Resources and Environmental Justice	The Navy considered all stressors that could potentially impact socioeconomic resources and environmental justice as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative:** • Under the No Action Alternative, the proposed training and testing activities would not occur in the MITT Study Area. Limits on accessibility to the ocean and airspace associated with the proposed training and testing activities would not be introduced. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. • Discontinuing training and testing activities would result in fewer stressors on socioeconomic resources within the marine environment where training and testing activities have historically occurred. Therefore, discontinuing training and testing activities would reduce the potential for impacts on socioeconomic resources, such as commercial and recreational fishing, commercial transportation and shipping, tourism, and traditional fishing practices in the Study Area. • The Navy and Navy personnel are an important and often stabilizing contributor to the local and regional economies. Therefore, not conducting the proposed at-sea training and testing activities may have negative impacts on the socioeconomic resources of Guam and the CNMI. The number and types of jobs available on Guam and to a lesser extent the CNMI may decline. For example, vessels and associated equipment used specifically for military readiness activities would no longer be needed if training and testing activities ceased. Consequently, the civilian and Navy personnel supporting those activities may be relocated or reassigned, or have to find other employment. The secondary effects from reducing the number of personnel who support at-sea military training and testing activities could include a decline in revenue for local businesses frequented by Navy personnel and their families, such as businesses in the food services, retail, and housing sectors.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.12 Socioeconomic Resources and Environmental Justice (continued)	**Alternative 1:** • Accessibility: Alternative 1 may result in impacts on commercial and recreational fishing, traditional fishing practices, or tourism when areas of co-use are temporarily inaccessible during training and testing activities to ensure public safety. Some areas in the Study Area are permanently restricted and inaccessible by the public, notably the waters extending 3 NM from shore around FDM. These restrictions remain in place to ensure the safety of the public. No impacts on commercial transportation and shipping are anticipated because training and testing activities are scheduled and located to avoid potential conflicts with commercial vessels and air traffic. The military would continue to collaborate with local communities to enhance existing means of communication with the public to reduce the potential effects of limiting accessibility. • Airborne Acoustics: Under Alternative 1, potential impacts from airborne acoustics from proposed training and testing activities would remain consistent with ongoing activities and would not be significant. • Physical Disturbance and Strike and Airborne Acoustic Disturbances: Alternative 1 is not expected to result in impacts from physical disturbance and strike or airborne acoustic disturbances on commercial and recreational fishing, traditional fishing practices, other recreational activities or tourism because the vast majority of training and testing activities would occur in areas far from locations typically used by the public for fishing and recreation activities. Furthermore, the large size of the Study Area over which the proposed military training and testing activities would be distributed, and adherence to the Navy's standard operating procedures, would further reduce the potential for impacts. • Environmental Justice: Traditional fishers in Guam and the CNMI would not be disproportionately impacted by limits on accessibility, airborne acoustic disturbances, or the possibility of physical disturbance and strike because traditional fishers typically use the same general areas as recreational fishers, specifically areas closer to shore and far from the majority of training and testing activities. **Alternative 2 (Preferred Alternative):** • Accessibility: Limits on accessibility to marine areas used by the public could increase under Alternative 2 due to an increase in some training and testing activities. However, this increase would be a slight change and would have no appreciable change on the potential for impacts over what is analyzed for Alternative 1. • Airborne Acoustics: Under Alternative 2, potential impacts from airborne acoustics from proposed training and testing activities would remain consistent with ongoing activities and would not be significant. • Physical Disturbance and Strike: Under Alternative 2, potential physical disturbance and strike impacts associated with training and testing activities would be similar to those as described under Alternative 1.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.12 Socioeconomic Resources and Environmental Justice (continued)	• Environmental Justice: Under Alternative 2, environmental justice impacts associated with training and testing activities would be similar to those as described under Alternative 1.
Section 3.13 Public Health and Safety	The Navy considered all stressors that could potentially impact public health and safety as a result of the Proposed Action. The following conclusions have been reached for the No Action and Action Alternatives: **No Action Alternative:** • Under the No Action Alternative, the proposed training and testing activities would not occur in the MITT Study Area. Not conducting the proposed at-sea training and testing activities may reduce the potential for interactions between the Navy and civilians but would not measurably improve public health and safety. **Alternative 1:** • Underwater Energy: Sources of underwater energy include active sonar, underwater explosions, air guns, vessel movements, aircraft overflights, mine warfare devices, and unmanned underwater vehicles. Standard operating procedures are in place to ensure no overlap between military and non-military activities. Impacts on public health and safety under Alternative 1 would be unlikely because of the military's implementation of safety procedures. • In-Air Energy: In-air energy stressors include sources of electromagnetic energy and lasers, such as radar, navigational aids, high-energy lasers, and electronic warfare systems. High-energy lasers would be used during testing activities that were not previously analyzed. Standard operating procedures would be in place to prevent personnel and non-participants from being exposed. Impacts on public health and safety under Alternative 1 would be unlikely because of the military's implementation of safety procedures. • Physical Interactions: Military aircraft, vessels, targets, munitions, towed devices, seafloor devices, and other expended materials have the potential to encounter recreational, commercial, institutional, and governmental aircraft; vessels; and users such as swimmers, divers, and anglers. Standard operating procedures are in place to ensure no overlap between military and non-military activities. Impacts on public health and safety under Alternative 1 would be unlikely because of the military's implementation of safety procedures.

Table ES.5-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.13 Public Health and Safety (continued)	• Secondary Stressors: Impacts on public health and safety would be unlikely because there would be no violation of any standards or guidelines structured to protect human health. **Alternative 2 (Preferred Alternative):** • Underwater Energy: The locations, number of events, and potential effects associated with underwater energy stressors would increase under Alternative 2 compared to Alternative 1. However, standard operating procedures for in-water energy sources would prevent impacts on public health and safety. • In-Air Energy: The locations, number of events, and potential effects associated with in-air energy stressors would increase under Alternative 2 compared to Alternative 1. However, standard operating procedures for in-air energy sources would prevent impacts on public health and safety. • Physical Interactions: Impacts on public health and safety under Alternative 2 would be unlikely, even with increased activity levels, because of the military's implementation of standard operating procedures. • Secondary Stressors: Potential impacts from secondary stressors under Alternative 2 would be the same as Alternative 1.

Notes: SEIS/OEIS = Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement, ESA = Endangered Species Act, FDM = Farallon de Medinilla, MBTA = Migratory Bird Treaty Act, MITT = Mariana Islands Training and Testing, MMPA = Marine Mammal Protection Act, Navy = United States Department of the Navy, U.S. = United States, USFWS = U.S. Fish and Wildlife Service, NMFS = National Marine Fisheries Service, MIRC = Mariana Islands Range Complex, CNMI = Commonwealth of the Northern Mariana Islands, NEW = Net Explosive Weight, ft. = feet, m = meter(s), NM = nautical miles, NM^2 = square nautical miles, NAAQS = National Ambient Air Quality Standards, NHPA = National Historic Preservation Act

ES.5.1 Cumulative Impacts

All resources are analyzed in Chapter 4 (Cumulative Impacts); however, based on guidance from the CEQ (Council on Environmental Quality, 1997), the 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 overlap with impacts from existing activities. Therefore, a full analysis of potential cumulative impacts is provided for marine mammals, marine invertebrates, sea turtles, and socioeconomic resources:

- Past human activities have impacted these resources to the extent that several marine mammals, sea turtles, marine invertebrate species, and some terrestrial species occurring in the Study Area are ESA-listed. Several marine mammal species have stocks that are classified as strategic stocks under the MMPA.
- The use of sonar and other non-impulsive sound sources under Alternative 1 and Alternative 2 has the potential to disturb or injure marine mammals and sea turtles.
- Explosive detonations, and vessel strikes under Alternative 1 and Alternative 2 have the potential to disturb, injure, or kill marine mammals and sea turtles.
- Under Alternative 1 and Alternative 2, danger zones would restrict access to fishing and recreational areas when ranges are in use.

The aggregate impacts of past, present, and other reasonably foreseeable future actions would continue to have significant impacts on some individual marine mammals and all sea turtle species in the Study Area. Alternative 1 or Alternative 2 would contribute to cumulative impacts; however, marine mammal and sea turtle mortality and injury from non-Navy actions associated with commercial fisheries, commercial vessel strikes, and entanglement in marine debris are the leading causes of direct mortality to marine mammals and sea turtles (Carretta et al., 2017; Helker et al., 2017; Lent & Squires, 2017; National Marine Fisheries Service, 2016; National Oceanic and Atmospheric Administration Marine Debris Program, 2014; Read et al., 2006). In summary, based on the analysis presented in Sections 3.4 (Marine Mammals), 3.5 (Sea Turtles), 3.8 (Marine Invertebrates), and 3.12 (Socioeconomic Resources), the current aggregate impacts of past, present, and other reasonably foreseeable future actions are not significantly different than the assessment in the 2015 MITT Final EIS/OEIS. For marine mammals, sea turtles, and marine invertebrates, Alternative 1 or Alternative 2 would contribute to and increase cumulative impacts, but the relative contribution would be negligible compared to other non-Navy actions. Cumulative effects on socioeconomic resources may have short-term impacts on accessibility to public services, fishing sites, and tourism, but they are not expected to have long-term negative impacts on these resources or the economy of Guam and the CNMI. No new information or circumstances are significant enough to warrant further cumulative impact review.

The analysis presented in Chapter 3 (Affected Environment and Environmental Consequences) and Chapter 4 (Cumulative Impacts) indicates the incremental contribution of Alternative 1 or Alternative 2 to cumulative impacts on sediments and water quality, air quality, marine habitats, marine birds, marine vegetation, fishes, cultural resources, and public health and safety would occur but be negligible.

ES.6 Standard Operating Procedures, Mitigation, and Monitoring

Within the Study Area, the Navy implements standard operating procedures, mitigation measures, and marine species monitoring and reporting. Marine species monitoring and reporting efforts are designed to track compliance with take authorizations, evaluate the effectiveness of mitigation measures, and improve understanding of the effects of training and testing activities on marine resources.

ES.6.1 Standard Operating Procedures

For training and testing to be effective, units must be able to safely use their sensors and weapons systems optimally as they are intended to be used in military missions and combat operations and to their optimum capabilities. Standard operating procedures applicable to training and testing have been developed through years of experience. The primary purpose of these procedures is to provide for safety (including public health and safety) and mission success and therefore are included as part of the Proposed Action and considered in the Chapter 3 (Affected Environment and Environmental Consequences) environmental analysis for applicable resources. As described in Section 2.3.3 (Standard Operating Procedures), there are benefits to environmental and cultural resources resulting from the Navy's implementation of standard operating procedures.

ES.6.2 Mitigation

Mitigation measures differ from standard operating procedures. Mitigation is designed specifically for the purpose of avoiding or reducing potential impacts from the Proposed Action on environmental and cultural resources, whereas standard operating procedures are designed to provide for safety and mission success. Mitigation measures that the Navy would implement under the Proposed Action are organized into three categories: procedural mitigation measures for at-sea activities, at-sea mitigation areas, and terrestrial mitigation measures for activities on FDM. Procedural mitigation is mitigation that would be implemented whenever and wherever an applicable training or testing activity takes place within the Study Area. Mitigation areas are geographic locations within the Study Area where the military would implement additional mitigation during all or part of the year. Terrestrial mitigation measures are measures that the Navy would implement during applicable training and testing activities on land at FDM.

The Navy coordinated with the appropriate regulators (e.g., NMFS) on the mitigation measures detailed in Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment) through the consultation and permitting processes. The Navy Record of Decision, MMPA Regulations and Letter of Authorization, ESA Biological Opinion, and other applicable consultation documents would document all mitigation measures the Navy would implement under the Proposed Action.

ES.6.3 Mitigation Measures Considered but Eliminated

A number of possible additional mitigation measures were suggested during the public scoping period and Draft SEIS/OEIS public comment period, as well as during comment periods of previous Navy environmental documents. Section 5.6 (Measures Considered but Eliminated) and Appendix I (Geographic Mitigation Assessment) contain information on measures that did not meet the appropriate balance between being effective and practical to implement and therefore would not be implemented under the Proposed Action.

ES.6.4 Monitoring and Reporting

The Navy is committed to demonstrating environmental stewardship while executing its national security mission, complying with the suite of applicable federal environmental laws and regulations, and providing required and relevant reports to appropriate regulatory agencies. Since 2006, across all Navy range complexes (Mariana Islands, Pacific, Atlantic, Gulf of Mexico, and Gulf of Alaska), the Navy has produced Major Exercise Reports, Annual Exercise Reports, and Monitoring Reports and submitted to

NMFS to further research goals aimed at understanding the Navy's impact on the environment as it trains and conducts tests to accomplish its mission. As a complement to the Navy's commitment to avoiding and reducing impacts of the Proposed Action through mitigation, the Navy will undertake monitoring efforts to track compliance with take authorizations, help investigate the effectiveness of implemented mitigation measures, and better understand the impacts of the Proposed Action on marine resources. Taken together, mitigation and monitoring comprise the Navy's integrated approach for reducing environmental impacts from the Proposed Action. The Navy's overall monitoring approach will seek to leverage and build on existing research efforts whenever possible.

Consistent with the cooperating agency agreement with NMFS, mitigation and monitoring measures presented in the SEIS/OEIS focus on the requirements for protection and management of marine resources. Since monitoring will be required for compliance with the Final Rule issued for the Proposed Action under the MMPA, details of the monitoring program are being developed in coordination with NMFS through the regulatory process.

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

The Navy is committed to documenting and reporting relevant aspects of training and testing activities to reduce environmental impacts and improve future environmental assessments. Initiatives include training and testing activity reporting and incident reporting. Additional information is available on the U.S. Navy Marine Species Monitoring Program website www.navymarinespeciesmonitoring.us.

ES.7 Other Considerations

ES.7.1 Consistency with Other Federal, Guam, CNMI, and Local Plans, Policies, and Regulations

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

ES.7.2 Relationship Between Short-Term Use of the Human Environment and Maintenance and Enhancement of Long-Term Productivity

In accordance with NEPA, the SEIS/OEIS provides an analysis of the relationship between a project's short-term impacts on the environment and the effects 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, it would not be expected to result in 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.7.3 Irreversible or Irretrievable Commitment of Resources

For both Alternative 1 and Alternative 2, 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 result of implementation of the Proposed Action. There would be no building or facility construction; therefore, the consumption of materials typically associated with such construction (e.g., concrete, metal, sand, or fuel) would not occur. Energy typically associated with construction activities would not be expended and irreversibly lost.

Implementation of the Proposed Action would require fuels used by aircraft, ships, and ground-based vehicles. Relative total fuel use could increase because fixed- and rotary-wing flight and ship activities could increase. Therefore, if total fuel consumption increased, this nonrenewable resource would be considered irretrievably lost.

ES.7.4 Energy Requirements and Conservation Potential of Alternatives

Resources that would be permanently and be continually consumed by implementation of the Proposed Action 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.

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

ES.8 Public Involvement

The first step in the NEPA process for an EIS is to prepare a Notice of Intent to develop an EIS. The Navy published a Notice of Intent for the SEIS/OEIS in the *Federal Register* and several newspapers on August 1, 2017. In addition, the public notices were distributed to federal, state, and local elected officials and government agencies. The Notice of Intent provided an overview of the Proposed Action and the scope of the SEIS/OEIS, and initiated the scoping process.

ES.8.1 Scoping Process

In accordance with CEQ regulations for implementing the requirements of NEPA, scoping is not required for a supplement to a draft or final EIS (40 CFR 1502.9(c)(4)); however, in an effort to maximize public participation and ensure the public's input was considered, the Navy chose to conduct scoping for the SEIS/OEIS.

Public scoping comments were accepted during the 45-day scoping period from August 1, 2017 to September 15, 2017. In total, the Navy received 36 comment submissions from individuals, groups, agencies, and elected officials. The Navy considered all scoping comments in preparing the SEIS/OEIS.

ES.8.2 Draft Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement Public Comments

The Draft SEIS/OEIS was released for public review and comment February 1, 2019 through April 17, 2019. The Navy made the following efforts to facilitate maximum public participation during the Draft SEIS/OEIS public review and comment period:

- Sent notification letters to federal and local elected officials and agencies.

- Mailed postcards to 350 recipients on the project mailing list, including individuals; non-governmental organizations; community and business groups; fishing, aviation, and recreation groups; and private companies.
- Distributed news releases to announce the availability of the Draft SEIS/OEIS and public meetings.
- Participated in numerous press and media engagements to broadcast availability of the Draft SEIS/OEIS and public meetings.
- Placed newspaper advertisements to announce the availability of the Draft SEIS/OEIS and public meetings in local and regional newspapers.
- Held three public meetings in the CNMI (Tinian, Rota, and Saipan) and one in Guam.

Changes in this Final SEIS/OEIS reflect comments made on the Draft SEIS/OEIS during the public comment period. Appendix K (Public Comment Responses) describes the public's participation and includes a list of the agencies and private entities that commented on the Draft SEIS/OEIS, along with a comment matrix with Navy responses associated with the comments received.

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Acronyms and Abbreviations

Acronym	Definition
µPa	Micropascal(s)
ac.	Acre(s)
AGL	Above Ground Level
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AnnualEx	Annual Exercise
ANSI	American National Standards Institute
BO	Biological Opinion
BOBO	2nd Lt. John P. Bobo class vessel
BSP	Bureau of Statistics and Plans
CD	Consistency Determination
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CJMT	Commonwealth of the Northern Mariana Islands Joint Military Training
CNMI	Commonwealth of the Northern Mariana Islands
CO	Carbon Monoxide
CV	Coefficient of Variation
dB	Decibel(s)
dB re 1 µPa	Decibels referenced to 1 micropascal
dB re 1 µPa^{2}s	Decibels referenced to 1 micropascal squared seconds
dBA	A-weighted decibel
dBA re 1 µPa	A-weighted db referenced to 1 micropascal
dBA re 1 µPa^{2}s	A-weighted db referenced to 1 micropascal squared seconds
DCRM	Division of Coastal Resources Management
DDT	Dichlorodiphenyltrichloroethane
DNT	Dinitrotoluene
DoD	Department of Defense
DPS	Distinct Population Segment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFHA	Essential Fish Habitat Assessment
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FDM	Farallon de Medinilla
FEP	Fishery Ecosystem Plan
FR	Federal Register
ft.	Foot/feet
FY	Fiscal Year
GDP	Gross Domestic Product
GuamEx	Guam Exercise
GUNEX	Gunnery Exercise
ha	Hectare
HAPC	Habitat Area of Particular Concern
HARM	High-Speed Anti-Radiation Missile
HE-ET	High Explosive-Electronic Time
HF	High Frequency
HMX	High Melting Explosive
HPO	Historic Preservation Officer
hr.	Hour(s)
HRC	Hawaii Range Complex
Hz	Hertz
in.	Inch(es)
JRM	Joint Region Marianas
kHz	Kilohertz
km	Kilometers
lb.	Pound(s)
LF	Low Frequency
LMSR	Large, Medium Speed, Roll On/Roll Off
LOA	Letter of Authorization
m	Meter(s)

Acronym	Definition
MBTA	Migratory Bird Treaty Act
MF	Mid-Frequency
MHz	Megahertz
mi.	Mile(s)
MIRC	Mariana Islands Range Complex
MISSILEX	Missile Exercise
MITT	Mariana Islands Training and Testing
mm	millimeter(s)
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSC	Military Sealift Command
Navy	U.S. Department of the Navy
NEPA	National Environmental Policy Act
NEPM	Non-Explosive Practice Munition
NEW	Net explosive weight
NM	Nautical Mile(s)
NM^2	Square Nautical Miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
NO_x	Nitrogen oxide
OEIS	Overseas Environmental Impact Statement
Pa	Pascal
Pa-s	Pascal-second(s)
PCB	Polychlorinated Biphenyl
PM_{10}	Particulate matter less than 10 microns
$PM_{2.5}$	Particulate matter less than 2.5 microns
PSD	Prevention of Significant Deterioration
psi	Pounds per square inch
Psi-ms	Pounds per square inch per millisecond
PTS	Permanent Threshold Shift
R	Restricted Area
RDX	Royal Demolition Explosive
RL	Received SPL
rms	Root-Mean-Square
ROD	Record of Decision
SAR	Stock Assessment Report
SEIS	Supplemental Environmental Impact Statement
SEL	Sound Exposure Level
SHPO	State Historic Preservation Officer
SL	Source Level
SO_2	Sulfur Dioxide
SO_X	Sulfur Oxide
SPL	Sound Pressure Level
SWATT	Surface Warfare Advanced Tactical Training
TNT	Trinitrotoluene
tpy	Tons per year
TS	Threshold Shift
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
UNDET	Underwater Detonation
USFWS	U.S. Fish and Wildlife Service
VOC	Volatile Organic Compound
W	Warning Area

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) has prepared this supplement to the May 2015 Mariana Islands Training and Testing (MITT) Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) (U.S. Department of the Navy, 2015) pursuant to Council on Environmental Quality Regulations. The Navy proposes to conduct training activities (referred to as "training"), and research, development, testing and evaluation (referred to as "testing") activities in the MITT Study Area, primarily within the existing Mariana Islands Range Complex (MIRC), as represented in Figure 1.1-1. Training and testing activities, collectively referred to as "military readiness activities," that prepare the Navy to fulfill its mission to protect and defend the United States and its allies, have the potential to impact the environment. The Navy prepared this Supplemental EIS (SEIS)/OEIS to comply with the National Environmental Policy Act (NEPA) and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, by reassessing the potential environmental impacts associated with the proposed military readiness activities to be conducted within the Study Area.

This SEIS/OEIS was prepared to update the Navy's assessment of the potential environmental impacts associated with proposed training and testing to be conducted at sea and on Farallon de Medinilla (FDM). These proposed activities are generally consistent with those at-sea and FDM activities analyzed in the May 2015 *Final Mariana Islands Training and Testing Activities Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy, 2015), referred to as the 2015 MITT Final EIS/OEIS, and are representative of activities the military has been conducting in the Study Area for decades.[1] These military readiness activities include the use of active sonar and explosives at sea off the coasts of Guam and the Commonwealth of the Northern Mariana Islands (CNMI), throughout the in-water areas around the MIRC, the transit corridor between the MIRC and the Hawaii Range Complex, and at select Navy pierside and harbor locations.

The 2015 MITT Final EIS/OEIS also analyzed training and testing activities conducted at existing MIRC land-based training areas located on Guam, Saipan, Tinian, and Rota. The Navy consulted with the U.S. Fish and Wildlife Service regarding effects of the land-based training activities on terrestrial species listed under the Endangered Species Act (ESA) and received a Biological Opinion (U.S. Fish and Wildlife Service, 2015) and concurrence letter (U.S. Fish and Wildlife Service, 2016). The Navy is not proposing any changes to those land-based activities on Guam, Saipan, Tinian, and Rota. Therefore, in accordance with 40 Code of Federal Regulations (CFR) Section 1502.9, the Navy will continue to rely on the 2015 MITT Final EIS/OEIS for land-based activities because there are no changes that are relevant to environmental concerns or that would have a bearing on the land-based activities or their impacts. In

[1] Activities analyzed in this Supplemental EIS/OEIS are largely a continuation of the ongoing training and testing activities that were analyzed in the 2015 MITT Final EIS/OEIS, 2010 MIRC EIS/OEIS, and 1999 Mariana EIS/OEIS. Section 1.2 (The Navy's Environmental Compliance and At-Sea Policy) of the 2015 MITT Final EIS/OEIS presents a summary of the Navy's environmental compliance and "At-Sea Policy."

addition, in accordance with 50 CFR Section 402.16, the 2015 and 2016 consultations remain valid as none of the factors necessary to trigger reinitiating consultation have been met.

New information specifically addressed in this SEIS/OEIS includes updates to training and testing requirements, an updated acoustic effects model, updated marine mammal density data, and evolving and emergent best available science.[2] Using the updated information, the Navy requested the reissuance of federal regulatory permits and authorizations under the Marine Mammal Protection Act (MMPA) and ESA to support training and testing requirements within the Study Area beyond the 2020 expiration of current authorization. The Navy consulted with the National Marine Fisheries Service (NMFS) to obtain new authorizations. While the 2015 MITT Final EIS/OEIS Study Area remains unchanged, this SEIS/OEIS focuses on the at-sea and FDM portion of that area. The Study Area consists of three primary components: (1) the MIRC, (2) additional areas on the high seas, and (3) a transit corridor between the MIRC and the Hawaii Range Complex. Collectively, these areas continue to be referred to as the MITT Study Area (Figure 1.1-1).

The United States is facing a complex and volatile security environment. Major conflicts, terrorism, and natural disasters all have the potential to threaten 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 Navy operates on the world's oceans, seas, and coastal areas—the international maritime domain—on which 90 percent of the world's trade and two-thirds of its oil are transported. The majority of the world's population also lives within a few hundred miles of an ocean. The U.S. Navy carries out training and testing activities to be able to protect the United States against its potential adversaries, to protect and defend the rights and interests of the United States and its allies to move freely on the oceans, and to provide humanitarian assistance.

Department of Defense actions in the Western Pacific have previously been, or are currently, the subject of various environmental planning documents. These include realignment of Marine Corps forces to Guam, ongoing EIS efforts to address joint training and land-based training requirements in the CNMI, and EIS efforts to discuss Air Force divert landing and training requirements in the CNMI. The training and testing activities covered by the 2015 MITT Final EIS/OEIS, as well as in this supplement, are separate and distinct from the actions proposed by Marine Corps forces and those of the U.S. Air Force within the CNMI. This SEIS/OEIS only addresses ongoing and future at-sea and FDM training and testing activities that are independent and do not rely on any realignment efforts. Further, the training and testing activities covered by the 2015 MITT Final EIS/OEIS and this SEIS/OEIS have been occurring in the Study Area for decades and would continue regardless of whether any of the other Department of Defense efforts in the Western Pacific come to fruition.

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[2] The 2015 MITT Final EIS/OEIS used a new modeling system known as the Navy Acoustics Effects Model and marine mammal density information, developed by the Navy in cooperation with the National Marine Fisheries Service, that was the best available information at the time. The Navy Acoustics Effects Model has been refined, marine mammal density estimates have been updated, NMFS has published new criteria, and criteria used in the acoustic model have been revised.

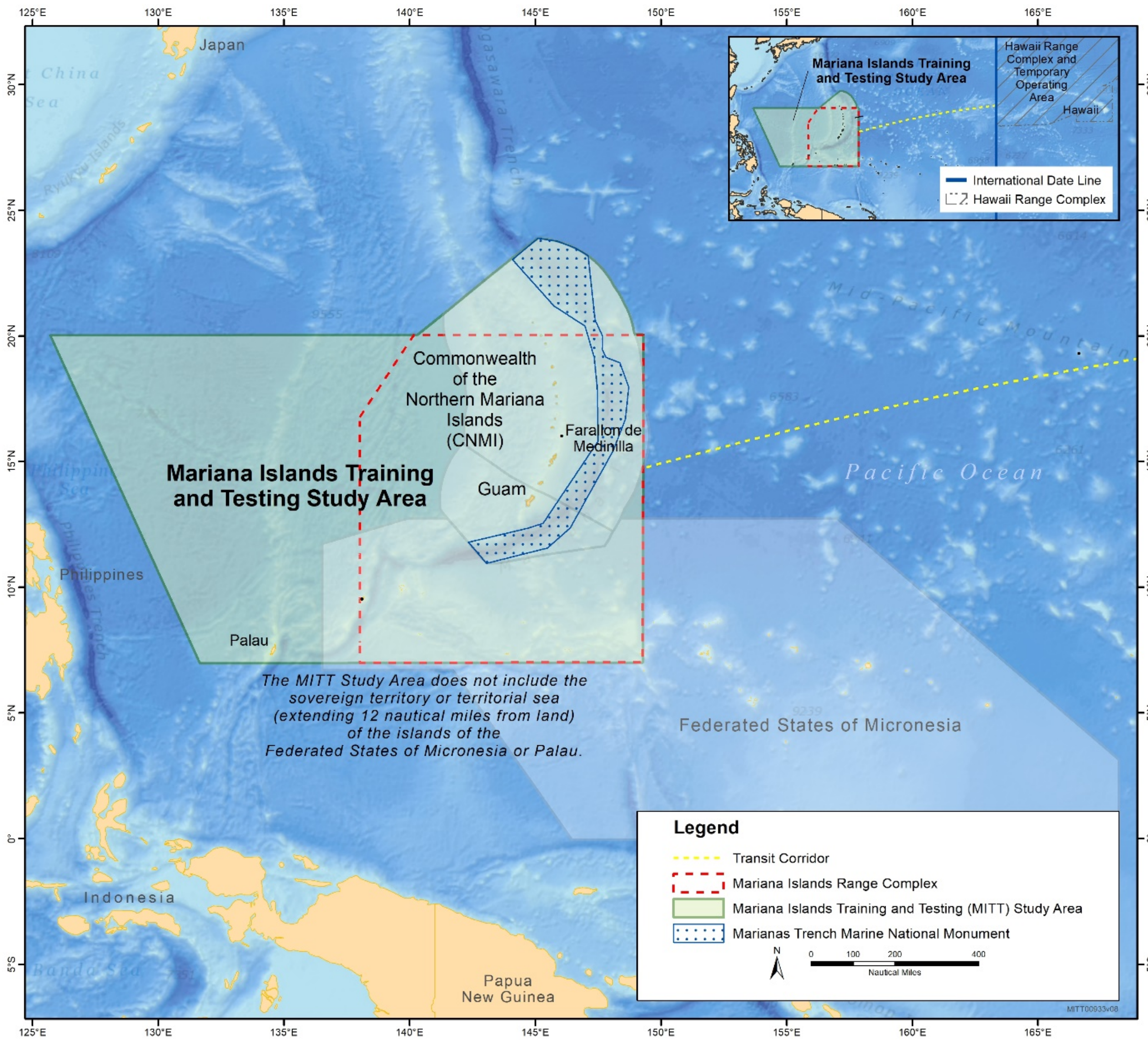

Figure 1.1-1: Mariana Islands Training and Testing Study Area

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 the "At-Sea Policy" (U.S. Department of the Navy, 2000) to ensure compliance with applicable environmental regulations and policies, and preserve the flexibility necessary for the Navy 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 operational areas 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, which are managed and used to conduct training and testing activities. Some ranges are further broken down into operational areas, to better manage and deconflict military readiness 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 first phase of the programmatic strategy was accomplished by the preparation and completion of individual or separate NEPA/Executive Order 12114 environmental documents for training and testing activities at each range complex. The second phase of the Navy's environmental compliance planning covered activities and existing ranges and operating areas previously analyzed in the Phase I NEPA/Executive Order 12114 documents and additional geographic areas including, but not limited to, pierside locations and a transit corridor. The Navy is currently in the third phase of implementing this programmatic approach, which covers similar types of military readiness training and testing activities in the same MITT Study Area analyzed in Phase II. As was done in Phase I and Phase II, the Navy will use the Phase III analysis to support regulatory consultations and a request for a letter of authorization under the MMPA and incidental take statements under the ESA. Given that the training and testing activities have not substantially changed, there is not a significant change in environmental impacts when compared to activities analyzed in the 2015 MITT Final EIS/OEIS, and the same Study Area is used for the proposed activities, the Navy determined an SEIS/OEIS to be appropriate for Phase III of the Navy's environmental compliance planning in the MITT Study Area. For further discussion of the first two phases, please see Section 1.2 (The Navy's Environmental Compliance and At-Sea Policy) of the 2015 MITT Final EIS/OEIS.

1.3 Proposed Action

The Navy's Proposed Action, described in detail in Chapter 2 (Description of Proposed Action and Alternatives), is to conduct military readiness training and testing activities in the Study Area (Figure 1.1-1).

1.4 Purpose and Need

The Navy and NMFS (as a cooperating agency) have coordinated from the outset and developed this document to meet each agency's distinct NEPA obligations and support the decision making of both agencies. The Navy's purpose of the Proposed Action is to conduct training and testing activities to ensure that the Navy and other Services meet their respective missions, which, for the Navy, is to maintain, train, and equip combat-ready military forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. The respective missions are achieved in part by conducting training and testing within the Study Area in accordance with established Navy military readiness requirements. The sections that follow provide a description of the need for military readiness activities. Appendix A (Training and Testing Activities Descriptions) provides detailed Navy and other Services' activities descriptions.

> 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."

The Navy has requested authorization to take marine mammals incidental to conducting their training and testing activities in the Study Area by Level A and B harassment, serious injury, and/or mortality. Take under the MMPA (50 CFR 216.3) is defined as "to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal." For military readiness activities, the MMPA defines harassment "(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]."

NMFS has issued proposed regulations and is considering issuance of a subsequent Letter of Authorization (LOA) under section 101(a)(5)(A) of the MMPA of 1972, as amended (16 United States Code [U.S.C.] 1361 et seq.) that would govern the taking of marine mammals incidental to the Navy training and testing activities within the Study Area. The issuance of regulations and associated LOA to the Navy is a major federal action requiring NMFS to analyze the effects of their issuance on the human environment pursuant to NEPA requirements and National Oceanic and Atmospheric Administration policies.

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

NMFS's purpose is to evaluate the Navy's Proposed Action pursuant to NMFS's authority under the MMPA, and to make a determination whether to issue incidental take regulations and a LOA, including any conditions needed to meet the statutory mandates of the MMPA. To authorize the incidental take of marine mammals, NMFS evaluates the best available scientific information to determine whether the take would have a negligible impact on the affected marine mammal species or stocks and an unmitigable impact on their availability for taking for subsistence uses (not relevant here for Navy's proposed action). 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 as stated above. The need for NMFS's action is to consider the impacts of the Navy's activities on marine mammals and meet NMFS's obligations under the MMPA. This SEIS/OEIS analyzes the environmental impacts associated with issuance of the requested authorization of the take of marine mammals incidental to the training and testing activities within the Study Area, to include a variety of mitigation measures that were considered during the MMPA authorization process. The analysis of mitigation measures considers benefits to species or stocks and their habitat, and analyzes the practicability and efficacy of each measure. This analysis of mitigation measures was used to support requirements pertaining to mitigation, monitoring, and reporting that would be specified in final MMPA regulations and subsequent LOA.

1.4.1 Why the Navy Trains

As described above, the Navy is statutorily mandated to protect U.S. national security by being ready, at all times, to effectively prosecute war and defend the nation by conducting operations at sea. The Navy is essential to protecting U.S. national interests, considering that 70 percent of the earth is covered in water, 80 percent of the planet's population lives within close proximity to coastal areas, and 90 percent of global commerce is conducted by sea. Naval forces must be ready for a variety of military operations to address the dynamic, social, political, economic, and environmental issues that occur in today's rapidly evolving world. Through its continuous presence on the world's oceans, the Navy can respond to a wide range of situations because, on any given day, over one-third of its ships, submarines, and aircraft are deployed overseas. Units must be able to respond promptly and effectively while forward deployed. This presence helps to dissuade aggression, which prevents conflict escalation, and provides the President with options to promptly address global contingencies. 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 and environmental conditions to humanitarian assistance and disaster relief efforts. Training prepares Navy personnel to be proficient in safely 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. Refer to Chapter 1, Section 1.4.1 (Why the Navy Trains) in the 2015 MITT Final EIS/OEIS for additional information on Navy training.

1.4.2 Why the Navy Tests

The Navy's research and acquisition community, including research-funding organizations, laboratory facilities, and systems commands, has a mission to provide weapons, systems, and platforms for the Navy to support its missions and ensure a technological edge over the United States' potential adversaries. This community is at the forefront of researching, developing, testing, evaluating, acquiring, and delivering modern platforms, systems, and related equipment to meet Fleet capability and readiness requirements. The Navy's research funding organizations and laboratories concentrate primarily on the development of new science and technology, and the initial testing of concepts that are relevant to the Navy of the future. As a result, systems commands develop ship, aircraft, and weapons products that support all Navy platforms throughout their lifecycles from systems acquisition through sustainment to end of life. Refer to Chapter 1, Section 1.5.1 (Why the Navy Tests) in the 2015 MITT Final EIS/OEIS for additional information on Navy testing. The Navy's research and acquisition community operating in the Study Area includes the following:

- The Naval Sea Systems Command, which develops, acquires, delivers, and maintains surface ships, submarines, unmanned vehicles, and weapon system platforms.
- The Naval Air Systems Command, which develops, tests, acquires, delivers, and sustains naval aviation aircraft, unmanned aerial systems, weapons, and systems.
- The Office of Naval Research, which plans, fosters, and encourages scientific research that promotes future naval sea power and enhances national security.

1.5 Overview and Strategic Importance of Existing Range Complex

The Navy has historically used areas in the Study Area for training and testing. The Navy has designated a portion of the Study Area as a "range complex" (see Figure 1.1-1) A range complex provides a controlled environment where military ship, submarine, and aircraft crews can train in realistic conditions while safely deconflicting with non-military activities, such as civilian shipping and aircraft. Sufficient sea and airspace in proximity to land training ranges, airfields, nearshore amphibious landing sites, and special use airspace is critical to realistic training and testing. Diverse and realistic training is critical to ensuring U.S. Forces, when needed, are both ready and able to effectively conduct operations in myriad environments.

Systems commands also require access to a realistic environment to conduct testing. The systems commands frequently conduct tests on Fleet range complexes and use Fleet assets to support the testing. The MIRC, which is primarily used by the systems commands, must provide the flexibility to meet diverse testing requirements, given the wide range of various advanced platforms and systems and capabilities that the fleets and systems commands must demonstrate before certification for deployment to the Fleet. This is important because testing in conditions that reflect (or are similar to) those in which the technology could be employed enhances combat readiness.

The MIRC is characterized by a unique combination of attributes that make it a strategically important range complex, including:

- Location within and adjacent to a U.S. territory
- Ranges and operating areas on the islands of Guam, Rota, Saipan, Tinian, and FDM
- Expansive airspace, surface sea space, and underwater sea space
- Authorized use of multiple types of explosive and non-explosive ordnance on FDM
- Support for all Navy warfare areas and numerous other service roles, missions, and tactical tasks
- Support for service units based at military installations on Guam
- Training support for deployed forces
- Ability to conduct joint and combined force exercises, including those in which foreign partners and allies participate
- Rehearsal area for Western Pacific contingencies

1.6 The Environmental Planning Process

NEPA and Executive Order 12114 require federal agencies to examine the environmental impacts of their proposed actions within the United States and its territories. An EIS 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 in accordance with applicable laws, regulations, and Executive Orders.

Pursuant to 40 CFR section 1502.9(c), a supplemental EIS is prepared when the agency makes substantial changes in the proposed action that are relevant to environmental concerns (40 CFR section 1502.9(c)(1)(i)); or there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts (40 CFR section 1502.9(c)(1)(ii)). An agency may also supplement a final EIS when the agency determines that the purpose of NEPA will be furthered by doing so (40 CFR section 1502(c)(2)).

Pursuant to Council on Environmental Quality Regulations, the Navy has prepared this supplement to the 2015 MITT Final EIS/OEIS to consider future activities conducted at sea and on FDM, and updated training and testing requirements; incorporate new information from an updated acoustic effects model and updated marine mammal density data; and incorporate evolving and emergent best available science. It will also support any reissuance of federal regulatory permits and authorizations under the MMPA and the ESA using the best available science and analytical methods to assess potential environmental impacts.

1.6.1 National Environmental Policy Act Requirements

When developing a supplement to an existing EIS/OEIS, the first step in the NEPA process (Figure 1.6-1) is to prepare a Notice of Intent. The Notice of Intent is published in the Federal Register and in local newspapers, and provides an overview of the proposed action and the scope of this SEIS/OEIS (see Appendix B, Federal Register Notices). The Notice of Intent is also the first step in engaging the public, initiating the scoping process.

Scoping is an early and open process for developing the "scope" of issues to be addressed in an EIS and for identifying significant issues related to a proposed action. In accordance with the Council on Environmental Quality regulations (40 CFR section 1501.7) for implementing the requirements of NEPA, scoping is not required for a supplement to a draft or final EIS; however, in an effort to maximize public participation and ensure the public's input was considered, the Navy chose to conduct a scoping period for this SEIS/OEIS.

After the scoping process, a Draft SEIS/OEIS is prepared to assess potential impacts of the proposed action and alternatives on the environment. When completed, a Notice of Availability is published in the Federal Register and notices are placed in local or regional newspapers announcing the availability of the Draft SEIS/OEIS. The Draft SEIS/OEIS is circulated for public review and comment. Public meetings may also be scheduled to further inform the public and solicit their comments.

The Final SEIS/OEIS considers and addresses all public comments received on the 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.

Finally, the decision-maker will issue a Record of Decision no earlier than 30 days after the Final SEIS/OEIS is made available to the public (40 CFR section 1505.2 and 40 CFR section 1506.10 (b)(2)).

For a description of how the Navy complies with each of these requirements during the development of this SEIS/OEIS, please see Chapter 8 (Public Involvement and Distribution).

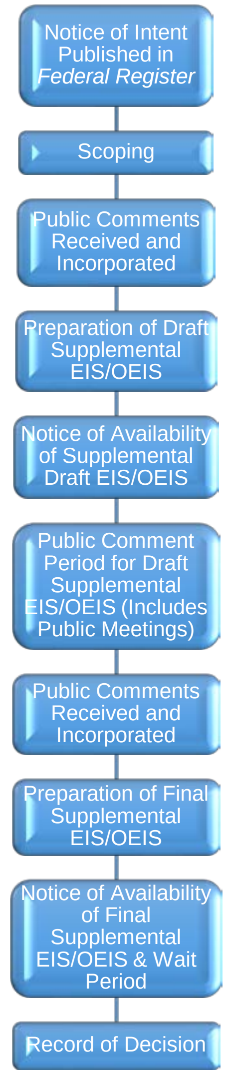

Figure 1.6-1: National Environmental Policy Act Process Conducted for this SEIS/OEIS

1.6.2 Executive Order 12114

Executive Order 12114 of 1979, *Environmental Impacts Abroad of Major Federal Actions*, furthers the purpose of NEPA by directing federal agencies to provide for informed environmental decision-making for major federal actions outside the United States and its territories. Presidential Proclamation 5928, issued December 27, 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 nautical miles (NM) from the shoreline; 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 Executive Order 12114 (an OEIS).

1.6.3 Other Environmental Requirements Considered

The Navy must comply with all applicable federal environmental laws, regulations, and executive orders as discussed in the 2015 MITT Final EIS/OEIS. Further information can be found in Chapter 6 (Additional Regulatory Considerations). Since the publication of the 2015 MITT Final EIS/OEIS, Executive Order 13840, *Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States* revoked and replaced Executive Order 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes.*

1.6.3.1 Executive Order 13840, Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States

On June 19, 2018, President Trump signed Executive Order 13840. The Executive Order is intended to advance the economic, security, and environmental interests of the United States through improved public access to marine data and information; efficient federal agency coordination on ocean-related matters; and engagement with marine industries, the science and technology community, and other ocean stakeholders, including Regional Ocean Partnerships. The Executive Order continues to require federal agencies to coordinate activities regarding ocean-related matters for effective management of the ocean as well as promote lawful use of the ocean by agencies, including the Armed Forces. The Navy continues to engage with regional and state ocean planning entities. This Executive Order revokes and replaces Executive Order 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*.

1.7 Scope and Content

In this SEIS/OEIS, the Navy reanalyzed at-sea and FDM military readiness activities that could potentially impact the natural resources, such as marine mammals, sea turtles, and other marine resources. Since the completion of the 2015 MITT Final EIS/OEIS, new information has become available and is incorporated in this analysis, in addition to proposed changes in training and testing requirements. The range of alternatives in this SEIS/OEIS includes the No Action Alternative and two action alternatives. In this SEIS/OEIS, the Navy analyzed direct, indirect, and cumulative impacts 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 U.S. Coast Guard is a cooperating agency, and this SEIS/OEIS addresses its at-sea and FDM training activities, which are included in the Proposed Action.

The National Oceanic Atmospheric Administration's NMFS is serving as a cooperating agency because the scope of the Proposed Action and alternatives involves activities that have the potential to impact protected resources under their jurisdiction by law and special expertise, including marine mammals, threatened and endangered species, and Essential Fish Habitat. The National Oceanic Atmospheric Administration's authorities and special expertise is based on their statutory responsibilities under the MMPA of 1972, as amended 16 U.S.C. 1361 et seq.), the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.), and the Magnuson-Stevens Fishery Conservation and Management Act. In addition, NMFS, in accordance with 40 CFR 1506.3 and 1505.2, may adopt this SEIS/OEIS and issue a separate Record of Decision associated with its decision to grant or deny the Navy's request for an incidental take authorization pursuant to Section 101(a)(5)(A) of the MMPA.

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

This SEIS/OEIS is organized as follows:

- Chapter 1 (Purpose and Need) describes the purpose of and need for the Proposed Action.

- Chapter 2 (Description of Proposed Action and Alternatives) describes the Proposed Action and proposed changes to the 2015 MITT Final EIS/OEIS implemented actions projected to take place starting in 2020, and alternatives to be carried forward for analysis.
- Chapter 3 (Affected Environment and Environmental Consequences) 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 2015 MITT Final EIS/OEIS.
- Chapter 4 (Cumulative Impacts) describes the analysis of cumulative impacts, which are the impacts of the Proposed Action when added to past, present, and reasonably foreseeable future actions.
- Chapter 5 (Mitigation) describes the measures the Navy evaluated that could mitigate impacts to the environment.
- Chapter 6 (Additional Regulatory Considerations) describes considerations required by NEPA and describes how the Navy complies with other federal, state, and local plans, policies, and regulations.
- Chapter 7 (List of Preparers) includes a list of preparers of this SEIS/OEIS.
- Chapter 8 (Public Involvement and Distribution) describes the public participation process.
- References are provided at the end of each section.
- Appendices provide technical information that support the SEIS/OEIS analyses and its conclusions.

REFERENCES

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U.S. Fish and Wildlife Service. (2016). *Informal Consultation on Mariana Islands Training and Testing Program Affects to Eighteen Newly-Listed Species, Guam and Tinian*. Honolulu, HI: Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office.

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2 Description of Proposed Action and Alternatives

Supplemental Environmental Impact Statement/
Overseas Environmental Impact Statement
Mariana Islands Training and Testing
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2 Description of Proposed Action and Alternatives

The United States (U.S.) Department of the Navy (Navy) proposes to conduct military readiness activities which include training activities (referred to as "training"), and research, development, testing, and evaluation (referred to as "testing") activities in the Mariana Islands Training and Testing (MITT) Study Area, primarily within the existing Mariana Islands Range Complex (MIRC). This Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement (SEIS/OEIS) is being prepared to assess the potential environmental impacts associated with proposed training and testing activities to be conducted at sea and on Farallon de Medinilla (FDM). These proposed activities are generally consistent with those at-sea and FDM activities analyzed in the 2015 MITT Final Environmental Impact Statement (EIS)/OEIS and are representative of activities the military has been conducting in the Study Area since the 1940s. These training and testing activities include the use of active sonar and explosives at sea off the coasts of Guam and the Commonwealth of the Northern Mariana Islands (CNMI), throughout the in-water areas around the MIRC, the transit corridor between the MIRC and the Hawaii Range Complex (HRC), and at select Navy pierside and harbor locations.

In this chapter, the military builds upon the purpose and need to train and test (as described in Chapter 1) by describing the Study Area and identifying the primary mission areas for which these training and testing activities are conducted. Each warfare community (e.g., aviation, surface, submarine, and expeditionary) conducts training and testing activities that contribute to the success of these primary mission areas. Each primary mission area requires unique skills, sensors, weapons, and technologies to accomplish the overall mission. For example, under the anti-submarine warfare primary mission area, surface, submarine, and aviation warfare communities each utilize different skills, sensors, and weapons to locate, track, and eliminate submarine threats. The testing community contributes to the success of anti-submarine warfare by anticipating and identifying technologies and systems that respond to the needs of the warfare communities. See Section 2.2 (Primary Mission Areas) and Section 2.3 (Proposed Activities) for additional information.

This chapter describes the activities that comprise the Proposed Action for this SEIS/OEIS necessary to meet training and testing requirements beyond 2020 and into the reasonably foreseeable future. These at-sea and FDM activities are then analyzed for their potential effects on the environment in the resource-specific chapters of this SEIS/OEIS. For further details regarding specific training and testing activities, please see Appendix A (Training and Testing Activities Descriptions). The Navy has requested from the National Marine Fisheries Service (NMFS) an incidental take authorization under the Marine Mammal Protection Act (MMPA), and an incidental take statement under the Endangered Species Act (ESA) for marine species. Relative to compliance with the National Environmental Policy Act (NEPA), NMFS' Proposed Action will be a direct outcome of responding to the Navy's request for an incidental take authorization pursuant to the MMPA.

The 2015 MITT Final EIS/OEIS also analyzed training and testing activities conducted at existing MIRC land-based training areas located on Guam, Saipan, Tinian, and Rota. The Navy consulted with the U.S. Fish and Wildlife Service regarding effects of the land-based training activities on terrestrial species listed under the ESA and received a Biological Opinion (U.S. Fish and Wildlife Service, 2015) and concurrence letter (U.S. Fish and Wildlife Service, 2016). As the Navy is not proposing any changes to those land-based activities on Guam, Saipan, Tinian, and Rota, the Navy will continue to rely on the 2015 MITT Final EIS/OEIS because there is no new information that would affect the EIS/OEIS analysis. In addition, in accordance with 50 Code of Federal Regulations (CFR) section 402.16, the 2015 and 2016 consultations remain valid as none of the factors necessary to trigger reinitiating consultation have been met.

2.1 Description of the Mariana Islands Training and Testing Study Area

The Study Area (Figure 2.1-1) for this SEIS/OEIS is the same used for the analysis in the 2015 MITT Final EIS/OEIS (Section 2.1, Description of the Mariana Islands Training and Testing Study Area), and is composed of three components: (1) the MIRC, (2) additional areas on the high seas outside of the MIRC, and (3) a transit corridor between the MIRC and the HRC. Collectively, for the purposes of this SEIS/OEIS, these areas continue to be referred to as the MITT Study Area (Figure 2.1-1). The transit corridor is outside the geographic boundaries of the MIRC and is a direct route across the high seas for Navy ships transiting between the MIRC and the HRC.

Section 2.1.1 (Description of the Mariana Islands Range Complex) and the 2015 MITT Final EIS/OEIS (Section 2.1, Description of the Mariana Islands Training and Testing Study Area) provide complete descriptions of range components that comprise the MIRC. For more information on the areas outside the boundaries of the MIRC but within the Study Area, see Section 2.1.2 (Description of the Ocean Operating Areas Outside the Bounds of the Mariana Islands Range Complex) and Section 2.1.3 (Description of Pierside Locations and Apra Harbor) below and in the 2015 MITT Final EIS/OEIS.

2.1.1 Description of the Mariana Islands Range Complex

The MIRC includes land training areas, ocean surface and subsurface areas, and special use airspace. These areas extend from the waters south of Guam to north of Pagan (Commonwealth of the Northern Mariana Islands), and from the Pacific Ocean east of the Mariana Islands to the Philippine Sea to the west, encompassing 501,873 square nautical miles (NM^2) of open ocean (Figure 2.1-1). The Department of Defense leases FDM for use as a live and inert gunnery, missile, and bombing range.

2.1.1.1 Special Use Airspace and Air Traffic Controlled Assigned Airspace

The MIRC includes approximately 40,000 NM^2 of special use airspace. Special use airspace is airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration, 2013). As described in the 2015 MITT Final EIS/OEIS, Section 2.1 (Description of the Mariana Islands Training and Testing Study Area), special use airspace includes restricted areas, military operations areas, and warning areas. As depicted in Figure 2.1-2 and Figure 2.1-3, most of this airspace is almost entirely over the ocean and includes warning areas and restricted areas:

Warning Areas (W): W-517 and W-12 include approximately 11,800 NM^2 of special use airspace (Figure 2.1-2 and Figure 2.1-3); W-11 (A/B) is approximately 10,500 NM^2 of special use airspace, and W-13 (A/B/C) is approximately 18,000 NM^2 of special use airspace.

Restricted Area Airspace (R): Over or near land areas within the MIRC includes approximately 2,463 NM^2 of special use airspace and includes restricted areas R-7201 and R-7201A, which extends in a 12 nautical mile radius around FDM (Figure 2.1-2 and Figure 2.1-4).

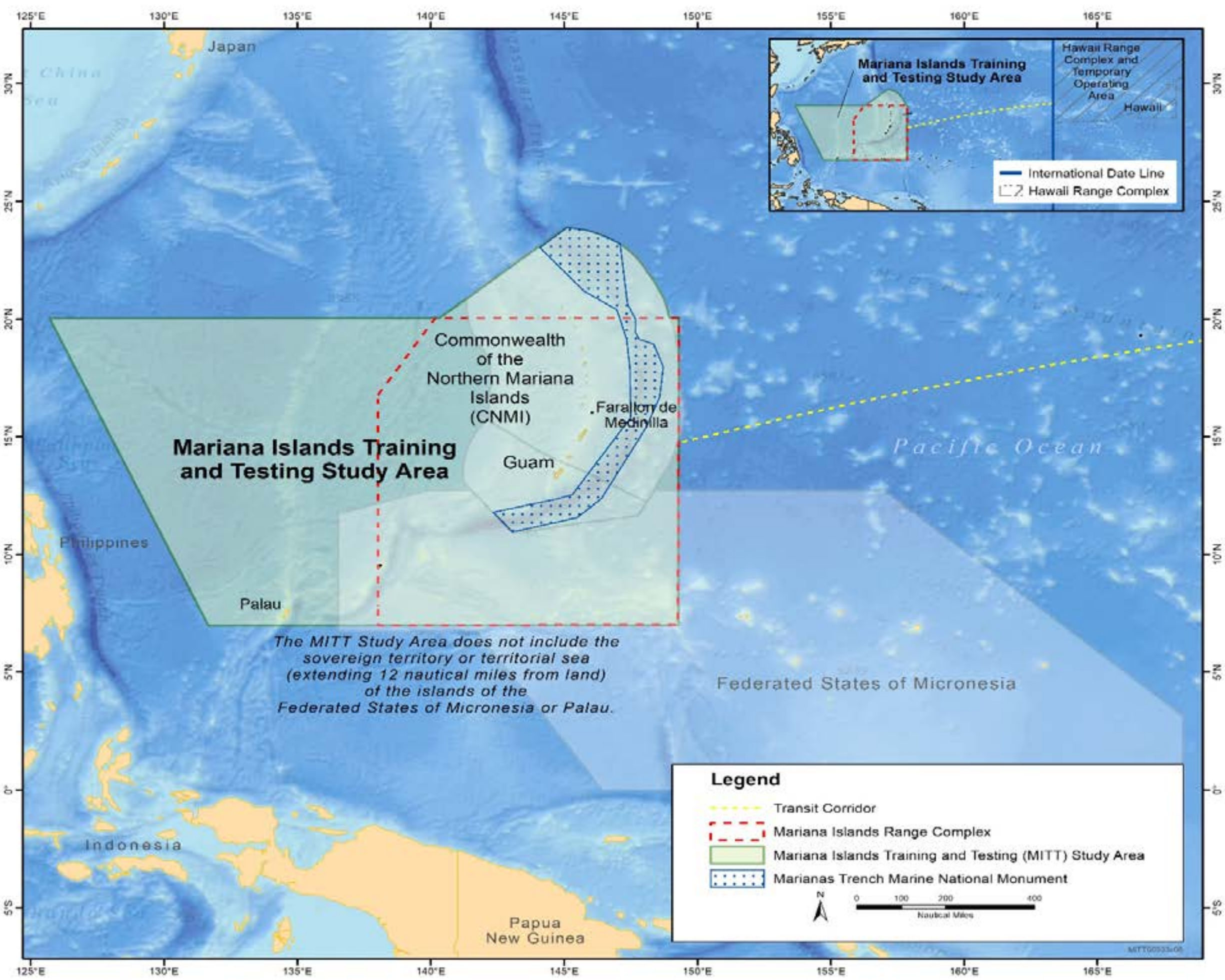

Figure 2.1-1: Mariana Islands Training and Testing Study Area

2.1.1.2 Sea and Undersea Space

The MIRC includes the sea and undersea space from the ocean surface to the ocean floor. The MIRC also consists of designated sea and undersea space training and testing areas, which include designated drop zones, underwater demolition and floating mine exclusion zones, danger zones associated with live-fire ranges, and training areas associated with military controlled beaches, harbors, and littoral areas.

W-517, W-12, W-11 and, W-13 (Figure 2.1-2) are designated as special use airspace where the sea space underneath may be restricted from public access during hazardous training events. Portions of the Marianas Trench Marine National Monument, established in January 2009 by Presidential Proclamation under the authority of the Antiquities Act (16 U.S. Code sections 431–433), lie within the MIRC and under all MIRC Warning Areas. However, the prohibitions required by the Proclamation do not apply to activities and exercises of the Armed Forces (including those carried out by the U.S. Coast Guard).

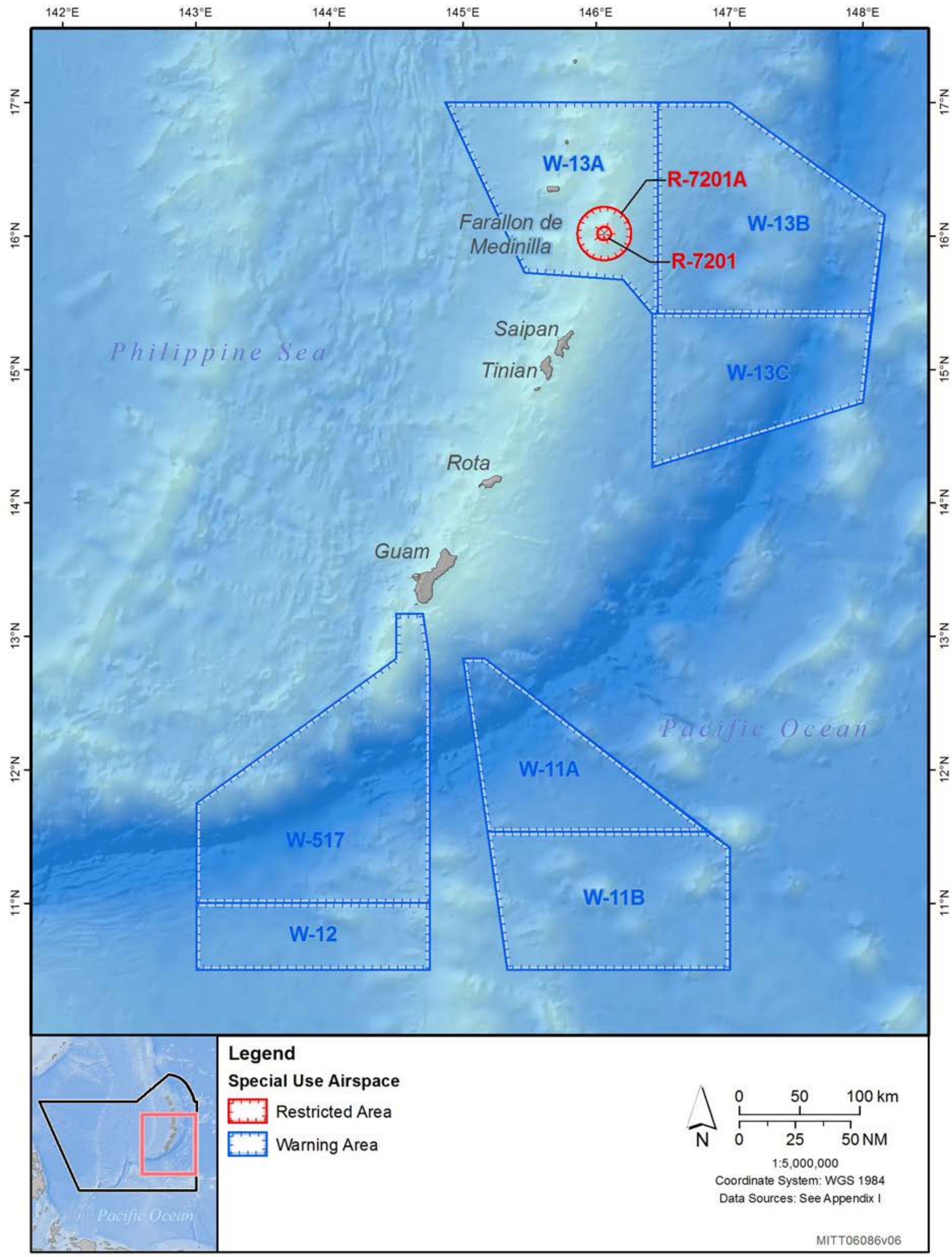

Figure 2.1-2: Mariana Islands Range Complex Airspace

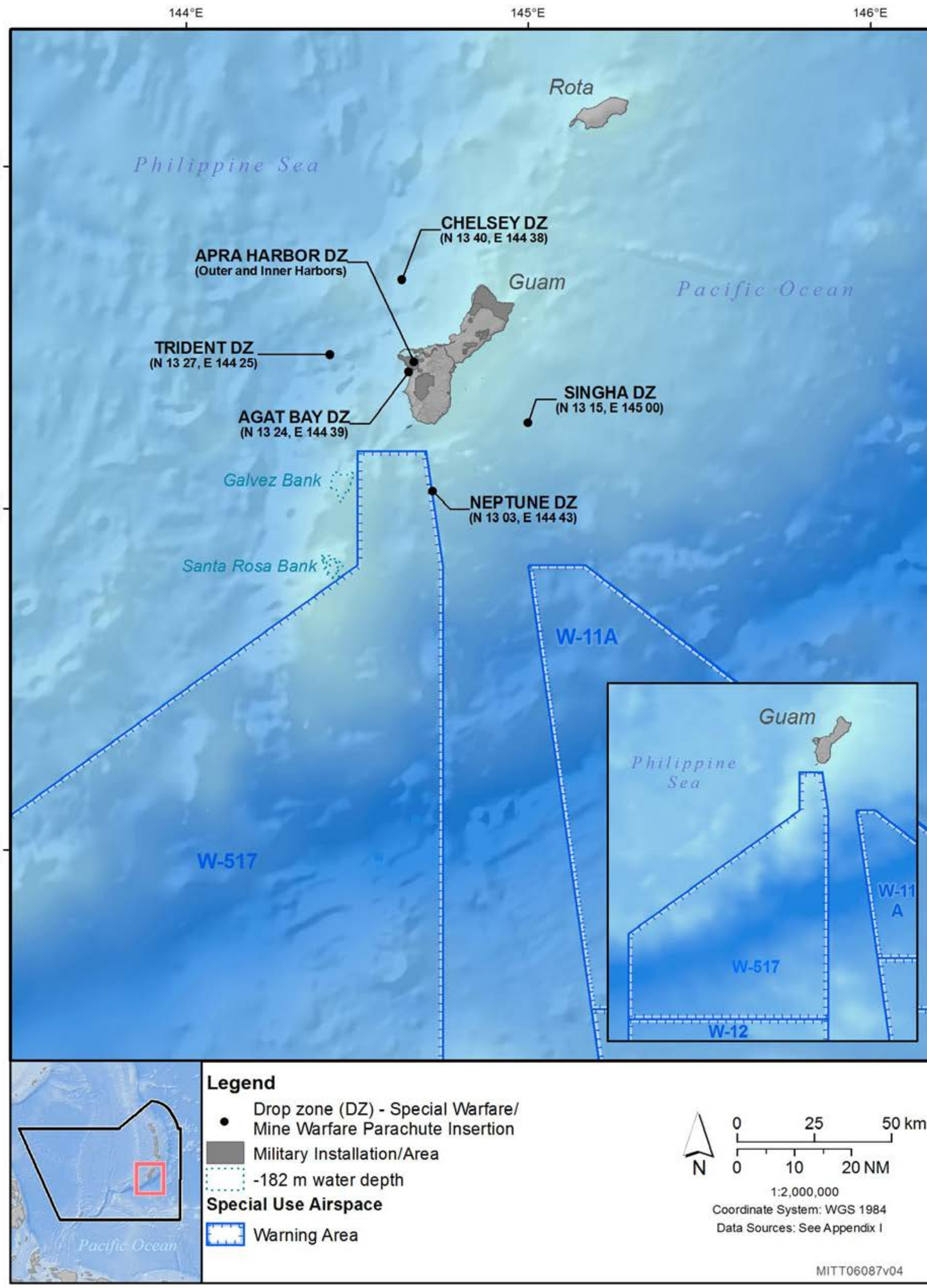

Figure 2.1-3: Warning Area 517

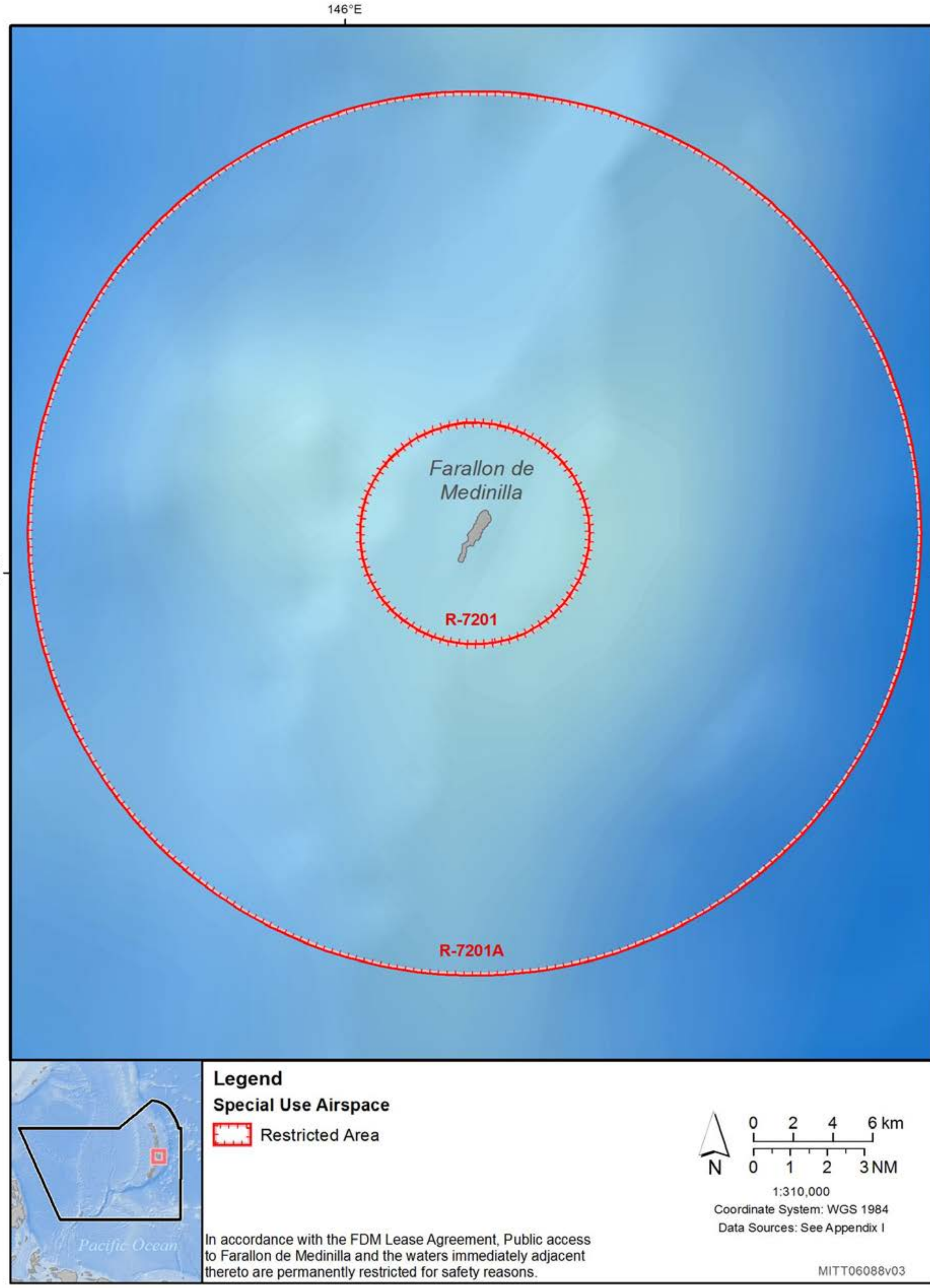

Figure 2.1-4: Farallon de Medinilla Restricted Area 7201, 7201A, and Danger Zone

2.1.2 Description of the Ocean Operating Areas Outside the Bounds of the Mariana Islands Range Complex

In addition to the MIRC, the Study Area includes the area to the north of the MIRC that is within the U.S. Exclusive Economic Zone of the CNMI and areas to the west of the MIRC, as depicted in Figure 2.1-1.

The transit corridor between MIRC and HRC, although not part of any defined range complex, is important to the Navy in that it provides available air, sea, and undersea space where vessels and aircraft conduct training and testing while in transit. The transit corridor is the shortest distance between the MIRC and the HRC.

2.1.3 Description of Pierside Locations and Apra Harbor

The Study Area includes pierside locations in Apra Harbor. For purposes of this SEIS/OEIS, pierside locations include channels and routes to and from the Navy port in the Apra Harbor Naval Complex, and associated wharves and facilities within the Navy port (Figure 2.2-1).

2.2 Primary Mission Areas

The Navy categorizes its at-sea activities into functional warfare areas called primary mission areas. Training and testing activities generally fall into the following eight primary mission areas:

- air warfare
- amphibious warfare
- anti-submarine warfare
- electronic warfare
- expeditionary warfare
- mine warfare
- strike warfare
- surface 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 “other activities” (e.g., precision anchoring, search and rescue at sea). Each warfare community (e.g., surface, subsurface, aviation, and expeditionary warfare) may train in some or all of these primary mission areas. The research and acquisition community also categorizes most, but not all, of its testing activities under these primary mission areas. A description of the sonar, munitions, targets, systems, and other material used during training and testing activities within these primary mission areas is provided in Appendix A (Training and Testing Activities Descriptions).

2.2.1 Air Warfare

The mission of air warfare (referred to as anti-air warfare in the 2015 MITT Final EIS/OEIS) is to destroy or reduce enemy air and missile threats (including unmanned airborne threats) and serves two purposes: to protect U.S. forces from attacks from the air and to gain air superiority. Air warfare provides U.S. forces with adequate attack warnings, while denying hostile forces the ability to gather intelligence about U.S. forces.

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

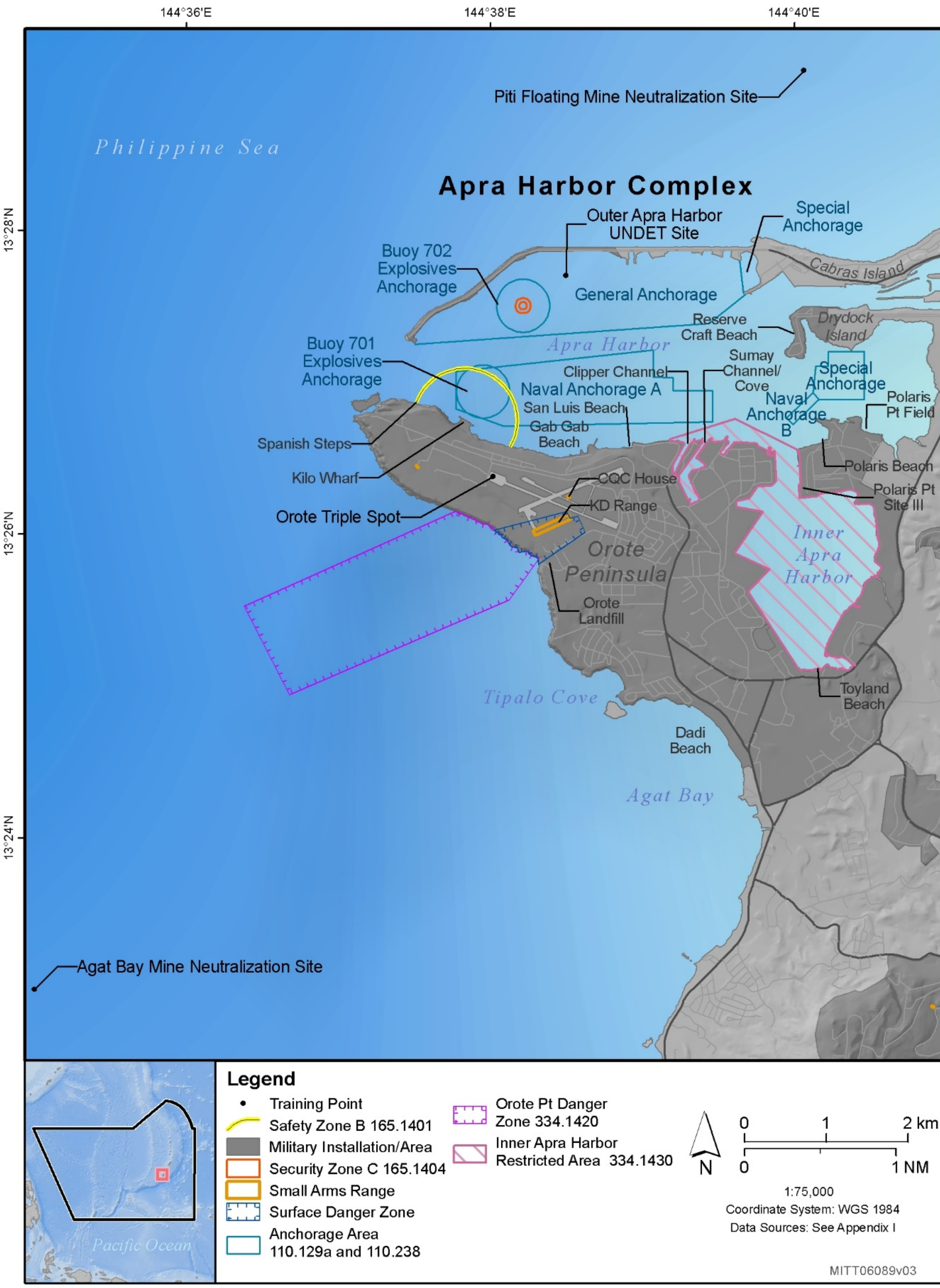

Figure 2.2-1: Apra Harbor Naval Complex (Main Base) and Main Base/Polaris Point

Testing of air warfare systems is required to ensure the equipment is fully functional under the conditions in which it will be used. Tests may be conducted on radar and other early-warning detection and tracking systems, new guns or gun rounds, and missiles. Testing of these systems may be conducted on new ships and aircraft, and on existing ships and aircraft following maintenance, repair, or modification. For some systems, tests are conducted periodically to assess operability. Additionally, tests may be conducted in support of scientific research to assess new and emerging technologies.

2.2.2 Amphibious Warfare

The mission of amphibious warfare is to project military power from the sea to the shore (i.e., attack a threat on land by a military force embarked on ships) through the use of naval firepower and expeditionary landing forces. Amphibious warfare operations include small unit reconnaissance or raid missions to large-scale amphibious exercises involving multiple ships and aircraft combined into a strike group.

Amphibious warfare training ranges from individual, crew, and small unit events to large task force exercises. Individual and crew training include amphibious vehicles and naval gunfire support training. Such training includes shore assaults, boat raids, airfield or port seizures, and reconnaissance. Large-scale amphibious exercises involve ship-to-shore maneuver, naval fire support, such as shore bombardment, and air strike and attacks on targets that are in close proximity to friendly forces.

2.2.3 Anti-Submarine Warfare

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine forces that threaten Navy surface forces. Anti-submarine warfare 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.

Anti-submarine warfare training addresses basic skills such as detection and classification of submarines, as well as evaluating sounds to distinguish between enemy submarines and friendly submarines, ships, and marine life. More advanced training integrates the full spectrum of anti-submarine warfare 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 anti-submarine warfare training exercises are conducted in coordinated, at-sea training events involving submarines, ships, and aircraft.

Testing of anti-submarine warfare systems is conducted to develop new technologies and assess weapon performance and operability with new systems and platforms, such as unmanned systems. Testing uses ships, submarines, and aircraft to demonstrate capabilities of torpedoes, missiles, countermeasure systems, and underwater surveillance and communications systems. Tests may be conducted as part of a large-scale Fleet training event involving submarines, ships, fixed-wing aircraft, and helicopters. These integrated training events offer opportunities to conduct research and acquisition activities and to train aircrew in the use of new or newly enhanced systems during a large-scale, complex exercise.

2.2.4 Electronic Warfare

The mission of 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.

Testing of electronic warfare systems is conducted to improve the capabilities of systems and ensure compatibility with new systems. Testing involves the use of aircraft, surface ships, and submarine crews to evaluate the effectiveness of electronic systems. Similar to training activities, typical electronic warfare testing activities include the use of airborne and surface electronic jamming devices (including testing chaff and flares; see Appendix A (Training and Testing Activities Descriptions) for a description of these devices) to defeat tracking and communications systems. Chaff tests evaluate newly developed or enhanced chaff, chaff dispensing equipment, or modified aircraft systems' use against chaff deployment. Flare tests evaluate deployment performance and crew competency with newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems' use against flare deployment.

2.2.5 Expeditionary Warfare

The mission of expeditionary warfare is to provide security and surveillance in the littoral (at the shoreline), riparian (along a river), or coastal environments. Expeditionary warfare is wide ranging and includes defense of harbors, operation of remotely operated vehicles, defense against swimmers, and boarding/seizure operations.

2.2.6 Mine Warfare

The mission of mine warfare is to detect, classify, and avoid or neutralize (disable) mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying to gain control of or deny the enemy access to sea space. Naval mines can be laid by ships, submarines, or aircraft.

Mine warfare neutralization training includes exercises in which ships, aircraft, submarines, underwater vehicles, unmanned vehicles, or marine mammal detection systems search for mine shapes. Personnel train to destroy or disable mines by attaching underwater explosives to or near the mine or using remotely operated vehicles to destroy the mine. Training would also include raising mine shapes and towing them ashore for recovery and inspection.

Testing and development of mine warfare systems is conducted to improve sonar, laser, and magnetic detectors intended to hunt, locate, and record the positions of mines for avoidance or subsequent neutralization. Mine warfare testing and development falls into two primary categories: mine detection and classification, and mine countermeasure and neutralization. Mine detection and classification testing involves the use of air, surface, and subsurface vessels and uses sonar, including towed and side-scan sonar, and unmanned vehicles to locate and identify objects underwater. Mine detection and classification systems are sometimes used in conjunction with a mine neutralization system. Mine countermeasure and neutralization testing includes the use of air, surface, and subsurface units to evaluate the effectiveness of tracking devices, countermeasure and neutralization systems, and general purpose bombs to neutralize mine threats. Most neutralization tests use mine shapes, or non-explosive practice mines, to evaluate a new or enhanced capability. For example, during a mine neutralization test, a previously located mine is destroyed or rendered nonfunctional using a helicopter or manned/unmanned surface vehicle-based system that may involve the deployment of a towed neutralization system.

The majority of mine warfare systems are deployed by ships, helicopters, and unmanned vehicles. Tests may also be conducted in support of scientific research to support these new technologies.

2.2.7 Strike Warfare

The mission of strike warfare is to conduct offensive attacks on land-based targets, such as refineries, power plants, bridges, major roadways, and ground forces to reduce the enemy's ability to wage war. Strike warfare employs weapons by manned and unmanned air, surface, submarine, and Navy special warfare assets in support of extending dominance over enemy territory (power projection).

Strike warfare includes training fixed-wing attack aircraft pilots and aircrews in the delivery of precision-guided munitions, non-guided munitions, rockets, and other ordnance against land-based targets. Not all strike mission training activities involve dropping ordnance and instead the activity is simulated with video footage obtained by onboard sensors.

2.2.8 Surface Warfare

The mission of surface warfare (referred to as anti-surface warfare in the 2015 MITT Final EIS/OEIS) is to obtain control of sea space from which naval forces may operate, and entails offensive action against other surface, subsurface, and air targets while also defending against enemy forces. In surface warfare, aircraft use guns, air-launched cruise missiles, or other precision-guided munitions; ships employ torpedoes, naval guns, and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles.

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

Testing of weapons used in surface warfare is conducted to develop new technologies and to assess weapon performance and operability with new systems and platforms, such as unmanned systems. Tests include various air-to-surface guns and missiles, surface-to-surface guns and missiles, and bombing tests. Testing activities may be integrated into training activities to test aircraft or aircraft systems in the delivery of munitions on a surface target. In most cases the tested systems are used in the same manner in which they are used for Fleet training activities.

2.3 Proposed Activities

The Navy has been conducting training and testing activities in the Study Area for decades. The tempo and types of training and testing activities have fluctuated because of the introduction of new technologies, the evolving nature of international events, advances in warfighting doctrine and procedures, and changes in force structure (organization of ships, submarines, aircraft, weapons, and Sailors). Such developments influence the frequency, duration, intensity, and location of required training and testing activities. The activities analyzed in this SEIS/OEIS are largely a continuation of activities that have been ongoing and were analyzed previously in the 2015 MITT Final EIS/OEIS. This SEIS/OEIS includes the analysis of those at sea and FDM activities necessary to meet readiness requirements beyond 2020 and into the reasonably foreseeable future, includes any changes to those activities previously analyzed, and reflects the most up-to-date compilation of training and testing activities deemed necessary to accomplish military readiness requirements.

2.3.1 Changes to Proposed Activities

The majority of proposed modifications to the activities included in the Proposed Action are changes to tempo of activity, and renaming or combining related types of activities for greater clarity in this document and for consistency across all Navy at-sea planning documents. A few activities assessed in 2015 have been discontinued from analysis, and a few new activities have been added to the proposed activities to enable the Navy to adopt new technology and new capabilities. The training and testing activities are listed in Table 2.5-1 and Table 2.5-2 and discussed in greater detail below.

2.3.1.1 New Technologies and Capabilities

As described above, new technologies and capabilities are introduced to be evaluated in testing. Some systems have been used and tested by the Navy in other locations, but not the MITT Study Area. Those systems that are new to the Study Area will be analyzed for environmental impacts in this SEIS/OEIS.

The Navy is proposing the testing of two new systems and technologies for Naval Sea Systems Command. Radar and Other Systems Testing may include the use of military or commercial radar, communication systems or simulators, or high-energy lasers. Testing may occur aboard a ship against drones, small boats, rockets, missiles, or other targets. Simulant Testing involves the testing of simulated chemical-biological agents and simulants that are deployed against surface ships. However, Naval Air Systems Command and the Office of Naval Research are not proposing any new testing capabilities in this SEIS/OEIS. Information on all testing activities is provided at the end of this chapter in Table 2.5-1.

2.3.1.2 Renamed and Reorganized Testing Activities

Some Naval Sea Systems Command testing activities have been renamed. Following is a list of testing activities that have been renamed since the 2015 MITT Final EIS/OEIS:

- Undersea Warfare Testing (previously named Torpedo Testing)
- Mine Countermeasure and Neutralization Testing (previously named Mine Countermeasure Mission Package Testing)
- Anti-Submarine Warfare Mission Package Testing (previously named Anti-Submarine Warfare)

In addition, some Naval Sea Systems Command testing activities have been reorganized under a different primary mission area. Following is a list of testing activities that have been reorganized since the 2015 MITT Final EIS/OEIS:

- Kinetic Energy Weapons Testing (now analyzed under Surface Warfare)
- At-Sea Sonar Testing (now analyzed under Anti-Submarine Warfare)
- Torpedo (Explosive) Testing (now analyzed under Anti-Submarine Warfare)
- Torpedo (Non-explosive) Testing (now analyzed under Anti-Submarine Warfare)
- Undersea Warfare Testing (now analyzed under Vessel Evaluation)
- Anti-Submarine Warfare Mission Package Testing (now analyzed under Anti-Submarine Warfare)
- Mine Countermeasure and Neutralization Testing (now analyzed under Mine Warfare)

2.3.2 Proposed Training and Testing Activities

A major training exercise is comprised of several "unit-level" range exercises conducted by several units operating together while commanded and controlled by a single commander. These exercises typically employ an exercise scenario developed to train and evaluate the strike group in naval tactical tasks. In a major training exercise, most of the operations and activities being directed and coordinated by the strike group commander are identical in nature to the operations conducted during individual, crew, and smaller unit-level training events. In a major training exercise, however, these disparate training tasks are conducted in concert, rather than in isolation. Some integrated or coordinated anti-submarine warfare exercises are similar in that they are comprised of several unit-level exercises but are generally on a smaller scale than a major training exercise, are shorter in duration, use fewer assets, and use fewer hours of hull-mounted sonar per exercise. These coordinated exercises are conducted under anti-submarine warfare. Three key factors used to identify and group the exercises are the scale of the exercise, duration of the exercise, and amount of hull-mounted sonar hours modeled/used for the exercise.

Table 2.3-1 provides the differences between major training exercises and smaller integrated/coordinated anti-submarine exercises based on scale, duration, and sonar hours for the purposes of exercise reporting requirements. Table 2.5-1 and Table 2.5-2 at the end of this chapter provides additional information on all training and testing activities, respectively, such as location, number of events per year, and ordnance used, if any. More information about each training and testing activity can be found in Appendix A (Training and Testing Activities Descriptions) and Appendix F (Training and Testing Activities Matrices). Except for the new activities described in Table 2.5-2, the activities proposed by the Navy in this SEIS/OEIS were described in the 2015 MITT Final EIS/OEIS in Table 2.4-2 and Table 2.4-3.

As described in the 2015 MITT Final EIS/OEIS, the Navy's research and acquisition community engages in a broad spectrum of testing activities in support of the Fleet. These activities include, but are not limited to, basic and applied scientific research and technology development; testing, evaluation, and maintenance of systems (missiles, radar, and sonar) and platforms (surface ships, submarines, and aircraft); and acquisition of systems and platforms. The individual commands within the research and acquisition community included in this SEIS/OEIS are Naval Air Systems Command, Naval Sea Systems Command, and Office of Naval Research.

Table 2.3-1: Major Training Exercises and Integrated/Coordinated Anti-Submarine Warfare Training Activities

	Exercise Group	*Description*	*Scale*	*Location*	*Duration*	*MITT Exercise Examples*	*Modeled Hull-mounted Sonar per Exercise*
Major Training Exercises	Large Integrated ASW	Large-scale, longer duration integrated ASW exercises	Up to three Carrier Strike Groups in coordination with other Services, 2 or more submarines, multiple ASW aircraft	Study Area; Apra Harbor	Typically a 10-day exercise	Joint Multi-Strike Group Exercise (e.g., Valiant Shield)	>500 hours
	Medium Integrated ASW	Medium-scale short duration integrated ASW exercises	Typically 15 surface ships, amphibious assault craft, helicopters, maritime patrol aircraft, strike fighter aircraft, 2 submarines, and various unmanned vehicles	Study Area to nearshore; Apra Harbor; Tinian; Guam; Rota; Saipan	Typically a 10-day exercise	Joint Expeditionary Exercise	100–500 hours
Integrated/Coordinated ASW Training	Small Integrated ASW	Small-scale short duration integrated ASW exercises	Approximately 3–6 surface ASW units, at least 1 submarine, 2–6 ASW aircraft	Study Area; Apra Harbor	Generally less than 5 days	Multi-Sail; SWATT	50–100 hours
	Medium Coordinated ASW	Medium-scale short duration coordinated ASW exercises	Approximately 2–4 surface ASW units, 2–5 ASW aircraft, possibly a submarine	Study Area; Apra Harbor	Generally 3–10 days	AnnualEx, GuamEx	Less than 100 hours
	Small Coordinated ASW	Small-scale short duration coordinated ASW exercises	Approximately 2–4 surface ASW units, possibly a submarine, 1–2 ASW aircraft	Study Area; Apra Harbor	Generally 2–4 days	Group Sail	Less than 50 hours

Notes: ASW = Anti-Submarine Warfare, SWATT = Surface Warfare Advanced Tactical Training, AnnualEx = Annual Exercise, GuamEx = Guam Exercise

2.3.3 Standard Operating Procedures

For training and testing to be effective, units must be able to safely use their sensors and weapon 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 and testing have been developed through years of experience, and their primary purpose is to provide for safety (including public health and safety) and mission success. Because they are essential to safety and mission success, standard operating procedures are part of the Proposed Action and are considered in the Chapter 3

(Affected Environment and Environmental Consequences) environmental analysis for applicable resources.

In many cases, there are benefits to environmental and cultural resources (some of which have high socioeconomic value in the Study Area) resulting from standard operating procedures. Those standard operating procedures that are recognized as providing a benefit to the resources analyzed in this Final SEIS/OEIS are included in Appendix A (Training and Testing Activities Descriptions), as applicable. The following standard operating procedure categories apply to the Proposed Action and are generally consistent with those included in the specified sections in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of the 2015 MITT Final EIS/OEIS:

- Section 5.1.1 (Vessel Safety)
- Section 5.1.2 (Aircraft Safety)
- Section 5.1.3 (Laser Procedures)
- Section 5.1.4 (Weapons Firing Procedures), except Section 5.1.4.3 (Target Deployment Safety), which has been updated in Section 2.3.3.3 (Target Deployment and Retrieval Safety) of this Final SEIS/OEIS
- Section 5.1.6 (Unmanned Aerial and Underwater Vehicle Procedures)
- Section 5.1.7 (Towed In-Water Device Procedures)
- Section 5.7.3 (Farallon de Medinilla Access Restrictions)

Standard operating procedures that apply to the Proposed Action and were not included in, or require a clarification from, the 2015 MITT Final EIS/OEIS, are discussed in the sections below.

2.3.3.1 High-Energy Laser Safety

The Navy operates laser systems approved for fielding by the Laser Safety Review Board or service equivalent. Only properly trained and authorized personnel operate high-energy lasers within designated areas. Designated areas where lasers are used are required to have a Laser Range Safety Certification Report that is updated every three years. Prior to commencing activities involving high-energy lasers, the operator performs a search of the intended impact location to ensure that the area is clear of unauthorized persons. These standard operating procedures benefit public health and safety by reducing the potential for interaction with high-energy lasers.

2.3.3.2 Sea Space and Airspace Deconfliction

The Navy schedules training and testing activities to minimize conflicts with the use of sea space and airspace within ranges and throughout the Study Area to ensure the safety of military personnel, the public, commercial aircraft, commercial and recreational vessels, and military assets. The Navy deconflicts its own use of sea space and airspace to allow for the necessary separation of multiple military units to prevent interference with equipment sensors and to avoid interaction with established commercial air traffic routes and commercial shipping lanes. The Navy also minimizes conflicts within areas used for commercial and recreational fishing, subsistence use, and tourism. For example, during applicable seasons around the islands of Guam and the CNMI, the Navy works collaboratively with local communities to deconflict sea space used for fishing to the maximum extent practicable, such as avoiding known fishery infrastructures (e.g., fish aggregating devices) and high-use fishing areas. To help civilian mariners better plan fishing and boating activities that involve accessing the waters around FDM, the Navy notifies them through various means, such as U.S. Coast Guard-issued Notices to Mariners and social media, of the time periods when FDM will not be in use for several consecutive days. Announcing in advance when FDM will be in use (and when it will not be in use for an extended period of time) facilitates use of waters around FDM by the public during time periods that will not conflict with training and testing activities. These standard operating procedures benefit public health and safety (including persons participating in activities that have subsistence benefits and socioeconomic value, such as recreational or commercial fishing) by reducing potential interactions with training and testing activities.

2.3.3.3 Target Deployment and Retrieval Safety

The standard operating procedures for target deployment and retrieval safety are consistent with the procedures described in Section 5.1.4.3 (Target Deployment Safety) of the 2015 MITT Final EIS/OEIS, except for the description of which activities will implement them. Under the Proposed Action, the standard operating procedure for target deployment and retrieval safety applies 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, and marine mammals and sea turtles by increasing the effectiveness of visual observations for mitigation, thereby reducing the potential for interactions with the weapons firing activities associated with the use of applicable deployed targets.

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

2.3.3.4 Pierside Testing Safety

The *U.S. Navy Dive Manual* (U.S. Department of the Navy, 2011) prescribes safe distances for divers from active sonar sources and in-water explosions. Safety distances for the use of electromagnetic energy are specified in Department of Defense Instruction 6055.11 (U.S. Department of Defense, 2009) and Military Standard 464A (U.S. Department of Defense, 2002). These distances are used as the standard safety buffers for in-water energy to protect military divers. If an unauthorized person is detected within the exercise area, the activity will be temporarily halted until the area is again cleared and secured. These standard operating procedures benefit public health and safety (including persons participating in activities that have socioeconomic value, such as commercial or recreational diving) by reducing the potential for interaction with pierside testing activities.

2.3.3.5 Underwater Detonation Safety

Underwater detonation training takes place in designated exercise areas located away from popular recreational dive sites, primarily for human safety. If an unauthorized person (e.g., a recreational diver) or vessel is detected within the exercise area, the activity will be temporarily halted until the area is cleared and secured. Recreational dive sites often include shallow-water coral reefs, artificial reefs, and wrecks. Notices to Mariners are issued when the events are scheduled to alert the public to stay clear of the area. These standard operating procedures benefit public health and safety, environmental resources (e.g., shallow-water coral reefs, artificial reefs, and the biological resources such as fish that inhabit, shelter in, or feed among them), and cultural resources by reducing the potential for interaction with underwater detonation activities.

2.3.3.6 Sonic Booms

As a general policy, aircraft do not intentionally generate sonic booms below 30,000 feet of altitude unless over water and more than 30 miles from inhabited land areas or islands. The military may authorize deviations from this policy for tactical missions, phases of formal training syllabus flights, or research, test, and operational suitability test flights. The standard operating procedures for sonic booms benefit public health and safety by reducing the potential for exposure to sonic booms.

2.3.3.7 Unmanned Surface Vehicle Safety

For activities involving unmanned surface vehicles, the Navy evaluates the need to publish a Notice to Airmen or Notice to Mariners based on the scale, location, and timing of the activity. When necessary, Notices to Airmen and Notices to Mariners are issued to alert the public to stay clear of the area. These standard operating procedures benefit public health and safety by reducing the potential for interaction with unmanned surface vehicles.

2.3.3.8 Sinking Exercise Safety

The Navy is required to conduct sinking exercises greater than 50 nautical miles from land and in waters at least 6,000 feet deep (40 CFR section 229.2). The Navy selects sinking exercise areas to avoid established commercial air traffic routes, commercial vessel shipping lanes, and areas used for recreational activities, and to allow for the necessary separation of Navy units to ensure safety for Navy personnel, the public, commercial aircraft and vessels, and Navy assets. These standard operating procedures benefit public health and safety (including persons participating in activities that have socioeconomic value, such as recreational or commercial fishing) by reducing the potential for interaction with sinking exercises.

2.3.3.9 Amphibious Assault and Amphibious Raid Procedures

All established harbor navigation rules are observed during amphibious assault and amphibious raid training activities, when applicable. The Navy conducts a hydrographic survey prior to amphibious assault and amphibious raid training activities involving beach landings by large amphibious vehicles (e.g., Landing Craft, Air Cushion vessel). During the surveys, Navy personnel identify and designate vessel traffic lanes that are free of coral, hard bottom substrate, and obstructions that could present personnel and equipment safety concerns. The Navy does not conduct hydrographic surveys for beach landings with small boats, such as rigid-hulled inflatable boats, which have a much smaller draft than large amphibious vehicles and are therefore less likely to damage seafloor resources. Large amphibious vehicle beach landings and departures are scheduled at high tide, and vehicles stay fully on cushion or hover when over shallow reefs to avoid corals, hard bottom, and other substrate that could potentially damage equipment.

Due to the grounding of the French Navy Landing Craft that occurred on May 12, 2017, in Apra Harbor, the Navy has implemented additional standard operating procedures for amphibious assault and raid activities. The Navy requires the following standard operating procedures for amphibious landings at Reserve Craft Beach: (1) Concept of Operations for the event and for notification and coordination with Naval Base Guam Operations Officer, (2) presence of craft master who will coordinate planned routes with Mariana Islands Range Complex Ops and Naval Base Guam, (3) presence of a beach master (observers) to assist in approach to shore and restore beach to original condition, and (4) distribution of the Reserve Craft Beach Training Aid to all vessel captains participating in any training event in the vicinity of Reserve Craft Beach.

2.3.4 Mitigation Measures

The Navy developed mitigation measures to avoid or reduce potential impacts from the Proposed Action on environmental and cultural resources. This Final SEIS/OEIS was prepared in coordination with the U.S. Air Force and U.S. Coast Guard, and these Services will implement the Navy's mitigation measures as applicable under the Proposed Action. Mitigation measures that the Navy will implement under the Proposed Action are organized into three categories: at-sea procedural mitigation measures, at-sea mitigation areas, and terrestrial mitigation measures. The Navy will implement procedural mitigation measures whenever and wherever applicable training or testing 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. Terrestrial mitigation measures will be implemented during activities conducted on FDM.

A list of the activity categories, stressors, and mitigation areas for which the Navy developed mitigation measures is provided in Table 2.3-2. Chapter 5 (Mitigation) of this Final SEIS/OEIS provides a full description of each mitigation measure that will be implemented under Alternative 1 and Alternative 2 of the Proposed Action. It also presents a discussion of how the Navy developed and assessed each measure and includes maps of the mitigation area locations. Mitigation developed for the Proposed Action is generally in line with the type and level of mitigation included in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015). The Navy has updated Chapter 5 (Mitigation) of this Final SEIS/OEIS in its entirety based on its ongoing analysis of the best available science and practicality of implementing potential mitigation measures. A full analysis of the mitigation areas the Navy developed for marine mammals and sea turtles in the Study Area is provided in Appendix I (Geographic Mitigation Assessment). Relevant mitigation details are also provided throughout Appendix A (Training and Testing Activities Descriptions). The Navy Record of Decision will document all mitigation measures the Navy will implement under the Proposed Action. The Navy's Record of Decision, MMPA Regulations and Letter of Authorization, ESA Biological Opinion, and other applicable consultation documents will include mitigation measures applicable to the resources for which the Navy has consulted.

Table 2.3-2: 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 Weapons Firing Noise
	Section 5.3.3 (Explosive Stressors)	Explosive Sonobuoys Explosive Torpedoes Explosive Medium-Caliber and Large-Caliber Projectiles Explosive Missiles and Rockets Explosive Bombs Sinking Exercises Explosive Mine Countermeasure and Neutralization Activities Explosive Mine Neutralization Activities Involving Navy Divers Maritime Security Operations – Anti-Swimmer Grenades
	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 Missiles and Rockets Non-Explosive Bombs and Mine Shapes
Mitigation Areas	Section 5.4 (At-Sea Mitigation Areas to be Implemented)	Seafloor Resource Mitigation Areas Marpi Reef Mitigation Area Chalan Kanoa Reef Mitigation Area Agat Bay Nearshore Mitigation Area
Terrestrial Mitigation	Section 5.5 (Terrestrial Mitigation Measures to be Implemented)	Farallon de Medinilla

2.4 Action Alternatives Development

The identification, consideration, and analysis of alternatives are critical components of 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 Code of Federal Regulations section 1502.14). CEQ guidance further provides that an EIS must rigorously explore and objectively evaluate all reasonable alternatives for implementing the proposed action and, for alternatives eliminated from detailed study, briefly discuss the reasons for their 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 alternatives, and in particular the mitigation measures that are incorporated in the action alternatives, were developed to meet both the Navy's purpose and need to train and test, and NMFS' independent purpose and need to evaluate the potential impacts of the Navy's activities, determine whether incidental take resulting from the Navy's activities will have a negligible impact on affected marine mammal species and stocks, and to prescribe measures to effect the least practicable adverse impact on species or stocks and their habitat, as well as monitoring and reporting requirements.

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

2.4.1 Alternatives Eliminated from Further Consideration

This SEIS/OEIS serves as an update to the 2015 MITT Final EIS/OEIS; therefore, alternatives eliminated from consideration in the 2015 MITT Final EIS/OEIS were evaluated to determine if they should be reconsidered for this SEIS/OEIS. In response to the comments received during the public scoping period, the Navy also considered developing an alternative that included geographic mitigation. Alternatives eliminated from further consideration are described in the subsections below. The Navy determined that these alternatives did not meet the purpose of and need for the Proposed Action after a thorough consideration of each.

2.4.1.1 "Status Quo" Alternative

In response to public comments, the Navy considered a Status Quo Alternative based on the 2015 MITT Final EIS/OEIS Preferred Alternative (Section 2.7, Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems) and the 2015 MITT EIS/OEIS Record of Decision. Under such an alternative, the Navy would continue training and testing in the MITT Study Area at current levels documented in the 2015 MITT EIS/OEIS Record of Decision, requesting separate authorizations under the MMPA and ESA as required. The Navy would continue to conduct training and testing activities, but not at the level and scope of activities necessary to fulfill its Title 10 responsibilities described in Chapter 1 (Purpose and Need). A Status Quo Alternative would not allow the Navy to meet future training and testing requirements necessary to achieve and maintain fleet readiness. Thus, such an alternative would not be reasonable and has been eliminated from detailed study.

2.4.1.2 Alternative Training and Testing Locations

As described in Section 2.5.1.1 (Alternative Training and Testing Locations) in the 2015 MITT Final EIS/OEIS, the diverse and multi-dimensional environment provided within the Study Area allows the military to develop and maintain high levels of readiness and interoperability with foreign partners in the Western Pacific. There are no other proximate alternative locations that provide for this capability. As a result, this alternative is neither reasonable or practicable and does not meet the purpose of and need for the Proposed Action and has been eliminated from detailed study.

2.4.1.3 Reduced Training and Testing

As described in Section 2.5.1.2 (Reduced Training and Testing) in the 2015 MITT Final EIS/OEIS, a reduction or cessation of training and testing would prevent the Navy and other Services from meeting its 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.

2.4.1.4 Alternatives Including Geographic Mitigation Measures within the Study Area

The Navy considered but did not develop an alternative based solely on geographic mitigation that would impose time or area restrictions on specific areas in the Study Area, such as areas associated with the presence of specific species. The Navy designed its alternatives development and mitigation development processes to ensure that the maximum level of mitigation that is practical for the Navy to implement when balanced against impacts to safety, sustainability, and the ability to continue meeting mission requirements would be implemented regardless of the action alternative selected. Developing geographic mitigation for both action alternatives is a more conservative (i.e., more environmentally protective) approach than developing geographic mitigation for one action alternative but not the other.

Further, regulations governing the NEPA allow agencies to "Include appropriate mitigation measures not already included in the proposed action or alternatives" (40 CFR 1502.14[f]). Under both action alternatives, the Navy would implement geographic mitigation that is both biologically effective as well as practical to implement. The Supplemental SEIS/OEIS considers and analyzes a comprehensive range of potential mitigation measures, including those that were not adopted, allowing for a robust analysis by the agencies. The mitigation areas developed for the Proposed Action are detailed in Appendix I (Geographic Mitigation Assessment).

2.4.1.5 Simulated Training and Testing Only

As described in Section 2.5.1.4 (Simulated Training and Testing) in the 2015 MITT Final EIS/OEIS, the Navy continues to use computer simulation for training and testing activities whenever possible; however, there are limits to the realism that current simulation technology can presently provide, and its use cannot substitute for live training or testing. Training and testing through simulated means cannot replicate the conditions in which Navy personnel and platforms are required to conduct military operations. While beneficial as a complementing medium to train and test personnel and platforms, simulation alone cannot accurately replicate both the conditions and the stresses that must be placed on personnel and platforms during training. These conditions and stresses are absolutely vital to adequately preparing Naval forces to conduct the broad spectrum of military operations required of them by operational Commanders. Therefore, simulation as an alternative that completely replaces training and testing in the field does not meet the purpose of and need for the Proposed Action and has been eliminated from detailed study.

2.4.1.6 Training and Testing Without the Use of Active Sonar

As explained in Section 2.4.1.5 (Simulated Training and Testing Only), in order to detect and counter submerged mines and potentially hostile submarines, the Navy uses 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 and testing with active sonar is needed to find and counter newer-generation submarines around the world, which are growing in number, as are torpedoes and underwater mines, which are true threats to global commerce, national security, and the safety of military personnel. As a result, defense against enemy submarines is a top priority for the Navy. The detection and countering of submarines is paramount to national security. Naval forces cannot counter this threat without the use of active sonar. Because the Navy is statutorily responsible to provide combat-ready forces to operational Commanders, it must train in a manner in which it will be utilized in military operations. Accordingly, training and testing without active sonar is not a reasonable alternative and will not be carried forward.

2.4.2 Alternatives Carried Forward

The military's anticipated level of training and testing activity evolves over time based on numerous factors. Over the past several years, the Navy's ongoing sonar reporting program has gathered classified data regarding the number of sonar hours used to meet anti-submarine warfare requirements. These data allow for a more accurate projection of the number of active sonar hours required to meet anti-submarine warfare training requirements into the reasonably foreseeable future. Alternatives carried forward for analysis in this SEIS/OEIS are discussed in the following subsections and presented in Table 2.5-1 and Table 2.5-2 at the end of this chapter. As previously discussed, in addition to meeting the Navy's purpose and need to train and test, the action alternatives, and in particular the mitigation measures that are incorporated in the action alternatives, were developed to meet NMFS' 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.

2.4.2.1 No Action Alternative

As mentioned above in Section 2.4 (Action Alternatives Development), the Council on Environmental Quality implementing regulations require inclusion of a No Action Alternative and analysis of all reasonable alternatives to provide a clear basis for choice among options by the decision maker and the public (40 CFR section 1502.14). Council on Environmental Quality guidance identifies two approaches in developing the No Action Alternative (46 *Federal Register* 18026, Forty Most Asked Questions Concerning CEQ's NEPA Regulations). 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 continuation of Navy training and testing at sea in the MITT Study Area at current levels, even if separate legal authorizations under the MMPA and ESA are required. Under this approach, which was used in the 2015 MITT Final EIS/OEIS, the analysis compares the effects of continuing current activity levels (i.e., the "status quo") with the effects of the Proposed Action. The second approach depicts a scenario where no authorizations or permits are issued, the Navy's training and testing activities do not take place, and the resulting environmental effects from taking no action are compared with the effects of the Proposed Action. The Navy applied the second approach in this SEIS/OEIS as it further supports NMFS' regulatory process by presenting the scenario where no authorization will be issued. Additionally, the second approach responds to comments submitted at various stages regarding the 2015 MITT Final EIS/OEIS and during the scoping process of this SEIS/OEIS.

Under the No Action Alternative analyzed in this SEIS/OEIS, the Navy would not conduct the proposed training and testing activities in the MITT Study Area. Other military activities not associated with this Proposed Action would continue to occur. For FDM, the lease agreement between the U.S. government and the Commonwealth of the Northern Mariana Islands would remain in place, and the island would continue to be maintained as a Navy range, although strike warfare would no longer continue on the island. Consequently, the No Action Alternative of not conducting the proposed at-sea training and testing activities in the Study Area is inherently unreasonable in that it does not meet the purpose and need (see Section 1.4, Purpose and Need for Proposed Training and Testing Activities) for the reasons stated below. However, the analysis associated with the No Action Alternative is carried forward in order to compare the degree 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, Overall Approach to Analysis).

From NMFS's perspective, pursuant to its obligation to grant or deny permit applications under the MMPA, the No Action Alternative involves NMFS denying 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 at-sea proposed training and testing activities in the MITT Study Area.

Cessation of proposed Navy at-sea training and testing activities would mean that the Navy would not meet its statutory requirements and would be unable to properly defend itself and the United States from enemy forces, unable to successfully detect enemy submarines, and unable to effectively use its weapons systems or defensive countermeasures due to a lack of training of forces and testing of systems that replicate the conditions to which Naval forces must operate while executing the range of military operations required to further national security objectives. Navy personnel would not obtain the unique skills or be prepared to safely and effectively use sensors, weapons, and technologies in realistic scenarios required to accomplish the overall mission. For example, sonar proficiency, which is a complex and perishable skill, requires regular, hands-on training in realistic and diverse conditions. In order to detect and counter potentially hostile submarines, the Navy uses both passive and active sonar. Inability to train with active sonar would result in no or greatly diminished anti-submarine warfare capability.

Additionally, without proper training, individual Sailors and Marines serving onboard Navy vessels would not be taught how to properly operate complex equipment in inherently dynamic and dangerous environments. Even with high levels of training, injuries, and death occur. Therefore, without proper training, it is likely that there would be an increase in the number of mishaps, potentially resulting in the death or serious injury of Sailors and Marines. Failing to allow our Sailors and Marines to achieve and maintain the skills necessary to defend the United States and its interests would result in an unacceptable increase in the danger they willingly face.

Finally, the lack of live training and testing would require a higher reliance on simulated training and testing. While the Navy continues to research new ways to provide realistic training through simulation, there are limits to the realism that technology provides. While simulators are used for the basic training of sonar technicians, they are of limited utility beyond basic training. A simulator cannot match the dynamic nature of the environment, such as bathymetry and sound propagation properties, or the training activities involving several units with multiple crews interacting in a variety of acoustic environments. Sole reliance on simulation would deny service members the ability to develop battle-ready required proficiency in the employment of active sonar during military operations (Section 2.4.1.5, Simulated Training and Testing Only).

2.4.2.2 Alternative 1

Alternative 1 reflects a representative year of training and testing to account for the typical fluctuation of training cycles, testing programs, and deployment schedules that generally limit the maximum level of training and testing from occurring for the reasonably foreseeable future.

2.4.2.2.1 Training

Under this alternative, the Navy proposes to conduct training activities into the reasonably foreseeable future, as necessary to meet current and future readiness requirements. These include training activities subject to previous analysis that are currently ongoing and have historically occurred in the Study Area. The requirements for the types of activities to be conducted, as well as the intensity at which they need to occur, have been validated by senior leadership. Specifically, training activities are based on changing world events, advances in technology, and U.S. tactical and strategic priorities. These activities account for force structure changes and include training with new aircraft, vessels, unmanned/autonomous systems, and weapon systems that will be introduced to the Fleets after August 2020. The numbers and locations of all proposed training activities are provided in Table 2.5-1.

2.4.2.2.2 Testing

Alternative 1 reflects a level of testing activities to be conducted into the reasonably foreseeable future, with adjustments from the 2015 MITT Final EIS/OEIS that account for changes in the types and tempo (increases or decreases) of testing activities to meet current and future military readiness requirements. The majority of testing activities that would be conducted under this alternative are the same as or similar as those conducted currently or in the past. This alternative includes the testing of new systems using new technologies and takes into account inherent uncertainties in this type of testing. The numbers and locations of all proposed testing activities are listed in Table 2.5-2.

2.4.2.2.3 Mitigation Measures

The Navy's entire suite of mitigation measures was applied to Alternative 1 to ensure that (1) the benefit of mitigation measures to environmental and cultural resources was considered during the applicable environmental analyses, and (2) Navy senior leadership approved each mitigation measure included in this Final SEIS/OEIS under Alternative 1. Navy senior leadership reviewed relevant supporting information to make a fully informed decision, including the benefit of mitigation measures to environmental and cultural resources, and the impacts that implementing mitigation will have on training and testing activities under Alternative 1. As discussed in Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment), 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 to safety, sustainability, and the ability to continue meeting its mission requirements.

2.4.2.3 Alternative 2 (Preferred Alternative)

2.4.2.3.1 Training

Alternative 2 is the Preferred Alternative and includes the same types of training activities as Alternative 1 but also considers additional Fleet exercises and associated unit-level activities should unanticipated emergent world events require increased readiness levels. For example, Alternative 2 contemplates Joint Multi-Strike Group Exercises (i.e., Valiant Shield) occurring annually as compared to every other year under Alternative 1 (see Table 2.5-1). Additionally, Alternative 2 contemplates three (vice two) Small Joint Coordinated Anti-Submarine Warfare exercises (Multi-Sail/Guam Exercises) per year with a 50 percent increase in associated unit-level events (e.g., Missile Exercise [Surface-to-Air]). The numbers and locations of all proposed training activities are provided in Section 2.3 (Proposed Activities) and listed in Table 2.5-1.

Alternative 2 reflects the maximum number of training activities that could occur within a given year, and assumes that the maximum number of Fleet exercises would occur annually. This allows for the greatest flexibility for the Navy to maintain readiness when considering potential changes in the national security environment, fluctuations in training and deployment schedules, and anticipated in-theater demands.

2.4.2.3.2 Testing

Alternative 2 entails a level of testing activities to be conducted into the reasonably foreseeable future. Under Alternative 2, types and tempo of testing activities would increase compared to Alternative 1 (see Table 2.5-2). This alternative includes the contingency for augmenting some weapon systems tests in response to potential increased world conflicts and changing Navy leadership priorities as the result of a direct challenge from a naval opponent that possesses near peer capabilities. The numbers and locations of all proposed testing activities are listed in Table 2.5-2.

2.4.2.3.3 Mitigation Measures

The Navy's entire suite of mitigation measures was applied to Alternative 2 to ensure that: (1) the benefit of mitigation measures to environmental and cultural resources was considered during the applicable environmental analyses, and (2) Navy senior leadership approved each mitigation measure included in this Final SEIS/OEIS under Alternative 2. Navy senior leadership reviewed relevant supporting information to make a fully informed decision, including the benefit of mitigation measures to environmental and cultural resources, and the impacts that implementing mitigation will have on training and testing activities under Alternative 2. As discussed in Chapter 5 (Mitigation), 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 to safety, sustainability, and the ability to continue meeting its mission requirements.

2.4.3 Comparison of Proposed Sonar and Explosive Use in the Action Alternatives

2.4.3.1 Sonar Use

As part of the 2015 MITT Final EIS/OEIS and 2015 MMPA Letter of Authorization, NMFS authorized the Navy to use non-impulsive sound sources including sonars and other transducers. Sonars and other transducers were grouped into classes that share one or more attributes, such as frequency range or purpose of use. The classes were further sorted into sound source bins. These bins are defined and quantified in Section 3.0.5.1 (Acoustic Stressors).

In the 2015 analysis, the Navy identified the type of sonar source that resulted in the highest number of exposures to marine mammals, which was hull-mounted mid-frequency active sonar in bin MF1. The Navy was authorized 1,872 hours of MF1 annually in the 2015 MITT Final EIS/OEIS and by NMFS under the MMPA permit and ESA Biological Opinion.

In this SEIS/OEIS, the Navy is evaluating the potential impacts associated with 1,729 hours of MF1 annually under Alternative 1, a reduction of approximately 8 percent from the currently authorized total (Figure 2.4-1). Under Alternative 2, the Navy is evaluating the potential impacts associated with 1,818 hours of MF1 annually, which is a decrease of approximately 3 percent over currently permitted levels.

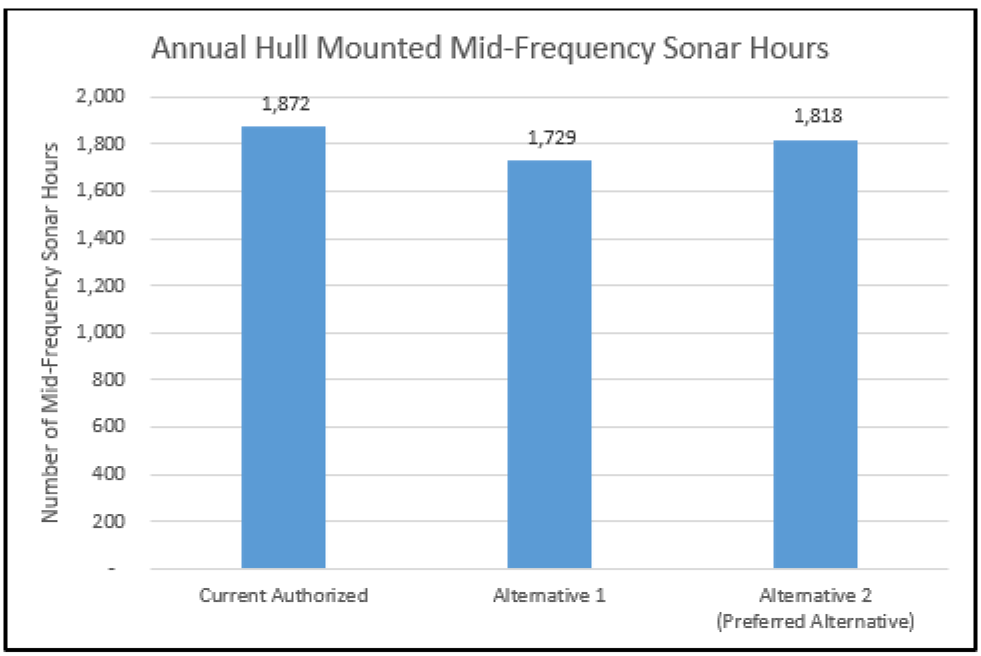

Figure 2.4-1: Proposed Annual Total Hull-Mounted Mid-Frequency Sonar Hour Use Compared to the Number Authorized in the 2015–2020 Marine Mammal Protection Act Permit

2.4.3.2 Explosives Use

As part of the 2015 MITT Final EIS/OEIS and 2015 MMPA Letter of Authorization, NMFS authorized the Navy to use impulsive sources (i.e., explosives). Similar to non-impulsive sources, the Navy sorted explosive sources into bins based on the net explosive weight of the explosive. After analyzing the level of explosive activities conducted during Phase II, the Navy identified that some explosive sources were incorrectly classed into bins with greater net explosive weights than actually is present in the munition. For example, 20-millimeter rounds were considered in bin E1 (defined as 0.1–0.25 pounds net explosive weight) during Phase II, but have less than 0.1 pound of net explosive weight (defined as bin E0) and are, therefore, analyzed qualitatively instead of quantitatively for Phase III. Additionally, in Phase II, munitions within the same category were all analyzed with the highest net explosive weight for all munitions in that category. For example, most bombs were analyzed as bin E12 (to account for the largest potential for environmental impact), whereas many fall within bins E9 and E10. For Phase III, munitions were divided into more appropriate bins based on current and anticipated weapon inventory. Bins used to sort explosive munitions are further defined and quantified in Section 3.0.4.2 (Explosive Stressors).

See Figure 2.4-2 and Figure 2.4-3 for a comparison between explosives authorized for training and testing in the 2015 MITT Final EIS/OEIS and proposed in this SEIS/OEIS. The number of impulsive sources in bins E2, E5, E8, E9, and E10 would increase in this SEIS/OEIS compared with the totals analyzed in the 2015 MITT Final EIS/OEIS. The number of impulsive sources that would decrease under this SEIS/OEIS are in bins E1, E3, E4, E6, E11, and E12.

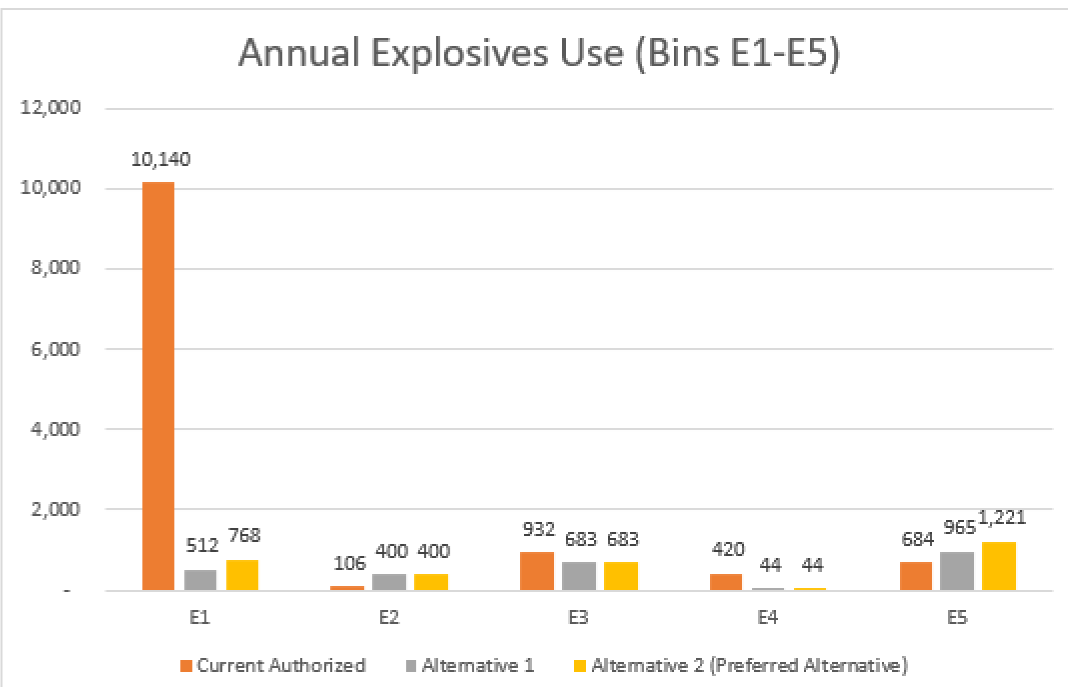

Figure 2.4-2: Proposed Annual Explosives Use (Bins E1–E5) Compared to the 2015–2020 Marine Mammal Protection Act Permit

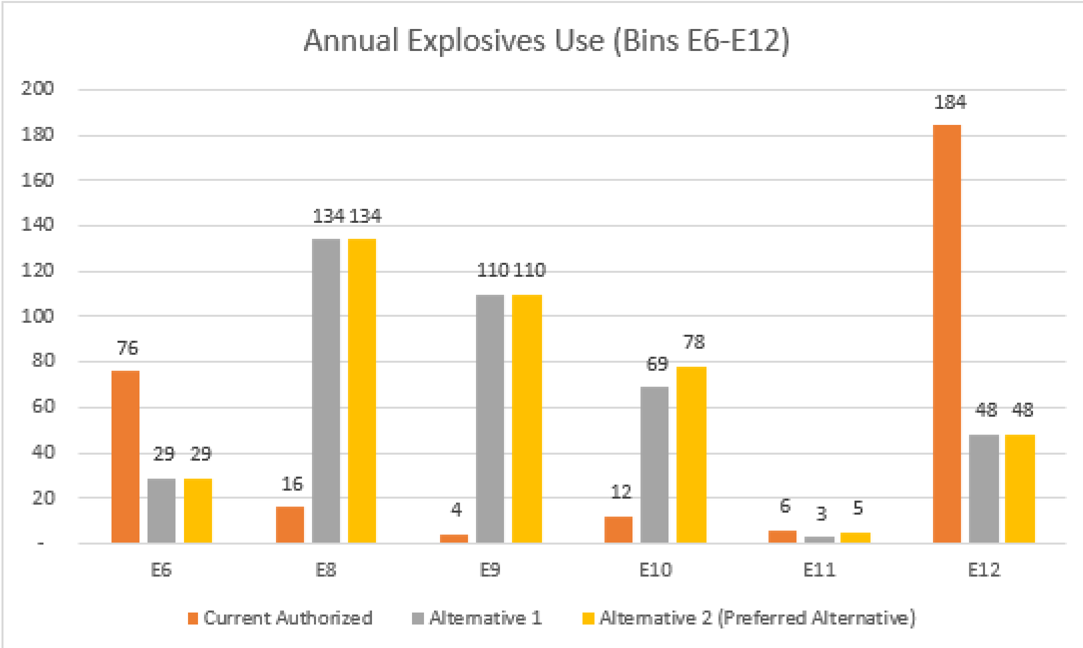

Figure 2.4-3: Proposed Annual Explosives Use (Bins E6–E12) Compared to the 2015–2020 Marine Mammal Protection Act Permit

2.5 Comparison of Alternatives

The following tables compare the proposed SEIS/OEIS action alternatives (Alternative 1 and Alternative 2) with the ongoing training and testing activities (Table 2.5-1, Table 2.5-2). Each table describes the activities in terms of the activity name and where in the Study Area the Navy proposes to conduct it (first two columns). The next two columns show the annual occurrence and ordnance or other expended items (if any) involved in the activity as is currently ongoing (under the heading "2015 MITT EIS/OEIS Ongoing Activities"). The final two pairs of columns present the same information (annual occurrence and ordnance/items) as the activities are analyzed in this SEIS/OEIS for Alternative 1 and Alternative 2, respectively. Table 2.5-1 is the table of training activities, while Table 2.5-2 is the table of Naval Air Systems Command testing activities, Naval Sea Systems Command testing activities, and Office of Naval Research testing activities.

Table 2.5-1: Current and Proposed Training Activities

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Legend:		[blue]	= Decrease in number of events from 2015 Final MITT EIS/OEIS		[orange]	= Increase in number of events from 2015 Final MITT EIS/OEIS	
Major Training Exercises							
Joint Expeditionary Exercise	Study Area; MIRC	1	Note 2	1	Note 2	1	Note 2
Joint Multi-Strike Group Exercise	Study Area; MIRC	1	Note 2	1 every other year	Note 2	1	Note 2
Air Warfare (AW) (previously named Anti-Air Warfare in 2015 MITT Final EIS/OEIS)							
Air Combat Maneuver	Study Area > 12 NM from land: SUA	4,800	None	3,800	None	3,800	None
Air Defense Exercise (ADEX)	Study Area > 12 NM from land: SUA	100	None	100	None	100	None
Air Intercept Control (AIC)	Study Area > 12 NM from land: SUA	4,800	None	5,300	None	5,300	None
Gunnery Exercise (GUNEX) (Air-to-Air [A-A]) – Medium-caliber	Study Area SUA > 12 NM from land	36	9,000 rounds	36	9,000 rounds	36	9,000 rounds

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Missile Exercise (MISSILEX) (A-A)	Study Area SUA > 12 NM from land	18	36 explosive missiles	18	36 explosive missiles	18	36 explosive missiles
GUNEX (Surface-to-Air [S-A]) – Large-caliber	Study Area SUA > 12 NM from land	5	40 rounds	6	60 rounds	9	90 rounds
GUNEX [S-A] – Medium-caliber	Study Area SUA > 12 NM from land	12	24,000 rounds	13	26,000 rounds	19	38,000 rounds
MISSILEX [S-A]	Study Area SUA > 12 NM from land	15	15 explosive missiles	18	18 explosive missiles	27	27 explosive missiles
Amphibious Warfare (AMW)							
Naval Surface Fire Support Exercise (FIREX) – Land-based target (Land)	FDM	10	1,800 NEPM rounds 1,000 explosive rounds	10	2,800 explosive rounds	15	4,200 explosive rounds
Marine Air Ground Task Force Exercise (Amphibious) – Battalion	Study Area to nearshore; MIRC; Tinian; Guam; Rota; Saipan; FDM	4	Note 2	4	Note 2	4	Note 2
Amphibious Rehearsal, No Landing	Study Area and Nearshore	12	None	12	None	12	None
Amphibious Assault	MIRC; Tinian; Guam	6	Blanks; Simunitions	6	Blanks; Simunitions	6	Blanks; Simunitions
Amphibious Raid	MIRC; Tinian; Guam; Rota	6	Blanks; Simunitions	6	Blanks; Simunitions	6	Blanks; Simunitions

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Noncombatant Evacuation Operation	MIRC; Guam; Tinian; Rota	5	Blanks; Simunitions	5	Blanks; Simunitions	5	Blanks; Simunitions
Humanitarian Assistance/Disaster Relief Operations	MIRC; Guam; Tinian; Rota	5	Blanks; Simunitions	5	Blanks; Simunitions	5	Blanks; Simunitions
Unmanned Aerial Vehicle – Intelligence, Surveillance, and Reconnaissance	MIRC; SUA	100	None	100	None	100	None
Special Purpose Marine Air Ground Task Force Exercise	Study Area to nearshore; MIRC; Tinian; Guam; Rota; Saipan	2	Note 2	2	Note 2	2	Note 2
Anti-Submarine Warfare (ASW)							
Tracking Exercise (TRACKEX) –Helicopter (Helo)	Study Area > 3 NM from land; Transit Corridor	62	None/ REXTORP	10	None	10	None/ REXTORP
Torpedo Exercise (TORPEX)–Helo	Study Area > 3 NM from land	4	4 EXTORP	4	4 EXTORP	6	6 EXTORP
TRACKEX – Maritime Patrol (Extended Echo Ranging Sonobuoys)	Study Area > 3 NM from land	11	None	0	0	0	0

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
TRACKEX – Maritime Patrol Aircraft	Study Area > 3 NM from land	34	None/ REXTORP	36	None/REXTORP	36	None/ REXTORP
TORPEX – Maritime Patrol Aircraft	Study Area > 3 NM from land	4	4 EXTORP	4	4 EXTORP	6	6 EXTORP
TRACKEX – Surface	Study Area > 3 NM from land	CG/DDG-92 FFG-30 LCS-10	None/ REXTORP	91	None/ REXTORP	91	None/ REXTORP
TORPEX – Surface	Study Area > 3 NM from land	3	3 EXTORP	4	4 EXTORP	6	6 EXTORP
TRACKEX – Submarine (Sub)	Study Area > 3 NM from land; Transit Corridor	12	None	4	None	4	None
TORPEX – Sub	Study Area > 3 NM from land	10	40 MK-48 EXTORP	6	24 MK-48 EXTORP	9	36 MK-48 EXTORP
Combined Small Coordinated ASW exercise (e.g., Multi-Sail/GUAMEX/SWATT) (see Note 3)	Study Area > 3 NM from land	Not called out in previous document, but components were covered under several unit-level exercises	None	2	None	3	None

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Electronic Warfare (EW)							
Electronic Warfare Operations (EW Ops)	Study Area	480	None	522	None	522	None
Counter Targeting Flare Exercise (FLAREX) – Aircraft	Study Area > 12 NM from land	3,200	25,600 rounds	2,200	17,600 rounds	2,200	17,600 rounds
Counter Targeting Chaff Exercise (CHAFFEX) – Ship	Study Area > 12 NM from land	40	240 rounds	41	244 rounds	60	360 rounds
CHAFFEX –Aircraft	Study Area > 12 NM from land	3,200	25,600 rounds	2,200	17,600 rounds	2,200	17,600 rounds
Expeditionary Warfare							
Personnel Insertion/ Extraction[4]	MIRC; Guam; Tinian; Rota	240	None	365	None	365	None
Parachute Insertion[4]	MIRC parachute drop zones; Guam; Tinian; Rota	20	None	64	None	64	None
Mine Warfare (MIW)							
Civilian Port Defense	Mariana littorals; MIRC; Inner and Outer Apra Harbor	1	None	1	None	1	None
Mine Laying	MIRC Warning Areas	4	480 mine shapes	4	480 mine shapes	4	480 mine shapes

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Mine Neutralization – Explosive Ordnance Disposal (EOD)	Agat Bay underwater detonation site Piti and Outer Apra Harbor underwater detonation sites	20	20 explosive charges	20	20 explosive charges	20	20 explosive charges
Limpet Mine Neutralization System	Mariana littorals; Inner and Outer Apra Harbor	40	40 charges	60	60 charges	60	60 charges
Airborne Mine Countermeasure – Towed Mine Detection	Study Area; nearshore	4	None	4	None	4	None
Mine Countermeasure Exercise – Towed Sonar (AQS-20, LCS)	Study Area	4	None	4	None	4	None
Mine Countermeasure Exercise – Surface Ship Sonar (SQQ-32, MCM)	Study Area	4	None	4	None	4	None
Mine Neutralization – Remotely Operated Vehicle Sonar (ASQ-235 [AQS-20], SLQ-48)	Study Area	4	4 explosive neutralizers	4	4 explosive neutralizers	4	4 explosive neutralizers

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Mine Countermeasure – Towed Mine Neutralization	Study Area	4	None	4	None	4	None
Underwater Demolition Qualification/ Certification	Agat Bay underwater detonation site Piti and Outer Apra Harbor underwater detonation sites	30	30 explosive charges	45	45 explosive charges	45	45 explosive charges
Submarine Mine Exercise	Mariana Littorals, Inner/Outer Apra Harbor	16	None	1	None	1	None
Surface Ship Object Detection	Study Area	Not previously analyzed	Not previously analyzed	6	None	6	None
Strike Warfare (STW)							
Bombing Exercise (BOMBEX) (Air-to-Ground [A-G])	FDM	2,300	2,670 NEPM 6,242 explosive rounds	2,300	2,670 NEPM 6,242 explosive rounds	2,300	2,670 NEPM 6,242 explosive rounds

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
GUNEX (A-G)	FDM	96	24,000 small-caliber rounds	96	24,000 small-caliber rounds	96	24,000 small-caliber rounds
			94,150 medium-caliber rounds		94,650 medium-caliber rounds		94,650 medium-caliber rounds
			17,350 explosive med.-caliber rounds		17,500 explosive med-caliber rounds		17,500 explosive med -caliber rounds
			200 explosive large-caliber rounds		200 explosive large-caliber rounds		200 explosive large-caliber rounds
MISSILEX	FDM	85	2,000 explosive rockets	115	2,000 explosive rockets	115	2,000 explosive rockets
			85 explosive missiles		115 explosive missiles		115 explosive missiles
Surface Warfare (SUW)							
GUNEX (Air-to-Surface [A-S]) – Small-caliber	Study Area SUA > 12 NM from land	242	48,040 rounds	321	128,400 rounds	321	128,400 rounds

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
GUNEX (A-S) – Medium-caliber	Study Area SUA > 12 NM from land; Transit Corridor	295	29,500 non-explosive rounds 7,150 explosive rounds	120	3,600 explosive rounds	120	3,600 explosive rounds
MISSILEX (A-S) – Rocket)	Study Area SUA > 12 NM from land	3	114 rockets (114 explosive)	111	2,109	111	2,109
MISSILEX (A-S)	Study Area SUA > 12 NM from land	20	20 explosive missiles	10	18 explosive missiles	10	18 explosive missiles
Laser Targeting (at sea)	Study Area SUA > 12 NM from land	600	None	600	None	600	None
BOMBEX (A-S)	Study Area > 50 NM from land	37	368 NEPM 184 explosive rounds	37	368 NEPM 184 explosive rounds	37	368 NEPM 184 explosive rounds
Torpedo Exercise (Submarine to Surface)	Study Area > 3 NM from land	5	10 EXTORP	0	None	0	None
MISSILEX (Surface-to-Surface [S-S])	Study Area > 50 NM from land	12	12 explosive missiles	19	19 explosive missiles	28	28 explosive missiles

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
GUNEX (S-S) Ship – Large-caliber	Study Area SUA > 12 NM from land; Transit Corridor	140	5,198 non-explosive rounds	170	16,320 non-explosive rounds	255	24,480 non-explosive rounds
			500 explosive rounds		510 explosive rounds		765 explosive rounds
GUNEX (S-S) Ship – Small- and Medium-caliber	Study Area SUA > 12 NM from land; Transit Corridor	100	21,000 non-explosive rounds	162	172,010 non-explosive rounds	234	250,800 non-explosive rounds
			900 explosive rounds		480 explosive rounds		720 explosive rounds

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity		Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
			No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Sinking Exercise (SINKEX) Representative ordnance. Actual ordnance used will vary.		Study Area > 50 NM from land and > 1,000 fathoms depth	2	28 explosive Bombs 42 explosive Missiles 800 explosive Large-caliber rounds 2 MK-48 explosive 4 explosive Demolitions	1	28 explosive Bombs 42 explosive Missiles 800 explosive Large-caliber rounds 2 MK-48 explosive 4 explosive Demolitions	1	28 explosive Bombs 42 explosive Missiles 800 explosive Large-caliber rounds 2 MK-48 explosive 4 explosive Demolitions
GUNEX [S-S] Boat – Small and Medium-caliber	Medium-caliber	Study Area SUA > 12 NM from land; Transit Corridor	10	2,000 non-explosive rounds	20	4,000 non-explosive rounds	20	4,000 non-explosive rounds
				100 explosive rounds		200 explosive rounds		200 explosive rounds
	Small-caliber	Study Area > 3 NM from land; Transit Corridor	40	36,000 rounds	43	36,600 rounds	43	36,600 rounds

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Maritime Security Operations (MSO)	Study Area; MIRC	40	200 G911 anti-swimmer grenades	40	200 G911 anti-swimmer grenades	40	200 G911 anti-swimmer grenades
Other							
Direct Action (Tactical Air Control Party)	FDM	18	18,000 small-caliber rounds	18	30,000 small-caliber rounds	18	30,000 small caliber rounds
			600 explosives (grenade/ mortar)		1,000 med-caliber explosive		1,000 med-caliber explosive
					1,000 explosive (grenade mortar)		1,000 explosive (grenade mortar)
Intelligence, Surveillance, Reconnaissance[4]	MIRC; Guam; Tinian; Rota; Saipan	16	None	44	None	44	None
Precision Anchoring	Apra Harbor; Mariana Islands anchorages	18	None	18	None	18	None
Search and Rescue At Sea	Study Area	40	None	45	None	45	None

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Small Boat Attack	Study Area > 3 NM from land	6	2,100 small-caliber rounds	18	2,100 small-caliber rounds	27	3,150 small-caliber rounds
	Study Area	12	4,000 blank rounds		4,000 blank rounds		6,000 blank rounds
Submarine Navigation	Apra Harbor and Mariana littorals	8	None	8	None	8	None
Submarine Sonar Maintenance	Study Area > 3 NM from land; Inner Apra Harbor; Transit Corridor	48	None	86	None	86	None
Surface Ship Sonar Maintenance	Study Area > 3 NM from land; Inner Apra Harbor; Transit Corridor	42	None	44	None	44	None
Underwater Survey	Mariana littorals	16	None	32	None	32	None
Unmanned Aerial Training and Certification	Study Area; Orote Point Airfield, Guam; Northwest Airfield, Guam; North Airfield, Tinian; MIRC SUA	1,000	None	951	None	951	None

Table 2.5-1: Current and Proposed Training Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Unmanned Underwater Vehicle Training (Note 2)	MIRC, Mariana Littorals, Warning Areas	N/A	N/A	64	None	64	None

Legend: [blue] = Decrease in number of events from 2015 Final MITT EIS/OEIS
[orange] = Increase in number of events from 2015 Final MITT EIS/OEIS

Note 1: Ongoing activities are those training and testing activities that were analyzed in the 2015 MITT Final EIS/OEIS. The Supplemental EIS/OEIS (1) includes the analysis of activities at sea and on FDM necessary to meet readiness requirements beyond 2020 and into the reasonably foreseeable future, (2) includes any changes to those activities previously analyzed in the 2015 MITT Final EIS/OEIS, and (3) reflects the most up-to-date compilation of training and testing activities deemed necessary to accomplish military readiness requirements.

Note 2: All ordnance use during the conduct of these exercises is analyzed within the Primary Mission events listed in this table.

Note 3: Small Joint Coordinated ASW exercise was not called out in the 2015 MITT Final EIS/OEIS, but the components of the exercise were covered under several unit-level activities.

Note 4: Proposed increases in Personnel Insertion/Extractions; Parachute Insertions; and Intelligence, Surveillance, Reconnaissance activities would only occur offshore within the MIRC.

Notes: MITT = Mariana Islands Training and Testing, ROD = Record of Decision, EIS = Environmental Impact Statement, OEIS = Overseas Environmental Impact Statement, MIRC = Mariana Islands Range Complex, FDM = Farallon de Medinilla, N/A = Not Applicable, No. = Number, SUA = Special Use Airspace, NM = Nautical Mile(s), NEPM = Non-Explosive Practice Munitions, EXTORP = Exercise Torpedo (non-explosive), REXTORP = Recoverable Exercise Torpedo (non-explosive/non-running practice torpedo shape), SWATT = Surface Warfare Advanced Tactical Training

Table 2.5-2: Current and Proposed Testing Activities

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
	Legend:	[blue]	= Decrease in number of events from 2015 Final MITT EIS/OEIS		[orange]	= Increase in number of events from 2015 Final MITT EIS/OEIS	
NAVAL AIR SYSTEMS COMMAND PROPOSED TESTING ACTIVITIES							
Surface Warfare (SUW)							
Air-to-Surface Missile Test	Study Area > 50 NM from land	8	8 Harpoon Missiles (up to 4 explosive)	4	4 Harpoon Missiles (up to 4 explosive)	4	4 Harpoon Missiles (up to 4 explosive)
Anti-Submarine Warfare (ASW)							
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoys)	Study Area > 3 NM from land	188	240 IEER 553 SUS	26	392 SUS	26	392 SUS
Anti-Submarine Warfare Torpedo Test	Study Area > 3 NM from land	40	40 EXTORP	20	20 REXTORPs	20	20 REXTORPs
Electronic Warfare (EW)							
Intelligence, Surveillance, Reconnaissance /Electronic Warfare Testing (previously named Broad Area Maritime Surveillance Testing – MQ-4C)	Study Area > 3 NM from land	10	None	20	None	20	None

Table 2.5-2: Current and Proposed Testing Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
NAVAL SEA SYSTEMS COMMAND TESTING ACTIVITIES							
Anti-Submarine Warfare							
Anti-Submarine Warfare Mission Package Testing	Mariana Island Range Complex	33	None	100	8 torpedoes (non-explosive)	100	8 torpedoes (non-explosive)
At-Sea Sonar Testing	Study Area	20	None	3	None	7	None
Countermeasure Testing	Study Area	2	56 torpedoes	0	None	0	None
Torpedo (Explosive) Testing	Mariana Island Range Complex	2[2]	20 torpedoes (up to 8 non-explosive[2])	2	4 explosive (8 non-explosive)	3	6 explosive (12 non-explosive)
Torpedo (Non-explosive) Testing	Mariana Island Range Complex			6	28 non-explosive	7	37 non-explosive
Mine Warfare							
Mine Countermeasure and Neutralization Testing (Previously covered under Mine Countermeasure Mission Package Testing)	Mariana Island Range Complex	32	48 neutralizers (up to 24 explosive)	3	40 neutralizers	3	40 neutralizers
Electronic Warfare (EW)							
Radar and Other System Testing	Study Area	Not Previously Analyzed	Not Previously Analyzed	54	None	60	None

Table 2.5-2: Current and Proposed Testing Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Shipboard Protection Systems and Swimmer Defense Testing							
Pierside Integrated Swimmer Defense	Inner Apra Harbor	11	None	0	None	0	None
Surface Warfare							
Gun Testing – Large Caliber	Mariana Island Range Complex	4	5,600 rounds (Up to 3,290 in-air explosives)	0	None	0	None
Gun Testing – Medium Caliber	Mariana Island Range Complex	4	4,080 rounds (up to 2,040 explosives)	0	None	0	None
Gun Testing – Small Caliber	Study Area	4	2,000 rounds	0	None	0	None
Missile and Rocket Testing	Mariana Island Range Complex	4	32 missiles/rockets (up to 16 explosives)	0	None	0	None
Kinetic Energy Weapon Testing	Study Area	50	2,000 projectiles	4	80 projectiles 160 non-explosive projectiles	9	180 projectiles 360 non-explosive projectiles
		1 time-only event	5,000 projectiles				

Table 2.5-2: Current and Proposed Testing Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Vessel Evaluation (previously named Life Cycle Activities)							
Ship Signature Testing	MITT Study Area	17	None	0	None	0	None
Undersea Warfare Testing (previously covered under torpedo testing)	Mariana Island Range Complex	2[2]	20 torpedoes (up to 8 explosive)[2]	1	8 non-explosive torpedoes	1	8 non-explosive torpedoes
Other Testing Activities							
Simulant Testing	Study Area	Not Previously Analyzed	Not Previously Analyzed	100	None	100	None
OFFICE OF NAVAL RESEARCH							
Acoustic and Oceanographic Research (previously named North Pacific Acoustic Lab Philippine Sea 2018–19 Experiment, Deep Water)	Study Area	1	None	1	None	1	None

Legend:
(blue) = Decrease in number of events from 2015 Final MITT EIS/OEIS
(orange) = Increase in number of events from 2015 Final MITT EIS/OEIS

Table 2.5-2: Current and Proposed Testing Activities (continued)

Range Activity	Location	2015 MITT FINAL EIS/OEIS Ongoing[1] Activities (MITT ROD Alternative)		Supplemental EIS/OEIS (Alternative 1)		Supplemental EIS/OEIS (Alternative 2 – Preferred Alternative)	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)

[1] Ongoing activities are those training and testing activities that were analyzed in the 2015 MITT Final EIS/OEIS. The Supplemental EIS/OEIS (1) includes the analysis of activities at sea and on FDM necessary to meet readiness requirements beyond 2020 and into the reasonably foreseeable future, (2) includes any changes to those activities previously analyzed in the 2015 MITT Final EIS/OEIS, and (3) reflects the most up-to-date compilation of training and testing activities deemed necessary to accomplish military readiness requirements.

[2] Torpedo (Explosive) Testing, Torpedo (Non-explosive) Testing, and Undersea Warfare Testing were previously covered under torpedo testing in the 2015 MITT EIS/OEIS.

Notes: MITT = Mariana Islands Training and Testing, ROD = Record of Decision, EIS = Environmental Impact Statement, OEIS = Overseas Environmental Impact Statement, MIRC = Mariana Islands Range Complex, NM = Nautical Mile(s), No. = Number, EXTORP = Exercise Torpedo (non-explosive), REXTORP = Recoverable Exercise Torpedo (non-explosive), IEER = Improved Extended Echo Ranging, SUS = Signal Underwater Sound

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3 Affected Environment and Environmental Consequences

Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

Mariana Islands Training and Testing

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3 Affected Environment and Environmental Consequences

This chapter describes the United States (U.S.) Department of the Navy's (Navy's) approach to analysis, existing environmental conditions in the Mariana Islands Training and Testing (MITT) Study Area, as well as the analysis of resources potentially impacted by the Proposed Action described in Chapter 2 (Description of Proposed Action and Alternatives). The Study Area is described in Section 2.1 (Description of the Mariana Islands Training and Testing Study Area) and depicted in Figure 2.1-1.

3.0 Introduction

In May 2015, the Navy released the MITT Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) (U.S. Department of the Navy, 2015a), hereafter referred to as the 2015 MITT Final EIS/OEIS, for which a Record of Decision was released (U.S. Department of the Navy, 2015b). The Navy applied the Navy Acoustics Effects Model for the 2015 MITT Final EIS/OEIS to quantitatively analyze potential acoustic effects from Navy training and testing activities. For this Supplemental EIS (SEIS)/OEIS, the Navy refined the Navy Acoustics Effects Model (U.S. Department of the Navy, 2018b) and updated marine mammal density estimates (U.S. Department of the Navy, 2018a), as well as the acoustic criteria and activity data inputs used in the acoustic model (U.S. Department of the Navy, 2017b).

The following subsections are included in Section 3.0:

- Section 3.0.1 (Overall Approach to Analysis) identifies the methodology used in this SEIS/OEIS to assess resource impacts associated with the Proposed Action.
- Section 3.0.2 (Regulatory Framework) presents the regulatory framework on which this SEIS/OEIS is based. It identifies applicable laws, regulations, executive orders (EOs), and directives used to develop the analyses.
- Section 3.0.3 (Resources and Issues Not Carried Forward for More Detailed Discussion) identifies the resources that were eliminated from further consideration in this SEIS/OEIS.
- Section 3.0.4 (Identification of Stressors for Analysis) discusses the stressors used in the analysis of impacts on resources

3.0.1 Overall 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 existing 2015 MITT Final EIS/OEIS and Record of Decision.
- Determine if the affected environment has changed.
- Identify new activities and proposed changes to existing activities.
- Identify the stressors associated with the updated list of activities.
- Review existing and identify new federal and state regulations and standards relevant to resource-specific management or protection and determine if there has been any change since the 2015 MITT Final EIS/OEIS.
- Review and apply new literature, including science, surveys, and information on how resources could be affected by stressors.
- Determine if there is a new method of analysis for those activities.
- Review and consider comments received from members of the public and other stakeholders during the scoping period.

- Identify past, present, and reasonably foreseeable future actions to analyze the cumulative impacts.
- Consider mitigation measures to reduce identified potential impacts.

3.0.1.1 Navy Compiled and Generated Data

While preparing this document, the Navy used the best available data, science, and information accepted by the relevant and appropriate regulatory and scientific communities to establish a baseline in the environmental analyses for all resources in accordance with the National Environmental Policy Act (NEPA), the Administrative Procedure Act (5 United States Code sections 551–596), and EO 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. 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. A survey of federally funded marine mammal research and conservation conducted by the Marine Mammal Commission found that the Navy was the second-largest source of funding for marine mammal activities (direct project expenditures, as well as associated indirect or support costs) in the United States in 2014, second only to National Oceanic and Atmospheric Administration Fisheries (Purdy, 2016).

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 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 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.

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

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's acoustic effects model takes the density and the criteria and thresholds as inputs and analyzes Navy training and testing 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, 2018b).

3.0.1.2.1 Marine Species Density Database

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

There is no single source of density data for every area of the world, species, and season because of the fiscal limitations, resources, effort involved in providing survey coverage to sufficiently estimate density, and practical limitations. Therefore, to characterize marine species density for large areas, such as the MITT Study Area, 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 and sea turtle species present within the Study Area. This database is described in the technical report titled *U.S. Navy Marine Species Density Database Phase III for the Mariana Islands Training and Testing Study Area* (U.S. Department of the Navy, 2018a), hereafter referred to as the Density Technical Report. These data were used as an input into the Navy Acoustic Effects Model.

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

1. Spatial density models are preferred and used when available because they provide an estimate with the least amount of uncertainty by deriving estimates for divided segments of the sampling area. These models (see Becker et al., 2016; Forney et al., 2015) predict spatial variability of animal presence as a function of habitat variables (e.g., sea surface temperature, seafloor depth). This model is developed for areas, species, and, when available, specific timeframes (months or seasons) with sufficient survey data.
2. Stratified design-based density estimates use line-transect survey data with the sampling area divided (stratified) into sub-regions, and a density is predicted for each sub-region (see 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 Study Area, 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, 2017a). 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.

3.0.1.2.2 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. The criteria and thresholds for quantitative modeling of impacts are based on the best available existing data from scientific journals, technical reports, and monitoring reports for estimating impacts to marine species. Working with NMFS, the Navy has developed updated criteria for marine mammals and sea turtles.

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, 2012a), 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 revised 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, 2017b), and details are provided in each resource section. A series of behavioral studies, largely funded by the U.S. Navy, has led to a new understanding of how some species of marine mammals react to military sonar. This understanding resulted in developing new behavioral response functions for estimating alterations in behavior. Additional information on auditory weighting functions has also emerged [e.g., (Mulsow et al., 2015)], leading to the development of a new methodology to predict auditory weighting functions for each hearing group along with the accompanying hearing loss thresholds. These criteria for predicting hearing loss in marine mammals were largely adopted by NMFS for species within their purview (National Marine Fisheries Service, 2016).

The Navy also uses criteria for estimating effects to fishes and the ranges to which those effects are likely to occur. A working group of experts generated a technical report that provides numerical criteria and relative likelihood of effects to fish within different hearing groups (i.e., fishes with no swim bladder versus fishes with a swim bladder involved in hearing) (Popper et al., 2014). Where applicable, thresholds and relative risk factors presented in the technical report were used to assist in the analysis of effects to fishes from Navy activities. Details on criteria used to estimate impacts on marine fishes are contained within the appropriate stressor section (e.g., sonar and other transducers, explosives) within Section 3.9 (Fishes). 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).

3.0.1.2.3 The Navy’s Acoustic Effects Model

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

The model accounts for environmental variability of sound propagation in both distance and depth when computing the received sound level on the animats. The model conducts a statistical analysis based on multiple model runs to compute the estimated effects on animals. 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.

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

- Naval activities are modeled as though they would occur regardless of proximity to marine mammals or sea turtles (i.e., mitigation and implementation of standard operating procedures that employ protective measures are not modeled) and without any avoidance of the activity by the animal. The final step of the quantitative analysis of acoustic effects is to consider the implementation of mitigation. For sonar and other transducers, the possibility that marine mammals or sea turtles would avoid continued or repeated sound exposures is also considered.

- Many explosions from munitions such as bombs and missiles actually occur upon impact with above-water targets and at the water's surface. However, for this analysis, sources such as these were modeled as exploding underwater. 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). A detailed explanation of the Navy's Acoustic Effects Model is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

3.0.1.2.4 Accounting for Mitigation

3.0.1.2.4.1 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 permanent threshold shift [PTS]) for a given sonar exposure. Therefore, the impact analysis quantifies the potential for mitigation to reduce the risk of PTS. Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

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 temporary threshold shift (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 in the vicinity of animals sighted at the ocean surface within the mitigation zone.

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

3.0.1.2.4.2 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. Therefore, the impact analysis quantifies the potential for mitigation to reduce the risk of mortality due to exposure to explosives. 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., gunnery exercise) 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, 2018b).

In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, model-estimated mortality is considered mitigated to the level of injury. The impact analysis does not analyze the potential for mitigation to reduce non-auditory injury, PTS, TTS, or behavioral effects, even though mitigation would 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.

3.0.1.2.5 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 that implement the requirements of the NEPA, other planning and environmental review procedures are integrated in this SEIS/OEIS to the fullest extent possible.

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

The federal statutes and EOs considered in this SEIS/OEIS that were described in Section 3.0.1 (Regulatory Framework) of the 2015 MITT Final EIS/OEIS have not changed.

3.0.3 Resources and Issues Not Carried Forward for More Detailed Discussion

Considerations under EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, were eliminated from further analysis because all of the proposed activities occur in the ocean where there are no child populations present. Therefore, the Proposed Action would not lead to disproportionate environmental health risks or safety risks to children.

3.0.4 Identification of Stressors for Analysis

Some of the stressors identified for consideration in this SEIS/OEIS in the analysis of resources have been refined from those considered in the 2015 MITT Final EIS/OEIS. The list of stressors analyzed in this SEIS/OEIS and changes from the 2015 MITT Final EIS/OEIS are shown in Table 3.0-1. Although the names of some stressors have changed, the analysis conducted on that stressor did not change. Where useful, an explanation of the change is provided in italics.

Table 3.0-1: Comparison of Stressors Analyzed

2015 MITT Final EIS/OEIS	***Supplemental EIS/OEIS***
Components and Stressors for Physical Resources	
Sediments and Water Quality Stressors	
• Explosives and explosive byproducts • Metals • Chemicals other than explosives • Other materials	• Explosives • Metals • Chemicals other than explosives • Other materials
Air Quality Stressors	
• Criteria pollutants • Hazardous air pollutants	• Criteria pollutants • Hazardous air pollutants
Components and Stressors for Biological Resources	
Acoustic Stressors	
• Sonar and other active acoustic sources • Vessel noise • Aircraft noise • Weapons firing, launch, and impact noise • Underwater explosives • Swimmer defense airguns	• Sonar and other transducers • Vessel noise • Aircraft noise • Weapons noise • (*"Underwater explosives" is moved to next category of "In-water explosions"*) • (*Swimmer defense airguns are not proposed or analyzed in this SEIS/OEIS*)
Explosive Stressors	
(*In the 2015 MITT Final EIS/OEIS, Explosives were included under Acoustic Stressors*)	• In-water explosions • In-air explosions

Table 3.0-1: Comparison of Stressors Analyzed (continued)

2015 MITT Final EIS/OEIS	*Supplemental EIS/OEIS*
Energy Stressors	
• Electromagnetic devices • Lasers	• In-air electromagnetic devices (*included under Electromagnetic Devices*) • In-water electromagnetic devices (*included under Electromagnetic Devices*) • Lasers (high energy)
Components and Stressors for Physical Resources	
Physical Disturbance and Strike Stressors	
• Aircraft and aerial targets • Vessels • In-water devices • Military expended materials • Seafloor devices • Ground disturbance • Wildfires	• Aircraft and aerial targets • Vessels and in-water devices • Military expended materials • Seafloor devices • Ground disturbance (FDM only) • Personnel disturbance • Wildfires (FDM only)
Entanglement Stressors	
• Fiber optic cables and guidance wires • Decelerators/parachutes	• Wires and cables • Decelerators/parachutes
Ingestion Stressors	
• Military expended materials from munitions • Military expended materials other than munitions	• Military expended materials from munitions • Military expended materials other than munitions
Secondary Stressors	
• Habitat • Prey availability	• Impacts on habitat • Invasive species introductions into terrestrial habitats (FDM only) • Impacts on prey availability
Components and Stressors for Human Resources	
Cultural Resources Stressors	
• Acoustic • Physical Disturbance and Strike	• Explosives (*previously referred to as Acoustic*) • Physical Disturbance and Strike
Socioeconomic Resources Stressors	
• Accessibility • Airborne acoustics • Physical disturbance and strike • Secondary impacts from availability of resources	• Accessibility • Airborne acoustics • Physical disturbance and strike • Secondary impacts from availability of resources
Public Health and Safety Stressors	
• In-water energy • In-air energy • Physical interactions • Secondary stressors (sediments and water quality)	• In-water energy • In-air energy • Physical interactions • Secondary stressors (sediments and water quality)

Notes: (1) *Italics* reflect changes in stressors/stressor analysis in this SEIS/OEIS as compared to 2015 MITT Final EIS/OEIS; (2) FDM = Farallon de Medinilla; OEIS = Overseas Environmental Impact Statement; SEIS = Supplemental Environmental Impact Statement

3.0.4.1 Acoustic Stressors

This section describes the characteristics of sounds produced during naval training and testing and the relative magnitude and location of these sound-producing activities. This section provides the basis for analysis of acoustic impacts on resources 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 H (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 testing and 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 sounds produced incidental to vessel and aircraft transits and weapons firing.

The use of source classification bins provides the following benefits:

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

3.0.4.1.1 Sonar and Other Transducers

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

The Navy employs a variety of sonars and other transducers to obtain and transmit information about the undersea environment. Some examples are mid-frequency hull-mounted sonars used to find and track potential enemy submarines, high-frequency small object detection sonars used to detect mines, 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 H (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 Study Area.

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

3.0.4.1.1.1 Anti-Submarine Warfare

Sonar used during anti-submarine warfare 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 anti-submarine warfare 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 anti-submarine warfare activities involving submarines or submarine targets would occur in waters greater than 600 feet (ft.) deep due to safety concerns about running aground at shallower depths. Sonars used for anti-submarine warfare activities would typically be used beyond 12 nautical miles (NM) from shore. Exceptions include use of dipping sonar by helicopters, maintenance of systems while in port, and system checks while transiting to or from port.

3.0.4.1.1.2 Mine Warfare, Small Object Detection, and Imaging

Sonars used to locate mines and other small objects, as well as those used in imaging (e.g., for hull inspections or imaging of the seafloor), are typically high frequency or very high-frequency. Higher frequencies allow for greater resolution and, due to their greater attenuation, are most effective over shorter distances. Mine detection sonar can be deployed (towed or vessel hull-mounted) at variable depths on moving platforms (ships, helicopters, or unmanned vehicles) to sweep a suspected mined area. Hull-mounted anti-submarine sonars can also be used in an object detection mode known as

"Kingfisher" mode. Sonars used for imaging are usually used in close proximity to the area of interest, such as pointing downward near the seafloor.

Mine detection sonar use would be concentrated in areas where practice mines are deployed, typically in water depths less than 200 ft., and at established training minefields, temporary minefields close to strategic ports and harbors, or at targets of opportunity such as navigation buoys. Kingfisher mode on vessels is most likely to be used when transiting to and from port. Sound sources used for imaging could be used throughout the Study Area.

3.0.4.1.1.3 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.

3.0.4.1.1.4 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 Study Area. These sources typically have low duty cycles and are usually only used when it is desirable to send a detectable acoustic message.

3.0.4.1.1.5 Classification of Sonar and Other Transducers

Sonars and other transducers are grouped into classes that share an attribute, such as frequency range or purpose of use. As detailed below, classes are further sorted by bins based on the frequency or bandwidth; source level; and, when warranted, the application in which the source would be used. Unless stated otherwise, a reference distance of 1 meter 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 (re) 1 micropascal (dB re 1 µPa), but less than 180 dB re 1 µPa
  - Equal to 180 dB re 1 µPa at 1 m and up to 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 length (duration of each pulse), beam pattern, and duty cycle

The bins used for classifying active sonars and transducers that are quantitatively analyzed in the Study Area are shown in Table 3.0-2. While general parameters or source characteristics are shown in the table, actual source parameters are classified.

Table 3.0-2 also shows the bin use that could occur in any year under each action alternative for training and testing activities; amounts used in on-going activities pursuant to the 2015 MITT Final EIS/OEIS and the 2015 NMFS Letter of Authorization are included for comparison.

Table 3.0-2: Sonar and Transducer Sources Quantitatively Analyzed

Source Class Category	*Bin*	*Unit**	*Training & Testing*		
			2015 Final EIS/OEIS	*Alternative 1*	*Alternative 2*
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF4	H	123	1	1
	LF5	H	11	10	10
	LF6	H	40	0	0
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	H	1,872	1,729	1,818
	MF1K	H	0	3	3
	MF2	H	625	0	0
	MF3	H	192	189	228
	MF4	H	214	172	185
	MF5	C	2,588	2,024	2,094
	MF6	C	33	62	74
	MF8	H	123	0	0
	MF9	H	47	15	29
	MF10	H	231	0	0
	MF11	H	324	292	304
	MF12	H	656	608	616
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	H	113	63	73
	HF3	H	0	4	4
	HF4	H	1,060	1,472	1,472
	HF5	H	336	0	0
	HF6	H	1,173	163	309
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	H	144	192	192
	ASW2	C	660	538	554
	ASW3	H	3,935	3,024	3,124
	ASW4	C	11	268	332
	ASW5	H	0	50	50
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	C	115	62	71
	TORP2	C	62	40	62
	TORP3	C	0	6	6
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	H	0	4	4
Acoustic Modems (M): Systems used to transmit data through the water	M3	H	112	17	31

Table 3.0-2: Sonar and Transducer Sources Quantitatively Analyzed (continued)

Source Class Category	*Bin*	*Unit**	*Training & Testing*		
			2015 Final EIS/OEIS	*Alternative 1*	*Alternative 2*
Swimmer Detection Sonar (SD): Used to detect divers and submerged swimmers	SD1	H	2,341	0	0
Air Guns (AG): Used during swimmer defense and diver deterrent training and testing activities	AG	C	308	0	0
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS2	H	0	449	449
	SAS4	H	0	6	6

* H = hours; C = 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 and testing activities, and in a typical environment, *de minimis* sources fall into one or more of the following categories:

- <u>Transmit primarily above 200 kHz</u>: 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 Study Area.
- <u>Source levels of 160 dB re 1 µPa or less</u>: 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.
- <u>Acoustic source classes listed in Table 3.0-3</u>: 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 3.0-3: Sonar and Transducers Qualitatively Analyzed

Source Class Category	*Bin*	*Characteristics*
Broadband Sound Sources (BB): Sources with wide frequency spectra	BB3	• very high frequency • very short pulse length
	BB8	• small imploding source (light bulb)
Doppler Sonar/Speed Logs (DS): High-frequency/very high-frequency navigation transducers	DS2–DS4	*Required for safe navigation* • downward focused • narrow beam width • very short pulse lengths
Fathometers (FA): High-frequency sources used to determine water depth	FA1–FA4	*Required for safe navigation* • downward focused directly below the vessel • narrow beam width (typically much less than 30º) • short pulse lengths (less than 10 milliseconds)
Hand-Held Sonar (HHS): High-frequency sonar devices used by Navy divers for object location	HHS1	• very high frequency sound at low power levels • narrow beam width • short pulse lengths • under control of the diver (power and direction)
Imaging Sonar (IMS): Sonars with high or very high frequencies used to obtain images of objects underwater	IMS1–IMS3	• High-frequency or very high-frequency • downward directed • narrow beam width • very short pulse lengths (typically 20 milliseconds)
High-Frequency Acoustic Modems (M): Systems that send data underwater **Tracking Pingers (P):** Devices that send a ping to identify an object location	M2 P1–P4	• low duty cycles (single pings in some cases) • short pulse lengths (typically 20 milliseconds) • low source levels
Acoustic Releases (R): Systems that ping to release a bottom-mounted object from its housing in order to retrieve the device at the surface	R1–R3	• typically emit only several pings to send release order
Side-Scan Sonars (SSS): Sonars that use active acoustic signals to produce high-resolution images of the seafloor	SSS1–SSS2	• downward-directed beam • short pulse lengths (less than 20 milliseconds)

Notes: ° = degree(s), kHz = kilohertz, lb. = pound(s)

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 Study Area. 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 and testing events, would be operating within the Study Area 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 & Parker, 2006; Mintz & Filadelfo, 2011; Mintz, 2012; Mintz, 2016). 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 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 & Filadelfo, 2011; Mintz, 2012).

Although the aforementioned studies did not include analysis of vessel traffic and associated vessel noise in the Study Area (the geographic scope was the continental United States and Hawaii), the conclusions of the studies are relevant to vessel noise in the Study Area. 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 and testing activities throughout the Study Area, 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 H, Acoustic and Explosive Concepts). Aircraft used in training and testing 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 Study Area from established airfields on land. The majority of aircraft noise would be generated at air stations, which are outside the Study Area. Takeoffs and landings occur at established airfields as well as on vessels at sea across the Study Area. Takeoffs and landings from Navy vessels produce in-water noise at a given location for a brief period as the aircraft climbs to cruising altitude. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Table 3.0-4 provides source levels for some typical aircraft used during training and testing in the Study Area 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

The 2015 MITT Final EIS/OEIS (Section 3.0.5.2.1.6, Aircraft Overflight Noise) describes underwater transmission of aircraft noise. Since information regarding underwater transmission of aircraft noise has not changed, this SEIS/OEIS will not further analyze underwater transmission of aircraft noise.

3.0.4.1.3.2 Helicopters

The 2015 MITT Final EIS/OEIS (Section 3.0.5.2.1.6, Aircraft Overflight Noise) describes characteristics and production of noise from helicopters. Since information regarding characteristics and production of noise from helicopters has not changed, this SEIS/OEIS will not further analyze characteristics and production of noise from helicopters.

Table 3.0-4: 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 (2012b).

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, 2017c), 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 NM 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 miles 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 mile 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 miles 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 more slender 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 meters) (Sohn et al., 2000). F/A-18 Hornet supersonic flight was modeled to obtain peak sound pressure levels and energy flux density at the water surface and at depth (U.S. Department of the Air Force, 2000). Table 3.0-5 shows these results.

Table 3.0-5: Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight

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

[1] Equivalent to SEL for a plane wave.
* Mach number equals aircraft speed divided by the speed of sound.
Notes: SPL = sound pressure level, dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 1 µPa^2-s = decibel(s) referenced to 1 micropascal squared seconds, m = meter(s)

3.0.4.1.4 Weapon Noise

The Navy trains and tests using a variety of weapons, as described in Appendix A (Training and Testing 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).

Noise associated with large-caliber weapons firing and the impact of non-explosive practice munitions or kinetic weapons would occur at locations greater than 12 NM from shore in warning areas or special use airspace for safety reasons, with the exception of areas near Farallon de Medinilla (FDM). Small- and medium-caliber weapons firing could occur throughout the Study Area in identified training areas.

Table 3.0-6 shows examples of some types of weapons noise and provides examples of launch noise. Noise produced by other weapons and devices are described further below.

Table 3.0-6: 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 (Table 3.0-6). 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.

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 H (Acoustic and Explosive Concepts), most sound enters the water in a narrow cone beneath the sound source (within about 13–14 degrees of vertical), with most sound outside of this cone being totally reflected from the water surface. In-water sound levels were measured during the muzzle blast of a 5-inch large caliber naval gun. The highest possible sound level in the water (average peak SPL of 200 dB re 1 µPa, measured 5 ft. below the surface) was obtained when the gun was fired at the lowest angle, placing the blast closest to the water surface (Yagla & Stiegler, 2003). The unweighted SEL would be expected to be 15–20 dB lower than the peak pressure, making the highest possible SEL in the water about 180 to 185 dB re 1 µPa squared seconds (dB re 1 μPa^{2}-s) directly below the muzzle blast. Configuration of the 5-inch gun on US Navy ships also affects how sound from much 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 3.0-1). 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.

Figure 3.0-1: 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-in/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)

3.0.4.1.4.2 Supersonic Projectile Bow Shock Wave

Supersonic projectiles, such as a fired gun shell or kinetic energy weapon, 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 H, 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 NM distance from the firing location and 10 degrees off the line of fire for safety (approximately 190 meters from the shell’s trajectory) (U.S. Department of the Navy, 1981).

Hyperkinetic projectiles may travel up to and exceeding approximately six times the speed of sound in air, or about 6,500 ft./second (U.S. Department of the Navy, 2014). For a hyperkinetic projectile sized similar to the 5 inch shell, peak pressures would be expected to be several dB higher than those described for the 5 inch projectile above, following the model in 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

The 2015 MITT Final EIS/OEIS (Section 3.0.5.2.1.4, Weapons Firing, Launch, and Impact Noise) describes launch noise. Since information regarding launch noise has not changed, this SEIS/OEIS will not further analyze launch noise. Table 3.0-6 provides examples of launch noise measurements.

3.0.4.1.4.4 Impact Noise (Non-Explosive)

The 2015 MITT Final EIS/OEIS (Section 3.0.5.2.1.4, Weapons Firing, Launch, and Impact Noise) describes characteristics and production of non-explosive impact noise. Since information regarding non-explosive impact noise has not changed, this SEIS/OEIS will not further analyze non-explosive impact noise.

3.0.4.1.4.5 Long Range Acoustic Device

The Long Range Acoustic Device is a communication device that can be used to warn vessels against continuing towards a high-value asset by emitting loud sounds in air. Although not a weapon, the Long Range Acoustic Device (and other hailing and deterrent devices) is considered along with in-air sounds produced by Navy sources. The system would typically be used in training activities nearshore, and use would be intermittent during these activities. Source levels at 1 meter range between 137 A-weighted decibels re 1 µPa for small portable systems and 153 A-weighted decibels re 1 µPa for large systems. Sound would be directed within a 30–60-degree wide zone and would be directed over open water.

3.0.4.2 Explosive Stressors

This section describes the characteristics of explosions during naval training and testing. The activities analyzed in the SEIS/OEIS that use explosives are described in Appendix A (Training and Testing Activities Descriptions). This section provides the basis for analysis of explosive impacts on resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). Explanations of the terminology and metrics used when describing explosives in this SEIS/OEIS are in Appendix H (Acoustic and Explosive Concepts).

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

3.0.4.2.1.1 Explosions in Water

Explosive detonations during training and testing activities are associated with high-explosive munitions, including, but not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations during training and testing activities involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could be detonated in the water column or on the ocean bottom. Detonations would typically occur in waters greater than 200 ft. in depth, and greater than 3 NM from shore, with the exception of existing mine warfare areas, including Outer Apra Harbor, Piti, and Agat. Section 5.3.3 (Explosive Stressors) outlines the procedural mitigation measures for explosive stressors to reduce potential impacts on biological resources.

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

Explosives detonated in water are binned by net explosive weight. The bins of explosives that are proposed for use in the Study Area are shown in Table 3.0-7. This table shows the number of explosive items that could be used in any year under each action alternative for training and testing activities. A range of annual bin use indicates that use of that bin is anticipated to vary annually, consistent with the variation in the number of annual activities described in Chapter 2 (Description of Proposed Action and Alternatives).

In addition to the explosives quantitatively analyzed for impacts on marine mammals and sea turtles shown in Table 3.0-7, the Navy uses some very small impulsive sources (less than 0.1 pounds net explosive weight), categorized in bin E0, that are not anticipated to result in takes of marine mammals or sea turtles. Quantitative modeling in multiple locations has validated that these sources have a very small zone of influence. These E0 charges, therefore, are categorized as *de minimis* sources for marine mammals and sea turtles 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.

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 H (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 Study Area.

Table 3.0-7: Explosive Sources Quantitatively Analyzed that Could Be Used Underwater or at the Water Surface

Explosives	*Training & Testing Activities (Annual In-Water Detonations)*		
	2015 Final EIS/OEIS	*Alternative 1*	*Alternative 2*
E1 (0.1–0.25 lb. NEW)	10,140	512	768
E2 (>0.25–0.5 lb. NEW)	106	400	400
E3 (>0.5–2.5 lb. NEW)	932	683	683
E4 (> 2.5–5 lb. NEW)	420	44	44
E5 (> 5–10 lb. NEW)	684	965	1,221
E6 (> 10–20 lb. NEW)	76	29	29
E8 (> 60–100 lb. NEW)	16	134	134
E9 (> 100–250 lb. NEW)	4	110	110
E10 (> 250–500 lb. NEW)	12	69	78
E11 (> 500–650 lb. NEW)	6	3	5
E12 (> 650–1,000 lb. NEW)	184	48	48

Notes: lb. = pound(s), NEW = Net Explosive Weight

3.0.4.2.1.2 Explosions in Air

Explosions in air include detonations of missiles during surface-to-air 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 3.0-8. Various missiles, rockets, and medium- and large-caliber projectiles may be explosive or non-explosive, depending on the objective of the training or testing activity in which they are used. Quantities of explosive and non-explosive missiles, rockets, and projectiles proposed for use during Navy training and testing are provided in the tables below.

Table 3.0-8: Typical Air Explosive Munitions During Navy Activities

Weapon Type[1]	*Net Explosive Weight (lb.)*	*Typical Altitude of Detonation (ft.)*
Surface-to-Air Missile		
RIM-66 SM-2 Standard Missile	80	> 15,000
RIM-116 Rolling Airframe Missile	39	< 3,000
RIM-7 Sea Sparrow	36	> 15,000 (can be used on low targets)
FIM-92 Stinger	7	< 3,000
Air-to-Air Missile		
AIM-9 Sidewinder	38	> 15,000
AIM-7 Sparrow	36	> 15,000
AIM-120 AMRAAM	17	> 15,000
Air-to-Surface Missile		
AGM-88 HARM	45	< 100
AGM-84 Harpoon	488	< 100
Projectile – Large-Caliber[2]		
5"/54 caliber HE-ET	7	< 100
5"/54 caliber Other	8	< 100

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

Bombs and projectiles that detonate at or near the water surface, which are considered for underwater impacts (see Table 3.0-8), would also release some explosive energy into the air. Appendix A (Training and Testing Activities Descriptions) describes where activities with these stressors typically occur.

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

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

3.0.4.3 Energy Stressors

Energy stressors are discussed in the 2015 MITT Final EIS/OEIS. Changes to energy stressors analyzed in this SEIS/OEIS are described below.

3.0.4.3.1 Electromagnetic Devices

In the 2015 MITT Final EIS/OEIS, electromagnetic devices included those used in water. For this SEIS/OEIS, electromagnetic devices are further categorized as either in-water electromagnetic devices or in-air electromagnetic devices.

3.0.4.3.1.1 In-Water Electromagnetic Devices

In-water electromagnetic devices were described in Section 3.0.5.2.2.1 (Electromagnetic Devices) of the 2015 MITT Final EIS/OEIS. Table 3.0-9 shows the number of ongoing events (from the 2015 MITT Final EIS/OEIS) and the number of events proposed in this SEIS/OEIS that include the use of in-water electromagnetic devices.

Table 3.0-9: Annual Number of Events in the Study Area that Include In-Water Electromagnetic Devices

Training & Testing		
2015 Final EIS/OEIS	***Alternative 1***	***Alternative 2***
5	4	4

3.0.4.3.1.2 In-Air Electromagnetic Devices

Sources of electromagnetic energy in the air include communications transmitters, radars, and electronic countermeasures transmitters. Electromagnetic devices on Navy platforms operate across a wide range of frequencies and power. On a single ship the source frequencies may range from 2 megahertz (MHz) to 14,500 MHz, and transmitter maximum average power may range from 0.25 watts to 1,280,00 watts.

The Navy originally coined the term “radar” to refer to Radio Detection And Ranging. A radar system is an electromagnetic device that emits radio waves to detect and locate objects. In most cases, basic radar systems operate by generating pulses of radio frequency energy and transmitting these pulses via directional antennae into space (Courbis & Timmel, 2008). Some of this energy is reflected by the target back to the antenna, and the signal is processed to provide useful information to the operator.

Radars come in a variety of sizes and power, ranging from wide-band milliwatt systems to very high-power systems that are used primarily for long-range search and surveillance (Courbis & Timmel, 2008). In general, radars operate at radio frequencies that range between 300 MHz and 300 gigahertz, and are often classified according to their frequency range. Navy vessels commonly operate radar systems that include S-band and X-band electronically steered radar. S-band radar serves as the primary search and acquisition sensor capable of tracking and collecting data on a large number of objects, while X-band radar can provide high-resolution data on particular objects of interest and discrimination for weapons systems. Both systems employ a variety of waveforms and bandwidths to provide high-quality data collection and operational flexibility (Baird et al., 2016).

It is assumed that most Navy platforms associated with the Proposed Action will be transmitting from a variety of in-air electromagnetic devices at all times when underway, with very limited exceptions. Most of these transmissions (e.g., for routine surveillance, communications, and navigation) will be at low power. High-power settings are used for a small number of activities, including ballistic missile defense training, radar and other system testing, and signature analysis operations. The number of Navy vessels or aircraft in the Study Area at any given time varies and is dependent on local training or testing requirements. Therefore, in-air electromagnetic energy as part of the Proposed Action would be widely dispersed throughout the Study Area, but more concentrated in portions of the Study Area near ports, naval installations, and range complexes. Because these stressors are operated at power levels, altitudes, and distances from people and animals to ensure that energy received is well below levels that could disrupt behavior or cause injury and because most in-air electromagnetic energy is reflected by water, in-air electromagnetic energy is not analyzed further in Section 3.4 (Marine Mammals) and Section 3.6 (Marine Birds).

3.0.4.3.2 Lasers

Laser devices can be organized into two categories: (1) low-energy lasers and (2) high-energy lasers.

3.0.4.3.2.1 Low-Energy Lasers

Low-energy lasers are proposed to be used as described in the 2015 MITT Final EIS/OEIS, where they would have an extremely low potential to impact marine biological resources (U.S. Department of the Navy, 2010). Therefore, as in the 2015 MITT Final EIS/OEIS, low-energy lasers will not be further analyzed in this SEIS/OEIS for possible impacts on biological resources.

3.0.4.3.2.2 High-Energy Lasers

While no high-energy lasers were proposed to be used in the Study Area previously, they are now proposed for use as part of the Proposed Action in this SEIS/OEIS. High-energy laser weapons activities involve the use of directed energy as a weapon against small surface vessels and airborne targets. High-energy lasers would be employed from surface ships and are designed to create small but critical failures in potential targets. The high-energy laser is expected to be used at short ranges. Marine life or birds at or near the ocean surface could be susceptible to injury by high-energy lasers. Table 3.0-10 shows the number of ongoing events (from the 2015 MITT Final EIS/OEIS) and the number of events proposed in this SEIS/OEIS that include the use of high-energy lasers.

Table 3.0-10: Annual Number of Events in the Study Area that Include High-Energy Lasers

Training & Testing		
2015 Final EIS/OEIS	***Alternative 1***	***Alternative 2***
0	54	60

3.0.4.4 Physical Disturbance and Strike Stressors

As described in the 2015 MITT Final EIS/OEIS, physical disturbance and strike stressors can result from the Navy's proposed use of aircraft and aerial targets, vessels, in-water devices, military expended materials, seafloor devices, and, on the island of FDM, ground disturbance and wildfires.

3.0.4.4.1 Aircraft and Aerial Targets

Section 3.0.5.2.3.1 (Aircraft and Aerial Targets) in the 2015 MITT Final EIS/OEIS described aircraft and aerial targets. Table 3.0-11 shows the number of ongoing events (from the 2015 MITT Final EIS/OEIS) and the number of events proposed in this SEIS/OEIS that include the use of aircraft.

Table 3.0-11: Annual Number of Events in the Study Area that Include Aircraft Movement

Training & Testing		
2015 Final EIS/OEIS	Alternative 1	Alternative 2
22,397	20,058	20,094

3.0.4.4.2 Vessels

Section 3.0.5.2.3.2 (Vessels) in the 2015 MITT Final EIS/OEIS described vessels. Table 3.0-12 shows the number of ongoing events (from the 2015 MITT Final EIS/OEIS) and the number of events proposed in this SEIS/OEIS that include the use of vessels.

Table 3.0-12: Annual Number of Events in the Study Area that Include Vessel Movement

Training & Testing		
2015 Final EIS/OEIS	Alternative 1	Alternative 2
3,968	4,249	4,493

3.0.4.4.3 In-Water Devices

Section 3.0.5.2.3.3 (In-Water Devices) in the 2015 MITT Final EIS/OEIS described in-water devices. Table 3.0-13 shows the number of ongoing events (from the 2015 MITT Final EIS/OEIS) and the number of events proposed in this SEIS/OEIS that include the use of towed in-water devices.

Table 3.0-13: Annual Number of Events in the Study Area that Include In-Water Devices

Training & Testing		
2015 Final EIS/OEIS	Alternative 1	Alternative 2
2,205	2,289	2,397

3.0.4.4.4 Military Expended Materials

Section 3.0.5.2.3.4 (Military Expended Materials) in the 2015 MITT Final EIS/OEIS described military expended materials. Table 3.0-14 shows the number of non-explosive practice munitions analyzed in the 2015 MITT Final EIS/OEIS and the number proposed in this SEIS/OEIS. Other military expended materials are listed in Table 3.0-15, explosive munitions in Table 3.0-16, and targets in Table 3.0-17. Since the 2015 MITT Final EIS/OEIS, the Navy has improved its ability to track expended items, which are now reflected in the following tables. If the newly listed items were used but not counted in the 2015 Final EIS/OEIS, that cell will include a note stating those items were not previously calculated.

Table 3.0-14: Annual Number of Non-Explosive Practice Munitions Expended At Sea in the Study Area

Non-Explosive Ordnance	*Training & Testing*		
	2015 Final EIS/OEIS	*Alternative 1*	*Alternative 2*
Mine Neutralization System Neutralizers	24	0	0
Anti-Torpedo Torpedoes	Note 1	8	11
Torpedoes [Note 2]	169	104	132
Bombs	848	152	152
Rockets	0	1,697	1,697
Rockets (Flechette)	Note 1	89	89
Missiles	20	0	0
Kinetic Energy Rounds	Note 1	80	180
Large-Caliber Projectiles	6,918	14,772	22,268
Large-Caliber Projectile Land-Based Casings	Note 1	2,800	4,200
Medium-Caliber Projectiles	87,540	223,150	280,750
Sabot	Note 1	80	180
Small-Caliber Projectiles	88,140	308,364	354,318
Small-Caliber Casings	Note 1	304,356	348,306

Note 1: These items were not calculated in the 2015 Final EIS/OEIS.
Note 2: Exercise torpedoes are recovered for reuse following completion of the training or testing activity.

Table 3.0-15: Annual Number of Other Military Expended Materials Used At Sea in the Study Area

Other Military Expended Materials	*Training & Testing*		
	2015 Final EIS/OEIS	*Alternative 1*	*Alternative 2*
Acoustic Countermeasures	294	387	466
Anchor (Expended)[Note 2]	Note 1	20	28
Anti-Torpedo Torpedo Accessories	Note 1	8	11
Buoy (Non-Explosive)	314	70	82
Canister – Miscellaneous	Note 1	1	1
Compression Pad or Plastic Pistons	Note 1	17,600	17,600
Endcap – Chaff and Flares	Note 1	35,218	35,218
Expended Bathythermograph	520	341	364
Fiber Optic Can	28	44	44
Flare O-ring	Note 1	17,618	17,618
Heavyweight Torpedo Accessories	54	49	73
Lightweight Torpedo Accessories	72	60	66
Illumination Flare	18	18	18
JATO Bottle	20	20	20
Marine Marker	617	538	538
Sonobuoys	11,912	5,386	5,876

Note 1: These items were not calculated in the 2015 Final EIS/OEIS.

Note 2: These are anchors used to secure objects like moored mines and bottom-placed instruments to the seafloor, not ship anchors.

Table 3.0-16: Annual Number of Explosive Munitions Expended At Sea in the Study Area

Explosive Ordnance	*Training & Testing*		
	2015 Final EIS/OEIS	*Alternative 1*	*Alternative 2*
Mine Neutralization System Neutralizers	28	44	44
Grenades	Note 1	400	400
Torpedoes	10	5	7
Bombs	212	198	198
Rockets	114	323	323
Missiles	145	231	249
Large-Caliber Projectiles	12,220	1,372	1,658
Medium-Caliber Projectiles	10,190	22,224	22,480
Buoys	804	392	392

Note 1: These items were not calculated in the 2015 Final EIS/OEIS.

Table 3.0-17: Annual Number of Targets Expended At Sea in the Study Area

Target	*Training & Testing*		
	2015 Final EIS/OEIS	*Alternative 1*	*Alternative 2*
Air Targets –Decoy	Note 1	153	168
Air Targets –Drone	Note 1	1	1
Mine Shape (Non-Explosive)	Note 1	599	599
Ship Hulk	2	1	1
Subsurface Target (Mobile)	Note 1	254	265
Subsurface Target (Stationary)	Note 1	4	5
Surface Target (Mobile)	Note 1	1,499	1,581
Surface Target (Stationary)	786	879	1,107

Note 1: These items were not calculated in the 2015 Final EIS/OEIS.

Table 3.0-14, Table 3.0-15, Table 3.0-16, and Table 3.0-17 show that some items are proposed to increase, while others would decrease or remain the same. As shown in Table 3.0-18, the surface area of the ocean bottom that could be impacted by the use of military expended materials as proposed in this Supplemental EIS/OEIS would decrease from the amount analyzed in the 2015 MITT Final EIS/OEIS.

Table 3.0-18: Impact Area of Proposed Military Expended Materials

Military Expended Materials	*Area of Potential Impact (acre)*		
	2015 Final EIS/OEIS	*Alternative 1*	*Alternative 2*
Bombs (Explosive)	0.5495	0.5132	0.5132
Bombs (Non-Explosive)	2.1980	0.3940	0.3940
Grenades (Explosive)	Note 1	0.0019	0.0019
Kinetic Energy Rounds	Note 1	0.0019	0.0042
Large-Caliber Projectiles (Explosive)	1.1330	0.1272	0.1537
Large-Caliber Projectiles (Non-Explosive)	0.6414	1.3696	2.0645
Large Caliber Land-Based Casings	Note 1	0.0649	0.0974
Medium-Caliber Projectiles (Explosive)	0.0524	0.1142	0.1155
Medium-Caliber Projectiles (Non-Explosive)	0.4500	1.1470	1.4431
Small-Caliber Projectiles	0.2460	0.8608	0.9891
Small Caliber Casing	Note 1	0.2103	0.2407
Missiles (Explosive)	0.2487	0.3963	0.4271
Missiles (Non-Explosive)	0.0285	0.0000	0.0000
Rockets (Explosive)	0.0042	0.0118	0.0118
Rockets (Non-Explosive)	0.0000	0.0622	0.0622
Rockets (Non-Explosive): Flechette	Note 1	0.0033	0.0033
Sabot	Note 1	0.0019	0.0042
Air Target - Expended (decoy)	Note 1	0.0985	0.1082
Air Target - Expended (drone)	Note 1	0.0044	0.0044
Mine Shape (Non-Explosive)	Note 1	0.2233	0.2233

Table 3.0-18: Impact Area of Proposed Military Expended Materials (continued)

Military Expended Materials	Area of Potential Impact (acre)		
	2015 Final EIS/OEIS	Alternative 1	Alternative 2
Subsurface Targets (Mobile)	Note 1	0.0142	0.0149
Subsurface Targets (Stationary)	Note 1	0.0011	0.0013
Surface Targets (Mobile)	Note 1	0.3959	0.4175
Surface Target (Stationary)	3.4960	3.9097	4.9238
Acoustic Countermeasures	0.0084	0.0110	0.0133
Chaff – Air Cartridge	0.0013	0.0009	0.0009
Chaff – Ship Cartridge	0.0404	0.0226	0.0331
Flares	2.9005	1.9710	1.9710
Mine Neutralization System Neutralizers (Explosive)	0.0021	0.0033	0.0033
Mine Neutralization System Neutralizers (Non-Explosive)	0.0002	0.0000	0.0000
Air-Launched Lightweight Torpedoes (Explosive)	0.0018	0.0009	0.0009
Surface-Launched Lightweight Torpedo (Explosive)	0.0009	0.0005	0.0005
Lightweight Torpedo Accessories	0.0033	0.0028	0.0031
Heavyweight Torpedo (Explosive)	0.0109	0.0055	0.0091
Heavyweight Torpedo Accessories	0.0040	0.0036	0.0054
Anchors (Other)	Note 1	0.0057	0.0080
Anti-torpedo Torpedo	Note 1	0.0017	0.0023
Anti-torpedo Torpedo Accessories	Note 1	0.0004	0.0005
Buoys (Explosive)	0.0720	0.0351	0.0351
Buoys (Non-Explosive)	0.0281	0.0063	0.0073
Cannister	Note 1	0.0001	0.0001
Compression Pad/Pistons	Note 1	0.0035	0.0035
Endcaps	Note 1	0.0035	0.0035
Flare O-Rings	Note 1	0.0035	0.0035
Sonobuoys (Non-Explosive)	0.6676	0.3019	0.3293
Expended Bathythermograph	0.0066	0.0043	0.0046
Marine Marker	0.0552	0.0482	0.0482
Illumination Flare	0.0020	0.0020	0.0020
Fiber Optic Can	0.0000	0.0000	0.0000
JATO Bottle	0.0033	0.0033	0.0033
Small Decelerator/Parachutes	2.1959	2.2571	2.4634
Medium Parachutes	0.4206	0.2103	0.2103
Large Parachutes	1.8030	0.9015	0.9015
Ship Hulk	29.0299	14.5150	14.5150
TOTAL	**49.31**	**30.25**	**32.80**

Note 1: These items were not calculated in the 2015 MITT Final EIS/OEIS.

3.0.4.4.5 Seafloor Devices

Seafloor devices represent items used during training or testing activities that are deployed onto the seafloor and recovered. These items include moored mine shapes, anchors, and bottom placed instruments. In certain cases, weights that anchor a device would be expended when the device is recovered (e.g., pop-up buoys). Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile organisms. The effect of devices on the bottom will be discussed as an alteration of the bottom substrate and associated living resources (i.e., invertebrates and vegetation). Table 3.0-19 shows the number of ongoing events (from the 2015 MITT Final EIS/OEIS) and the number of events proposed in this SEIS/OEIS that include the use of seafloor devices.

Table 3.0-19: Annual Number of Events in the Study Area that Include Seafloor Devices

Training & Testing		
2015 Final EIS/OEIS	*Alternative 1*	*Alternative 2*
200	180	182

3.0.4.4.6 Ground Disturbance and Wildfires

Section 3.0.5.2.3.6 (Ground Disturbance and Wildfires) in the 2015 MITT Final EIS/OEIS described ground disturbance and wildfires on FDM. Table 3.0-20 shows the number and type of munitions analyzed in the 2015 MITT Final EIS/OEIS and proposed in this SEIS/OEIS.

Table 3.0-20: Annual Number of Munitions Used on Farallon de Medinilla

Ordnance Use	*2015 Final EIS/OEIS*	*Alternative 1*	*Alternative 2*
Small-caliber Rounds	24,000	24,000	24,000
NEPM Bombs ≤ 2,000 lb.	2,670	2,670	2,670
Explosive Bombs ≤ 2,000 lb.	6,242	6,242	6,242
Explosive Missiles and Rockets ≤ 5"	85 missiles; 2,000 rockets	115 missiles; 2,000 rockets	115 missiles; 2,000 rockets
Explosive Grenades and Mortars	600	1,000	1,000
Medium-caliber Projectiles	17,350 explosives; 94,150 NEPM	17,500 explosives; 94,650 NEPM	17,500 explosives; 94,650 NEPM
Large-caliber Projectiles	1,200 explosives; 1,800 NEPM	3,000 explosives	4,400 explosives

Notes: lb. = pound, NEPM = Non-Explosive Practice Munition

3.0.4.4.7 Personnel Disturbance

Personnel disturbance accounts for the potential for physical impacts on the nearshore seafloor from personnel involved in training or testing activities. During some activities, such as amphibious activities, military personnel approaching land from the ocean may walk in the shallow water through nearshore areas. For example, as amphibious boats approach a beach, military personnel may be required to exit the boat, stand up, and walk to the beach landing area. Table 3.0-21 shows the number of ongoing events (from the 2015 MITT Final EIS/OEIS) and the number of events proposed in this SEIS/OEIS that include the potential for personnel disturbance.

Table 3.0-21: Annual Number of Events in the Study Area that Include the Potential for Personnel Disturbance

Training & Testing		
2015 Final EIS/OEIS	*Alternative 1*	*Alternative 2*
272	272	272

3.0.4.5 Entanglement Stressors

As described in the 2015 MITT Final EIS/OEIS, entanglement stressors can result from the Navy's proposed use of fiber optic cables, guidance wires, and decelerators/parachutes. In addition, sonobuoy wires, not previously identified as entanglement stressors, can be entanglement stressors and are included in this SEIS/OEIS for analysis.

3.0.4.5.1 Wires and Cables

3.0.4.5.1.1 Fiber Optic Cables

Although a portion may be recovered, some fiber optic cables used during Navy training and testing associated with remotely operated mine neutralization activities would be expended. The length of the expended tactical fiber would vary (up to about 3,000 meters) depending on the activity. Tactical fiber has an 8-micrometer (0.008 millimeter [mm]) silica core and acrylate coating, and looks and feels like thin monofilament fishing line. Other characteristics of tactical fiber are a 242-micrometer (0.24 mm) diameter, 12-pound tensile strength, and 3.4-mm bend radius (Corning Incorporated, 2005; Raytheon Company, 2015). Tactical fiber is relatively brittle; it readily breaks if knotted, kinked, or abraded against a sharp object. Deployed tactical fiber will break if looped beyond its bend radius (3.4 mm), or exceeds its tensile strength (12 pounds). If the fiber becomes looped around an underwater object or marine animal, it will not tighten unless it is under tension. Such an event would be unlikely based on its method of deployment and its resistance to looping after it is expended. The tactical fibers are often designed with controlled buoyancy to minimize the fiber's effect on vehicle movement. The tactical fiber would be suspended within the water column during the activity, and then be expended and sink to the seafloor (effective sink rate of 1.45 centimeters/second (Raytheon Company, 2015)) where it would be susceptible to abrasion and burial by sedimentation.

3.0.4.5.1.2 Guidance Wires

Section 3.0.5.2.4.1 (Guidance Wires) in the 2015 MITT Final EIS/OEIS described guidance wires.

3.0.4.5.1.3 Sonobuoy Wires

Sonobuoys consist of a surface antenna and float unit and a subsurface hydrophone assembly unit. The two units are attached through a thin-gauge, dual-conductor, and hard-draw copper strand wire, which is then wrapped by a hollow rubber tubing or bungee in a spiral configuration. The tensile breaking strength of the wire and rubber tubing is no more than 40 pounds. The length of the wire is housed in a plastic canister dispenser, which remains attached upon deployment. The length of wire that extends out is no more than 1,500 ft. and is dependent on the water depth and type of sonobuoy. Attached to the wire is a kite-drogue and damper disk stabilizing system made of non-woven nylon fabric. The nylon fabric is very thin and can be broken by hand. The wire runs through the stabilizing system, and leads to the hydrophone components. The hydrophone components may be covered by thin plastic netting depending on type of sonobuoy, but pose no entanglement risk. Each sonobuoy has a saltwater activated polyurethane float that inflates when the sonobuoy is submerged and keeps the sonobuoy components floating vertically in the water column below it. Sonobuoys remain suspended in the water column for no more than 30 hours, after which they sink to the seafloor.

Bathythermographs are similar to sonobuoys in that they consist of a subsurface unit (to measure temperature of the water column in the case of the bathythermograph) that is connected by wire to the float unit (for air-deployed bathythermographs) or directly to the ship (for ship-deployed bathythermographs). The bathythermograph wire is similar to the sonobuoy wire as described above.

Table 3.0-22 shows the number of wires and cables analyzed in the 2015 MITT Final EIS/OEIS and the number proposed in this SEIS/OEIS.

Table 3.0-22: Annual Number of Wires and Cables Expended in the Study Area

Training & Testing		
2015 Final EIS/OEIS	***Alternative 1***	***Alternative 2***
Fiber Optic Cables		
144	44	44
Guidance Wires		
60	49	73
Sonobuoy Wires		
Note 1	5,386	5,876
Bathythermograph Wires		
Note 1	341	364

Note 1: These items were not calculated in the 2015 Final EIS/OEIS.

3.0.4.5.2 Decelerators/Parachutes

Decelerators/parachutes used during training and testing activities are classified into four different categories based on size: small, medium, large, and extra-large; extra-large are not proposed for use in the MITT Study Area (Table 3.0-23). Aircraft-launched sonobuoys and lightweight torpedoes (such as the MK 46 and MK 54) use nylon decelerators/parachutes ranging in size from 18 to 48 inches in diameter (small). The majority of the decelerators/parachutes in the small size category are smaller (18 inches) cruciform shape decelerators/parachutes associated with sonobuoys (Figure 3.0-2). Illumination flares use medium decelerators/parachutes, up to approximately 19 ft. in diameter. Both small- and medium-sized decelerators/parachutes are made of cloth and nylon, many with weights attached to their short attachment lines to speed their sinking. At water impact, the decelerator/parachute assembly is expended and sinks away from the unit. The decelerator/parachute assembly may remain at the surface for 5–15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Environmental Sciences Group, 2005). Once settled on the bottom the canopy may temporarily billow if bottom currents are present.

Table 3.0-23: Size Categories for Decelerators/Parachutes Expended During Training and Testing Activities

Size Category	Diameter (ft.)	Associated Use
Small	1.5–6	Air-launched sonobuoys, lightweight torpedoes, and drones (drag decelerator/parachute)
Medium	19	Illumination flares
Large	30–50	Drones (main decelerator/parachute)

Figure 3.0-2: Sonobuoy Launch Depicting the Relative Size of a Small Decelerator/Parachute

Aerial targets (drones) use large (between 30 and 50 ft. in diameter) decelerators/parachutes (Figure 3.0-3). Large decelerators/parachutes are also made of cloth and nylon, with suspension lines of varying lengths (40–70 ft. in length [with up to 28 lines per decelerator/parachute]). Some aerial targets also use a small drag parachute (6 ft. in diameter) to slow their forward momentum prior to deploying the larger primary decelerator/parachute. Unlike the small- and medium-sized decelerators/parachutes, drone decelerators/parachutes do not have weights attached and may remain at the surface or suspended in the water column for some time prior to eventual settlement on the seafloor.

Figure 3.0-3: Aerial Target (Drone) with Parachute Deployed

Table 3.0-24 shows the number of decelerators/parachutes analyzed in the 2015 MITT Final EIS/OEIS and the number proposed in this SEIS/OEIS.

Table 3.0-24: Annual Number of Decelerators/Parachutes Expended in the Study Area

Training & Testing		
2015 Final EIS/OEIS	***Alternative 1***	***Alternative 2***
12,572	10 Large, 18 Medium, 5,437 Small	10 Large, 18 Medium, 5,934 Small

3.0.4.6 Ingestion Stressors

As described in the 2015 MITT Final EIS/OEIS, ingestion stressors can result from the Navy's proposed use of non-explosive practice munitions (small- and medium-caliber), fragments from explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and decelerator/parachutes. The annual number of non-explosive practice munitions expended is shown in Table 3.0-14, the number of explosive munitions that could fragment is shown in Table 3.0-16, the number of targets that could fragment is shown in Table 3.0-17, the number of decelerator/parachutes is shown in Table 3.0-24, the number of chaff cartridges is shown in Table 3.0-25, and the number of flares is shown in Table 3.0-26.

Table 3.0-25: Annual Number of Chaff Cartridges Expended in the Study Area

Training & Testing		
2015 Final EIS/OEIS	***Alternative 1***	***Alternative 2***
Chaff – Air Cartridge		
26,000	17,600	17,600
Chaff – Ship Cartridge		
440	246	360

Table 3.0-26: Annual Number of Flares Expended in the Study Area

Training & Testing		
2015 Final EIS/OEIS	***Alternative 1***	***Alternative 2***
25,900	17,600	17,600

3.0.4.7 Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities

This conceptual framework describes the potential effects from exposure to acoustic and explosive activities and the accompanying short-term costs to the animal (e.g., expended energy or missed feeding opportunity). It then outlines the conditions that may lead to long-term consequences for the individual if the animal cannot fully recover from the short-term costs and how these in turn may affect the population. The methods to predict effects on each 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 that 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; although, 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 3.0-4 is a flowchart that diagrams the process used to evaluate the potential effects to marine animals exposed to sound-producing activities. The shape and color of each box on the flowchart represents either a decision point in the analysis (green diamonds); specific processes such as responses, costs, or recovery (blue rectangles); external factors to consider (purple parallelograms); and final outcomes for the individual or population (orange ovals and rectangles). Each box is labeled for reference throughout the following sections. For simplicity, sound is used here to include not only sound waves but also blast waves generated from explosive sources. Box A1, the Sound-Producing Activity, is the source of this stimuli and therefore the starting point in the analysis.

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

Sounds emitted from a sound-producing activity (Box A1) travel through the environment to create a spatially variable sound field. The received sound by 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 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).

3.0.4.7.1 Injury

Injury (Box B1) refers to the direct injury of tissues and organs by shock or pressure waves impinging upon or traveling through an animal's body. Marine animals are well adapted to large, but relatively slow, hydrostatic pressure changes that occur with changing depth. However, injury may result from exposure to rapid pressure changes, such that the tissues do not have time to adequately adjust.

Therefore, injury is normally limited to relatively close ranges from explosions. Injury can be mild and fully recoverable or, in some cases, lead to mortality.

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

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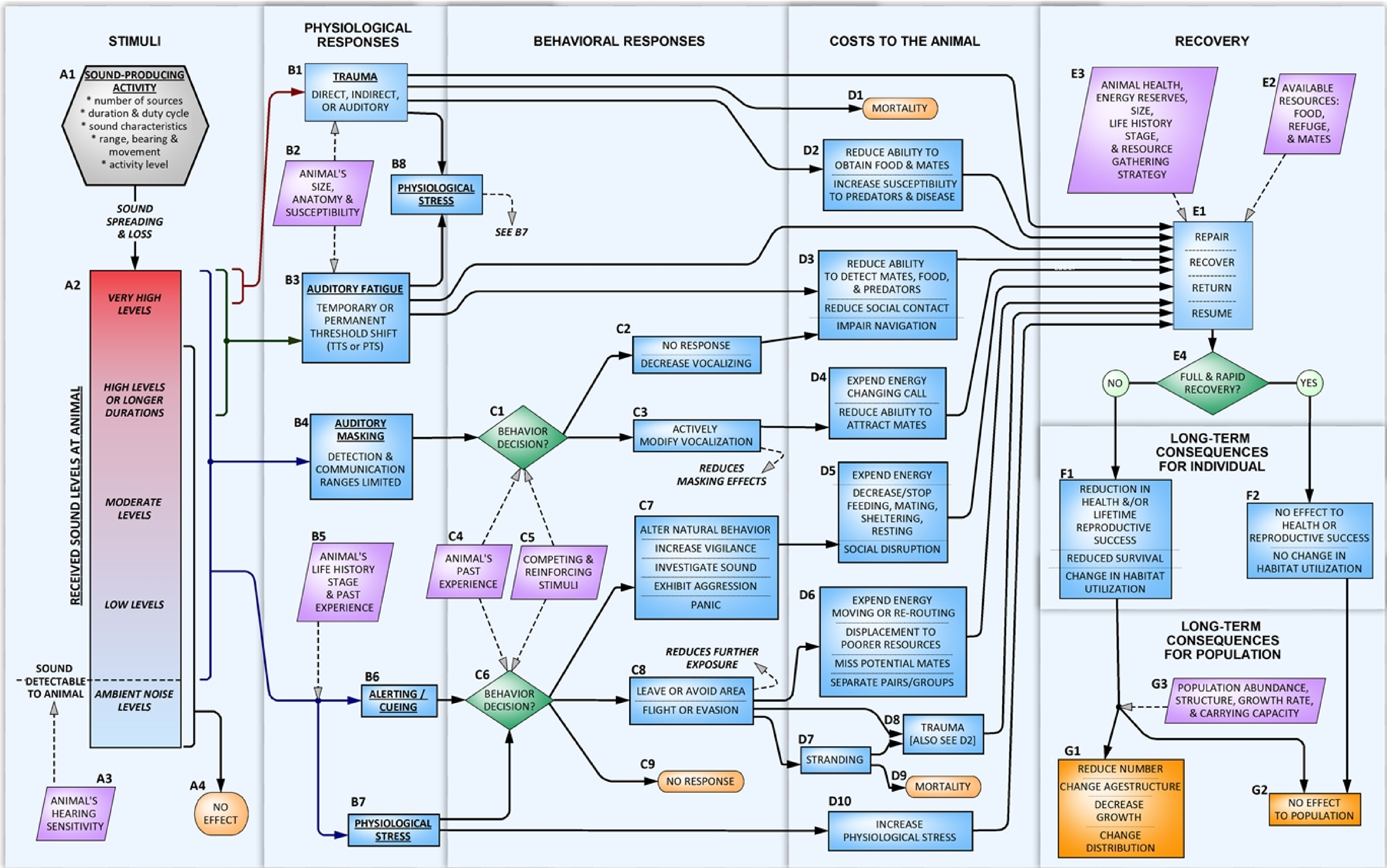

Figure 3.0-4: Flow Chart of the Evaluation Process of Sound-Producing Activities

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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 & Mao, 1996; Crum et al., 2005); 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, 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.

3.0.4.7.2 Hearing Loss

Hearing loss, also called a noise-induced threshold shift, is possibly the most studied type of effect from sound exposures to animals. Hearing loss manifests itself as loss in hearing sensitivity across part of an animal's hearing range, which is dependent upon the specifics of the noise exposure. Hearing loss may be either PTS or TTS. If the threshold shift eventually returns to zero (the animal's hearing returns to pre-exposure value), the threshold shift is a TTS. If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 3.0-5 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.

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).

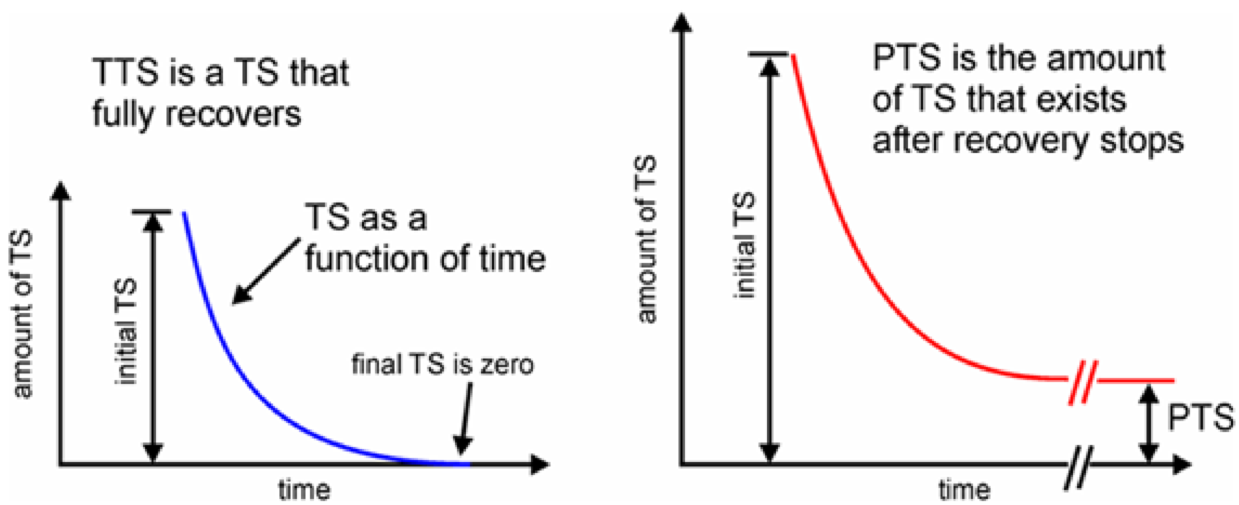

Figure 3.0-5: Two Hypothetical Threshold Shifts

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 decibels 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 increases 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.

3.0.4.7.3 Masking

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

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

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

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

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

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

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

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

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

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

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

3.0.4.7.5 Behavioral Reactions

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

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

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

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

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

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

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

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

3.0.4.7.6 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 increase the probability of causing long-term consequences to individuals.

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

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

Long-term consequences to individuals can translate into consequences for populations dependent upon population abundance, structure, growth rate, and carry 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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3.1 Sediments and Water Quality

Supplemental Environmental Impact Statement/

Overseas Environmental Impact Statement

Mariana Islands Training and Testing

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3.1 Sediments and Water Quality

3.1.1 Affected Environment

The purpose of this section is to supplement the analysis of impacts on sediments and water quality as presented in the 2015 Mariana Islands Training and Testing (MITT) Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) with new information relevant to proposed changes in training and testing activities conducted at sea and on Farallon de Medinilla (FDM). Information presented in the 2015 MITT Final EIS/OEIS that remains valid is noted as such and referenced in the appropriate sections. Any new or updated information describing the affected environment and analysis of impacts on sediments and water quality associated with the Proposed Action is provided in this section. Comments received from the public during scoping related to Sediments and Water Quality are addressed in Section 3.1.3 (Public Comments). Comments received from the public during the Draft Supplemental EIS (SEIS)/OEIS commenting period related to Sediments and Water Quality are addressed in Appendix K (Public Comment Responses).

3.1.1.1 Existing Conditions

Ocean water resources, climate, and the existing water quality in the MITT Study Area were discussed in the 2015 MITT Final EIS/OEIS. The 2015 MITT Final EIS/OEIS analyzed potential impacts on sediment quality in nearshore and deep water sediments, as well as water quality on the surface and within the water column, and determined that potential impacts on sediment and water quality would not be significant. As stated in the 2015 MITT Final EIS/OEIS, some studies suggest that deep water is, in general, of higher quality than surface waters. Additionally, water quality in marine environments is determined by complex interactions between physical, chemical, and biological processes (U.S. Department of the Navy, 2015).

There is no new information since the publication of the 2015 MITT Final EIS/OEIS for marine sediments that would alter the analysis of potential impacts on water and sediment quality. New information, however, has been released that would improve the understanding of existing conditions for water quality, mainly with regards to marine debris and climate change. In addition, published results that inform the evaluation for water quality impacts in the immediate vicinity of FDM are now available and summarized below. The new information, however, does not indicate an appreciable change to the existing environmental conditions as described in the 2015 MITT Final EIS/OEIS.

3.1.1.1.1 Water Quality Criteria and Screening Levels in Waters Surrounding Guam and the Commonwealth of the Northern Mariana Islands

<u>Guam Water Quality Standards and Classifications</u>

Title 22 Division II Chapter 5 Section 102 of the Guam Administrative Code (22 GAR Section 5102) defines marine waters as all coastal waters offshore, including estuarine waters, lagoons, bays, brackish areas, wetlands, and other inland waters that are subject to the ebb and flow of tides. General water quality classifications for marine waters include

- **Category M-1 (Excellent)**. Water in this category must be of high enough quality to protect for whole body contact recreation; to ensure the preservation and protection of marine life, including corals and reef-dwelling organisms, fish, and related fisheries resources; and to enable the pursuit of marine scientific research as well as aesthetic enjoyment. This category of water shall remain substantially free from pollution attributed to domestic, commercial, and industrial discharges; shipping and boating; or mariculture, construction, and other activities that can reduce the waters' quality.

- **Category M-2 (Good)**. Water in this category must be of sufficient quality to allow for the propagation and survival of marine organisms, particularly shellfish and other similarly harvested aquatic organisms, corals and other reef-related resources, and whole body contact recreation. Other important and intended uses include mariculture activities, aesthetic enjoyment, and related activities.
- **Category M-3 (Fair)**. Water in this category is intended for general, commercial, and industrial use, while allowing for protection of aquatic life, aesthetic enjoyment, and compatible recreation with limited body contact. Specific intended uses include shipping, boating and berthing, industrial cooling water, and marinas.

Title 22 GAR Section 5102 also classifies different surface waters. These classifications include

- **Category S-1 (High)**. Surface water in this category is used for drinking water, wilderness areas, propagation and preservation of aquatic life, whole body contact recreation, and aesthetic enjoyment. It is the objective of these standards that these waters shall be kept free of substances or pollutants from domestic, commercial, and industrial discharges, or agricultural activities, construction, or other land-use practices that may impact water quality.
- **Category S-2 (Medium)**. Surface water in this category is used for recreational purposes, including whole body contact recreation; for use as potable water supply after adequate treatment is provided; and for propagation and preservation of aquatic wildlife and aesthetic enjoyment.
- **Category S-3 (Low)**. Surface water in this category is primarily used for commercial, agricultural, and industrial activities. Aesthetic enjoyment and limited body contact recreation are acceptable in this zone, as is maintenance of aquatic life. Discharges within this zone may be required to have construction or discharge permits under existing Guam Sediment and Soil Erosion regulations or under National Pollution Discharge Elimination System.

Table 3.1-1 lists each standard with specific criteria in Guam's regulations and applicability to each water classification. The water quality standards include criteria for microbiological concentrations (Enterococci and *E. coli*), pH, nutrients (nitrate-nitrogen, total nitrogen, orthophosphate, ammonia), dissolved oxygen, total filterable suspended solids, salinity, temperature, turbidity, radioactive materials, oil and petroleum products, toxic pollutants, and other general considerations.

Commonwealth of the Northern Mariana Islands Water Quality Standards and Classification

Chapter 65-130 Part 200 of the Northern Mariana Islands Administrative Code establishes definitions of water use areas within the Commonwealth of the Northern Mariana Islands (CNMI) coastal zone. Class "AA" waters are coastal waters surrounding Saipan, Tinian, Rota, and the northern islands (FDM, Anatahan, Sariguan, Guguan, Alamagan, Pagan, Agrihan, Asuncion, Maug, and Farallon de Pajaros) that are not designated as class "A" waters. Class "A" waters off of Saipan include waters out to 3,000 feet from the shoreline, from the entrance to Smiling Cove Marina to Saddok As Agatan, inclusive of the waters within Smiling Cove Marina and its entrance channel; and waters surrounding the Agingan Wastewater Treatment Plant, within a 1,000-foot radius of the outfall. Class "A" waters off of Tinian include coastal waters known as San Jose Harbor. Class "A" waters off of Rota include coastal waters known as East Harbor and West Harbor. Class "A" waters off of the northern islands includes waters surrounding FDM; however, these waters are not included in the CNMI coastal zone. Class "1" and Class "2" waters are associated with freshwater features. No land-based training activities are included in the Proposed Action, and the military does not conduct any training activities on land within waters that would be considered Class "1" or Class "2."

Chapter 65-130 Part 400 provides water quality standards for water use areas in nearshore waters of the CNMI. Table 3.1-1 lists each standard with specific criteria in CNMI's regulations and applicability to each water use area. The water quality standards include criteria for microbiological concentrations (Enterococci and *E. coli*), pH, nutrients (nitrate-nitrogen, total nitrogen, orthophosphate, ammonia), dissolved oxygen, total filterable suspended solids, salinity, temperature, turbidity, radioactive materials, oil and petroleum products, toxic pollutants, and other general considerations. The military readiness activities that generate stressors to water quality do not occur in the water use areas; rather, they occur outside of the CNMI coastal zone and are analyzed in the context of their potential to induce reasonably foreseeable effects into Class "AA" or Class "A" water use areas.

Table 3.1-1: Water Quality Standard, Criteria, and Applicable Water Use Areas

Water Quality Standard[1]		Criteria/Threshold[2]	Guam Water Classification[3]	CNMI Water Classification[4]
Microbiological Requirements	Enterococci	The Enterococci concentration shall not exceed a geometric mean of 35 per 100 mL based on samples taken in any 30-day interval. No single sample result shall exceed 130 Enterococci per 100 mL.	M-1, M-2, M-3	All Waters
	E. coli	The *E. coli* concentration shall not exceed a geometric mean of 126 per 100 mL based on samples taken in any 30-day interval. The Statistical Threshold Value is 410 *E. coli* per 100 ml.	M-1, M-2, M-3	All Waters
pH		pH shall remain within the range of 6.5–8.5	M-1, M-2, M-3	A, AA
		pH shall not deviate more than 0.5 units from a value of 8.1; no lower than 7.6 or higher than 8.6.	N/A	1, 2
		pH shall not deviate more than 0.5 from ambient conditions and shall not be lower than 6.5 nor higher than 8.5.	M-1, M-2, M-3	A, AA
Nutrients	Nitrate-Nitrogen	Not to exceed 0.10 mg/L	M-1, S-1	AA
		Not to exceed 0.20 mg/L	M-2, S-2	N/A
		Not to exceed 0.50 mg/L	M-3, S-3	A
	Total Nitrogen	Not to exceed 0.4 mg/L	N/A	AA
		Not to exceed 0.75 mg/L	N/A	A, 1
		Not to exceed 1.50 mg/L	N/A	2
	Ortho-phosphate	Not to exceed 0.025 mg/L	M-1, S-1	AA
		Not to exceed 0.05 mg/L	M-2, S-2	A
		Not to exceed 0.10 mg/L	M-3, S-3	1, 2
	Total Phosphorus	Not to exceed 0.025 mg/L	M-1, S-1	AA
		Not to exceed 0.05 mg/L	M-2, S-2	A
		Not to exceed 0.10 mg/L	M-3, S-3	1, 2
	Ammonia (un-ionized)	Not to exceed 0.02 mg/L	All Waters	All Waters

Table 3.1-1: Water Quality Standard, Criteria, and Applicable Water Use Areas (continued)

Water Quality Standard[1]		Criteria/Threshold[2]	Guam Water Classification[3]	CNMI Water Classification[4]
Dissolved Oxygen		Not less than 75% saturation/or further reduce DO when low DO is attributed to natural causes	All Waters	All Waters
Total filterable suspended solids		Concentrations of suspended matter at any point shall not be increased from ambient conditions at any time, and should not exceed 5 mg/L except when due to natural conditions.	M-1, S-1	AA, 1
		Concentrations of suspended matter at any point shall not be increased from ambient conditions at any time, and should not exceed 20 mg/L except when due to natural conditions.	M-2, M-3	N/A
		Concentrations of suspended matter at any point shall not be increased from ambient conditions at any time, and should not exceed 40 mg/L except when due to natural conditions.	M-3, S-3	A, 2
Salinity	Marine waters	M-1, M-2, M-3		AA, A
	Fresh waters	S-1, S-2, S-3		1,2
Temperature		Water temperature shall not vary by more than 1.0°C from the ambient conditions.	All Waters	All Waters
Turbidity		Turbidity at any point, as measured by NTU, shall not exceed 0.5 NTU over ambient conditions except when due to natural conditions.	M-1, M-2	AA, 1
		Turbidity values (NTU) at any point shall not exceed 1.0 NTU over ambient conditions.	M-2, M-3, S-2, S-3	A, 2
Radioactive Materials		Discharge of radioactive materials at any level into any waters of the Commonwealth or state waters is strictly prohibited.	All Waters	All Waters
Oil and Petroleum Products		The concentration of oil or petroleum products shall not (a) be detectable as a visible film, sheen, or discoloration of the surface or cause an objectionable odor; (b) cause tainting of fish or other aquatic life, be injurious to the indigenous biota, or cause objectionable taste in drinking water; or (c) form an oil deposit on beaches or shoreline, or on the bottom of a body of water.	All Waters	All Waters

Table 3.1-1: Water Quality Standard, Criteria, and Applicable Water Use Areas (continued)

Water Quality Standard[1]	Criteria/Threshold[2]	Guam Water Classification[3]	CNMI Water Classification[4]
Toxic Pollutants	All waters shall be free from toxic pollutants in concentrations that are lethal to, or that produce detrimental physiological responses in human, plant, or animal life. Detrimental responses include, but are not limited to decreased growth rate and decreased reproductive success of resident or indicator species; or significant alterations in population, community ecology, or receiving water biota.	All Waters	All Waters

[1]Water Quality Standards are provided in section 65-130 Part 400 of the CNMI Administrative Code.
[2]The Proposed Action will not exceed criteria/thresholds within the CNMI coastal zone.
[3]Water use areas are specified in Title 22 Section 5103 of the Guam Administrative Code.
[4]Water use areas are specified in section 65-130 Part 200 of the CNMI Administrative Code.
Notes: °C = degrees Celsius, CFU = coliform forming units, DO = dissolved oxygen, L = Liters, mg = milligrams, NTU = nephelometric turbidity unit

3.1.1.1.2 Marine Debris and Water Quality

Richardson et al. (2016) describe the results of seine net (vertical nets that are held in place with weights and buoys) surveys in open ocean waters of the western and central Pacific Ocean within exclusive economic zones (EEZs) of 25 Pacific countries and territories, as well as in international waters. A majority of the reported purse seine (a seine net that fully encompasses an area of fish) pollution incidents are related to plastics waste. Other common pollution incidents are related to oil spillages and to abandoned, lost, or dumped fishing gear. Data analysis highlighted the need for increased monitoring, reporting, enforcement of pollution violations for all types of fishing vessels operating in the Pacific region, a regional outreach and compliance assistance program on marine pollution prevention, and improvements in Pacific port waste reception facilities. Most of the pollution incidents associated with marine debris occurred in Papua New Guinea's EEZ (approximately 45 percent), while less than 1 percent of the debris accumulations collected on the surface by Richardson et al. (2016) were within the portion of the United States (U.S.) EEZ surrounding Guam, the CNMI, and other U.S. Pacific islands.

3.1.1.1.3 Climate Change and Water Quality

New information on the potential for climate change to impact water quality was obtained for the western Pacific region. The 2015 MITT Final EIS/OEIS identified decreasing ocean pH (i.e., increasing acidity), increasing water temperatures, and increasing storm activity as aspects of climate change that potentially impact water quality.

Rainfall and tropical cyclones are significant aspects of the climate on islands within the Study Area; however, potential impacts on rainfall and tropical cyclone patterns are difficult to estimate (Keener et al., 2015). One study for Guam predicts fewer, but more intense, storms, that would likely follow new storm tracks, and a moderate increase in daily and annual average rainfall (U.S. Marine Corps, 2014). On Saipan, an assessment of vulnerability to climate change assumed a future small increase in average rainfall, an increase in extreme rainfall, as well as more extreme wet and dry seasons. Although difficult to predict, changes in rainfall and storm intensity are generally anticipated to be harmful to ecosystems that provide ecological services beneficial to water quality within the Study Area.

Keener et al. (2015) documented a coral bleaching event off of Guam in 2013 through 2014. That event, combined with the strong associations between sea surface temperature increases and coral bleaching events throughout the Pacific (Griesser & Spillman, 2016), suggests that it is highly likely sea surface temperature increases in the Mariana Islands are at least partially to blame for coral bleaching events. Coral cover on Guam is generally similar to other southern Mariana Islands, but lower than the northern islands (Raymundo et al., 2016). Because coral distribution and coral cover on reefs is naturally patchy and heterogeneous, a single island-wide number is not a particularly useful summary of the coral community. Long-term monitoring surveys conducted by the National Oceanic and Atmospheric and Administration's Coral Reef Ecosystem Division Pacific Assessment and Monitoring Program found approximately 10−15 percent coral cover overall, but the recent multi-year coral bleaching events have had dramatic, if patchy, consequences for the reef communities on Guam. For example, Raymundo et al. (2017) estimated a 53 percent decline in staghorn *Acropora* spp. on Guam. Of the 21 sites in the study, 6 are on Joint Region Marianas-administered submerged lands, including 4 in Apra Harbor. The estimated mean mortality of staghorn *Acropora* spp. was 80 percent at Big Blue Shoals, 80 percent at Western Shoals, 30 percent at Dogleg, and 90 percent at Gab (Raymundo et al., 2016). In the past several years, corals in Guam have been bleaching regularly each summer and recovery has been limited, leading to significant levels of coral mortality (Harvey, 2016; Raymundo et al., 2017).

Even though the new studies show variability in coral cover at FDM and decreases in some coral species off Guam, this information does not appreciably change the analysis presented in the 2015 MITT Final EIS/OEIS because the species composition on the reefs has not changed.

Changes in pH outside the normal range can make it difficult for marine organisms that make hard structures through calcification (e.g., shells or skeletons) to maintain their structures. Many of those creatures are at the base of the marine food chain, such as phytoplankton, so changes may cascade through the ecosystem. Rising water temperatures can be detrimental to coastal ecosystems and, by extension, coastal water quality because these ecosystems provide ecological services (e.g., sediment trapping, nutrient cycling).

3.1.1.1.4 Farallon de Medinilla

Range condition assessments are conducted at all operational ranges within the Mariana Islands Range Complex in accordance with Department of Defense (DoD) Instruction 4715.14, Operational Range Assessments, and the Chief of Naval Operations Range Sustainability Environmental Program Analysis Policy. The Navy is committed to surveying in accordance with the Biological Opinion provided to the Navy in 2017, which includes terms and conditions for conducting in-water surveys at FDM. These surveys would ascertain the status and health of the coral reef environment and occur every five years (one of the terms and conditions of the Biological Opinion). The Navy will also conduct routine clearance of unexploded ordnance and other range debris from the FDM impact areas. The coral reef surveys could provide an indication if the waters surrounding FDM (designated Class A) are degrading in quality, as evidenced by coral health. Routine clearance of unexploded ordnance from the FDM impact areas removes potential sources of munition constituents, helping to protect CNMI's water quality. The Navy engaged with the National Marine Fisheries Service in coral consultations under the Endangered Species Act (ESA) and through the Essential Fish Habitat Assessment, relevant to all species of corals and essential fish habitats that are present in the Study Area. These consultations and regulatory conclusions were summarized in the 2015 MITT Final EIS/OEIS (U.S. Fish and Wildlife Service, 2015). After the release of the 2015 MITT Final EIS/OEIS, the Navy and NMFS entered into a subsequent consultation with a focus on potential effects of military use of FDM on coral species listed since the previous consultation between the Navy and NMFS (National Marine Fisheries Service, 2017). The Navy and NMFS have reinitiated consultation for activities described under Alternative 2 of this SEIS/OEIS. Any new provisions included in NMFS's Biological Opinion will be included in the Record of Decision.

No detailed data was available for munitions expenditure during the last three decades of the 20th century on FDM, but early environmental planning documents in 1974 and 1999 provide some insight to the source loading. Delivered munitions that resulted in either a low-order detonation or a "dud" are the predominant energetic munition constituent source material on FDM. Munition constituents commonly associated with munitions such as high melting explosive (HMX) (also referred to as octogen), royal demolition explosive (RDX) (also referred to as cyclonite), Dinitrotoluene (DNT), and heavy metals are likely present in small dispersed residual quantities associated with high-order detonations and in localized higher concentrations associated with duds or low-order detonations. Areas with high explosive concentrations are often found around "carcasses" of munitions that were only partly detonated. Heavily cratered areas on military ranges often have below detection or low high-explosive concentrations, suggesting that high-order detonations leave only trace amounts of explosive residues (Walsh, 2007). The frequency of low-order detonations or dud rates of munitions fired into the impact zones at FDM is not known; however (MacDonald & Mendez, 2005) provided failure rates and low-order detonation rates for various munitions types, shown in Table 3.1-2. As part of the Operational Range Clearance activities that occur on FDM, qualititative observations of partially detonated munitions suggest that the dud and low-order explosion rates of munitions expended on FDM are generally low and consistent with the rates shown in Table 3.1-1.

Table 3.1-2: Rates of Failure and Low-Order Detonations

Ordnance	Failure Rate (Percent)	Low-Order Detonation Rate (Percent)
Guns/artillery	4.68	0.16
Hand grenades	1.78	–
Explosive ordnance	3.37	0.09
Rockets	3.84	–
Submunitions[1]	8.23	–

[1] Submunitions are munitions contained within and distributed by another device such as a rocket.
Sources: MacDonald and Mendez (2005); Walsh (2007)

Since the publication of the 2015 MITT Final EIS/OEIS, the draft analysis of multi-year dive surveys conducted in nearshore waters of FDM between 1997 and 2012 has been published (Smith & Marx, 2016). During these dive surveys, Smith and Marx (2016) provide qualitative observations of water quality and sediment quality surrounding the live-fire range. A summary of the observations is included below, and a more detailed description of the surveys and observations may be found in Section 3.1.3.1.5.3 (Farallon de Medinilla Specific Impacts) of the 2015 MITT Final EIS/OEIS.

- **Natural causes of erosion**. Based on these direct observations of damage off the coast of FDM, the majority of disturbances to the seafloor sediments, substrates, and mass movement of FDM can be attributed to typhoons and storm surges. Further, damage attributed to military training activities recovered within two to three years at the same rate of damage associated with natural phenomenon (Smith & Marx, 2016). As discussed in Section 3.10 (Terrestrial Species and Habitats), prior to the mid-1990s, the ordnance drops on FDM were not confined to designated impact zones, and there were no ordnance constraints in terms of net explosive weight. The vegetation loss on the island and subsequent erosion has likely decreased under current training constraints for FDM relative to the intensive range use over the decades prior to the mid-1990s.

- **Assessment of long-term impacts: military impacts**. Based on the dive surveys, there is no evidence that long-term adverse impacts on the nearshore environment have taken place as a result of military training activities. These findings are based on the number of detectable impacts (e.g., from visual observation during dive surveys), the size of those impacts, and the apparent recovery time (e.g., how long an ordnance fragment or physical damage is no longer visually apparent). Impacts on the physical environment clearly attributable to military training activities were noted in 2007, 2008, 2010, and 2012 (Smith & Marx, 2016). Indirect impacts, such as ordnance skipping or eroding off of FDM and rock and ordnance fragments blasted off of the island, were detected in every survey year. Dive surveys completed in 2005 noted that disturbed sites in 2004 showed no color differences with surrounding undamaged areas, and revealed new, small (less than 3 centimeters), scattered colonies of coral and crustose coralline algae. By 2006 and observed again through 2012, no visual evidence of abnormalities, or of damaged or diseased coral, could be detected (Smith et al., 2013). Further, no new submerged cliff blocks were observed between 2005 and 2012. Small-to-medium-sized fresh rock fragments (generally less than 1 foot [30 centimeters]) have been observed yearly, and are attributed to detonation impacts. In 2007, the first clear indication of a detonation of a bomb on the seafloor was observed. The impact area was measured to be approximately 100 square feet (9 square meters). During the subsequent survey in 2008, the impact area supported new growth of stony corals and crustose algae; by 2009, no trace of the disturbance could be detected by the surveyors (Smith & Marx, 2009). The vast majority of unexploded ordnance observed in the water lacked fins and tail assemblies, which indicates that the ordnance either skipped or ricocheted off of the island, or eroded or washed off of FDM at a later date (Smith & Marx, 2016).
- **Indicators of diminished water quality**. The dive surveys have looked for indicators of diminished water quality in waters surrounding FDM. For instance, high densities of macrobioeroders (e.g., boring sponges), bleaching of corals, surface lesions, or dead patches on stony corals or stony coral mucus production have been associated with sedimentation, pollutants, or other stressors that diminish water quality. Although a moderate bleaching event was noted in 2007, and a barnacle infestation was noted in 2012 (Smith et al., 2013), the bleaching event was regional and extended from southern Japan through the Mariana Islands and south through waters surrounding Palau, which suggests that it was not due to training events at FDM. In addition, subsequent surveys observed soft and fire corals had recovered completely, and 75 percent of the stony corals had recovered by 2008 (Smith & Marx, 2009, 2016). The dive surveys were not conducted in more recent years with bleaching events; however, the health of the marine ecosystem surrounding FDM was comparable to similar habitats within the Mariana Archipelago, demonstrating that training activities occurring at FDM do not have an appreciable impact on the water quality (Smith & Marx, 2016). A subsequent survey around the island was conducted to identify coral species, specifically species listed under the ESA (Carilli et al., 2018). In addition to conducting the in-water coral survey, the Navy reported observations of ordnance and any impacts on nearshore habitat from the use of ordnance (e.g., craters). All but three ordnance encountered were deemed old based on the

amount of encrusted corals and other colonizing species using the ordnance as hard substrate. The report concluded that there were no impacts due to the use of ordnance on the island, including the use of explosive ordnance (Carilli et al., 2018).

3.1.2 Environmental Consequences

Section 3.1 (Sediments and Water Quality) of the 2015 MITT Final EIS/OEIS analyzed potential impacts of training and testing activities resulting from the following stressors: (1) explosives (in-air explosives and in-water explosives) and explosives byproducts, (2) metals, (3) chemicals other than explosives, and (4) a miscellaneous category of other materials. The 2015 MITT Final EIS/OEIS assessed the likelihood for these stressors to result in the following potential impacts on sediments and water quality:

- The potential release of materials into the water that subsequently disperse, react with seawater, or dissolve over time
- The potential for depositing materials on the ocean bottom and any subsequent interactions with sediments or the accumulation of such materials over time
- The potential for depositing materials on the ocean bottom and any subsequent interaction with the water column
- The potential for depositing materials on the ocean bottom and any subsequent disturbance of those sediments or their resuspension in the water column

This section evaluates how, and to what degree, potential impacts on sediments and water quality from stressors described in Section 3.0 (Introduction) may have changed since the analysis presented in the 2015 MITT Final EIS/OEIS was completed. Tables 2.5-1 and 2.5-2 in Chapter 2 (Description of Proposed Action and Alternatives) list the proposed training and testing activities, the number of times each event would be conducted annually, and the locations within the Study Area where the activity would typically occur under each alternative. The tables also present the same information for activities described in the 2015 MITT Final EIS/OEIS so that the proposed levels of training and testing under this supplement can be easily compared.

The Navy conducted a review of federal and state regulations and standards relevant to sediments and water quality, as well as a review of new literature pertaining to sediments and water quality that could inform the analysis presented in the 2015 MITT Final EIS/OEIS. Although additional information was found and described in Section 3.1.1 (Affected Environment), the new information does not indicate an appreciable change to the existing environmental conditions as described in the 2015 MITT Final EIS/OEIS. Thus, the analysis in the 2015 MITT Final EIS/OEIS remains valid. The analysis presented in this section also considers standard operating procedures, which are discussed in Section 2.3.3 (Standard Operating Procedures) of this SEIS/OEIS, and mitigation measures that are described in Chapter 5 (Mitigation). These measures are not specifically designed to offset potential impacts on water resources; however, implementation of some of these measures designed for other resource areas discussed in this SEIS/OEIS would avoid or reduce potential impacts on sediments and water quality. For example, Table 5-18 (Seafloor Resource Mitigation Areas) lists several protective measures that avoid or reduce disturbance to corals and benthic habitats, as well as targeting and ordnance restrictions that would reduce runoff into FDM’s nearshore habitats.

The most relevant new information used in this section is published by the Hawaii Undersea Military Munitions Assessment, a program administered by the DoD and the University of Hawaii at Manoa (Briggs et al., 2016; Edwards et al., 2016b; Kelley et al., 2016; Silva & Chock, 2016; Tomlinson & De Carlo, 2016). The investigations completed as part of the program provide quantitative information on the fate and transport of sea-disposed conventional munitions at a munitions dump site south of Oahu, including (1) the spatial extent and distribution of munitions; (2) the integrity of munitions casings; (3) whether munitions constituents could be detected in sediment, seawater, or animals near munitions; (4) whether constituent levels at munitions sites differed significantly from levels at reference control sites; (5) whether statistically significant differences in ecological population metrics could be detected between the two types of sites; and (6) whether munitions constituents or their derivatives potentially pose an unacceptable risk to human health.

3.1.2.1 Explosives and Explosives Byproducts

Sources of explosives and explosives byproducts include the various munitions used during training and testing activities. Potential impacts of explosives and explosive byproducts were analyzed in Section 3.1.3.1 (Explosives and Explosives Byproducts) in the 2015 MITT Final EIS/OEIS, and that analysis remains valid.

Over 98 percent of residual explosive materials would result from ordnance failures (i.e., the munition fails to detonate and explosives remain in the casing). Ordnance failure rates for various munition types are shown in Table 3.1-4 in Section 3.1.3.1.3 (Ordnance Failure and Low-Order Detonations) of the 2015 MITT Final EIS/OEIS. The percentages for ordnance failure range from just below two percent to just over eight percent.

There have been no comprehensive studies of the fate and transport of residual explosives residing on the seafloor in the Study Area. However, analysis of potential impacts on sediments and water quality in similar marine environments has been applied. Research conducted at other sites can inform the analysis of potential impacts on sediments and water quality in the Study Area. These studies are summarized below:

- Results reported by Walker et al. (2006) and Beck et al. (2018) demonstrate that trinitrotoluene, RDX, and octogen (HMX) experience rapid biological and photochemical degradation in marine systems. Walker et al. (2006) noted that productivity in marine and estuarine systems is largely controlled by the limited availability of nitrogen. Because nitrogen is a key component of explosives, they are attractive as substrates for marine bacteria that metabolize other naturally occurring organic matter such as polycyclic aromatic hydrocarbons. The mineralization of explosives (RDX and HMX are readily mineralized) requires multiple steps, some of which may be biologically driven (Beck et al., 2018). Tobias (2019) used stable isotope tracers to show that over 50 percent of RDX compounds were mineralized into inert inorganic constituents, particularly in sediments with high organic content. The breakdown of trinitrotoluene (TNT) compounds resulted in aqueous (i.e., in a water solution) organic constituents, suggesting that TNT constituents remain suspended in the water column. The results are consistent with observations by Montgomery et al. (2011) that showed TNT may degrade at higher rates where turbidity levels in the water column are higher (e.g., at a turbidity front where fresh water from a river encounters brackish water in an estuary). Juhasz and Naidu (2007) also noted that microbes use explosives as sources of carbon and energy.
- Lotufo et al. (2017) found concentrations that exceeded the ecological screening level for at least one explosive in nearshore waters of Ostrich Bay near Bremerton, Washington, and along Elliott Bay near Seattle at piers formerly used by the Navy as a supply depot during World War II. The piers, referred to as Terminal 91, are now managed by the Port of Seattle under the DoD

Military Munitions Response Program. It is likely that the small quantities of munitions found at Terminal 91 were dropped overboard during vessel loading; there are no records of detonations occurring at the piers. The Terminal 91 site had a sufficient number of samples to allow for a site-wide characterization of contamination. The Ostrich Bay site had fewer than five samples, which was insufficient to characterize the entire site. Off Terminal 91, 1 out of 12 samples exceeded the screening level for the explosives constituent 2,4,6-trinitrophenylmethylnitramine (or "tetryl"). The data from the Terminal 91 site, and others assessed in the study, appear to be consistent with previous reports that the spatial distribution of munitions constituents in sediments at a given geographic site is highly variable but generally decreases with distance from the munition, such that munitions constituents are not detectable beyond 1–2 m from the munition (Edwards et al., 2016b; Lotufo, 2018; Rosen & Lotufo, 2010; University of Hawaii, 2014).

- As part of the Hawaii Undersea Military Munitions Assessment program, Briggs et al. (2016) sampled for explosive materials in sediments and marine invertebrates and fish, showing no detections of explosive residue chemical markers in the biological samples. In 2009, no explosive residues were located within sediments; however, in 2012, 2 of the 121 samples showed low concentrations (0.09 and 0.12 milligrams per kilogram) of an explosive residue compound, 4-nitrotoluene. These samples were collected within 50 centimeters of a munitions casing, with no detections further away from the casing (Briggs et al., 2016).
- Scientific research focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al., 2016; Kelley et al., 2016; Koide et al., 2016) and an intensively used live-fire range in the Mariana Islands (Smith & Marx, 2016) were published after the 2015 MITT Final EIS/OEIS. These publications provide information on the impacts of undetonated materials and unexploded munitions on habitat and marine life. On a localized scale, the studies at munitions ocean disposal sites in Hawaii investigated the sediments, seawater, or marine life, depending on the study, in close proximity to corroding munitions to determine if released constituents from the munitions (including explosive materials and metals) could be detected. Comparisons were made between disposal site samples and "clean" nearby reference sites. Analysis of the samples showed no confirmed detection for explosive materials despite decades since the disposal and a relatively high concentration of munitions at the site. Munitions residing on the seafloor as a result of training and testing activities would be more widely dispersed with much lower concentrations than munitions in a disposal site. Investigations by Kelley et al. (2016) and Koide et al. (2016) found that intact munitions (i.e., ones that failed to detonate or non-explosive practice munitions) residing in or on soft sediments habitats provided hard substrate similar to other disposed objects or "artificial reefs" that attracted "hard substrate species," which would not have otherwise colonized the area. Sampling these species revealed that there was no bioaccumulation of munitions-related chemicals in the species (Koide et al., 2016).
- These findings are consistent with other assessments such as that done for the Potomac River Test Range at Dahlgren, Virginia which was established in 1918 and is the Nation's largest fully instrumented, over-the-water gun-firing range. Munitions tested at Dahlgren have included rounds from small-caliber guns up to the Navy's largest (16-inch guns), bombs, rockets, mortars, grenades, mines, depth charges, and torpedoes (U.S. Department of the Navy, 2013b). Results from the assessment indicate that munitions expended at Dahlgren have not contributed significant concentrations of explosive materials or explosives byproducts to the Potomac River

water and sediments given those contributions are orders of magnitude less than concentrations already present in the Potomac River from natural and other manmade sources (U.S. Department of the Navy, 2013b).

In summary, multiple investigations since 2007 involving survey and sampling of World War II munitions disposal sites in Hawaii and other locations where munitions are known to reside have found the following (Briggs et al., 2016; Edwards & Bełdowski, 2016; Edwards et al., 2016a; Edwards et al., 2016b; Koide et al., 2016; Silva & Chock, 2016): (1) chemicals and degradation products, including explosive materials, from underwater munitions “do not pose a risk to human health or to fauna living in direct contact with munitions”; (2) the concentrations of metals measured in sediment samples in very close proximity to degrading World War II-era munitions are higher than naturally occurring marine levels, but they decrease rapidly to baseline levels within a few inches of munitions and “do not cause a significant impact on the environment”; and (3) sediment is not a significant sink of chemicals released by degradation of the explosive components in munitions.

The concentration of explosive munitions and any associated explosives byproducts at any single location in the MITT Study Area would be a small fraction of the totals that have accumulated over decades at World War II-era disposal sites and military ranges. Based on findings from much more intensively used locations, effects on sediments from the use of explosive munitions during training and testing activities in the MITT 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 MITT Study Area.

3.1.2.1.1 Impacts from Explosives and Explosives Byproduct Stressors Under Alternative 1

Under Alternative 1, the number of explosive munitions used during at-sea training and testing activities would increase, compared to the number analyzed in the 2015 MITT Final EIS/OEIS (see Table 3.0-16); however, there would be an increase in the number of activities on FDM that use explosive ordnance (Table 3.0-20). In addition, all munitions would be dropped on the same existing impact areas on FDM. The Navy conducted an analysis as part of this SEIS/OEIS to quantify the amount of ordnance used on FDM, in terms of net explosive weight, that would change compared to what was analyzed in the 2015 MITT Final EIS/OEIS. This analysis shows that the proposed increases in ordnance use on FDM would be less than 1 percent compared to levels analyzed previously.

This small increase on FDM under Alternative 1 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS because (1) most of the explosives would be consumed during detonation; (2) the frequency of low-order detonations would be low, and therefore the frequency of releases of explosives would be low; and (3) the constituents of explosives would be subject to physical, chemical, and biological processes that would render the materials harmless or otherwise disperse them to undetectable levels. Neither state nor federal standards or guidelines would be violated. The impacts of unconsumed explosives on water and sediment quality would be long term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS, and Guam, CNMI, or federal standards or guidelines would not be violated.

3.1.2.1.2 Impacts from Explosives and Explosives Byproduct Stressors Under Alternative 2 (Preferred Alternative)

As with Alternative 1, activities proposed under Alternative 2 would decrease the number of explosive munitions used during at-sea training and testing activities, compared to the number analyzed in the

2015 MITT Final EIS/OEIS (see Table 3.0-16) and increase the number on FDM. At-sea ordnance use under Alternative 2 would be greater than Alternative 1; however, the amount of ordnance use on FDM would slightly increase under Alternative 2 as with Alternative 1 (Table 3.0-20). In addition, all munitions would be dropped on the same existing impact areas on FDM. The small increase of at-sea ordnance and on FDM under Alternative 2 would have no appreciable change on the impact conclusions for explosives and explosives byproducts stressor presented in the 2015 MITT Final EIS/OEIS.. Therefore, under Alternative 2, impacts on sediments and water quality from the use of explosives and generating explosives byproducts would be negligible.

3.1.2.1.3 Impacts from Explosives and Explosives Byproduct Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Explosives and explosives byproduct stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing at-sea training and testing activities would result in fewer explosives and explosive byproducts introduced into the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing at-sea training and testing activities under the No Action Alternative would lessen the potential for impacts on sediments and water quality resulting from explosives and explosive byproducts.

3.1.2.2 Metals

Sources of metals introduced into the marine environment as part of training and testing activities include munitions and expended materials containing metals (i.e., lead, brass, manganese, copper, nickel, tungsten, chromium, molybdenum, vanadium, boron, selenium, columbium, or titanium). Since the publication of the 2015 MITT Final EIS/OEIS, the Navy has conducted a review of new literature pertaining to the potential impacts of metals on sediments and water quality. Although additional information was found, as described in the following paragraph, the new information does not indicate an appreciable change to the existing environmental conditions as described in the 2015 MITT Final EIS/OEIS.

As described in Section 3.1.3.1 (Explosives and Explosives Byproducts) of the 2015 MITT Final EIS/OEIS, sediment samples collected from World War II-era munitions disposal sites and heavily used Navy ranges show that metals are not impacting sediment quality despite longtime use and high concentrations of military munitions composed primarily of metal components (Briggs et al., 2016; Edwards et al., 2016b; Kelley et al., 2016; Smith & Marx, 2016; U.S. Department of the Navy, 2013a). The concentration of munitions and other expended materials containing metals in any one location in the Study Area would be a small fraction of that from a munitions disposal site, a target island used for 45 years, or a water range in a river used for almost 100 years. Chemical, physical, or biological changes to sediments or water quality in the Study Area would not be detectable and would be similar to nearby areas without munitions or other expended materials containing metals. This conclusion is based on the following: (1) most of the metals are benign, and those of potential concern make up a small percentage of expended munitions and other metal objects; (2) metals released through corrosion would be diluted by currents or bound up and sequestered in adjacent sediments; (3) elevated concentrations of metals in sediments would be limited to the immediate area around the expended material; and (4) the areas over which munitions and other metal components would be distributed are large.

3.1.2.2.1 Impacts from Metal Stressors Under Alternative 1

Under Alternative 1, the number of sources of metals that would be expended during training and testing would increase as compared to the 2015 MITT Final EIS/OEIS (see Table 3.0-14 through Table 3.0-17 and Table 3.0-20). Although the overall amount of metals introduced to the Study Area would increase, the analysis is not dependent on the amount of metals. Instead, the 2015 MITT Final EIS/OEIS analyzed whether or not the metals deposited from training and testing activities would impact sediments and water quality.

Since the publication of the 2015 MITT Final EIS/OEIS, the Navy has conducted a review of existing federal and local regulations and standards relevant to sediments and water quality, as well as a review of new literature pertaining to sediments and water quality. There is no new information that changes the basis of the conclusions presented for the potential impacts of metals on sediments and water quality. Therefore, the increases shown in Tables 2.5-1 and 2.5-2 for training and testing activities proposed under Alternative 1 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

3.1.2.2.2 Impacts from Metal Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of sources of metals being expended would increase as compared to the 2015 MITT Final EIS/OEIS and Alternative 1 (see Tables 3.0-14 through Table 3.0-17 and Table 3.0-20). These increases would have no appreciable change on the impact conclusions for metals as summarized above under Alternative 1 and as presented in the 2015 MITT Final EIS/OEIS. Therefore, under Alternative 2, impacts on sediments and water quality from activities that expend metals would be negligible.

3.1.2.2.3 Impacts from Metal Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Metal stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing training and testing activities would result in fewer metals introduced into the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for impacts on sediments and water quality resulting from metals released during training and testing activities.

3.1.2.3 Chemicals Other than Explosives

Chemicals other than explosives are associated with the following military expended materials: (1) solid-fuel propellants in missiles and rockets; (2) Otto Fuel II torpedo propellant and combustion byproducts; (3) polychlorinated biphenyls in target vessels used during sinking exercises; (4) other chemicals associated with explosive munitions; and (5) chemicals that simulate chemical warfare agents, referred to as "simulants."

<u>Simulants</u>: Simulants were not analyzed in the 2015 MITT Final EIS/OEIS. The DoD uses compounds, referred to as simulants, as substitutes for chemical and biological warfare agents to test equipment intended to detect their presence. Simulants must have one or more characteristics of a real chemical or

biological agent—size, density, or aerosol behavior—to effectively mimic the agent. Simulants must also pose a minimal risk to human health and the environment to be used safely in outdoor tests.

Simulants are selected using the following criteria: (1) safety to humans and the environment, and (2) the ability to trigger a response by sensors used in the detection equipment. Simulants would be relatively benign (e.g., low toxicity or effects potential) from a human health, safety, and environmental perspective. Exposure levels during testing activities would be well below concentrations associated with any adverse human health or environmental effects. The degradation products of simulants used during testing would also be harmless. Given these characteristics of simulants used during testing activities, it is reasonable to conclude that simulants would have no impact on sediments and water quality in the Study Area. Simulants are not analyzed further in this section.

3.1.2.3.1 Impacts from Chemicals Other Than Explosives Under Alternative 1

Under Alternative 1, the number of sources of chemicals other than explosives would increase as compared to the 2015 MITT Final EIS/OEIS (see Table 3.0-14 through Table 3.0-17 and Table 3.0-20).

The fate and transport of solid fuel propellants are described in Section 3.1.3.3.2 (Missile and Rocket Propellant – Solid Fuel) of the 2015 MITT Final EIS/OEIS. The analysis in the 2015 MITT Final EIS/OEIS concluded that, based on the small amount of residual propellant that would remain from training and testing activities using missiles or rockets, perchlorates would not occur in concentrations that would impact sediments and water quality in the Study Area. The changes in the number of missiles and rockets shown in Tables 2.5-1 and 2.5-2 for activities proposed under Alternative 1 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

The fate and transport of Otto Fuel II torpedo propellant and combustion byproducts are described in Section 3.1.3.3.3 (Torpedo Propellant – Otto Fuel II and Combustion Byproducts) of the 2015 MITT Final EIS/OEIS. Otto Fuel II and its combustion byproducts would be released into the water column only in small amounts during combustion. Furthermore, all non-explosive torpedoes are typically recovered for reuse following training and testing activities, which removes any unconsumed fuel from the environment immediately after completion of the activity. Combustion byproducts of Otto Fuel II would be released into the water column, where they would dissolve, dissociate, or be dispersed and diluted. One combustion byproduct, hydrogen cyanide, does not normally occur in seawater; however, it is soluble in seawater and would be diluted to less than 1 micrograms per liter (1.0 part per billion)—below U.S. Environmental Protection Agency-recommended concentrations (U.S. Environmental Protection Agency, 2010)—at a distance of approximately 18 feet from the center of the torpedo's path when first discharged. Additional dilution would occur thereafter, with the rate of dilution depending, in part, upon circulation in the water column in the vicinity of the discharge. The changes in the number of torpedoes shown in Tables 2.5-1 and 2.5-2 for activities proposed under Alternative 1 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

The fate and transport of Polychlorinated Biphenyls (PCBs) are described in Section 3.1.3.3.4 (Polychlorinated Biphenyls in Target Vessels) of the 2015 MITT Final EIS/OEIS. Sinking exercises would decrease under Alternative 1 in this SEIS/OEIS and are therefore not analyzed further. Public comments, however, were received that concerned the potential resuspension of PCBs in the water column after activities that use underwater explosives in Outer Apra Harbor. Figure 2.1-5 in Chapter 2 (Description of the Proposed Activities and Alternatives) shows the location of the Outer Apra Harbor Underwater Detonation (UNDET) site. The Navy's literature review found PCB measurements obtained by a University of Guam study in 1997 for PCB contamination within Apra Harbor (Denton et al., 1997). The location of the UNDET site in Outer Apra Harbor corresponds to a sediment sampling site that was considered by Denton et al. (1997) as within the "light" contamination range (1–10 nanograms/gram dry weight). PCB profiles, determined in sediments from Hotel Wharf and the Commercial Port area, closely resembled those of Aroclor 1254, a commercial PCB mixture that was once widely used as a dielectric fluid in electrical transformers (Denton et al., 1997). Another set of samples were collected in 2014 within Outer Apra Harbor. As part of this sampling regime, preliminary remediation goals were established for different types of PCBs. The location within Outer Apra Harbor that is used for underwater explosions did not exceed these preliminary remediation goal thresholds for PCBs (U.S. Department of the Navy, 2017). Because the same location is used for UNDET sites, the Navy avoids resuspension of PCBs from undisturbed benthic habitats where PCBs may have migrated. There is no information in the University of Guam study that changes the basis of the above findings. Therefore, based on the findings above, the changes in the numbers of UNDETs used within Outer Apra Harbor as shown in Tables 2.5-1 and 2.5-2 would have not appreciably changed the impacts that chemicals would have on sediments and water quality.

The fate and transport of other chemicals associated with explosive munitions are described in Section 3.1.3.3.5 (Other Chemicals Associated with Ordnance) of the 2015 MITT Final EIS/OEIS. Residual chemical constituents associated with explosive munitions can remain in the environment after low-order (i.e., incomplete) detonations and in unconsumed explosives. These constituents, listed in Table 3.1-10 of the 2015 MITT Final EIS/OEIS, are in addition to the explosives contained in the munition. Lead azide, titanium compounds, perchlorates, barium chromate, and fulminate of mercury are not naturally constituents of seawater. Another residual constituent, lead oxide, is a rare, naturally occurring mineral (Agency for Toxic Substances and Disease Registry, 2007). As noted in Section 3.1.2.1 (Explosives and Explosives Byproducts), fewer explosive munitions would be used during training activities under Alternative 1 compared to the number of explosives proposed in the 2015 MITT Final EIS/OEIS. Some testing activities would use more explosive munitions, while others would use fewer. Based on the detailed analysis in Section 3.1.3.1 (Explosives and Explosion Byproducts) in the 2015 MITT Final EIS/OEIS and the summary of recent studies in Section 3.1.2.1 (Explosives and Explosives Byproducts) in this SEIS/OEIS, concentrations of chemical constituents associated with explosive munitions is expected to be localized to areas adjacent to the munition and similar to concentrations from nearby sites. The changes in the number of explosions shown in Tables 2.5-1 and 2.5-2 for activities proposed under Alternative 1 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

3.1.2.3.2 Impacts from Chemicals Other Than Explosives Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of sources used that would generate chemicals other than explosives would increase as compared to Alternative 1 and to the 2015 MITT Final EIS/OEIS (see 3.0-14 through Table 3.0-17 and Table 3.0-20). As discussed in Alternative 1, increases as associated with Alternative 2 would have no appreciable change on the impact conclusions for chemicals as summarized above under Alternative 1 and as presented in the 2015 MITT Final EIS/OEIS. Therefore, under Alternative 2, impacts on sediments and water quality from activities that expend chemicals would be negligible.

3.1.2.3.3 Impacts from Chemicals Other Than Explosives Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Chemical other than explosives as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer releases of chemical other than explosives into the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for impacts on sediments and water quality resulting from chemical stressors.

3.1.2.4 Other Materials

Other materials include marine markers and flares, chaff, towed and stationary targets, and miscellaneous components of other devices. These materials and components are made mainly of nonreactive or slowly reactive materials (e.g., glass, carbon fibers, and plastics), or they break down or decompose into benign byproducts (e.g., rubber, steel, iron, and concrete). Most of these objects would settle to the sea floor where they would (1) be exposed to seawater, (2) become lodged in or covered by seafloor sediments, (3) become encrusted (e.g., by rust) through oxidation, (4) dissolve slowly, or (5) be covered by marine organisms such as coral. Plastics may float or descend to the bottom, depending upon their buoyancy.

The various types of expended materials that would be used during training and testing activities are described in detail in Section 3.1.3.4 (Other Materials) in the 2015 MITT Final EIS/OEIS. The section describes the constituent components of marine markers, flares, and chaff as well as other items, and the fate and transport of those constituents in the marine environment. Pyrotechnic materials in marine markers and flares are largely consumed during use, and byproducts are released into the air. Chemical constituents of marine markers and flares are listed in Table 3.1-11 and the constituents of chaff are listed in Table 3.1-12 of the 2015 MITT Final EIS/OEIS.

3.1.2.4.1 Impacts from Other Materials Under Alternative 1

Under Alternative 1, the number of proposed training and testing activities that would introduce other materials, such as marine markers and flares, chaff, towed and stationary targets, and miscellaneous components would increase over levels analyzed previously in the 2015 MITT Final EIS/OEIS (see Table 3.0-17, Tables 3.0-22 through 3.0-26). Increases in training and testing activities under Alternative 1 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

3.1.2.4.2 Impacts from Other Materials Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of proposed training and testing activities that would introduce other materials, such as marine markers and flares, chaff, towed and stationary targets, and miscellaneous components would increase over levels analyzed previously in the 2015 MITT Final EIS/OEIS (see Table 3.0-17, Tables 3.0-22 through 3.0-26). There would also be increases under Alternative 2 in the number of training and testing activities that would likely introduce other materials into the environment, as compared to Alternative 1. As with Alternative 1, increases in training and testing activities proposed under Alternative 2 would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

3.1.2.4.3 Impacts from Other Materials Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Other materials as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer releases of other materials within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for impacts on sediments and water quality resulting from plastics, marine markers, flares, and chaff released during training and testing activities.

3.1.3 Public Comments

The public raised a number of issues during the scoping period in regard to sediments and water quality. The issues are summarized in the list below. Comments received from the public during the Draft SEIS/OEIS commenting period related to sediments and water quality are addressed in Appendix K (Public Comment Responses).

- **FDM** – Commenters noted a lack of studies documenting the amount of ordnance debris and unexploded ordnance in waters surrounding FDM, while other comments requested that the Navy analyze potential loss of land mass associated with military training activities on FDM. The Navy has included a detailed summary of recent published studies that describe multi-year dive studies conducted by Smith and Marx (2016) and Carilli et al. (2018).The results of these surveys are included in Section 3.1.1.1.4 (Farallon de Medinilla) of this SEIS/OEIS. Throughout all dive surveys, the coral fauna at FDM were observed to be healthy and robust. The nearshore physical environment and basic habitat types at FDM have remained unchanged over the 13 years of survey activity. These conclusions are based on (1) a limited amount of physical damage, (2) very low levels of partial mortality and disease (less than 1 percent of all species observed), (3) absence of excessive mucus production, (4) good coral recruitment, (5) complete recovery by 2012 of the 2007 bleaching event, and (6) a limited number of macrobioeroders and an absence of invasive crown of thorns starfish (*Acanthaster planci*). These factors suggest that sedimentation that may result from military use of FDM is not sufficient as to adversely impact water quality, a conclusion substantiated by repeated dive surveys discussed above (Carilli et al., 2018; Smith & Marx, 2016).
- **Potential loss of landmass through erosion of FDM from military use** – Commenters have expressed concerns regarding erosion of FDM, and the potential loss of landmass. The U.S. military has used FDM as a bombing range since at least 1971. FDM's vegetation appears to have undergone significant changes since the island was leased by the DoD and the subsequent use for military training. The 2015 MITT Final EIS/OEIS compared historic aerial photographs to recent aerial imagery, which shows that the island has lost substantial forests over the decades, with the northern portion of the island with the most intact forest structure remaining on FDM (see Section 3.10, Terrestrial Species and Habitats, of the 2015 MITT Final EIS/OEIS). It is likely that the loss of vegetation over the past decades has accelerated erosion of soils and limestone weathering on the island. The current training activities that use ordnance are constrained in terms of ordnance type and target location (e.g., designated impact zones). These restrictions were put in place as part of past section 7 ESA consultations with the U.S. Fish and Wildlife Service and would continue under the SEIS/OEIS. While these measures were specifically designed to protect ESA-listed species and habitats on FDM, the restrictions would likely reduce

the rates of erosion experienced in previous decades on the island. In addition, since the 2015 MITT Final EIS/OEIS, the Navy has relocated vertical cliff targets (established on the western side of the island) to interior locations within impact zones. The target relocations were done to minimize impacts on seabird rookeries along the western side of the island. The Navy's analysis of mass movement and erosion on FDM includes historical photograph analyses and direct observations during dive surveys conducted off FDM since 1999. Additionally, the Navy will investigate methods to baseline current physical conditions on FDM and to monitor those conditions over time. Smith and Marx (2016) also provided anecdotal observations of coral reefs surrounding the island over the course of multi-year dive surveys. These observations suggest healthy reef environments surrounding the island, without signs of sedimentation that would result from erosion of soils from the impact areas. In summary, the intensive bombing regimes of FDM in past decades likely resulted in the loss of forested areas on the island; such reductions in forests likely resulted in erosion of the upper plateau of the island. Current restrictions, however, confine the bombing activities to discrete impact zones located in the interior of the island, with additional restrictions on the types of ordnance allowed for use on the island, thereby reducing the potential for erosion and loss of land mass of FDM. In summary, multiple investigations since 2007 involving survey and sampling of World War II munitions disposal sites off Oahu Hawaii and other locations, have found the following (Briggs et al., 2016; Edwards & Bełdowski, 2016; Edwards et al., 2016a; Edwards et al., 2016b; Koide et al., 2016; Silva & Chock, 2016): (1) chemicals and degradation products, including explosive materials, from underwater munitions "do not pose a risk to human health or to fauna living in direct contact with munitions"; (2) metals measured in sediment samples next to World War II munitions are lower than naturally occurring marine levels and "do not cause a significant impact on the environment"; and (3) sediment is not a significant sink of chemicals released by degradation of the explosive components in munitions. The concentration of explosive munitions and any associated explosives byproducts at any single location in the Study Area would be a small fraction of the totals that have accumulated over decades at World War II era disposal sites and military ranges. Based on findings from much more intensively used locations, effects on sediments from the use of explosive munitions during training and testing activities in the Study Area would be negligible by comparison. As a result, explosives and explosives byproducts would have no meaningful effect on sediments or water quality in the Study Area. The conclusions presented in Section 3.1.3.1.6.2 (Alternative 1) of the 2015 NWTT Final EIS/OEIS remain valid. Specifically, short-term impacts on sediments and water quality would arise from explosives byproducts prior to their degradation, and long-term impacts would arise from the presence of unconsumed explosives encased in intact munitions residing on the seafloor. Impacted sediments and water quality would only be immediately adjacent to the munition. Chemical, physical, or biological changes in sediment or water quality would have no appreciable change on the impact conclusions presented in the 2015 MITT Final EIS/OEIS and Guam, CNMI, or federal standards or guidelines would be violated. This conclusion on the level of impact is based on the following: (1) most of the explosives would be consumed during detonation; (2) the frequency of low-order detonations would be low, and therefore the frequency of releases of explosives directly into the water column would be low; (3) the amounts of explosives used would be small relative to the area over which they would be distributed; and (4) the constituents of explosives would be subject to physical, chemical, and biological processes that would render the materials harmless or otherwise disperse them to undetectable levels.

- **Resuspension of PCBs in Outer Apra Harbor** – Commenters were concerned about resuspension of PCBs in the water column resulting from underwater explosions within Outer Apra Harbor. Section 3.1.2.3 (Chemicals) of this SEIS/OEIS includes additional information on the potential for resuspension of PCBs in the water column, which includes sediment data collected from a site in close proximity to the Outer Apra Underwater Detonation Site. The potential for resuspension of PCBs in the water column is reduced because (1) the sediment samples collected by Denton et al. (1997) showed that this location is within the "light" concentration range (1–10 nanograms/gram dry weight), (2) additional sediment sampling from 2014 shows that the area where underwater detonations would occur contains sediments that do not exceed remediation goals for different types of PCBs, and (3) the Navy uses the same seafloor location for underwater explosions. Therefore, the Navy does not conduct this training activity in other areas of Apra Harbor identified as "moderate" or "high" concentrations. In addition, no new undisturbed benthic locations that are contaminated by PCBs would be used for underwater explosions.
- **General impacts on water quality in offshore marine environments** – Commenters were concerned about the fate and transport of metal fragments as they are deposited in open ocean training locations. Section 3.1.3.2 (Metals) in the 2015 MITT Final EIS/OEIS describes the potential impacts of metals introduced into marine environments from training locations. Although Guam does not maintain screening standards for metals in sediments or water, the U.S. Environmental Protection Agency maintains "threshold" values for metals in marine environments (see Table 3.1-8 of the 2015 MITT Final EIS/OEIS). In 2014, the CNMI Bureau of Environmental and Coastal Quality established water quality standards, designating the coastal waters surrounding FDM as "Class A" waters, which are maintained for recreational and aesthetic use, with some allowable uses as long as it is compatible with the protection and propagation of fish, shellfish, and wildlife (Commonwealth of the Northern Mariana Islands Bureau of Coastal and Environmental Quality, 2014). Based on the multi-year dive surveys discussed above, there are no indications of adverse impacts on fish, shellfish, or wildlife within the coastal waters surrounding FDM, with the dive surveys showing healthy ecosystem functions and wildlife abundance within these waters. While no quantitative sampling for metals in training areas have been completed, there are a number of studies conducted in marine training and testing locations that have attempted to measure metal content where military activities occur. In one study, the water was sampled for lead, manganese, nickel, vanadium, and zinc at a shallow bombing range in Pamlico Sound (state waters of North Carolina) immediately following a training event with non-explosive practice bombs. All water quality parameters tested, except nickel, were within the state limits. The nickel concentration was significantly higher than the state criterion, although the concentration did not differ significantly from the control site located outside the bombing range. The results suggest that bombing activities were not responsible for the elevated nickel concentrations (U.S. Department of the Navy, 2010). A recent study conducted by the U.S. Marine Corps sampled sediments and water quality for 26 different constituents related to munitions at several U.S. Marine Corps water-based training ranges. Metals included lead and magnesium. These areas were also used for bombing practice. No munitions constituents were detected above screening values used at

the U.S. Marine Corps water ranges (U.S. Department of the Navy, 2010). A study by Pait et al. (2010) of previous Navy training areas at Vieques, Puerto Rico, found generally low concentrations of metals in marine sediments. Areas in which live ammunition and loaded weapons were used ("live-fire areas") were also included in the analysis. Additional studies are summarized in the 2015 MITT Final EIS/OEIS. In no instance did metals exceed federal or state thresholds. It is unlikely that metals in sediments or the water column from military training activities would exceed federal thresholds in the Study Area, a conclusion that is consistent with other range locations and qualitative observations of ecosystem health surrounding FDM, as observed by Smith and Marx (2016) and Carilli et al. (2018).

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3.2 Air Quality

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3.2 Air Quality

The purpose of this section is to supplement the analysis of impacts on air quality presented in the 2015 Mariana Islands Training and Testing (MITT) Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) with new information relevant to proposed changes in training and testing activities conducted at sea and on Farallon de Medinilla (FDM). Information presented in the 2015 Final MITT EIS/OEIS that remains valid is noted as such and referenced in the appropriate sections. Any new or updated information describing the affected environment and analysis of impacts on air quality associated with the Proposed Action is provided in this section.

3.2.1 Methods

3.2.1.1 National Ambient Air Quality Standards

National ambient air quality and criteria pollutant attainment limits are defined by National Ambient Air Quality Standards, promulgated by the United States (U.S.) Environmental Protection Agency, and are requisite to protect the public health and welfare. Areas that exceed a standard are designated as "nonattainment" for that pollutant, while areas in compliance with a standard are in "attainment" for that pollutant. An area may be nonattainment for some pollutants and attainment for others simultaneously.

States and U.S. territories, through their air quality management agencies, are required to prepare and implement State Implementation Plans for nonattainment areas, which demonstrate how the area will meet the National Ambient Air Quality Standards. Areas that have achieved attainment may be designated as "maintenance areas," subject to maintenance plans showing how the area will continue to meet federal air quality standards. Nonattainment areas for some criteria pollutants are further classified, depending on the severity of their air quality problem, to facilitate their management:

- Ozone – marginal, moderate, serious, severe, and extreme
- Carbon Monoxide – moderate and serious
- Particulate Matter – moderate and serious

The U.S. Environmental Protection Agency delegates the regulation of air quality to the state once the state has an approved State Implementation Plan. The Clean Air Act (CAA) also allows states to establish air quality standards more stringent than the National Ambient Air Quality Standards.

The MITT Study Area is mostly offshore of the Territory of Guam and the Commonwealth of the Northern Mariana Islands and some onshore and nearshore areas. Some elements of the Proposed Action would occur onshore and within or over state waters. Most of the Study Area is offshore, beyond territory and commonwealth boundaries where attainment status is unclassified and CAA National Ambient Air Quality Standards do not apply. However, given fluctuations in wind direction, air quality in adjacent onshore areas may be affected by releases of air pollutants from offshore Study Area sources. Therefore, National Ambient Air Quality Standards attainment status of adjacent onshore areas is considered in determining whether appropriate controls on air pollution sources in the adjacent offshore state waters is warranted.

3.2.1.2 Conformity Analyses in Nonattainment and Maintenance Areas

Federal actions are required to conform with the approved State Implementation Plan for those areas of the United States designated as nonattainment or maintenance air quality areas for any criteria pollutant under the CAA (40 Code of Federal Regulations sections 51 and 93). The purpose of the

General Conformity Rule is to demonstrate that the Proposed Action would not cause or contribute to new violations of an air quality standard and that the Proposed Action would not adversely affect the attainment and maintenance of federal ambient air quality standards. A federal action would not conform if it increased the severity of any existing violations of an air quality standard or delayed the attainment of a standard, required interim emissions reductions, or delayed any other air quality milestone. To ensure that federal activities do not impede local efforts to control air pollution, Section 176(c) of the CAA (42 United States Code section 7506(c)) prohibits federal agencies from engaging in or approving actions that do not conform to an approved State Implementation Plan. The emissions thresholds that trigger the conformity requirements are called *de minimis* thresholds.

Federal agency compliance with the General Conformity Rule can be demonstrated in several ways. The requirement can be satisfied by a determination that the Proposed Action is not subject to the General Conformity Rule, by a Record of Non-Applicability, or by a Conformity Determination. Compliance is presumed if the net increase in emissions from a federal action would be less than the relevant *de minimis* threshold. If net emissions increases exceed the *de minimis* thresholds, then a formal conformity determination must be prepared.

3.2.2 Affected Environment

3.2.2.1 Climate of the Study Area

Climate in the MITT Study Area was discussed in detail in the 2015 MITT Final EIS/OEIS. The climate within the Study Area has not changed since the publication of the 2015 MITT Final EIS/OEIS (Climatemps.com, 2017). However, greenhouse gas emissions were analyzed in this Supplemental EIS (SEIS)/OEIS by illustrating their cumulative contribution to climate change.

3.2.2.2 Regional Emissions

Regional emissions have changed since the publication of the 2015 MITT Final EIS/OEIS. Guam and Saipan still contain the majority of the stationary sources of air pollutants within the Study Area. The largest point source emitters for air pollutants were the power-generating facilities at Piti and Tanguisson. However, the power-generating facility at Tanguisson has been retired since then and an explosion and fire at the power-generating facility in Piti has left two turbines inoperable. This has reduced the amount of pollutants being released into the atmosphere from manmade sources. In addition to anthropogenic sources, volcanic activity within the Study Area naturally contributes to sulfur dioxide concentrations in the region.

3.2.2.3 Existing Air Quality

Guam and the Commonwealth of the Northern Mariana Islands, including FDM, meet all national and local ambient air quality standards except for sulfur dioxide. The area of Piti-Cabras is nonattainment for the 2010 sulfur dioxide primary National Ambient Air Quality Standards. The nonattainment area extends in a circle with a radius of 6.074 kilometers from the power-generating facilities. This circle encompasses the majority of Apra Harbor, Agat Bay, and nearshore areas, which includes the Piti Floating Mine Neutralization Site.

Piti and Tanguisson are in nonattainment of the 1971 sulfur dioxide primary National Ambient Air Quality Standards (U.S. Environmental Protection Agency, 2017). These nonattainment areas extend in a circle with a radius of 2.2 miles from the power-generating facilities. However, the retirement of the Tanguisson facility and reduction in functionality of the Piti facility have decreased pollutant emissions and could potentially affect the attainment status for these areas. In general, the islands are considered to have good ambient air quality due to geographic isolation and favorable climate. Consistent winds (shown in Figure 3.2-1) and rain help to remove and carry away pollutants from the islands.

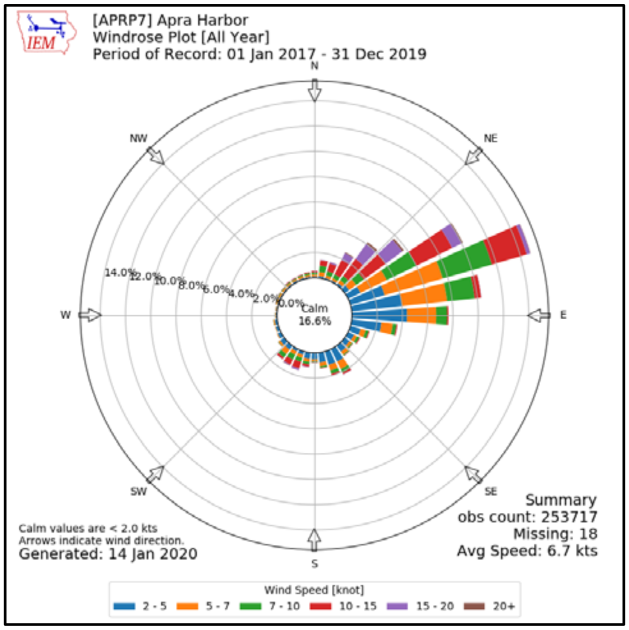

Figure 3.2-1: Annual Wind Speed and Direction at Apra Harbor, Guam

3.2.3 Environmental Consequences

The 2015 MITT Final EIS/OEIS analyzed potential impacts on air quality resulting from proposed training and testing activities. This supplemental analysis will update and consider changes to air quality resulting from proposed changes to training and testing activities conducted at sea and on FDM (see Tables 2.5-1 and 2.5-2). The Study Area includes pierside locations in Apra Harbor. For purposes of this SEIS/OEIS, pierside locations include channels and routes to and from the Navy port in the Apra Harbor Naval Complex, and associated wharves and facilities within the Navy port.

3.2.3.1 Criteria Pollutants

Estimated emissions are compared against baseline emissions (Table 3.2-1). While most of the emissions would be off shore, only emissions that would be released below 3,000 feet of elevation and within 3 nautical miles (NM) of the coastline are analyzed for their impacts on ambient air quality. Pollutants that would be emitted more than 3 NM offshore would be intermittent and distributed across a very large area of ocean (501,873 square nautical miles), and would not be concentrated in any one area. Therefore, pollutants emitted beyond 3 NM are not expected to impact the general public in Guam or the Commonwealth of the Northern Mariana Islands. Emissions calculations for the Baseline, Alternative 1, and Alternative 2 can be seen in Appendix D (Air Quality Emissions Calculations). Baseline emissions are derived from those presented in Alternative 1 of the 2015 MITT Final EIS/OEIS (Table 3.2-7). However, this SEIS/OEIS only addresses at-sea activities and activities occurring at FDM, whereas the 2015 MITT Final EIS/OEIS addressed those activities in addition to land-based activities. Therefore, only those activities that are covered under this SEIS/OEIS are considered in the baseline emissions.

Table 3.2-1: Baseline Pollutant Emissions for At-Sea and FDM Training and Testing Activities that Occur Within 3 Nautical Miles of the Coast from Aircraft, Vessels, and Ordnance (tpy)

Criteria Pollutant	NO_x	CO	VOC	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	111	163	23	8	48	43
Vessels	345	38	95	229	41	37
Ordnance	5	203	0	0	8	8
Total of At-Sea and FDM Emissions	461	404	118	237	97	88

Notes: NO_x = nitrogen oxides, CO = carbon monoxide, VOC = volatile organic compounds, SO_x = sulfur oxides, PM_{10} = particulate matter less than 10 microns in diameter, $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter, FDM = Farallon de Medinilla, tpy = tons per year. Baseline emissions are derived from those presented in Alternative 1 of the 2015 MITT Final EIS/OEIS.

3.2.3.1.1 Alternative 1

Under Alternative 1, estimated pollutant emissions from aircraft, vessels, and ordnance would increase, as shown in Table 3.2-2. Criteria pollutants emitted in the Study Area within territorial waters could be transported ashore but would not affect the attainment status of the relevant air quality control regions nor impact the general public. Under Alternative 1, the emissions increase for sulfur dioxide (SO_2) from all training and testing activities in the nonattainment areas of Guam in comparison to the baseline is estimated to be 17 tons per year. The *de minimis* threshold for a full conformity determination is an SO_2 emissions increase of 100 tons per year. Therefore, the General Conformity Rule does not apply under Alternative 1.

Table 3.2-2: Annual Emissions for At-Sea and FDM Training and Testing Activities that Occur Within 3 Nautical Miles of the Coast Under Alternative 1 from Aircraft, Vessels, and Ordnance (tpy)

Criteria Pollutant	NO_x	CO	VOC	SO_x	PM_{10}	$PM_{2.5}$
Aircraft Emissions	146	219	31	10	66	60
Vessel Emissions	377	43	134	244	43	39
Ordnance Emissions	5	205	0	0	9	9
Alternative 1 Emissions	**528**	**467**	**166**	**254**	**119**	**107**
Baseline Emissions	461	404	118	237	97	88
Changes in Emissions	**67**	**63**	**47**	**17**	**22**	**19**

Notes: NO_x = nitrogen oxide, CO = carbon monoxide, VOC = volatile organic compounds, SO_x = sulfur oxide, PM_{10} = particulate matter less than 10 microns, $PM_{2.5}$ = particulate matter less than 2.5 microns, tpy = tons per year. Individual values may not add exactly to total values due to rounding.

3.2.3.1.2 Alternative 2 (Preferred Alternative)

Under Alternative 2, there would be an increase in annual air emissions from the baseline (Table 3.2-3) as well as an increase in relation to Alternative 1 (Table 3.2-2). However, the change in emissions would not affect the attainment status of the relevant air quality control regions nor significantly impact the general public.

Under Alternative 2, the emissions increase for SO_2 from all training and testing activities in the nonattainment areas of Guam in comparison to the baseline is estimated to be 17 tons per year. The *de minimis* threshold for a full conformity determination is an SO_2 emissions increase of 100 tons per year. Therefore, the General Conformity Rule does not apply under Alternative 2. A Record of Non-Applicability has been prepared (Appendix D, Section D.5).

Table 3.2-3: Annual Emissions for At-Sea and FDM Training and Testing Activities that Occur Within 3 Nautical Miles of the Coast Under Alternative 2 from Aircraft, Vessels, and Ordnance (tpy)

Criteria Pollutant	NO_x	CO	VOC	SO_x	PM_{10}	$PM_{2.5}$
Aircraft Emissions	146	219	31	10	66	60
Vessel Emissions	398	48	137	303	55	50
Ordnance Emissions	6	205	0	0	10	9
Alternative 2 Emissions	**549**	**473**	**168**	**313**	**131**	**119**
Baseline Emissions	461	404	118	237	97	88
Difference	**89**	**68**	**50**	**76**	**34**	**31**

Notes: NO_x = nitrogen oxides, CO = carbon monoxide, VOC = volatile organic compounds, SO_x = sulfur oxides, PM_{10} = particulate matter less than 10 microns in diameter, $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter, tpy = tons per year. Individual values may not add exactly to total values due to rounding.

3.2.3.1.3 No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Therefore, implementation of the No Action Alternative would mean that the emissions shown in Table 3.2-1 would no longer be produced; however, there would be no measurable change in air quality conditions.

3.2.3.2 Hazardous Air Pollutants

These emissions are typically one or more orders of magnitude smaller than concurrent emissions of criteria air pollutants, and could become a concern when large amounts of fuel, explosives, or other materials are consumed during a single activity or in one location. Hazardous air pollutants are analyzed qualitatively in relation to the prevalence of the sources emitting these pollutants during training and testing activities. The 2015 MITT Final EIS/OEIS concluded that emissions of hazardous air pollutants are not significant and would mostly occur far from land. While there are increases in hazardous air pollutants from the Proposed Action, the results of the analysis as described in the 2015 MITT Final EIS/OEIS does not appreciably change and remains valid. Therefore, human health is not anticipated to be significantly impacted by emissions of hazardous air pollutants in the Study Area.

3.2.3.3 Greenhouse Gases

Table 3.2-4 summarizes the greenhouse gas emissions that would be generated under baseline conditions, Alternative 1, and Alternative 2. Greenhouse gas emissions would decrease from the baseline by approximately 4 percent under Alternative 1 and Alternative 2. Since greenhouse gases are relevant in a global scope, they are analyzed based on the extent to which they would contribute to climate change. Implementation of Alternative 1 or 2 would generate a decrease from baseline contributions.

Table 3.2-4: Annual Greenhouse Gas Emissions Under All Three Alternatives

	Annual Greenhouse Gas Emissions (metric tons per year)			
	CO_2	N_2O	CH_4	CO_2e
Baseline Emissions	696,436	23	20	703,853
Alternative 1	668,301	22	19	675,418
Alternative 2	666,794	22	19	673,895
Nationwide Emissions	-	-	-	6,511,000,000

Notes: CO_2 = carbon dioxide, N_2O = nitrous oxide, CH_4 = methane, CO_2e= carbon dioxide equivalent

3.2.4 Public Comments

The public did not raise any issues during the scoping period in regard to air quality. No comments were received from the public during the Draft SEIS/OEIS commenting period related to air quality.

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3.3 Marine Habitats

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3.3 Marine Habitats

3.3.1 Affected Environment

The purpose of this section is to supplement the analysis of impacts on marine habitats presented in the *2015 Mariana Islands Training and Testing (MITT) Final Environmental Impact Statement/Overseas Environmental Impact Statement* (EIS/OEIS) with new information relevant to proposed changes in training and testing activities conducted at sea. New information made available since the publication of the 2015 MITT Final EIS/OEIS is included below to better understand potential stressors and impacts on the nonliving (abiotic) marine habitats resulting from training and testing activities. Information presented in the 2015 MITT Final EIS/OEIS that remains valid is noted as such and referenced in the appropriate sections (U.S. Department of the Navy, 2015). Other necessary habitats for living resources, including those that form biotic habitats such as aquatic plant beds and coral reefs, are discussed in other sections (e.g., Section 3.7, Marine Vegetation; and Section 3.8, Marine Invertebrates). Comments received from the public during scoping related to marine habitats are addressed in Section 3.3.3 (Public Comments). Comments received from the public during the Draft Supplemental EIS (SEIS)/OEIS commenting period related to marine habitats are addressed in Appendix K (Public Comment Responses). Additional or updated information on the Mariana Trench Marine National Monument was added to this section.

3.3.1.1 Existing Conditions

The information on marine habitat types (i.e., soft shores, rocky shores, vegetated shores, aquatic beds, soft bottoms, hard bottoms, and artificial structures) presented in the 2015 MITT Final EIS/OEIS has not substantially changed and remains valid. In 2017, Kendall et al. (2017) mapped the benthic habitat of Saipan Lagoon. This new data was taken into consideration during the development of this SEIS/OEIS and is shown in Figure 3.3-1. After reviewing this data, the information and analysis on marine habitat types (i.e., soft shores, rocky shores, vegetated shores, aquatic beds, soft bottoms, hard bottoms, and artificial structures) presented in the 2015 MITT Final EIS/OEIS has not substantially changed and remains valid. The majority of the MITT Study Area lies within open-ocean areas. Located in the Mariana Archipelago, the Marianas Trench Marine National Monument protects approximately 95,216 square miles of submerged lands and waters (U.S. Fish & Wildlife Service, 2012). This area is comprised of three units: the Islands Unit (waters and submerged lands of the three northernmost Mariana Islands), the Volcanic Unit (submerged lands within 1 nautical mile of 21 designated volcanic sites), and the Trench Unit (submerged lands extending from the northern limit of the Exclusive Economic Zone of the United States in the Commonwealth of the Northern Mariana Islands to the southern limit of the Exclusive Economic Zone of the United States in the Territory of Guam (U.S. Fish & Wildlife Service, 2012). Information on the biological resources that inhabit the hydrothermal vents are presented in Section 3.8 (Marine Invertebrates).

Relatively little of the Study Area includes intertidal and shallow subtidal areas in U.S. territory waters where numerous habitats are exclusively present (e.g., salt/brackish marsh, mangrove, coral reefs, and seagrass beds). Intertidal abiotic habitats (e.g., beaches, tidal deltas, mudflats, rocky shores) are addressed only where intersections with military training and testing activities are reasonably likely to occur. Impacts on the water column are analyzed in Section 3.1 (Sediments and Water Quality). In addition, since the publication of the 2015 MITT Final EIS/OEIS, no critical habitat has been designated that needs to be considered here. Essential Fish Habitat (EFH) is discussed in Section 6.1.3 (Magnuson-Stevens Fishery Conservation and Management Act) and is not discussed further in this section.

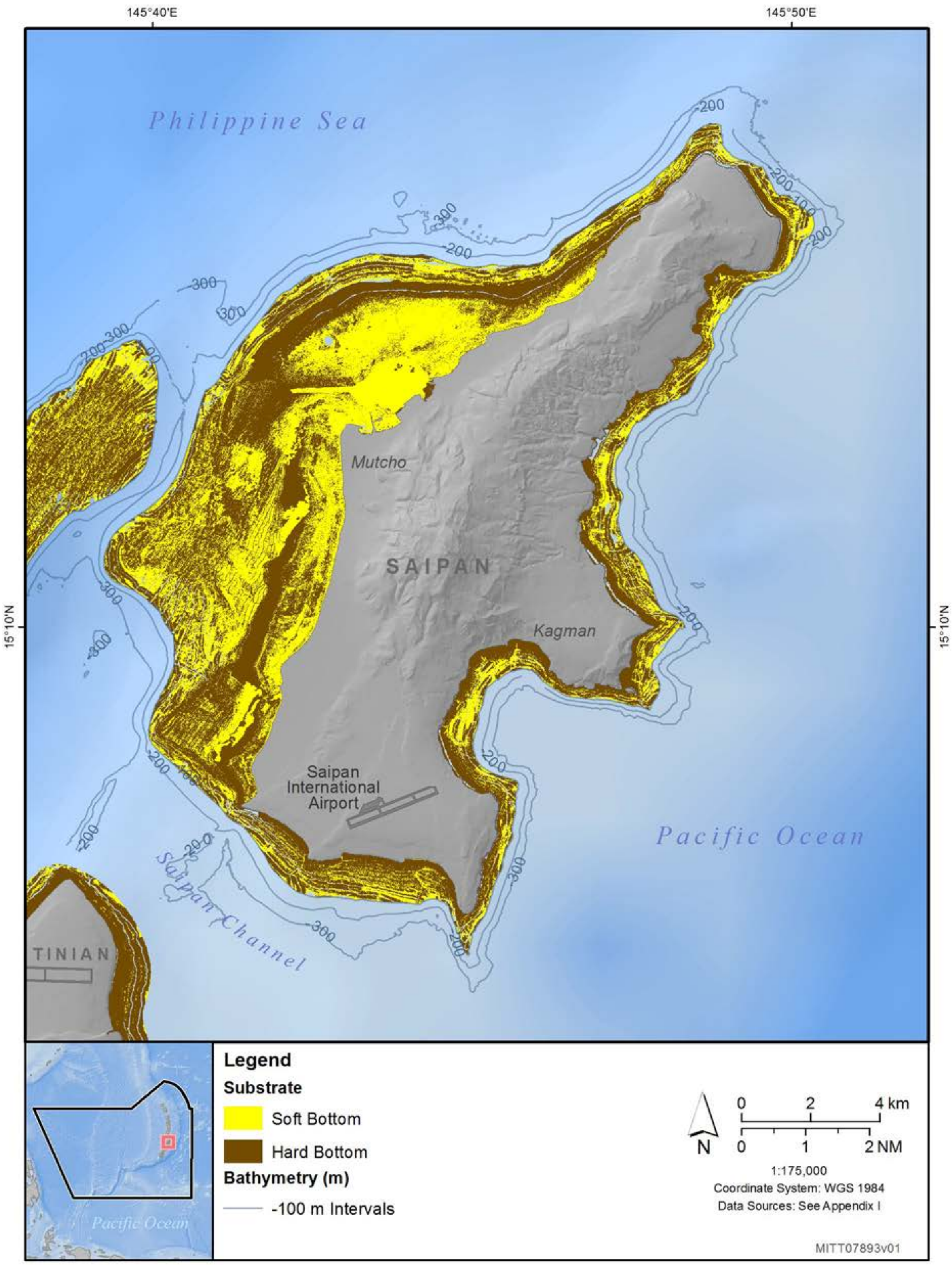

Figure 3.3-1: Nearshore Marine Habitats around Saipan

3.3.2 Environmental Consequences

The 2015 MITT Final EIS/OEIS considered training and testing activities that currently occur in the Study Area and considered potential stressors related to marine habitats. The stressors applicable to marine habitats in the Study Area for this SEIS/OEIS are the same stressors considered in the 2015 MITT Final EIS/OEIS.

- Explosive (in-air explosions and in-water explosions)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, seafloor devices, and personnel disturbance)

This section evaluates how and to what degree potential impacts on marine habitats from stressors described in Section 3.0.1 (Overall Approach to Analysis) may have changed since the analysis presented in the 2015 MITT Final EIS/OEIS was completed. Proposed training and testing activities, the number of times each event would be conducted annually, and the locations within the Study Area where the activity would typically occur under each alternative are presented in Tables 2.5-1 and 2.5-2 in Chapter 2 (Description of Proposed Action and Alternatives). Information for training and testing activities proposed in the 2015 MITT Final EIS/OEIS is also included for comparison purposes.

The analysis presented in this section also considers standard operating procedures, which are discussed in Section 2.3.3 (Standard Operating Procedures) of this SEIS/OEIS, and mitigation measures that are described in Chapter 5 (Mitigation). The Navy would implement these measures to avoid or reduce potential impacts on marine habitats from stressors associated with the proposed training and testing activities. Marine habitats in the remainder of this section will be referred to as marine substrates to reflect the subset of marine habitats being evaluated, similar to the 2015 MITT Final EIS/OEIS analysis.

3.3.2.1 Explosive Stressors

As stated in the 2015 MITT Final EIS/OEIS, underwater detonations that occur on or near the bottom are the only explosive stressors that would impact marine substrates. All other explosive stressors (e.g., gunnery exercises, missile exercises, and air-to-surface rockets) used during training and testing activities occur on the water surface or in the water column and would not impact marine substrates. Underwater detonations that occur on or near the bottom are primarily used during various mine warfare training activities. The impacts of in-water explosions vary with the bottom substrate type. As stated in the 2015 MITT Final EIS/OEIS, mine warfare training and testing activities utilizing bottom placed detonations would only occur in the existing mine warfare underwater detonation area at Outer Apra Harbor, as shown in Figure 3.3-2. Mid-water detonations at Piti and Agat would occur in the water column and would not impact bottom habitat. Therefore, impacts on marine habitats from explosive stressors at Piti and Agat are not discussed further. The majority of Outer Apra Harbor is sandy bottom habitat; however, cobble, rocky reef, and other hard-bottom habitat may be scattered throughout the area. Those hard-bottom areas, which may contain coral or wrecks, would be avoided during training and testing to the maximum extent practicable.

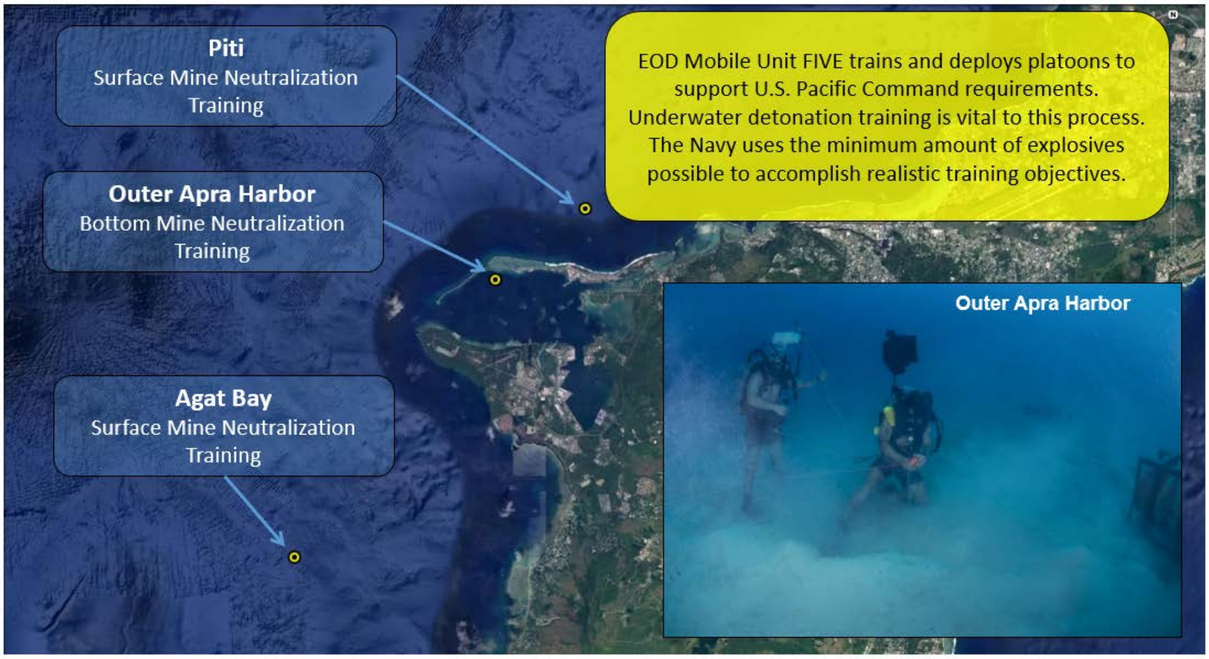

Figure 3.3-2: Existing Mine Warfare Underwater Detonation (UNDET) Areas

3.3.2.1.1 Impacts from Explosive Stressors Under Alternative 1

Under Alternative 1, underwater detonations associated with training activities would increase for underwater demolition qualification/certification (Table 2.5-1). However, these activities would continue to occur in the same areas at the Agat Bay site, Piti, and Outer Apra Harbor sites, and would have no appreciable change in the impact analysis or conclusions for explosive stressors as presented in the 2015 MITT Final EIS/OEIS. There would be no increases in underwater detonations associated with testing activities. Therefore, the analysis in the 2015 MITT Final EIS/OEIS remains valid.

Mitigation measures will help the Navy avoid or reduce impacts on seafloor resources (including shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks) from explosives during applicable activities, as described in Section 5.4.1 (Mitigation Areas for Seafloor Resources).

3.3.2.1.2 Impacts from Explosive Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of explosives used during training and testing events are proposed to be the same as under Alternative 1 described in this SEIS/OEIS (Table 3.0-7) and increase compared to the 2015 MITT Final EIS/OEIS. Under Alternative 2, proposed increases would have no appreciable change on the impact conclusions for explosive stressors as summarized above under Alternative 1 because these activities would continue to occur in the same designated areas as presented in the 2015 MITT Final EIS/OEIS.

Mitigation measures will help the Navy avoid or reduce impacts on seafloor resources (including shallow-water coral reefs, live hard bottom, artificial reefs, and submerged cultural resources) from explosives during applicable activities, as described in Section 5.4.1 (Mitigation Areas for Seafloor Resources).

3.3.2.1.3 Impacts from Explosive Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Explosive stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer explosive stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for explosive impacts on marine habitat, but would not measurably improve the overall distribution or abundance of marine habitat.

3.3.2.2 Physical Disturbance and Strike Stressors

Bottom substrates could be disturbed by vessels (i.e., during amphibious landings and only in amphibious landing areas) and in-water devices, military expended materials, seafloor devices used for training and testing activities, and from personnel disturbance such as walking, standing, or swimming in the nearshore waters during activities such as raids and assaults. The Navy takes precautions to avoid or reduce impacts on bottom substrates from vessel strikes. These precautions include only performing amphibious landings in amphibious landing areas, at high tide, and where there are clear routes. By implementing these precautions, disturbance from vessel strikes would be avoided or reduced to the maximum extent practicable. Raids and assaults are planned to occur in areas that are primarily soft-bottom sandy habitat. Due to the nature of high-energy surf and shifting sands in these areas, ocean approaches would not be expected to affect marine habitats.

Seafloor devices would be located in areas that would be primarily soft-bottom and previously disturbed habitat to the greatest extent practical. The impact of seafloor devices on marine habitats is unlikely because these activities would occur over soft-bottom sediment, the items used in nearshore areas have a small footprint, and the items are retrieved. These potential impacts to bottom substrates would be minimal in size and temporary (recovery in days to weeks) to short term (recovery in weeks up to three years) in duration. Further, the majority of military expended materials are widely distributed throughout the Study Area offshore, where the majority of the marine habitat is expected to consist of soft-bottom habitat. Once on the seafloor, military expended material would be buried by sediment, corroded from exposure to the marine environment, or colonized by benthic organisms. As stated in the 2015 MITT Final EIS/OEIS, impacts of physical disturbance or strike resulting from training and testing activities on biogenic soft bottom (e.g., seagrasses, macroalgae, etc.) and hard bottom (e.g., corals, sponges, tunicates, oysters, mussels, macroalgae, etc.) substrates are discussed in Sections 3.7 (Marine Vegetation) and 3.8 (Marine Invertebrates), respectively.

3.3.2.2.1 Impacts from Physical Disturbance and Strike Stressors Under Alternative 1

Under Alternative 1, there would be a slight increase in the use of towed in-water devices (Table 3.0-13). The increase in the number of in-water devices is unlikely to change the impact conclusion presented in the 2015 MITT Final EIS/OEIS. As stated in the 2015 MITT Final EIS/OEIS, the impact of vessels and in-water devices on marine habitats would remain inconsequential because vessel and in-water activities that could come into contact with marine substrates would be located in previously disturbed areas (i.e., nearshore shallow waters), and seafloor devices would be used in predominantly soft bottom previously disturbed areas and therefore would not be expected to affect marine substrates.

Various activities (such as amphibious assault and raid activities) that could involve personnel disturbance from walking, standing, and swimming in nearshore waters to shore would not increase under Alternative 1 on Tinian or Guam within the Mariana Islands Range Complex. These activities would cause minor and temporary increases in suspended sediments in soft-bottom habitats, similar to impacts that occur on beaches that are open to the public (i.e., where people walk around and swim). Hard-bottom substrates would be impacted by personnel disturbance from walking and standing in cobble-laid or reef areas. Contact with hard-bottom substrate in nearshore waters, such as coral reefs, would be avoided or reduced to the greatest extent possible.

Under Alternative 1, the number of military expended materials used for training and testing events that have the potential to impact marine habitats would generally increase (see Tables 3.0-14 through 3.0-17). As shown in Table 3.0-18, the surface area of the ocean bottom that could be impacted by the use of military expended materials as proposed in this Supplemental EIS/OEIS would decrease from the amount analyzed in the 2015 MITT Final EIS/OEIS under Alternative 1. Military expended materials are very small relative to the amount of available marine habitat and would not significantly change the quality or type of habitat present throughout the Study Area. Therefore, these increases are not expected to pose a risk to marine habitats.

Under Alternative 1, the number of seafloor devices used in shallow-water habitats during training and testing events would decrease from the number presented in the 2015 MITT Final EIS/OEIS (Table 3.0-18). Seafloor devices would pose a negligible risk to marine habitat for the same reason described above for military expended materials.

Any impacts on marine habitats incurred by vessel movements and in-water devices or military expended materials to soft-bottom substrates would be minimal and temporary. Physical disturbance and strike of live hard-bottom substrates would be permanent but minimal if it were to occur, and would be avoided or reduced through implementation of standard operating procedures as described in Section 2.3.3 (Standard Operating Procedures) and mitigation measures as described in Section 5.4.1 (Mitigation Areas for Seafloor Resources).

In addition, potential impacts on bottom substrates would be localized and temporary (recovery in days to weeks) to short-term (recovery in weeks up to three years) in duration. Artificial structures should not be adversely affected by the use of seafloor devices.

Mitigation measures will help the Navy avoid or reduce impacts on shallow-water coral reefs, live hard bottom, artificial reefs, and submerged cultural resources from precision anchoring and military expended materials during applicable activities, as described in Section 5.4.1 (Mitigation Areas for Seafloor Resources).

3.3.2.2.2 Impacts from Physical Disturbance and Strike Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the combined number of proposed training and testing events involving vessels and in-water devices (Table 3.0-12 and Table 3.0-13) are proposed to increase compared to Alternative 1 and the numbers presented in the 2015 MITT Final EIS/OEIS. Military expended materials (Table 3.0-14, Table 3.0-15, and Table 3.0-16) are proposed to increase, and seafloor devices (Table 3.0-19) are proposed to decrease compared to Alternative 1 and the number in the 2015 MITT Final EIS/OEIS. However, the total footprint of military expended materials in the Study Area would decrease under Alternative 2. Proposed increases in some physical disturbance and strike stressors, such as military expended materials, could increase the impact risk on marine habitats but does not appreciably change the analysis as described under Alternative 1, or impact conclusions presented in the 2015 MITT Final EIS/OEIS.

Mitigation measures will help the Navy avoid or reduce impacts on shallow-water coral reefs, live hard bottom, artificial reefs, and submerged cultural resources from precision anchoring and military expended materials during applicable activities, as described in Section 5.4.1 (Mitigation Areas for Seafloor Resources).

3.3.2.2.3 Impacts from Physical Disturbance and Strike Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Physical disturbance and strike stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer physical disturbance and strike stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for physical disturbance and strike impacts on marine habitat, but would not measurably improve the overall distribution or abundance of marine habitat.

3.3.3 Public Comments

The public raised a number of issues during the scoping period in regard to marine habitats. The issues are summarized in the list below. Comments received from the public during the Draft SEIS/OEIS commenting period related to marine habitats are addressed in Appendix K (Public Comment Responses).

- **Impact of unexploded ordnance on the ocean floor** – Unexploded ordnance is not part of the military expended materials proposed to be expended under the Proposed Action.
- **Destruction of habitat** – Proposed training and testing activities are not expected to cause the destruction of marine habitat in the Study Area. Any impacts on marine habitats incurred by vessel movements and in-water devices or military expended materials to soft- and hard-bottom substrates would be minimal. Explosive impacts on hard-bottom habitat are not expected to occur, because bottom explosions only occur in sandy-bottom habitat (i.e., Outer Agat Harbor). Furthermore, the implementation of mitigation measures helps to avoid or reduce impacts on live hard bottom, as defined in Chapter 5 (Mitigation). Impacts on the soft-bottom substrate are determined to be short term and minimal due to the mobile nature of soft-bottom substrates (i.e., sandy bottoms can be stirred up and settle relatively quickly when compared to impacts on hard-bottom substrates).
- **Recommend consideration of temporal mitigation and habitat avoidance mitigation** – Temporal mitigation and habitat avoidance mitigation were considered, and mitigation areas are discussed in Section 5.4 (Mitigation Areas to be Implemented) of Chapter 5 (Mitigation) as well as Appendix I (Geographic Mitigation Assessment).
- **Impacts on EFH from training activities (deposition and resuspension of sediments, erosion and sedimentation, and impacts from unexploded ordnance)** – Because training activities would have adverse effects on EFH, the Navy completed supplemental consultation with NMFS

addressing activities that have changed (i.e., increased) as a result of the Proposed Action; see Section 6.1.3 (Magnuson-Stevens Fishery Conservation and Management Act), and Appendix C (Agency Correspondence) for further discussion. To avoid or reduce adverse impacts on hard-bottom habitat, the Navy created mitigation measures to protect the resource. As shown in Table 5.4-1 of Chapter 5 (Mitigation), shallow-water coral reefs, live hard bottom, artificial reefs, and submerged cultural resources are areas of focus for protection from explosives and physical disturbance and strike stressors. Mitigation area requirements to reduce impacts on live hard-bottom substrate are listed in Table 5.4-1.

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3.4 Marine Mammals

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3.4 Marine Mammals

3.4.1 Affected Environment

The purpose of this section is to supplement the analysis of impacts on marine mammals presented in the 2015 Mariana Islands Training and Testing (MITT) Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) with new information relevant to proposed changes in training and testing activities conducted at sea and on Farallon de Medinilla (FDM). Information presented in the 2015 MITT Final EIS/OEIS that remains valid is noted as such and referenced in the appropriate sections. Any new or updated information describing the affected environment and analysis of impacts on marine mammals associated with the Proposed Action is provided in this section. Comments received from the public during scoping related to marine mammals are addressed in Section 3.4.6 (Public Comments). Comments received from the public during the Draft Supplemental EIS (SEIS)/OEIS commenting period related to marine mammals are addressed in Appendix K (Public Comment Responses). Additional or updated information regarding beaked whale strandings and newly published journal articles were added to this section.

The complete analysis and summary of potential impacts of the Proposed Action on marine mammals are found in Section 3.4.2 (Environmental Consequences) and Section 3.4.3 (Summary of Potential Impacts on Marine Mammals). For additional information, also see the 2015 MITT Final EIS/OEIS, Section 3.4 (Marine Mammals) (U.S. Department of the Navy, 2015a).

3.4.1.1 General Background

Marine mammals are a diverse group of approximately 130 species. Most live predominantly in the marine habitat, although some species, such as seals, spend time in terrestrial habitats, and other species such as manatees and certain dolphins spend time in freshwater habitats (Rice, 1998; U.S. Department of the Navy, 2007). The exact number of formally recognized marine mammal species changes periodically with new scientific understanding or findings (Rice, 1998). For a list of current species classifications, see the formal list of *Marine Mammal Species and Subspecies* maintained online by the Society for Marine Mammalogy. In this document, the Navy follows the naming conventions presented by National Marine Fisheries Service (NMFS) in the applicable annual Stock Assessment Reports (SAR) for the Pacific and Alaska[1] regions covering the marine mammals present in the MITT Study Area (Carretta et al., 2019c; Muto et al., 2019).

All marine mammals in the United States are protected under the Marine Mammal Protection Act (MMPA), and some species receive additional protection under the Endangered Species Act (ESA). The MMPA defines a marine mammal "stock" as "a group of marine mammals of the same species or smaller taxon in a common spatial arrangement that interbreed when mature" (16 United States Code [U.S.C.] section 1362; for further details, see Oleson et al. (2013). As provided by NMFS guidance, "for purposes of management under the MMPA a stock is recognized as being a management unit that identifies a demographically independent biological population." (Carretta et al., 2017c; National Marine Fisheries Service, 2016f). However, in practice, recognized management stocks may fall short of this ideal for various reasons, including a lack of information, and, in some cases, may even include multiple distinct

[1] Some stocks in the Pacific and the Mariana Islands, such as the Northeast Pacific stocks of sperm whales and fin whales, and the Western North Pacific Stock of humpback whales, include individuals that may spend the summer season foraging in Alaska waters and are therefore included in the Alaska Stock Assessment Report.

population segments in a management unit, such as with the Western North Pacific humpback whale stock (Bettridge et al., 2015).

The ESA provides for listing species, subspecies, or distinct population segments of species, all of which are referred to as "species" under the ESA. The *Interagency Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the ESA* defines a distinct population segment as, "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature" (61 Federal Register [FR] 4722, February 7, 1996). If a population meets the criteria to be identified as a distinct population segment, it is eligible for listing under the ESA as a separate species (National Marine Fisheries Service, 2016f).

Twenty-six cetacean marine mammal species are known to exist in the Study Area, including 7 mysticetes (baleen whales) and 19 odontocetes (dolphins and toothed whales) (U.S. Department of the Navy, 2005, 2018a). The species expected to be present in the Study Area are provided in Table 3.4-1 and listed alphabetically within the two suborder groupings. The information presented in this SEIS/OEIS incorporates data from the U.S. Pacific and the Alaska Marine Mammal Stock Assessments (Carretta et al., 2019c; Muto et al., 2019), which cover some of those species present in the Study Area and incorporate the best available science, including monitoring data from Navy marine mammal research efforts. For those few species for which stock information exists in the region, relevant data are included in the species-specific Status and Management summaries provided subsequently in this section.

Table 3.4-1: Marine Mammal Occurrence within the Study Area

Common Name[1]	*Scientific Name*	*ESA Status*	*Occurrence in Study Area*		
			Mariana Islands	*Transit Corridor*	*Apra Harbor*
Mysticetes					
Blue whale	*Balaenoptera musculus*	Endangered	Seasonal	Seasonal	-
Bryde's whale	*Balaenoptera edeni*	n/a	Regular	Regular	-
Fin whale	*Balaenoptera physalus*	Endangered	Rare	Rare	-
Humpback whale	*Megaptera novaeangliae*	Endangered	Seasonal	Seasonal	-
Minke whale	*Balaenoptera acutorostrata*	n/a	Seasonal	Seasonal	-
Omura's whale	*Balaenoptera omurai*	n/a	Rare	Rare	-
Sei whale	*Balaenoptera borealis*	Endangered	Seasonal	Seasonal	-
Odontocetes					
Blainville's beaked whale	*Mesoplodon densirostris*	n/a	Regular	Regular	-
Common bottlenose dolphin	*Tursiops truncatus*	n/a	Regular	Regular	-
Cuvier's beaked whale	*Ziphius cavirostris*	n/a	Regular	Regular	-
Dwarf sperm whale	*Kogia sima*	n/a	Regular	Regular	-

Table 3.4-1: Marine Mammal Occurrence within the Study Area (continued)

Common Name[1]	Scientific Name	ESA Status	Occurrence in Study Area		
			Mariana Islands	Transit Corridor	Apra Harbor
Odontocetes					
False killer whale	*Pseudorca crassidens*	n/a	Regular	Regular	-
Fraser's dolphin	*Lagenodelphis hosei*	n/a	Regular	Regular	-
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	n/a	Regular	Regular	-
Killer whale	*Orcinus orca*	n/a	Regular	Regular	-
Longman's beaked whale	*Indopacetus pacificus*	n/a	Regular	Regular	-
Melon-headed whale	*Peponocephala electra*	n/a	Regular	Regular	-
Pantropical spotted dolphin	*Stenella attenuata*	n/a	Regular	Regular	-
Pygmy killer whale	*Feresa attenuata*	n/a	Regular	Regular	-
Pygmy sperm whale	*Kogia breviceps*	n/a	Regular	Regular	-
Risso's dolphin	*Grampus griseus*	n/a	Regular	Regular	-
Rough-toothed dolphin	*Steno bredanensis*	n/a	Regular	Regular	-
Short-finned pilot whale	*Globicephala macrorhynchus*	n/a	Regular	Regular	-
Sperm whale	*Physeter macrocephalus*	Endangered	Regular	Regular	-
Spinner dolphin	*Stenella longirostris*	n/a	Regular	Regular	-
Striped dolphin	*Stenella coeruleoalba*	n/a	Regular	Regular	-

[1] If available for the species, information on stocks is included in the species-specific Status and Management summaries.

Notes: n/a = status is not applicable for those species that are not listed under ESA; Regular = a species that occurs as a regular or usual part of the fauna of the area, regardless of how abundant or common it is; Rare = a species that occurs in the area only sporadically; Seasonal = species is only seasonally present in the Study Area. Additional details regarding presence in the Study Area are provided in the species-specific subsections.

3.4.1.2 Species Unlikely to Be Present in the Study Area

Consistent with the analysis provided in the 2015 MITT Final EIS/OEIS, the species carried forward for analysis in this SEIS/OEIS are those likely to be found in the Study Area based on the most recent sighting, survey, and habitat modeling data available. The analysis does not include species that may have once inhabited or transited the area, but have not been sighted in recent years (e.g., species which no longer occur in an area due to factors such as 19th-century commercial exploitation). These species include the North Pacific right whale (*Eubalaena japonica*), the western subpopulation of gray whale (*Eschrichtius robustus*), short-beaked common dolphin (*Delphinus delphis*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), northern elephant seal (*Mirounga angustirostris*), and dugong (*Dugong dugon*). Details regarding the reasons for these exclusions are explained in detail in the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015a).

3.4.1.3 Group Size

Many species of marine mammals, particularly odontocetes, are highly social animals that spend much of their lives living in groups called "pods." The size and structures of these groups are dynamic and depending on the species, can range from several to several thousand individuals. Similarly, aggregations of mysticete whales may form during particular breeding or foraging seasons, although they do not persist through time as a social unit. Marine mammals that live or travel in groups are more likely to be detected by observers, and group size characteristics are incorporated into the many density and abundance calculations. Group size characteristics are also incorporated into acoustic effects modeling to represent a more realistic patchy distribution for a given density. The behavior of aggregating into groups is also important for the purposes of mitigation and monitoring since animals that occur in larger groups have an increased probability of being detected. A comprehensive and systematic review of relevant literature and data was conducted for available published and unpublished literature, including journals, books, technical reports, cruise reports, and raw data from cruises, theses, and dissertations. The results of this review were compiled into a Technical Report, which includes tables of group size information by species along with relevant citations (U.S. Department of the Navy, 2017c).

3.4.1.4 Habitat Use

Many factors influence the distribution of marine mammals in the Study Area, primarily patterns of major ocean currents, bottom relief, and water temperature, which, in turn, affect prey distribution and productivity. The continuous movement of water from the ocean bottom to the surface creates a nutrient-rich, highly productive environment for marine mammal prey in upwelling zones (Jefferson et al., 2015); the equatorial upwelling in the western Pacific is one such area (Di Lorenzo et al., 2010; Helber & Weisberg, 2001). While most baleen whales (such as humpback whales) are migratory, some species such as Bryde’s whales and Omura’s whales are thought to be present within the Study Area year round. Many of the toothed whales do not migrate in the strictest sense, but some do undergo seasonal shifts in distribution both within and outside of the Study Area.

3.4.1.5 Dive Behavior

All marine mammals, with the exception of polar bears, spend part of their lives underwater while traveling or feeding. Some species of marine mammals have developed specialized adaptations to allow them to make deep dives lasting over an hour, primarily for the purpose of foraging on deep-water prey such as squid. Other species spend the majority of their lives close to the surface, and make relatively shallow dives. The diving behavior of a particular species or individual has implications for the ability to visually detect them for mitigation and monitoring. In addition, their relative distribution through the water column based on diving behavior is an important consideration when conducting acoustic effects modeling. Information and data on diving behavior for each species of marine mammal were compiled and summarized in a technical report (U.S. Department of the Navy, 2017c) that provides the detailed summary of time at depth.

3.4.1.6 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, 2014; 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 (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 methods are used to measure hearing sensitivity (e.g., Castellote et al., 2014; Finneran et al., 2009; Montie et al., 2011; Mulsow et al., 2011; Nachtigall et al., 2007; Nachtigall et al., 2008; Supin et al., 2001). For odontocetes, the procedure for creating audiograms from auditory evoked potential measurements has recently been standardized (American National Standards Institute & Acoustical Society of America, 2018).

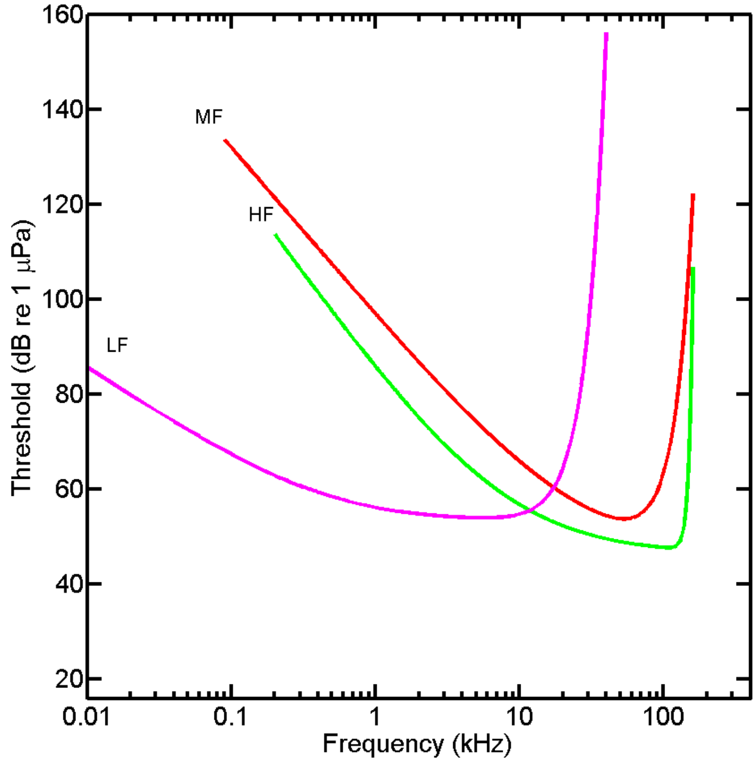
These auditory evoked potential methods, which measure electrical potentials generated by the auditory system in response to sound and do not require the extensive training needed for psychophysical methods, can provide an efficient estimate of hearing sensitivity (Finneran & Houser, 2006; Schlundt et al., 2007; Yuen et al., 2005). The thresholds provided by auditory evoked potential methods are, however, typically elevated above behaviorally measured thresholds, and auditory evoked potential methods are not appropriate for estimating hearing sensitivity at frequencies much lower than the region of best hearing sensitivity (Finneran, 2015; Finneran et al., 2016). For marine mammal species for which access is limited and therefore psychophysical or auditory evoked potential 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 3.4-2 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 (HF) cetaceans (HF group: porpoises, Kogia whales), mid-frequency (MF) cetaceans (MF group: delphinids, beaked whales, sperm whales), and low-frequency (LF) cetaceans (LF group: mysticetes). 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 3.4-1) was created for each functional hearing group using audiograms from published literature. For discussion of all marine mammal functional hearing groups and their derivation see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b). The mid-frequency cetacean composite audiogram is consistent with behavioral audiograms of killer whales (Branstetter et al., 2017a) published following development of the technical report. The high-frequency cetacean composite audiogram is consistent with behavioral audiograms of harbor porpoises (Kastelein et al., 2017a) published after the technical report.

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., 2005a; Popov & Supin, 2009).

Table 3.4-2: Species within Marine Mammal Hearing Groups Likely Found in the Study Area

Hearing Group	*Species within the Study Area*
High-frequency cetaceans	Dwarf sperm whale
	Pygmy sperm whale
Mid-frequency cetaceans	Blainville's beaked whale
	Common bottlenose dolphin
	Cuvier's beaked whale
	False killer whale
	Fraser's dolphin
	Ginkgo-toothed beaked whale
	Killer whale
	Longman's beaked whale
	Melon-headed whale
	Northern right whale dolphin
	Pantropical spotted dolphin
	Pygmy killer whale
	Risso's dolphin
	Rough-toothed dolphin
	Short-finned pilot whale
	Sperm whale
	Spinner dolphin
	Striped dolphin
Low-frequency cetaceans	Blue whale
	Bryde's whale
	Fin whale
	Humpback whale
	Minke whale
	Omura's whale
	Sei whale



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

Notes: For hearing in the water; LF = low-frequency, MF = mid-frequency, HF = high-frequency

Figure 3.4-1: Composite Audiograms for Hearing Groups Likely Found in the 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 species (see Avens, 2003; Richardson et al., 1995b). This makes a succinct summary difficult (see Richardson et al., 1995b; Wartzok & Ketten, 1999 for thorough reviews); however, a division can be drawn between lower frequency communication signals that are used by marine mammals in general, and the specific, high-frequency biosonar signals that are used by odontocetes to sense their environment.

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

Odontocete cetaceans use underwater communicative signals that, while not as low in frequency as those of many mysticetes, likely serve similar functions. 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 (500–200 µs), 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 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. 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).

3.4.1.7 General Threats

Marine mammal populations can be influenced by various natural factors as well as human activities. There can be direct effects from disease, hunting, and whale watching, or indirect effects such as through reduced prey availability or lowered reproductive success of individuals. Research presented in Twiss and Reeves (1999) and National Marine Fisheries Service (2011a, 2011b, 2011c, 2011e) provides a general discussion of marine mammal conservation and the threats they face. As detailed in National Marine Fisheries Service (2011d), investigations of stranded marine mammals are undertaken to monitor threats to marine mammals (Simeone et al., 2015). Investigations into the cause of death for stranded animals can also provide indications of the general threats to marine mammals in a given location (Bradford & Forney, 2017; Carretta et al., 2019a; Carretta et al., 2017b; Helker et al., 2019; Helker et al., 2017). The causes for strandings include infectious disease, parasite infestation, climate change reducing prey availability and leading to starvation, pollution exposure, trauma (e.g., injuries from ship strikes or fishery entanglements), sound (human-generated or natural), harmful algal blooms and associated biotoxins, tectonic events such as underwater earthquakes, and ingestion of or interaction with marine debris (for more information see NMFS Marine Mammal Stranding Response Fact Sheet (National Marine Fisheries Service, 2016a). Since 1963, Guam Department of Agriculture Division of Aquatic and Wildlife Resources has conducted aerial surveys twice every month (weather permitting) of the coastal margin around Guam at a distance of approximately 200–300 meters (m) offshore of the outer reef margin (Martin et al., 2016). Therefore, the Navy assumes any animals stranded on Guam are likely to have been identified; see also Mobley (2007). 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 *Strandings Associated with U.S. Navy Activity* (U.S. Department of the Navy, 2017a).

3.4.1.7.1 Water Quality

Chemical pollution and impacts on ocean water quality are of great concern, although the effects on marine mammals are just starting to be understood (Bachman et al., 2014; Bachman et al., 2015;

Desforges et al., 2016; Foltz et al., 2014; Godard-Codding et al., 2011; Hansen et al., 2015; Jepson & Law, 2016; Law, 2014; Peterson et al., 2014; Peterson et al., 2015; Ylitalo et al., 2005; Ylitalo et al., 2009). 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).

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 (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, which can accumulate in the bodies of marine mammals, and be transferred to nursing young through the 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., 2014; Peterson et al., 2015). 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 and marine life in general (Bonito et al., 2016; Jepson & Law, 2016; Law, 2014).

3.4.1.7.2 Commercial Industries

Human impacts on marine mammals through fisheries interactions have received much attention in recent decades, and include bycatch (accidental or incidental catch), gear entanglement, and indirect effects from takes of prey species; noise pollution; marine debris (ingestion and entanglement); hunting (both commercial and native practices); vessel strikes; entrainment into power plant water intakes; increased ocean acidification; and general habitat deterioration or destruction.

3.4.1.7.3 Bycatch

Fishery bycatch is likely the most impactful threat to marine mammal individuals and populations and may account for the deaths of more marine mammals than any other cause (Bradford & Forney, 2017; Carretta et al., 2016b; Carretta et al., 2017b; Geijer & Read, 2013; Hamer et al., 2010; Helker et al., 2019; Helker et al., 2017; Lent & Squires, 2017; National Marine Fisheries Service, 2016c; National Oceanic and Atmospheric Administration, 2019; Northridge, 2009; Read, 2008; Song, 2017). In 1994, the MMPA was amended to formally address bycatch in the United States. The amendment required the development of a take reduction plan when bycatch exceeds a level considered sustainable and 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.

At least in part as a result of the amendment, estimates of bycatch in the Pacific by U.S. fisheries declined by a total of 96 percent from 1994 to 2006 (Geijer & Read, 2013). Information on bycatch associated with non-U.S. fishery activities is generally not available in the Study Area. It has been argued that the bycatch of marine mammals by Japan and South Korea is more like an unregulated commercial hunt than an incidental or illegal fishery given the products from bycatch whales can be sold openly on commercial markets in both countries (Baker et al., 2006b; Lukoschek et al., 2009). For example, in 2008 the reported bycatch in Japan and South Korea totaled 214 minke whales (Lukoschek et al., 2009) and in nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that 230 products contained minke whale meat in addition to that of other species (Baker et al., 2006b). A total of 717 cetacean bycatches involving South Korean fish vessels in the East Sea that involved 10 species were reported in a two-year period between 2013 and 2014 (Song, 2017).

3.4.1.7.4 Other Fishery Interactions

Fishery interactions other than bycatch include entanglement in abandoned or partial nets, fishing line, hooks, and the ropes and lines connected to fishing gear (Bradford & Lyman, 2015; Bradford & Forney, 2016, 2017; Carretta, 2013; Carretta et al., 2014; Carretta et al., 2016b; Carretta et al., 2017b; Helker et al., 2019; Helker et al., 2015; Helker et al., 2017; National Oceanic and Atmospheric Administration, 2017, 2019; Richardson et al., 2016; Saez et al., 2013). The National Oceanic and Atmospheric Administration Marine Debris Program (2014a) reports that abandoned, lost, or otherwise discarded fishing gear constitutes the vast majority of mysticete entanglements. For the identified sources of entanglement, none included Navy-expended materials. Identified species entangled in the Pacific in 2015 and 2016 included humpback, gray, blue, fin and killer whales with a total of 133 entanglements in the two-year period (National Oceanic and Atmospheric Administration, 2017).

In waters off Alaska where humpback whales from the Study Area may forage in the summer season, passive acoustic monitoring efforts since 2009 have documented the routine use of non-military explosives at sea (Baumann-Pickering et al., 2013; Rice et al., 2015; Wiggins et al., 2019). Based on the acoustic 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). 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 (National Marine Fisheries Service, 2015b; Wiggins et al., 2019). The prevalent and continued use of seal bombs in Alaska seems to indicate that, while a potential threat, their use has had no significant effect on populations of marine mammals given that it is likely at least some individuals, if not larger groups of marine mammals, have been repeatedly exposed to this explosive stressor.

3.4.1.7.5 Noise

In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise can be a potential habitat-level stressor (Dunlop, 2016; Dyndo et al., 2015; Erbe et al., 2014; Frisk, 2012; Gedamke et al., 2016; Hermannsen et al., 2014; Li et al., 2015; McKenna et al., 2012; Melcón et al., 2012; Miksis-Olds & Nichols, 2016; Nowacek et al., 2015; Pine et al., 2016; Williams et al., 2014c). Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. Noise may cause marine mammals to leave a habitat, impair their ability to communicate, or cause physiological stress (Courbis & Timmel, 2008; Erbe, 2002; Erbe et al., 2016; Hermannsen et al., 2014; Hildebrand, 2009; Rolland et al., 2012; Tyack et al., 2011; Tyne et al., 2017; Williams et al., 2014b). 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., 2014; Erbe et al., 2016; National Research Council, 2003, 2005; Nowacek et al., 2007; Southall et al., 2009; Tyack, 2009; Würsig & Richardson, 2009). Anthropogenic noise is generated from a variety of sources including commercial shipping, oil and gas exploration and production activities, commercial and recreational fishing (including fish-finding sonar, fathometers, and acoustic deterrent and harassment devices), foreign navies, recreational boating and whale watching activities, offshore power generation, and research (including sound from air guns, sonar, and telemetry).

Vessel noise in particular is a major contributor to noise in the ocean (Southall et al., 2018). Commercial shipping's contribution to ambient noise in the ocean increased by as much as 12 decibels (dB) between approximately the 1960s and 2005 (Hildebrand, 2009; McDonald et al., 2008). Frisk (2012) confirmed the trend and reported that between 1950 and 2007 ocean noise in the 25–50 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). Subsequently, Miksis-Olds and Nichols (2016) have demonstrated that the trends for low-frequency ocean sound levels no longer show a uniform increase across the globe. Most research has focused on only the low-frequency components of ship noise, given that low-frequency noise propagates farther and is easier to sample, although mid- and high-frequency components are also present in ship noise. When in proximity to transiting vessels, odontocete hearing is more likely to be impacted by substantially elevated mid- to high-frequency noise components, relative to mysticetes, given those frequencies are where toothed whale hearing is most sensitive (Hermannsen et al., 2014).

Although Guam and the Mariana Islands lack a major port, many thousands of trans-Pacific shipments to and from Asia occur as part of the global shipping transportation network and pass in proximity to the Mariana Islands and throughout the Study Area (Kaluza et al., 2010). Redfern et al. (2017) found that shipping channels leading to and from the ports of Los Angeles and Long Beach may have degraded the habitat for blue, fin, and humpback whales due to the loss of communication space where important habitat for these species overlaps with elevated noise from commercial vessel traffic, and similar impacts are also likely in the Study Area on great circle routes and other shortest point-to-point shipping routes.

In many areas of the world, including the Study Area, oil and gas seismic exploration in the ocean is undertaken using a group of air guns towed behind large research vessels. The airguns convert high pressure air into very strong shock wave impulses that are designed to return information off the various buried layers of sediment under the seafloor. Seismic exploration surveys last many days and cover vast overlapping swaths of the ocean area being explored. Most of the impulse energy 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.

3.4.1.7.6 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, hunting-related mortality has decreased over the last 40 years. Unregulated harvests are still considered as 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, only 169,638 were reported by the

Union of Soviet Socialist Republics to the International Whaling Commission (Ilyashenko et al., 2013; Ilyashenko et al., 2014; Ilyashenko & Chapham, 2014; Ilyashenko et al., 2015). In July 2019, Japan withdrew from the International Whaling Commission and resumed commercial whaling within its waters (BBC News, 2019; Nishimura, 2019; Victor, 2018). Japan had set an annual quota of more than 600 whales per year while a member of the International Whaling Commission, when whales were taken for "research" purposes, but the current cap for commercial whaling set through 2019 now stands at 227 whales. This includes 52 minke whales, 150 Bryde's whales, and 25 sei whales (Nishimura, 2019). It is possible that some of the whales in Japan waters may be part of the same North Pacific populations that are also present seasonally in the MITT Study Area.

3.4.1.7.7 Vessel Strike

Ship strikes are also a growing issue for most marine mammals, especially for large whales as populations recover from widespread commercial whaling. Some of the largest ports in the world are located to the west of the Study Area, and a substantial portion of the world's commercial vessel traffic from Asia and Japan transits through the Study Area heading south to ports of call along the coast of eastern Australia and to New Zealand, in addition to goods shipped into the Mariana Islands.

Since 1995, the U.S. Navy and U.S. Coast Guard have reported all known or suspected vessel collisions with whales to NMFS. There are no known collisions between Navy vessels and whales in the MITT Study Area associated with any of the proposed training or testing activities. 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 is recognized by NMFS; for example, in the Technical Memorandum providing the analysis of the impacts from vessel collisions with whales in Hawaii (Bradford & Lyman, 2015), NMFS takes into account unreported vessel strikes by civilian vessels.

3.4.1.7.8 Disease and Parasites

As with humans, marine mammals, especially the young, old, and weak, are susceptible to disease. For example, the first case of morbillivirus (a virus related to measles in humans) in the central Pacific was documented for a stranded juvenile male Longman's beaked whale discovered in 2010 in Hawaii (West et al., 2012; West et al., 2015) and subsequently in 2011 *brucella* (a bacterial pathogen) and *morbillivirus* were discovered in a sperm whale that stranded on Oahu (West et al., 2015); both these species are present in the Study Area. 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). Recent review of odontocetes stranded along the California coast from 2000 to 2015 found evidence for morbilliviral infection in 9 of the 212 animals examined, therefore indicating this disease may be a contributor to mortality in cetaceans stranding along the California coast (Serrano et al., 2017).

Mass die-offs of some marine mammal species have been linked to toxic algal blooms, which occur as larger organisms consume multiple prey containing those toxins and thereby accumulating fatal doses. A comprehensive study that sampled over 900 marine mammals across 13 species, including several mysticetes, odontocetes, pinnipeds, and mustelids in Alaska, 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 30 whales found around the islands in the western Gulf of Alaska and the southern shoreline of the Alaska Peninsula starting in May 2015 (National Oceanic and Atmospheric Administration, 2016; Rosen, 2015; Savage et al., 2017; Summers, 2017). These findings from studies in Alaska are relevant to the

Study Area given that the fin and humpback whales from the Mariana Islands migrate to Alaska waters in the summer to feed.

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 (Bull et al., 2006; Fauquier et al., 2009; Jepson et al., 2005). Parasitic toxoplasmosis from feral cats (introduced into the ocean from urban runoff) has been found in two stranded spinner dolphins and eight monk seals in Hawaii (Rogers, 2016; West, 2018). In 2011, a Cuvier's beaked whale stranded at Saipan, when necropsied, it was found to have abnormalities and a level of parasitism that resulted in "the worst example of kidneys" the stranding coordinator said he had ever seen (Saipan Tribune, 2011).

3.4.1.7.9 Climate Change

The global climate is warming and is having impacts on some populations of marine mammals (National Marine Fisheries Service, 2015e; National Oceanic and Atmospheric Administration, 2018b; Salvadeo et al., 2010; Shirasago-Germán et al., 2015; Simmonds & Eliott, 2009). Climate change can affect marine mammal species directly by causing them to shift their distribution to match physiological tolerance under changing environmental conditions (Doney et al., 2012; 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, changes in prey distributions and locations, and changes in water temperature (Giorli & Au, 2017). Sanford et al. (2019) have noted that severe marine heatwaves in 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 reproductive success and survival. Researchers in July 2016 shifted the location of blue, fin, and humpback whale satellite tagging efforts from Southern California to Central California, following sightings of thin and apparently unwell whales. The whales' conditions were thought to be the result of a change in the distribution of their prey away from traditional foraging areas. (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 waters with increased salinity levels such that blooms will begin earlier, last longer, and cover a larger geographical range (Edwards, 2013; Moore, 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. Most of the mysticetes found in the Study Area spend part of the year in the North Pacific. The spread of the algae and associated blooms has led to disease in marine mammals in locations where algae-caused diseases 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).

Marine mammals are influenced by climate-related phenomena, such as typhoons and shifts in 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; Zellar et al., 2017), or other oceanographic conditions. Indirect impacts of climate change may include altered water chemistry in estuaries (low dissolved oxygen or increased nutrient loading) causing massive fish kills (Burkholder et al., 2004), which changes prey distribution and availability for cetaceans (Stevens et al., 2006). Human responses to extreme weather events may indirectly affect behavior and reproductive rates of marine mammals. For example, Miller et al. (2010) reported an increase in reproductive rates in bottlenose dolphins after Hurricane Katrina in the Mississippi Sound, presumably resulting from an increase in fish abundance due to a reduction in fisheries landings, a decrease in recreational and commercial boat activities (National Marine Fisheries Service, 2007b), and an increase in the number of reproductively active females available during the breeding seasons following the storm. Smith et al. (2013a) supplemented the findings from this study and documented a marked increase in foraging activity in newly identified foraging areas that were observed during the two-year study period after the storm.

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals and may include such factors as depleting a habitat's prey base and the complete loss of habitat (Ayres et al., 2012; Kemp, 1996; Pine et al., 2016; Rolland et al., 2012; Smith et al., 2009; Veirs et al., 2015; Williams et al., 2014a). Many researchers predict that if oceanic temperatures continue to rise with an associated effect on marine habitat and prey availability, then either changes in foraging or life history strategies, including poleward shifts in many marine mammal species distributions, should be anticipated (Alter et al., 2010; Fleming et al., 2016; Ramp et al., 2015; Salvadeo et al., 2015; Sydeman & Allen, 1999). Poloczanska et al. (2016) analyzed climate change impact data that integrates 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. Their results predict a northward expansion in the distribution of zooplankton, fish, and squid, all of which are prey for many marine mammal species. There remains scientific uncertainty about how or if such climate changes will affect marine mammals and their prey. However, acidification of the ocean could also potentially impact the mobility, growth, and reproduction of calcium carbonate-forming organisms such as crustaceans and plankton, which are the direct prey of some marine mammals, are an important part of the overall food chain in the ocean, and slightly alter the propagation of sound underwater (Lynch et al., 2018; Meyers et al., 2019; Rossi et al., 2016).

3.4.1.7.10 Marine Debris

The majority of marine debris in the ocean comes from land-based sources (Jambeck et al., 2015; Thiel et al., 2018). 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 debris is a global threat to marine mammals (National Oceanic and Atmospheric Administration Marine Debris Program, 2014b; Puig-Lozano et al., 2018). A literature review by Baulch and Perry (2014) found that 56 percent of cetacean species are documented as having ingested marine debris and that it can be a significant source of injury and mortality. A Cuvier's beaked whale that stranded at Saipan in 2011 was found to have an approximate 1-inch-diameter circular piece of plastic in its stomach (Saipan Tribune, 2011), and a Cuvier's stranding discovered at Mindanao in the Philippines in spring of 2019 found that individual had 88 pounds of plastic marine debris in its stomach (Paul, 2019). In other cases, attributing cause of death to marine debris ingestion is often 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), pygmy sperm whales (Sadove & Morreale, 1989; Stamper et al., 2006; Tarpley & Marwitz, 1993), and sperm whales (Jacobsen et al., 2010; Sadove & Morreale, 1989; Unger et al., 2016).

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). There have been no marine debris surveys in the Mariana Islands, so information from the Hawaiian Islands may be relevant. Since 1996, the National Oceanic and Atmospheric Administration has removed 848 metric tons of derelict fishing nets and debris from the Northwest Hawaiian Islands and has estimated that an additional 52 tons of debris collects on the shallow coral reefs and shores there every year (National Oceanic and Atmospheric Administration, 2018d). From April 2013 to April 2016 in the waters around Lanai and channels between Lanai, Maui, and Kahoolawe, surveys were conducted to quantify the presence of marine mammals and floating marine debris (Currie et al., 2017). The surveys encountered, collected, and categorized 1,027 pieces of marine debris. Items categorized as "plastic" were the predominant type of debris encountered, accounting for 86 percent of total debris and consisting mainly of plastic bottles, tubs, baskets, foamed polystyrene disposable plates, cups, fragments, plastic bags, and other soft plastic films. A smaller portion of the plastic debris (13 percent; 11 percent of the total debris) was fishing-related and included items such as buoys, netting, rope, and fishing lines; milled lumber and rubber accounted for 10 percent of debris, with the remaining 4 percent attributed to metal, glass, and clothing/fabric. Similar findings have been documented for other locations in the Pacific region (Choy & Drazen, 2013; Horton et al., 2017; Smith, 2012).

Although there are no similar records for the Study Area, for some of the same cetacean species in Hawaii between 2007 and 2012, there were 48 humpback whales, a sperm whale, a bottlenose dolphin, 3 spinner dolphins, and a pantropical spotted dolphin found entangled in marine debris (Bradford & Lyman, 2015). One humpback whale was known to be injured, and it is believed that interaction with debris led to the mortality of a second humpback whale and a spinner dolphin (Bradford & Lyman, 2015). Marine mammals migrating from the Mariana Islands to Alaska also encounter threats outside the Study Area. 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).

An estimated 75 percent or more of marine debris consists of plastic (Derraik, 2002; Hardesty & Wilcox, 2017). High concentrations of floating plastic have been reported in the central and western Pacific Ocean (Cozar et al., 2014; Gibbs et al., 2019; Mu et al., 2019). 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 (mm) that are not readily visible to the naked eye (Andrady, 2015). 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 (Gibbs et al., 2019; 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. This finding and those from other similar studies (Mu et al., 2019) should be applicable to all urban centers in the Pacific, including those in the 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 mm to 17 centimeters. There is still a large knowledge gap about possible 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; Burkhardt-Holm & N'Guyen, 2019; Carlos de Sá et al., 2018; Gallo et al., 2018; Nelms et al., 2018).

Marine mammals as a whole are subject to the various influences and factors delineated in this section above. If specific threats to individual species in the Study Area are known, those threats are described below in individual species accounts.

Mysticetes

3.4.1.8 Blue Whale (*Balaenoptera musculus*)

3.4.1.8.1 Status and Management

The blue whale is listed as endangered under the ESA and as depleted under the MMPA throughout its range, but there is no designated critical habitat for this species. NMFS has determined that more research is still needed to rigorously and specifically define the features that make habitat important to blue whales (National Marine Fisheries Service, 2018b). Although the designated Central North Pacific Stock of blue whales are present in winter in "lower latitudes in the western and central Pacific, including Hawaii," blue whales in the Study Area have not been assigned to a stock in either the Alaska or Pacific SARs (Carretta et al., 2019c; Muto et al., 2019).

3.4.1.8.2 Geographic Range and Distribution

Blue whales inhabit all oceans and typically occur in both nearshore and deep oceanic waters. Blue whales belonging to the Central Pacific Stock feed in summer in the Pacific south of the Aleutian Islands and in the Gulf of Alaska, and then migrate to lower latitudes in the winter. There are no recent sighting records for blue whales in the Study Area (Fulling et al., 2011; Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2019; Uyeyama, 2014). Although rare, acoustic detections from passive monitoring devices deployed at Saipan and Tinian have recorded the presence of blue whales over short periods of time (a few days) (Oleson et al., 2015). However, since blue whale calls can travel up to 621 miles (mi.) (1,000 kilometers [km]), it is unknown whether the animals were actually within the Study Area. Blue whales would be most likely to occur in the Study Area during the winter and are expected to be few in number.

3.4.1.8.3 Population and Abundance

Widespread whaling over the last century was believed to have decreased the global blue whale population to approximately 1 percent of its pre-whaling population size (Branch, 2007; Monnahan, 2013; Monnahan et al., 2014; Rocha et al., 2014; Širović et al., 2004). The most current information suggests that following the cessation of commercial whaling in 1971, the population in the North Pacific may have recovered and since the 1990s has been at a stable level despite the impacts of ship strikes, interactions with fishing gear, and increased levels of ambient sound in the Pacific Ocean (Campbell et al., 2015; Carretta et al., 2017c; Carretta et al., 2018a; International Whaling Commission, 2016; Monnahan, 2013; Monnahan et al., 2014; Monnahan et al., 2015; National Marine Fisheries Service, 2018b; Rockwood et al., 2017; Širović et al., 2015; Valdivia et al., 2019). For the portion of the population present in the eastern Pacific, findings have suggested that the population is now near the environment's carrying capacity and that the rate of change of the population size has declined as a result (Carretta et al., 2018a; International Whaling Commission, 2016; Monnahan et al., 2014; Monnahan et al., 2015).

3.4.1.8.4 Predator-Prey Interactions

Blue whales feed almost exclusively on various types of zooplankton, especially krill (Jefferson et al., 2015); however, it has recently been shown that blue whales can locate and feed on dense swarms of other larger prey when present (De Vos et al., 2018). Blue whales with data recording tags have been recorded feeding from the surface to depths approaching 300 m (Goldbogen et al., 2013a; Goldbogen et al., 2013b).

Blue whales have been documented to be preyed on by killer whales, and 25 percent of photo-identified whales in the Gulf of California carry rake scars from killer whale attacks (Jefferson et al., 2015; Pitman et al., 2007; Sears & Perrin, 2009).

3.4.1.8.5 Species-Specific Threats

Blue whales are susceptible to entanglement in fishing gear and ship strikes (Berman-Kowalewski et al., 2010; Calambokidis et al., 2009a; Calambokidis, 2012; Carretta et al., 2013; Carretta et al., 2016b; Carretta et al., 2019c; Laggner, 2009; Monnahan et al., 2015; National Marine Fisheries Service, 2011d; Rockwood et al., 2017).

3.4.1.9 Bryde's Whale (*Balaenoptera edeni*)

3.4.1.9.1 Status and Management

Bryde's whales are not listed as endangered under the ESA. There is currently no biological basis for defining separate stocks of Bryde's whales in the western or central North Pacific. (Carretta et al., 2017c; Carretta et al., 2017d; Carretta et al., 2019c; Constantine et al., 2018). NMFS recognizes two stocks of Bryde's whales in the Pacific with one for Hawaiian waters and the other for the Gulf of California and waters off California (Carretta et al., 2017c; Carretta et al., 2017d; Carretta et al., 2019c); none of the ranges described for these stocks include the Study Area.

3.4.1.9.2 Geographic Range and Distribution

Data suggest that winter and summer grounds partially overlap in the central North Pacific (Murase et al., 2015). Bryde's whales are distributed in the central North Pacific in summer; the southernmost summer distribution of Bryde's whales inhabiting the central North Pacific is about 20° N (Kishiro, 1996). Some whales remain in higher latitudes (around 25° N) in both winter and summer, but are not likely to move poleward of 40° N (Jefferson et al., 2015; Kishiro, 1996). Bryde's whales are expected to be present in the Study Area based on sighting records (Fulling et al., 2011; Hill et al., 2017a; Mobley, 2007; Oleson & Hill, 2010b; Uyeyama, 2014). Bryde's whales were detected in the Transit Corridor between the Study Area and Hawaii during a NMFS survey in January 2010 (Oleson & Hill, 2010b) and regularly encountered during the 2007 survey of the MITT Study Area[2] (Fulling et al., 2011). Bryde's whales were

[2] The Mariana Islands Sea Turtle and Cetacean Survey (MISTCS) undertaken in 2007 covered an area of approximately 301,300 square kilometers within the larger MITT Study Area, which encompasses approximately

encountered during a NMFS cetacean survey in May–June 2015 off Pagan, Alamagan, and south of Guam (Hill et al., 2018d; Oleson, 2017), and later that same year off Rota during a small boat survey in August–September 2015 (Hill et al., 2017a). In May 2017 a single individual was encountered in deep water off the west side of Saipan (Hill et al., 2018b); none were detected in the 2018 small boat surveys (Hill et al., 2018c; Hill et al., 2019).

3.4.1.9.3 Population and Abundance

Based on the best available science, there are an estimated 233 (Coefficient of Variation [CV] = 0.45) Bryde's whales present in the Study Area (Fulling et al., 2011).

3.4.1.9.4 Predator-Prey Interactions

Bryde's whales primarily feed on schooling fish and are lunge feeders. Prey includes anchovy, sardine, mackerel, herring, krill, and other invertebrates, such as pelagic red crab (Baker & Madon, 2007; Nemoto & Kawamura, 1977). Bryde's whales have been observed using "bubble nets" to herd prey (Kato & Perrin, 2009). Bubble nets are used in a feeding strategy where the whales dive and release bubbles of air that float up in a column and trap prey inside where whales lunge through the column to feed.

Bryde's whale is known to be prey for killer whales, as evidenced by an aerial observation of 15 killer whales attacking a Bryde's whale in the Gulf of California (Weller, 2009).

3.4.1.9.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Bettridge et al., 2015; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that four products contained Bryde's whale meat (Baker et al., 2006a). There has been one recorded stranding of a Bryde's whale (at Tinian in 2005) within the Study Area (Trianni & Tenorio, 2012).

3.4.1.10 Fin Whale (*Balaenoptera physalus*)

3.4.1.10.1 Status and Management

Fin whales are listed as endangered under the ESA, but there is no designated critical habitat for this species. The stock structure of fin whales remains uncertain (Mizroch et al., 2009), and fin whales in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2019c; Muto et al., 2019). NMFS recognizes three stocks of fin whales in the North Pacific (Carretta et al., 2019c; Muto et al., 2019), and none of the ranges described for these stocks include the Study Area.

3.4.1.10.2 Geographic Range and Distribution

Fin whales prefer temperate and polar waters; they are rarely seen in warm, tropical waters and are not expected south of 20°N latitude (Miyashita et al., 1996; Reeves et al., 2002). There are no sighting records for fin whales in the Study Area (Fulling et al., 2011; Hill et al., 2017a; Hill et al., 2018c; Hill et al.,

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1,300,000 square kilometers; see Chapter 2 (Description of Proposed Action and Alternatives) for more details with regard to the extent of the MITT Study Area. The MISTCS abundance estimates from the 2007 survey as reported in Fulling et al. (2011) and cited throughout this section, thus represent the number of marine mammals estimated to be present in the approximately 24 percent of the MITT Study Area covered by the MISTCS survey.

2019; Oleson et al., 2015; Uyeyama, 2014). Based on acoustic detections, fin whales are expected to be seasonally present in the Study Area although few in number. Acoustic detections from passive monitoring devices deployed at Saipan and Tinian have recorded the presence of fin whales over short (a few days) periods of time (Oleson et al., 2015), and fin whale vocalizations were detected in January 2010 in the Transit Corridor between Hawaii and Guam (Oleson & Hill, 2010b). Fin whales were not, however, detected in the Transit Corridor using the same equipment and methods in May of that year (Oleson & Hill, 2010b).

3.4.1.10.3 Population and Abundance

There is no current abundance estimate available for fin whales in the Study Area (Carretta et al., 2019c; Muto et al., 2019).There were approximately 50,000 reported fin whales killed during commercial whaling in the North Pacific from 1911 to 1985 (C. Allison, pers. comm. as provided in Mizroch et al. (2009), and it is assumed the population is still recovering.

3.4.1.10.4 Predator-Prey Interactions

Fin whale prey vary by region and may include krill, small invertebrates such as copepods, squid, and schooling fish such as capelin, herring, pollock, and mackerel (Goldbogen et al., 2006; Jefferson et al., 2015; Mizroch et al., 2009).

The fin whale is not known to have a significant number of predators. However, in regions where killer whales are abundant, some fin whales exhibit attack scars on their flippers, flukes, and flanks, suggesting possible predation by killer whales (Aguilar de Soto et al., 2008).

3.4.1.10.5 Species-Specific Threats

Fin whales are susceptible to entanglement in fishing gear (Carretta et al., 2013; Carretta et al., 2016b; Carretta et al., 2017a; Helker et al., 2015; National Oceanic and Atmospheric Administration, 2019). Given this and as discussed in Section 3.4.1.7.3 (Bycatch) for other species, entanglement risk includes fishing activities out of Japan and South Korea.

3.4.1.11 Humpback Whale (*Megaptera novaeangliae*)

3.4.1.11.1 Status and Management

Humpback whales in the Study Area are indirectly addressed in the Alaska SAR given that the historic range of humpbacks in the "Asia wintering area" includes the Mariana Islands. The detected presence of humpbacks in the Mariana Islands (Fulling et al., 2011; Hill et al., 2016a; Hill et al., 2017a; Hill et al., 2018b; Hill et al., 2018c; Hill et al., 2019; Klinck et al., 2016b; Munger et al., 2014; Oleson et al., 2015; Uyeyama, 2014) are consistent with the Study Area as a plausible migratory destination for humpback whales from Alaska (Muto et al., 2017; Muto et al., 2018; Muto et al., 2019).

Effective as of October 11, 2016, NMFS changed the status of all humpback whales from an endangered species to a specific status for each of 14 newly identified distinct population segments (DPS) (81 FR 62259). For the Study Area, the Navy believes it is likely that humpback whales in the Mariana Islands are part of the endangered Western North Pacific DPS based on the available science (Bettridge et al., 2015; Calambokidis et al., 2008; Calambokidis et al., 2010; Carretta et al., 2017c; Carretta et al., 2017d; Hill et al., 2017b; Hill et al., 2018c; Hill et al., 2019; Hill et al., 2020; Muto et al., 2017; Muto et al., 2018; Muto et al., 2019; National Marine Fisheries Service, 2016b; National Oceanic and Atmospheric Administration, 2015a, 2018c; Wade et al., 2016). Humpback whales from the winter range of the Western North Pacific DPS (including the Study Area) that feed in the summer off Russia and Alaska have been designated by NMFS as the Western North Pacific Stock (Muto et al., 2019). As part of the Western North Pacific Stock, the population is considered depleted under the MMPA (Muto et al., 2017; Muto et al., 2018; Muto et al., 2019).

There has been no critical habitat designated for the Western North Pacific Distinct Population Segment.

3.4.1.11.2 Geographic Range and Distribution

Between 1948 and 1979, Soviet Union commercial whaling alone took 7,344 humpback whales from the North Pacific (Ilyashenko & Chapham, 2014). It is therefore likely that humpback whales in the western North Pacific are still recovering and will remain rare in parts of their former range. Researchers have concluded that humpback whales use the Mariana Islands as a winter breeding and calving area (Hill et al., 2016a; Hill et al., 2018c; Hill et al., 2019; Hill et al., 2020; National Oceanic and Atmospheric Administration, 2018c).

For purposes of the analysis presented in this SEIS/OEIS, the Navy assumes humpback whales in the Study Area are part of the endangered Western North Pacific DPS.[3] This population segment is based on a known breeding group of individuals found off Okinawa and Ogasawara Islands (approximately 1,230 nautical miles [NM] north of Guam) in Japan waters and in Philippine waters (approximately 1,350 NM west of Guam), as identified by photographic identification of individuals (Calambokidis et al., 2008; Calambokidis et al., 2010), in addition to an "unknown breeding group" from a location in the western North Pacific that remained unidentified until recently (National Oceanic and Atmospheric Administration, 2018c). Humpback whales found off Okinawa, Ogasawara, the Philippines, and the unknown area were combined to form the Western North Pacific population (Bettridge et al., 2015). This "unknown area" corresponds to the historical range for the western North Pacific that included waters extending from the South China Sea east through the Philippines, the Ryukyu Islands, Mariana Islands, and Marshall Islands and from there, north to the Arctic (Muto et al., 2017; Muto et al., 2018; Muto et al., 2019; Rice, 1998). Photographic data collected during Navy-funded small boat surveys has provided matches to individuals identified many years previously off the Ogasawara Islands and the Western North Pacific DPS (Hill et al., 2017a; Hill et al., 2017b; Hill et al., 2018b; Hill et al., 2018c; Hill et al., 2019). Completed analyses of genetic samples to date have found humpback whale in the Mariana Islands share four haplotypes[4] 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., 2018c; Hill et al., 2020). Findings from analysis of additional biopsy samples from humpback whales in the Mariana Islands have not yet been published, although DNA analyses are underway, and additional data will be necessary before there can be any

[3] There is reference to a "Second West Pacific DPS" in the latest NMFS humpback whale status report (Bettridge et al., 2015), although that terminology did not carry over into the rule-making establishing the 14 distinct population segments. As a result, although the humpback whales in the Study Area may exactly fit the parameters of the intended "Second West Pacific DPS," in this SEIS/OEIS the Navy has assumed that humpback whales in the Study Area are part of the Western North Pacific Distinct Population Segment consistent with the determinations presented in 81 FR 62259, the range for the Western North Pacific Stock as presented in the Alaska Stock Assessment Report (Muto et al., 2019), and the findings based on a series of small boat surveys in the Mariana Islands (National Marine Fisheries Service, 2018c).

[4] A haplotype is a combination of alleles or polymorphisms found at multiple locations on the same chromosome, that tend to be inherited together. The degree of relatedness can be predicted based on the number of haplotypes shared between individuals.

definitive connection made between humpback whales in the Mariana Islands based on genetic data (Hill et al., 2018c).

Navy aerial monitoring surveys occurring at FDM conducted monthly from 1997 to 2009 and irregularly thereafter documented the occasional presence of humpback whales, including mother-calf pairs and other adult individuals (Uyeyama, 2014). Shipboard survey in the MITT Study Area in February 2007 acoustically detected and subsequently sighted an estimated group of eight humpbacks at Marpi Reef north of Saipan (Fulling et al., 2011; Norris et al., 2012a, 2014). Small boat surveys in 2010 and 2014 off Guam, Saipan, Tinian, Aguijan, and Rota did not encounter humpback whales (Hill et al., 2014). The next documented observations of humpback whales in the Mariana Islands occurred from February 26 to March 8, 2015, when four mother/calf pairs and four other individual humpback whales were observed at Chalan Kanoa Reef off Saipan (Hill et al., 2015a; Hill et al., 2016b). During the subsequent NMFS Mariana Archipelago Cetacean Survey (two months later; May 8 to June 6, 2015), survey transects sampling all the Mariana Islands out to 50 NM from shore detected no humpback whales visually or acoustically in the Mariana Islands (Hill et al., 2018d; Hill et al., 2019; Oleson, 2017). Humpback whales were seen again off Saipan during Navy-funded surveys in 2016, 2017, and 2018 (Hill et al., 2017a; Hill et al., 2017b; Hill et al., 2018b; Hill et al., 2019; Hill et al., 2020; National Marine Fisheries Service, 2019; National Oceanic and Atmospheric Administration, 2018c); see Appendix I (Geographic Mitigation Assessment) for additional details regarding all humpback whale sightings in the MITT Study Area. These Navy-funded small boat survey investigations have included photo-identification and genetic sampling and have resulted in the documentation of mother-calf pairs, competitive groups, and 43 additional photo-identified non-calf whales that include seven individuals that were photographed in a previous year (Fulling et al., 2011; Hill et al., 2017a; Hill et al., 2017b; Hill et al., 2018b; Hill et al., 2019; Hill et al., 2020; National Oceanic and Atmospheric Administration, 2018c; Norris et al., 2012a, 2014). The presence of newborn calves and competitive groups documented during the aforementioned small boat surveys confirm the Mariana Islands are serving as a breeding location for Western North Pacific DPS humpback whales (Hill et al., 2019; Hill et al., 2020; National Oceanic and Atmospheric Administration, 2018c). Investigations in Hawaii over consecutive breeding seasons between 1997 through 2008 in the Maui Basin found a preference by individual mother-calf pairs for both water depth and sea-bed terrain type, with the pair moving into deeper water and rougher terrain as a calf matured (Pack et al., 2017); this habitat preference by mother-calf pairs may also be present in the Mariana Islands.

Based on a compendium of all detections, humpback whales have been sighted in the Study Area in the months of January through March (U.S. Department of the Navy, 2005; Uyeyama, 2014), male humpback songs have been recorded from December through April, and humpback whale sounds were infrequently detected at Tinian during June to October (Hill et al., 2017a; Hill et al., 2019; Klinck et al., 2016b; Munger et al., 2014; Norris et al., 2014; Oleson et al., 2015). Humpback whales were not observed or acoustically detected in the Transit Corridor during a May 2010 survey (Oleson & Hill, 2010b), which is consistent with the presumption that, except when migrating to or from summer feeding areas, humpback whales will most likely be present in relative shallow water locations in the vicinity of the Mariana Islands.

Humpback whales from the Western North Pacific, Hawaii, and Mexico DPSs overlap to some extent on feeding grounds off Alaska (Bettridge et al., 2015; Muto et al., 2017; Muto et al., 2018; Muto et al., 2019; National Marine Fisheries Service, 2016d; Titova et al., 2017; Wade et al., 2016). Photographic identification data have also documented the presence of at least one whale seen multiple years off Ogasawara (Japan) later seen feeding off British Columbia (Darling et al., 1996), and studies of similarities in humpback whale song across the Pacific (Darling et al., 2019) indicate there may be greater overlap of DPSs in the summer feeding areas than has been characterized in the SARs for Alaska and the Pacific (Carretta et al., 2017c; Carretta et al., 2017d; Carretta et al., 2018b; Carretta et al., 2019c; Muto et al., 2017; Muto et al., 2018; Muto et al., 2019). Comparison of photographic identification data from Russian waters (where the Western North Pacific DPS humpback whales may also feed) has found 35 individual whales that were also documented in Hawaii and 11 that were from the Mexican breeding grounds (Titova et al., 2017).

3.4.1.11.3 Population and Abundance

Based on photographic identifications off Okinawa and Ogasawara gathered previously and conclusions reached in 2008 (Calambokidis et al., 2008), the abundance of humpback whales in the Western North Pacific population was estimated to be approximately 1,000 individuals (Bettridge et al., 2015; Muto et al., 2017). From that same data set, the growth rate of the Western North Pacific Distinct Population Segment was estimated to be 6.9 percent (Bettridge et al., 2015; Calambokidis et al., 2008). This can be viewed in context of the North Pacific population, which has been increasing at a rate of between 5.5 percent and 6.0 percent per year, approximately doubling every 10 years (Bettridge et al., 2015; Muto et al., 2017; Wade et al., 2016).The inclusion of more recent data from photographic identifications off Okinawa has documented the presence of at least 1,402 unique individuals in the Western North Pacific Distinct Population Segment (Kobayashi et al., 2016). Additional information from Navy-funded surveys and passive acoustic hydrophone recordings in the Mariana Islands has confirmed the presence of mother-calf pairs, non-calf whales, and singing males in the Study Area (Fulling et al., 2011; Hill et al., 2016a; Hill et al., 2019; Munger et al., 2014; Munger et al., 2015; National Marine Fisheries Service, 2019; National Oceanic and Atmospheric Administration, 2018c; Norris et al., 2014; Oleson & Hill, 2010b; Oleson et al., 2015; Uyeyama et al., 2012). The NMFS Alaska SAR provides a population estimate for humpbacks in Ogasawara Islands, Okinawa, and the Philippines of 1,107 animals, with a minimum population of 865, noting that these are likely to be an underestimate of the Western North Pacific Stock's true abundance (Muto et al., 2017; Muto et al., 2018; Muto et al., 2019). Although not specific to the Study Area, the overall abundance of humpback whales in the North Pacific was recently estimated at 21,808 individuals (Carretta et al., 2017c; Carretta et al., 2017d), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al., 2011; Bettridge et al., 2015; Muto et al., 2017; Muto et al., 2018; Wade et al., 2016).

3.4.1.11.4 Predator-Prey Interactions

When on the summer feeding grounds in Alaska, humpback whales from the Study Area feed on a wide variety of invertebrates and small schooling fishes. The most common invertebrate prey are krill (tiny crustaceans); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham & Mead, 1999). Feeding occurs both at the surface and in deeper waters, wherever prey is abundant. Humpback whales are the only species of baleen whale that show strong evidence of cooperation when they feed in large groups (D'Vincent et al., 1985).

This species is known to be attacked by both killer whales and false killer whales as evidenced by tooth rake scars on their bodies and fins (Jefferson et al., 2015; Steiger et al., 2008).

3.4.1.11.5 Species-Specific Threats

Based on data from Alaska (including the Western North Pacific Stock), Hawaii, and the U.S. Pacific coast (Bradford & Lyman, 2015; Carretta et al., 2019a; Carretta et al., 2016c; Carretta et al., 2017b; Helker et al., 2019; Helker et al., 2017; National Oceanic and Atmospheric Administration, 2019), humpback whales are subject to risk from entanglement in marine debris and active fishing gear; most often recorded is pot/trap fishery gear. As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that three products contained humpback whale meat (Baker et al., 2006a).

The mean vessel collision mortality and serious injury rate in Alaska is 4.2 humpback whales annually (Muto et al., 2019), but that rate reflects Southeast Alaska waters where the presence of the Western North Pacific Stock is less likely.

3.4.1.12 Minke Whale (*Balaenoptera acutorostrata*)

3.4.1.12.1 Status and Management

Minke whales are not listed as endangered under the ESA. The stock structure for minke whales remains uncertain in the Pacific, and minke whales in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2019c; Muto et al., 2019). NMFS recognizes three stocks of minke whales in the North Pacific: (1) the Hawaii Stock, (2) the California/Oregon/Washington Stock, and (3) the Alaska Stock (Carretta et al., 2019c; Muto et al., 2019).

3.4.1.12.2 Geographic Range and Distribution

Surveys employing towed hydrophone arrays and sonobuoys, and long-term monitoring efforts using fixed passive acoustic recording devices, have routinely detected the presence of minke whales in the Study Area (Klinck et al., 2016a; Norris et al., 2017; Oleson & Hill, 2010b; Oleson et al., 2015). Minke whales have not been visually detected in the Study Area during any survey efforts within approximately the last decade although they are the most common acoustically detected mysticete in the area (Fulling et al., 2011; Hill et al., 2011; Hill et al., 2013a; Hill et al., 2014; Hill et al., 2015b; Hill et al., 2017a; Mobley, 2007; Norris et al., 2014; Oleson & Hill, 2010b; Tetra Tech Inc., 2014; Uyeyama, 2014).

3.4.1.12.3 Population and Abundance

No estimates have been made for the number of minke whales in the North Pacific (Carretta et al., 2019c; Muto et al., 2019). Acoustic data collected during a Navy-funded 2007 line-transect survey employing a towed hydrophone array in the Mariana Islands were used to estimate a minimum abundance of calling minke whales (Norris et al., 2017). Abundance was estimated using two different methodologies, resulting in minimum estimates of 80 or 91 animals in the surveyed area (a density of 0.13 and 0.15 animals per 1,000 square kilometers, respectively; CV = 0.34) (Norris et al., 2017). This study provided the first abundance and density estimates for calling minke whales and the first minimum estimates by which the number of minke whales in the Mariana Islands region could be derived.

3.4.1.12.4 Predator-Prey Interactions

Similar to other rorquals, minke whales are lunge feeders, often plunging through patches of shoaling fish or krill (Hoelzel et al., 1989; Jefferson et al., 2008). In the north Pacific, their major prey include small invertebrates, krill, capelin, herring, pollock, haddock, and other small shoaling fish (Jefferson et al., 2008; Kuker et al., 2005; Lindstrom & Haug, 2001). Minke whales are prey for killer whales (Ford & Ellis, 1999; Ford et al., 2005; Weller, 2009).

3.4.1.12.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk for the population of minke whales includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Dalebout et al., 2002a; Lukoschek et al., 2009). For example in 2008, the reported bycatch in Japan and South Korea totaled 214 minke whales (Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that 230 products contained minke whale meat (Baker et al., 2006a). In the two-year period between 2013 and 2014, the total bycatch by South Korean fisheries in the East Sea totaled a reported 48 minke whales (Song, 2017).

3.4.1.13 Omura's Whale (*Balaenoptera omurai*)

3.4.1.13.1 Status and Management

Omura's whale is not listed under the ESA and is not mentioned in the Pacific or Alaska SARs (Carretta et al., 2019c; Muto et al., 2019). There is no managed stock or population within U.S. waters pursuant to the MMPA, but the species is protected under that statute nonetheless, as are all marine mammals.

3.4.1.13.2 Geographic Range and Distribution

The species was first described in 2003 based on eight specimens taken by Japanese research whaling vessels in the Sea of Japan, the Solomon Sea, and the eastern Indian Ocean (Cerchio et al., 2019; Wada et al., 2003). Records of the species from Philippines shore-based whaling provide additional indication of a broad distribution that includes the western Pacific (Cerchio et al., 2015; Cerchio et al., 2019). Given the documented occurrence of the species, it is assumed the species may be present in the Study Area. Recent well-documented sightings have occurred in nearshore waters off Korea, Madagascar, and Sri Lanka, indicating in those cases a preference for relatively shallow water less than approximately 200 m in depth (Cerchio et al., 2015; Cerchio et al., 2019; de Vos, 2017).

3.4.1.13.3 Population and Abundance

There are no data available to estimate abundance for Omura's whale in the Study Area.

3.4.1.13.4 Predator-Prey Interactions

Observations of feeding Omura's whales in waters off Madagascar suggested the animals were skim feeding on zooplankton given there was an absence of fish or other observable prey (Cerchio et al., 2015), which also corresponds to an account of four individuals feeding on krill in waters off Borneo (Cerchio et al., 2019).

3.4.1.13.5 Species-Specific Threats

An individual Omura's whale observed in Sri Lanka waters showed evidence of an entanglement scar on the left side of its upper jaw, indicating that entanglement is a potential threat for this species (Cerchio et al., 2015; Cerchio et al., 2019; de Vos, 2017). One Omura's whale was reported struck by a fishing boat in the Philippines (Obusan et al., 2016), and there is record of one known strike off Japan (Cerchio et al., 2019).

3.4.1.14 Sei Whale (*Balaenoptera borealis*)

3.4.1.14.1 Status and Management

Sei whales are listed as endangered under the ESA, but there is no designated critical habitat for this species. The stock structure for sei whales is uncertain in the Pacific (Carretta et al., 2017c; Carretta et al., 2017d; Carretta et al., 2019c). NMFS recognizes three stocks of sei whales in the North Pacific: (1) the Hawaii Stock, (2) the California/Oregon/Washington Stock, and (3) the Alaska Stock. The western Pacific and waters within the Study Area have not been addressed by NMFS, and sei whales in the Study Area have not been assigned to a stock (Carretta et al., 2019c; Muto et al., 2019).

3.4.1.14.2 Geographic Range and Distribution

In a January–February survey in 1972, a single group of approximately 13 sei whales were sighted during a survey of the Mariana Islands and Ogasawara (Masaki, 1972). In the 2007 survey of the Mariana Islands (Fulling et al., 2011), a total of 16 sei whales were sighted. Sei whale calls documented during the 2007 survey indicated a greater variability in the vocal repertoire of sei whales than documented elsewhere (Norris et al., 2014), which may have contributed to the lack of acoustic detections in the three-year record from 2010 to 2013 (Oleson et al., 2015). Sei whales were also visually detected in the Transit Corridor between the Study Area and Hawaii during a NMFS survey in January 2010 (Oleson & Hill, 2010b).

3.4.1.14.3 Population and Abundance

During a 2007 systematic survey of the Study Area, sei whales were sighted on 16 occasions with a resulting abundance estimate of 166 individuals (CV = 0.49) (Fulling et al., 2011).

3.4.1.14.4 Predator-Prey Interactions

In the North Pacific, sei whales feed on a diversity of prey, including copepods, krill, fish [specifically sardines and anchovies], and cephalopods [squids, cuttlefish, octopuses] (Horwood, 1987; Horwood, 2009; Nemoto & Kawamura, 1977). Feeding occurs primarily around dawn, which appears to be correlated with vertical migrations of prey species (Horwood, 2009). As with other mysticetes, sei whales have been observed lunging and gulping dense concentrations of prey, but more often tend to obtain prey by skimming (Horwood, 2009). Sei whales, like other large baleen whales, are likely subject to occasional attacks by killer whales.

3.4.1.14.5 Species-Specific Threats

Based on the discovery of a sei whale entangled in rope and fishing gear in Hawaii that presumably came from Alaska (Bradford & Lyman, 2015), sei whales may be subject to entanglement from fishery activity taking place in the western Pacific, including the Study Area. Based on the statistics of other large whales along the U.S. Pacific coast and Alaska (Carretta et al., 2019a; Helker et al., 2019), it is likely that ship strikes also pose a threat to sei whales in the Study Area from commercial vessels transiting that area.

Odontocetes

3.4.1.15 Blainville's Beaked Whale (*Mesoplodon densirostris*)

3.4.1.15.1 Status and Management

Blainville's beaked whale is not listed under the ESA. The stock structure for Blainville's beaked whales remains uncertain in the western Pacific, and Blainville's beaked whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c). NMFS recognizes a single stock of Blainville's beaked whales in the Pacific in Hawaiian waters (Carretta et al., 2019c).

3.4.1.15.2 Geographic Range and Distribution

Blainville's beaked whales are one of the most widely distributed of the toothed whales within the *Mesoplodon* genus, occurring in temperate and tropical deep waters areas in all oceans (Jefferson et al., 2015; MacLeod, 2000; MacLeod & Mitchell, 2006). In Hawaii, some populations have been documented to be long-term residents to particular areas (Baird et al., 2009b; Baird, 2011; Baird et al., 2015; McSweeney et al., 2007). There were two *Mesoplodon* whale sightings during the 2007 survey of the Study Area, over the West Mariana Ridge, but they were not identified to the species level (Fulling et al., 2011). During the 2015 NMFS survey of the Mariana Islands, two groups of Blainville's beaked whales were identified and photographed in addition to seven other beaked whale sightings identified only as *Mesoplodon* beaked whales (Hill et al., 2018d; Oleson, 2017). During Navy-funded 2010–2018 small boat surveys in the Mariana Islands, five *Mesoplodon* beaked whales were encountered on two occasions in a median depth of approximately 1,140 m and median approximate distance from shore of 15 km (Hill et al., 2013a; Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2018d; Hill et al., 2019). It could not be determined if these were Blainville's beaked whales or ginkgo-toothed beaked whales, both of which belong to the genus *Mesoplodon* and are believed to be present in the Study Area. Acoustic monitoring has indicated that Blainville's beaked whales occur regularly and year-round in the Study Area (Klinck et al., 2016a; Oleson et al., 2015; Tetra Tech Inc., 2014). Although there is no record of similar occurrences in the Mariana Islands, it has been suggested that the Philippines are a stranding "hot spot" for Blainville's beaked whales in Asia (Bachara & Blatchley, 2018).

3.4.1.15.3 Population and Abundance

There are no abundance estimates for Blainville's beaked whales in the Study Area.

3.4.1.15.4 Predator-Prey Interactions

All beaked whales probably feed at or close to the bottom in deep oceanic waters, taking suitable prey opportunistically or as locally abundant, typically by suction feeding (Heyning & Mead, 1996; Jefferson et al., 2015; Werth, 2006a, 2006b). Feeding may also occur at mid-water as shown by tagging data from Blainville's beaked whales (Baird et al., 2005; Baird et al., 2006c). Blainville's beaked whales are known to echolocate in groups when they are on foraging dives, which makes them more easily detectable by passive acoustic means (Moretti & Baird, 2015). *Mesoplodon* beaked whales have been observed being actively preyed upon by killer whales (Wellard et al., 2016).

3.4.1.15.5 Species-Specific Threats

There were five observed interactions between an unidentified beaked whale, unidentified Mesoplodont beaked whale, or Blainville's beaked whale and longline fishing activities in Hawaiian waters between 2010 and 2014 (Bradford & Forney, 2016, 2017). As similar information for U.S. fishing vessels or foreign fishing vessels in the Study Area is unavailable, this data from Hawaii provides information regarding the species interactions with fishing activities in general. As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated at least one product contained Blainville's beaked whale meat (Baker et al., 2006a).

3.4.1.16 Common Bottlenose Dolphin (*Tursiops truncatus*)

3.4.1.16.1 Status and Management

Bottlenose dolphin is not listed under the ESA. The stock structure for bottlenose dolphin remains uncertain in the western Pacific and the Mariana Islands (Martien et al., 2014b), and bottlenose dolphins in the Study Area have not been assigned to a stock in the current Pacific SAR (Carretta et al., 2019c). Other than small and resident Main Hawaiian island-associated populations of bottlenose dolphins, NMFS recognizes a single pelagic stock of bottlenose dolphin in the Pacific in Hawaiian waters (Carretta et al., 2019c).

3.4.1.16.2 Geographic Range and Distribution

Multiple fishery interactions with bottlenose dolphins in the western North Pacific (Miyashita, 1993b) indicated their presence beginning approximately 400 NM north of the Study Area. It is possible that bottlenose dolphins do not occur in great numbers in the Mariana Island chain, but they have been frequently sighted, although in small numbers. In the main Hawaiian Islands, data suggest that bottlenose dolphins exhibit site fidelity (Baird et al., 2009a; Baird et al., 2013c; Martien et al., 2012). Gannier (2002) noted that large densities of bottlenose dolphins do not occur at the Marquesas Islands and attributed this to the area's lack of a significant shelf component, which would be similar to the MITT Study Area.

Common bottlenose dolphins are generally found in coastal and continental shelf waters of tropical and temperate regions of the world and are known to occur in small enclosed bays or harbors (Martien et al., 2012; Rossman et al., 2015; Wells & Scott, 2009), but they have not been detected in any such enclosed water in the Study Area (such as Apra Harbor). During the 2007 survey of the Mariana Islands, there were three sightings of bottlenose dolphins to the east of Saipan in deep waters near the Mariana Trench (Fulling et al., 2011). Bottlenose dolphins were not detected during the 2010 survey of the Mariana Islands and the Transit Corridor (Oleson & Hill, 2010b), but were detected on three occasions during the 2015 NMFS cetacean survey of the Mariana Islands (Hill et al., 2018d; Oleson, 2017). In total during Navy-funded 2010–2018 small boat surveys in the Mariana Islands, bottlenose dolphins were encountered on 38 occasions in a median depth of approximately 122 m and median approximate distance from shore of 5 km (Hill et al., 2017a; Hill et al., 2018b; Hill et al., 2018c; Hill et al., 2018d; Hill et al., 2019). On multiple occasions, encounters with bottlenose dolphins in the Mariana Islands have involved a mixed-species aggregation with one other species that have included short-finned pilot whales, pantropical spotted dolphins, false killer whales, spinner dolphins, or rough-toothed dolphins (Hill et al., 2011; Hill et al., 2018c; Hill et al., 2018d; Hill et al., 2019).

3.4.1.16.3 Population and Abundance

In some regions of the Pacific, "inshore" and "offshore" or pelagic species differ genetically and morphologically (Baird et al., 2009a; Baird et al., 2013c; Tezanos-Pinto et al., 2009), but this has not been demonstrated for the Mariana Islands (Martien et al., 2014b). A total of 4,610 photos taken during small boat surveys between 2011 and 2014 were analyzed to identify individual bottlenose dolphins. A total of 47 individuals were identified with 30 individuals (64 percent) re-encountered and the remaining 17 of those individuals (36 percent) encountered three or more times (Hill et al., 2017a). These re-encounters occurred between all islands and may be similar to the site fidelity present for some of the island-associated populations present in the Hawaiian Islands (Baird et al., 2009a). Genetic samples from 21 bottlenose dolphins encountered off Guam and Saipan in 2007 suggest a history of hybridization with Fraser's dolphin (Martien et al., 2014b). The Mariana Islands samples shared DNA haplotypes with individuals from the Philippines, South Korea, Taiwan, and the main Hawaiian Islands but precluded determination of any small populations associated with specific locations in the Mariana Islands similar to what has been found in Hawaii (Martien et al., 2014b).

A bottlenose dolphin abundance estimate of 31,700 animals was made for the area approximately 400 NM north of the Mariana Islands (Miyashita, 1993b). There were three sightings of bottlenose dolphin during a 2007 systematic survey of the Study Area, resulting in an abundance estimate of 122 animals (CV = 0.992) (Fulling et al., 2011).

3.4.1.16.4 Predator-Prey Interactions

Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimps (Wells & Scott, 1999, 2009), and using a variety of feeding strategies (Shane, 1990). In addition to using echolocation, bottlenose dolphins detect and orient fish prey by listening for the sounds their prey produce (i.e., passive listening) (Gannon et al., 2005). Nearshore bottlenose dolphins prey predominantly on coastal fish and cephalopods, while offshore individuals prey on open ocean cephalopods and a large variety of near-surface and mid-water fish species (Mead & Potter, 1995). Throughout their range bottlenose dolphins are known to be preyed on by killer whales and sharks (Ferguson et al., 2012; Heithaus, 2001a; Heithaus, 2001b; Sprogis et al., 2018; Wells & Scott, 1999).

3.4.1.16.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least two products contained bottlenose dolphin meat, reflecting an estimated 23 bottlenose dolphins (Baker et al., 2006a). The stranding of a single bottlenose dolphin in 2013 near Tumon, Guam, is the only known stranding for this species in the Mariana Islands area (Uyeyama, 2014).

3.4.1.17 Cuvier's Beaked Whale (*Ziphius cavirostris*)

3.4.1.17.1 Status and Management

Cuvier's beaked whale is not listed under the ESA. The stock structure for Cuvier's beaked whales remains uncertain in the western Pacific, and Cuvier's beaked whales in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2019c; Muto et al., 2019). With the exception of the U.S. West Coast, NMFS only recognizes a stock of Cuvier's beaked whale in the Pacific in Hawaiian waters (Carretta et al., 2017c; Carretta et al., 2017d; Carretta et al., 2019c) and in the "eastern North Pacific" and Alaskan waters (Muto et al., 2019), whose distribution does not extend to the Study Area.

3.4.1.17.2 Geographic Range and Distribution

Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres (Ferguson et al., 2006a; Ferguson et al., 2006b; Jefferson et al., 2008; Pitman et al., 1988). Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters. They are commonly sighted around seamounts, escarpments, and canyons (MacLeod et al., 2004). Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 655 feet (ft.) (200 m) and are frequently recorded in waters with bottom depths greater than 3,280 ft. (1,000 m) (Falcone et al., 2009; Jefferson et al., 2008). While there are indications of potential seasonal re-distribution of Cuvier's beaked whales and documented satellite tag movements in Southern

California waters (Falcone & Schorr, 2014; Moretti, 2017; Schorr et al., 2014; Schorr et al., 2018), no such research findings are available from the Mariana Islands. A study spanning 21 years off the west coast of the Island of Hawaii suggests that this species may show long-term site fidelity in certain areas (McSweeney et al., 2007).

During aerial surveys conducted in August 2007 covering 2,352 km of linear effort, a single Cuvier's beaked whale was observed about 65 NM south of Guam at the edge of the Mariana Trench (Mobley, 2007). One ziphiid whale (the taxon that Cuvier's beaked whales belong to) was observed in deep water during the 2007 shipboard survey of the Study Area but was not identified to the species level (Fulling et al., 2011). A single Cuvier's beaked whale was sighted and others acoustically detected during an August 2013 survey at Pagan Island (Tetra Tech Inc., 2014). A year's duration of acoustic monitoring at Saipan and at Tinian recorded vocalizing Cuvier's beaked whales (Oleson et al., 2015). These vocalizations were detected in all months having sufficient samples to detect their presence in the Study Area, suggesting there is no seasonal aspect to the Cuvier's beaked whale's distribution.

3.4.1.17.3 Population and Abundance

There are no abundance estimates for Cuvier's beaked whales in the Study Area.

3.4.1.17.4 Predator-Prey Interactions

Cuvier's beaked whales, similar to other beaked whale species, are deepwater feeders. Stomach content analyses show that they feed mostly on deep-sea squid, fish, and crustaceans (Hickmott, 2005; Santos et al., 2007). They apparently use suction to swallow prey (Jefferson et al., 2008; Werth, 2006b).

Cuvier's beaked whales may be preyed upon by killer whales (Heyning & Mead, 2009; Jefferson et al., 2008).

3.4.1.17.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least one product contained Cuvier's beaked whale meat (Baker et al., 2006a).

Single Cuvier's beaked whales were found stranded on Saipan in 2007, and on Rizal Beach, Guam, in 2008 (*Ziphius* sp.). One out of area beaked whale was sighted at-sea in water less than 200 m, but with close proximity of deep water, it is unclear if this sighting was an in-distress animal, or some as yet unknown normal behavior. Two beaked whales were found (one alive and one dead) on Micro Beach, Saipan, in 2011 (Uyeyama, 2014). A necropsy conducted on one of the 2011 stranded animals revealed abnormalities in the animal's kidneys and intestines (Hawaii Pacific University, 2012; Saipan Tribune, 2011). Two strandings of Cuvier's beaked whales occurred in 2015; one in March and one in July. The individual that stranded in March 2015 had a severe Crassicauda (nematode) infestation in its kidneys (West, 2018). The individual stranded in July 2015 was not accessible for transport until days after the stranding and, because of the resulting decomposition, necropsy and histopathology was not conducted for this whale (West, 2018). One stranding occurred on Guam in 2016 (alive and pushed back to sea). A stranding of a single whale occurred on Guam in 2019, with necropsy finding the animal to be young and in good body condition. A stranding of a single whale occurred on Rota in 2019, in which the milling animal went back to sea.

3.4.1.18 Dwarf Sperm Whale (*Kogia sima*)

3.4.1.18.1 Status and Management

Dwarf sperm whale is not listed under the ESA. The stock structure for dwarf sperm whales remains uncertain in the western Pacific, and dwarf sperm whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c). Other than for waters along the U.S. West Coast, NMFS recognizes a single stock of dwarf sperm whale in the Pacific in Hawaiian waters (Carretta et al., 2019c).

3.4.1.18.2 Geographic Range and Distribution

Records of this species have been documented from the western Pacific (Taiwan and Japan) (Sylvestre, 1988; Wang et al., 2001; Wang & Yang, 2006), and there have been four known dwarf sperm whale strandings in the Mariana Islands (Trianni & Tenorio, 2012; Uyeyama, 2014).

There were no species of *Kogia* sighted during the 2007 shipboard survey of the Study Area, although this cryptic species is difficult to detect, particularly in the high sea states that are normally present in the Mariana Islands (Fulling et al., 2011). Aerial surveys in August 2007 covering 2,352 km of linear effort encountered three dwarf sperm whales (Mobley, 2007). In total during Navy-funded 2010–2018 small boat surveys in the Mariana Islands, five dwarf sperm whales have been encountered on four occasions in a median depth of approximately 750 m and at a median distance of approximately 3 km from shore (Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2019).

3.4.1.18.3 Population and Abundance

There are no abundance estimates for dwarf sperm whales in the Study Area.

3.4.1.18.4 Predator-Prey Interactions

Dwarf sperm whales feed on cephalopods and, less often, on deep sea fishes and shrimps (Caldwell & Caldwell, 1989; Sekiguchi et al., 1992). Dwarf sperm whales are believed to generally forage near the seafloor (McAlpine, 2009).

Killer whales are predators of dwarf sperm whales (Dunphy-Daly et al., 2008).

3.4.1.18.5 Species-Specific Threats

Based on data collected in Hawaiian waters, dwarf sperm whales are susceptible to injury or mortality from fisheries interactions (Bradford & Forney, 2014, 2017). It is assumed that fishery activities in the Study Area pose a similar threat to the species.

3.4.1.19 False Killer Whale (*Pseudorca crassidens*)

3.4.1.19.1 Status and Management

The population of false killer whales in the Mariana Islands is not listed under the ESA. The stock structure for false killer whales remains uncertain in the western Pacific (Chivers et al., 2007; Martien et al., 2014a), and false killer whales in the Study Area have not been assigned to a stock in the current SAR for the Pacific (Carretta et al., 2019c). NMFS recognizes multiple stocks of false killer whale in the Pacific within the U.S. Exclusive Economic Zone in Hawaiian waters, at Palmyra Atoll, and waters around America Samoa (Carretta et al., 2019c).

3.4.1.19.2 Geographic Range and Distribution

The false killer whale is an oceanic species, occurring in deep waters of the North Pacific (Miyashita et al., 1996; Wang et al., 2001) but also known to occur close to shore near oceanic islands (Baird, 2012). In

Hawaii, false killer whales have been seen in groups of up to 100 over a wide range of depths and distance from shore (Baird et al., 2003; Baird et al., 2013a; Bradford et al., 2014; Bradford et al., 2015; Oleson et al., 2013). False killer whales are not considered a migratory species, although seasonal shifts in density likely occur. Seasonal movements in the western North Pacific may be related to prey distribution (Odell & McClune, 1999). Satellite-tracked individuals around the Hawaiian islands indicate that false killer whales can move extensively among different islands and also sometimes move from an island coast to as far as 60 mi. (96.6 km) offshore (Baird, 2009b).

During the 2007 survey of the Study Area, there were 10 false killer whale sightings in deep water offshore locations with group sizes ranging from 2 to 26 individuals (Fulling et al., 2011). During the 2010 NMFS survey, one sighting of a pod containing five false killer whales was made approximately midway between Guam and Hawaii in the Transit Corridor (Oleson & Hill, 2010b). During the NMFS 2015 survey of the Mariana Islands, false killer whales were encountered on only two occasions, once off Asuncion Island and once off Alamagan Island, with estimated group sizes of 6–31 individuals (Hill et al., 2018d; Oleson, 2017). In small boat surveys in the Study Area conducted between 2010 and 2018, false killer whales were encountered only on six occasions (Hill et al., 2014; Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2018d; Hill et al., 2019). Three reported false killer whale strandings have been reported between 1963 and 2013; these occurred in 2000, 2003, and 2007 (Trianni & Tenorio, 2012; Uyeyama, 2014).

3.4.1.19.3 Population and Abundance

There are estimated to be about 6,000 false killer whales in the North Pacific (starting approximately 50 NM off the Study Area from 25° N to 39° N latitude) based on fishery interaction data (Miyashita, 1993b). Based on sighting data from the 2007 survey, there were an estimated 637 (CV = 0.74) false killer whales in the Study Area (Fulling et al., 2011).

3.4.1.19.4 Predator-Prey Interactions

False killer whales feed primarily on deep-sea cephalopods and fish (Baird et al., 2008; Koen-Alonso et al., 1999; Odell & McClune, 1999). Four false killer whales found stranded in Hawaii from 2010 through 2016 had stomach contents that included prey items from various squid, yellowfin tuna, mahi mahi, jack, marlin, and bonefish (West, 2016).

False killer whales have been observed to attack other cetaceans, including dolphins and large whales, such as humpback and sperm whales (Baird, 2009a, 2009b). They are known to behave aggressively toward small cetaceans in tuna purse seine nets. Unlike other whales or dolphins, false killer whales frequently pass prey back and forth among individuals before they start to eat the fish, in what appears to be a way of affirming social bonds (Baird et al., 2010b). This species is believed to be preyed on by large sharks and killer whales (Baird, 2009a).

3.4.1.19.5 Species-Specific Threats

Based on a historic decline in the number of false killer whales in Hawaii, which is believed to have been the result of various factors that include incidental take by commercial fisheries (Bradford et al., 2014; Bradford & Forney, 2017; Oleson et al., 2010; Reeves et al., 2009), it should be assumed that foreign and the limited domestic commercial longline fishing in the Study Area may also pose a similar threat to false killer whales in the Mariana Islands. (Allen & Amesbury, 2012; National Marine Fisheries Service, 2015f, 2018d; National Oceanic and Atmospheric Administration, 2018a). Necropsy results from four stranded false killer whales in Hawaii documented stomach contents that included fishing gear (hooks, leaders, and line) in two of the four animals (West, 2016). As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least 19 products contained false killer whale meat (Baker et al., 2006a). In the two-year period between 2013 and 2014, the total bycatch by South Korean fisheries in the East Sea totaled one false killer whale (Song, 2017).

3.4.1.20 Fraser's Dolphin (*Lagenodelphis hosei*)

3.4.1.20.1 Status and Management

Fraser's dolphin is not listed under the ESA. The stock structure for Fraser's dolphin remains uncertain in the western Pacific, and Fraser's dolphin in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c). NMFS recognizes a single stock of Fraser's dolphin in the Pacific in Hawaiian waters (Carretta et al., 2019c).

3.4.1.20.2 Geographic Range and Distribution

Fraser's dolphin is a tropical oceanic species, except where deep water approaches the coast (Dolar, 2009). This species has been found off the Pacific coast of Japan (Amano et al., 1996). Fraser's dolphin does not appear to be a migratory species (Jefferson & Leatherwood, 1994). In Hawaiian waters, Fraser's dolphin was one of the most abundant species offshore, having large pod group sizes with an observed mean of 283 animals (Bradford et al., 2017).

3.4.1.20.3 Population and Abundance

There are no abundance estimates for Fraser's dolphin in the Study Area. Genetic samples from 21 bottlenose dolphins encountered off Guam and Saipan in 2007 suggests a history of hybridization with Fraser's dolphin (Martien et al., 2014b).

3.4.1.20.4 Predator-Prey Interactions

Fraser's dolphin feeds on mid-water fish, squid, and shrimp (Jefferson & Leatherwood, 1994; Mignucci-Giannoni et al., 1999; Perrin et al., 1994a; Watkins et al., 1994).

3.4.1.20.5 Species-Specific Threats

There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in other locations. There is a report of a Fraser's dolphin being taken as a result of a fishery interaction in the Philippines (Obusan et al., 2016). Fraser's dolphin has been subjected to predation by killer whales in the Bahamas (Dunn et al., 2007).

3.4.1.21 Ginkgo-Toothed Beaked Whale (*Mesoplodon ginkgodens*)

3.4.1.21.1 Status and Management

Ginkgo-toothed beaked whale is not listed under the ESA. Due to the difficulty in distinguishing the different *Mesoplodon* beaked whale species during visual surveys, ginkgo-toothed beaked whales are combined with all other *Mesoplodon* species that occur off the U.S. West Coast and are managed by NMFS as a species guild (Carretta et al., 2019c). The stock structure for ginkgo-toothed beaked whale remains uncertain in the western Pacific, and ginkgo-toothed beaked whales present in the Study Area or the remainder of the Pacific have not been assigned to a stock in the current SAR (Carretta et al., 2019c).

3.4.1.21.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep ocean waters (greater than 200 m) and are only occasionally reported in waters over the continental shelf (Cañadas et al., 2002; Ferguson et al., 2006a; MacLeod & D'Amico, 2006; Pitman, 2009). Acoustic monitoring at sites around the North Pacific have encountered the "BWC type" beaked whale vocalizations, which are assumed to be produced by ginkgo-toothed beaked whales (Baumann-Pickering et al., 2012; Oleson et al., 2015). Strandings of ginkgo-toothed beaked whales are not common anywhere, but the largest number of records are from Japan (Baumann-Pickering et al., 2012); there have been no known strandings of the species in the Mariana Islands.

In total, during Navy-funded 2010–2018 small boat surveys in the Mariana Islands, five *Mesoplodon* beaked whales have been encountered on two occasions in a median depth of approximately 1,140 m and median approximate distance from shore of 15 km (Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2018d; Hill et al., 2019); it could not be determined if these were ginkgo-toothed beaked whales, which are believed to be present in the Study Area; or Blainville's beaked whales, which have been observed elsewhere in the Mariana Islands (Hill et al., 2018d; Oleson, 2017).

A year of acoustic monitoring at Saipan and at Tinian recorded the BWC type beaked whale vocalizations assumed to be produced by ginkgo-toothed beaked whales (Oleson et al., 2015). These vocalizations were detected in all months having sufficient samples to detect their presence in the Study Area, suggesting there is no seasonal aspect to their distribution. This correlates with the findings reported from a previous acoustic monitoring site off Saipan where this same signal type was encountered during 24 percent of days sampled (Baumann-Pickering et al., 2012).

3.4.1.21.3 Population and Abundance

There are no abundance estimates for ginkgo-toothed beaked whale in the Study Area.

3.4.1.21.4 Predator-Prey Interactions

All beaked whales probably feed at or close to the bottom in deep oceanic waters, taking suitable prey opportunistically or as locally abundant, typically by suction feeding (Heyning & Mead, 1996; Jefferson et al., 2015; Werth, 2006a, 2006b). Feeding may also occur at mid-water as shown from tagging data from Blainville's beaked whale habits documented in Hawaii (Baird et al., 2005; Baird et al., 2006c). *Mesoplodon* beaked whales have been observed being actively preyed upon by killer whales (Wellard et al., 2016).

3.4.1.21.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of the Philippines, Japan, and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009; Obusan et al., 2016). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated at least one product contained Blainville's beaked whale meat (Baker et al., 2006a), suggesting the same risk may be present for ginkgo-toothed beaked whales. There were five observed interactions between an unidentified beaked whale, unidentified Mesoplodont beaked whale, or Blainville's beaked whale and longline fishing activities in Hawaiian waters between 2010 and 2014 (Bradford & Forney, 2016, 2017). There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in Hawaii.

3.4.1.22 Killer Whale (*Orcinus orca*)

3.4.1.22.1 Status and Management

The stock structure for killer whales remains uncertain in the western Pacific, and killer whales present in the Study Area have not been assigned to a stock in the current SARs (Carretta et al., 2019c; Muto et al., 2019). NMFS recognizes eight stocks of killer whales for the Pacific, but none of the identified ranges are within the Study Area (Carretta et al., 2019c; Muto et al., 2019).

Under the ESA, the Southern Resident Distinct Population Segment of killer whales is the only species listed as endangered, but those animals do not venture beyond the North American nearshore waters. Killer whales in the Study Area are not listed pursuant to the ESA.

3.4.1.22.2 Geographic Range and Distribution

Killer whales are found in all marine habitats from inland and nearshore coastal areas, to the deep mid-ocean, and from equatorial regions to the polar pack ice zones of both hemispheres. Forney and Wade (2006) found that killer whale densities increased by one to two orders of magnitude from the tropics to the poles.

There are accounts of killer whales off the coast of Japan (Kasuya, 1971). Japanese whaling and whaling sighting vessels indicate that concentrations of killer whales occurred north of the Northern Mariana Islands (Miyashita et al., 1995), and the species has been reported in the tropical waters around Guam, Yap, and Palau (Rock, 1993). Between 1987 and 2017 in the Mariana Islands, killer whales in pods of three to five individuals were observed on only six occasions (Eldredge, 1991; Uyeyama, 2014). There was also a badly decomposed killer whale found stranded on Guam in August 1981 (Kami, 1982). There were no sightings of the species during a 2007 systematic line-transect survey (Fulling et al., 2011) or a 2010 survey of the area (Oleson & Hill, 2010b). In May 2010, a group of approximately five killer whales, including one calf, were observed about 20 NM south of Farallon de Medinilla (Uyeyama, 2014; Wenninger, 2010). The Navy-funded small boat surveys between 2010 and 2018 in the Mariana Islands did not encounter any killer whales (Hill et al., 2014; Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2019). Vocalizations from killer whales were detected on three occasions south of Guam by passive acoustic recorders aboard an underwater glider survey in 2014 (Klinck et al., 2016a).

3.4.1.22.3 Population and Abundance

There are no abundance estimates for killer whales in the Study Area.

3.4.1.22.4 Predator-Prey Interactions

Killer whales feed on a variety of prey, including bony fishes, elasmobranchs (a class of fish composed of sharks, skates, and rays), cephalopods, seabirds, sea turtles, and other marine mammals (Fertl et al., 1996; Ford et al., 2013; Ford et al., 2014; Jefferson et al., 2015). In May 2010 during the routine Navy aerial survey of Farallon de Medinilla about 20 mi. (32 km) south of the island, a group of approximately five killer whales, including one calf, were observed feeding on a large whale carcass (Uyeyama, 2014; Wenninger, 2010). The killer whale has no known natural predators; it is considered to be the top predator of the oceans (Ford, 2008).

3.4.1.22.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law

(Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least two products contained killer whale meat (Baker et al., 2006a).

3.4.1.23 Longman's Beaked Whale (*Indopacetus pacificus*)

3.4.1.23.1 Status and Management

Longman's beaked whale is not listed under the ESA. Only one stock has been identified for the Pacific for the population present in Hawaiian waters (Carretta et al., 2019c).The stock structure for Longman's beaked whale remains uncertain in the western Pacific, and the species in the Study Area has not been assigned to a stock in the current SAR (Carretta et al., 2019c).

3.4.1.23.2 Geographic Range and Distribution

Longman's beaked whales are found in warm tropical waters, and most sightings occur in waters with sea surface temperatures warmer than 78°F (26°C) (Anderson et al., 2006; MacLeod et al., 2006; MacLeod & D'Amico, 2006). Based on systematic survey data collected from 1986 to 2005 in the eastern Pacific, all Longman's beaked whale sightings were south of 25° N (Hamilton et al., 2009). Sighting records of this species in the Indian Ocean showed that Longman's beaked whales are typically found in waters over deep bathymetric slopes reaching 200–2,000 m or greater (Anderson et al., 2006).

Although the full extent of this species' distribution is not fully understood, there have been many recorded sightings at various locations in tropical waters of the Pacific and Indian Oceans (Afsal et al., 2009; Dalebout et al., 2002b; Dalebout et al., 2003; Moore, 1972). In the Pacific, records of this species indicate presence in the eastern, central, and western Pacific, including waters off the coast of Mexico and Hawaii. Longman's beaked whales have not been observed or detected acoustically in the Study Area, although it is assumed they are present in the area. In Hawaii, there was a single sighting of approximately 18 Longman's beaked whales during a NMFS 2002 survey (Barlow, 2006). During the follow-on 2010 survey, there were three sightings of Longman's beaked whales, with group sizes ranging from approximately 32 to 99 individuals (Bradford et al., 2017). It is assumed that Longman's beaked whales would have similar grouping behavior in the Study Area.

3.4.1.23.3 Population and Abundance

There are no abundance estimates for Longman's beaked whales in the Study Area.

3.4.1.23.4 Predator-Prey Interactions

All beaked whales probably feed at or close to the bottom in deep oceanic waters, taking suitable prey opportunistically or as locally abundant, typically by suction feeding (Heyning & Mead, 1996; Jefferson et al., 2015; Werth, 2006a, 2006b). Feeding may also occur at mid-water as shown by tagging data from Cuvier's and from Blainville's beaked whales in Hawaii (Baird et al., 2005; Baird et al., 2006c). *Mesoplodon* beaked whales have been observed being actively preyed upon by killer whales (Wellard et al., 2016); it is assumed this may also be the case with Longman's beaked whales.

3.4.1.23.5 Species-Specific Threats

Disease may be relatively common in Longman's beaked whales since morbillivirus was documented in a juvenile male Longman's beaked whale that stranded in Hawaii in 2010 (West et al., 2012) and in five individuals stranded in New Caledonia (Garrigue et al., 2016), and also given the small sample sizes involved in those findings.

There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in Hawaii. There were two observed interactions between unidentified beaked whales and longline fishing activities in Hawaiian waters between 2009 and 2013 (Bradford & Forney, 2016), so it is assumed that interactions with fishing activities in the Mariana Islands may also occur. As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence from three different species of beaked whale were identified (Baker et al., 2006a).

3.4.1.24 Melon-Headed Whale (*Peponocephala electra*)

3.4.1.24.1 Status and Management

Melon-headed whale is not listed under the ESA. The stock structure for melon-headed whales remains uncertain in the western Pacific, and melon-headed whales in the Study Area have not been assigned to a stock in the current Pacific SAR (Carretta et al., 2019c). NMFS recognizes two stocks of melon-headed whales in the Pacific associated with Hawaiian waters (Carretta et al., 2019c).

3.4.1.24.2 Geographic Range and Distribution

Melon-headed whales are found worldwide in tropical and subtropical waters, but movement patterns for this species are poorly understood. It has been suggested that melon-headed whales near oceanic islands rest near shore during the day and feed in deeper waters at night (Brownell et al., 2009a; Gannier, 2002; Woodworth et al., 2012). In surveys around the main Hawaiian Islands, melon-headed whales showed no clear pattern in depth use (Baird, 2013). Melon-headed whales are also known to enter shallow water areas on occasion, although these are generally characterized as animals being "out of habitat" or "mass strandings." Such out-of-habitat events, each involving a few hundred melon-headed whales, have occurred at Sasanhaya Bay, Rota (Jefferson et al., 2006); and in Hawaii (Fromm et al., 2006; Mobley et al., 2007; Southall et al., 2006) on the same day in 2004. Similar numbers did so twice in the Philippines entering Manila Bay in February 2009 and the bay at Odiongan, Romblon in March of 2009 (Aragones et al., 2010; Obusan et al., 2016).

There were two sightings of melon-headed whales during the 2007 survey of the Study Area, with group sizes of 80–109 individuals (Fulling et al., 2011). There was one sighting of approximately 53 individuals southeast of Guam and two mid-ocean sightings (pods sizes of 43 and 72) in the Transit Corridor portion of the Study Area during the large vessel Pacific Islands Fisheries Science Center survey (Oleson & Hill, 2010b). During small boat surveys occurring from 2010 to 2018, melon-headed whales have been encountered on only three occasions, but in large pods numbering between 85 and 380 individuals off Guam and Tinian/Saipan (HDR, 2012; Hill et al., 2014; Hill et al., 2018c; Hill et al., 2019). The NMFS 2015 month-long survey of the Mariana Islands encountered melon-headed whales on four occasions, in offshore waters and in large pods estimated to number between 90 and 268 individuals (Hill et al., 2018d; Oleson, 2017).

There was a live stranding of a melon-headed whale on the beach at Inarajan Bay, Guam in April 1980 (Donaldson, 1983; Kami, 1982), and four individuals at Orote in 2009 (Uyeyama, 2014).

3.4.1.24.3 Population and Abundance

Based on sighting data from a systematic survey in 2007, there were an estimated 2,455 (CV = 0.70) melon-headed whales in the Study Area (Fulling et al., 2011).

3.4.1.24.4 Predator-Prey Interactions

Melon-headed whales prey on squid, pelagic fishes, and occasionally crustaceans. Most of the fish and squid families eaten by this species consist of mid-water forms found in waters up to 1,500 m deep, suggesting that feeding takes place deep in the water column (Baird et al., 2010a; Jefferson & Barros, 1997).

3.4.1.24.5 Species-Specific Threats

Melon-headed whales are believed to be preyed on by killer whales and have been observed fleeing from killer whales in Hawaiian waters (Baird et al., 2006a). The 2016 Pacific SAR (Carretta et al., 2017c; Carretta et al., 2017d) suggested that melon-headed whales may be particularly sensitive to impacts from anthropogenic sounds; see the U.S. Navy's Technical Report (U.S. Department of the Navy, 2017a) for a general discussion of strandings potentially related to the use of sonar and other anthropogenic sound.

3.4.1.25 Pantropical Spotted Dolphin (*Stenella attenuata*)

3.4.1.25.1 Status and Management

The pantropical spotted dolphin is not listed under the ESA. The stock structure for pantropical spotted dolphin remains uncertain in the western Pacific, and pantropical spotted dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c). NMFS recognizes a single pelagic stock and three Hawaiian Island-associated stocks of pantropical spotted dolphin in Hawaiian waters (Carretta et al., 2019c). Results from genetic analyses of pantropical spotted dolphin populations, including the Indo-Pacific and eastern tropical Pacific Ocean (including eight samples from Guam and the Northern Mariana Islands), support the current taxonomy and indicate very close genetic relationships among the Indo-Pacific populations (Leslie & Morin, 2018).

3.4.1.25.2 Geographic Range and Distribution

A survey of the Mariana Islands in 2007 encountered 17 groups of pantropical spotted dolphins, ranging in size from 1 to 115 individuals (Fulling et al., 2011). Aerial surveys in August 2007 covering 2,352 km of linear effort encountered a single pod of 30 pantropical spotted dolphins (Mobley, 2007). In total during the Navy-funded 2010 to 2018 small boat surveys in the Mariana Islands, pantropical spotted dolphins were encountered on 53 occasions in group sizes of 1–145 individuals at a median approximate distance from shore of 6 km (Hill et al., 2014; Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2019). Approximate satellite tag locations from a pantropical spotted dolphin in 2016 demonstrated wide-ranging use of the waters at a median of 6.1 km offshore of Guam (Hill et al., 2017a), although they have also been encountered off Rota, Antiguan, Tinian, and Saipan (Hill et al., 2018c).

3.4.1.25.3 Population and Abundance

Based on sighting data from the 2007 systematic survey of the Mariana Islands, the estimated abundance for pantropical spotted dolphins in the Study Area is 12,981 (CV = 0.704) (Fulling et al., 2011).

3.4.1.25.4 Predator-Prey Interactions

Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans and on some mid-water species (Perrin & Hohn, 1994). Results from various tracking and feeding studies suggest that pantropical spotted dolphins in the eastern tropical Pacific and off Hawaii feed primarily at night on surface and mid-water species that rise with the deep scattering layer toward the water's surface after dark (Baird et al., 2001; Silva et al., 2016).

3.4.1.25.5 Species-Specific Threats

There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in other locations. Pantropical spotted dolphins in Hawaii and Samoa have been observed interacting with the longline fishery, resulting in injury (Bradford & Forney, 2014), and there was one case of serious injury to a spotted dolphin observed entangled in fishing line (Bradford & Lyman, 2015). Given the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

Pantropical spotted dolphins may be preyed on by killer whales and sharks and have been observed fleeing killer whales in Hawaiian waters (Baird et al., 2006b). Other predators may include the pygmy killer whale, false killer whale, and occasionally the short-finned pilot whale (Perrin, 2009b).

3.4.1.26 Pygmy Killer Whale (*Feresa attenuata*)

3.4.1.26.1 Status and Management

The pygmy killer whale is not listed under the ESA. The stock structure for pygmy killer whale remains uncertain in the western Pacific, and pygmy killer whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c).

3.4.1.26.2 Geographic Range and Distribution

This species has been documented in the western Pacific (Taiwan and Japan) (Sylvestre, 1988; Wang et al., 2001; Wang & Yang, 2006). Like similar deep-water and deep-diving cetaceans, pygmy killer whales are likely highly mobile in the marine environment with no known concentration areas in the Mariana Islands. There was only one pygmy killer whale sighting of a group of six animals during the 2007 systematic survey of the Study Area (Fulling et al., 2011). The sighting occurred near the Mariana Trench, south of Guam, where the bottom depth was 14,564 ft. (4,413 m). This is consistent with the known habitat preference of this species for deep, oceanic waters. In the Study Area, where there are deep waters relatively close to the islands, pygmy killer whale sightings close to shore are not unexpected. During small boat surveys between 2010 and 2018, there was a single pygmy killer whale sighting northeast of Saipan in 2011 and then single sightings in 2013 and 2014 off Guam; group sizes were from six to nine individuals (Hill et al., 2014; Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2019). Median distance from shore for these sightings was 6.9 km (range 1.1–10 km). There is no information on the wider distribution of pygmy killer whales in the Study Area given the limitations of the survey coverage (Hill et al., 2019). Boat surveys for the most recent pygmy killer whale sightings between 2010 and 2018 are typically of short duration (day-trips over a period of 6–20 days) and may not reflect year-round occurrence or distribution (Hill et al., 2019).

3.4.1.26.3 Population and Abundance

Based on a single sighting during the 2007 survey of the Study Area, pygmy killer whale abundance was estimated at 78 individuals (CV = 0.881) (Fulling et al., 2011).

3.4.1.26.4 Predator-Prey Interactions

Pygmy killer whales feed predominantly on fish and squid. They have been known to attack other dolphin species, apparently as prey, although this is not common (Jefferson et al., 2015; Perryman & Foster, 1980; Ross & Leatherwood, 1994).

3.4.1.26.5 Species-Specific Threats

Fisheries interactions in the Study Area are likely given documented evidence from fishery activities in Hawaii (Bradford & Forney, 2017; Carretta et al., 2017c). Based on the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

The 2016 Pacific SAR (Carretta et al., 2017c; Carretta et al., 2017d) suggested that two mass strandings of pygmy killer whales (that occurred in 2004 and 2005) on Taiwan were, "…possibly associated with offshore naval training exercises" based on the citation to Wang and Yang (2006). Wang and Yang (2006) only speculatively suggested that, "…naval sonar and live ammunition exercises are two of many plausible causes that need to be investigated" given there was a lack of necessary information (such as if sonar was even in use) regarding relatively contemporaneous and distant events involving the U.S. Navy, People's Republic of China Navy, Taiwan's Republic of China Navy, Japanese Navy, and oil and gas seismic exploration occurring in the eastern Pacific. Further, between 1995 and 2005 there were a total of six pygmy killer whale Mass Stranding Events and three milling events involving the same species in Taiwan (Brownell et al., 2009b; Yang et al., 2008), confounding the identification of a specific cause for these particular stranding events. The suggestion that sonar, underwater detonations, or seismic oil and gas exploration may have caused the 2004 and 2005 strandings has remained speculative with researchers pointing to the need for further investigation (Brownell et al., 2009b; Wang & Yang, 2006; Yang et al., 2008). The technical report from the U.S. Department of the Navy (U.S. Department of the Navy, 2017a) provides a general discussion of strandings potentially related to the use of sonar and other anthropogenic sound.

The pygmy killer whale has no documented predators (Weller, 2009), although it may be subject to predation by killer whales.

3.4.1.27 Pygmy Sperm Whale (*Kogia breviceps*)

3.4.1.27.1 Status and Management

Pygmy sperm whale is not listed under the ESA. The stock structure for pygmy sperm whales remains uncertain in the western Pacific, and pygmy sperm whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c). Other than for waters along the U.S. West Coast, NMFS recognizes a single stock of pygmy sperm whale in the Pacific in Hawaiian waters (Carretta et al., 2019c).

3.4.1.27.2 Geographic Range and Distribution

During marine mammal monitoring for Valiant Shield 07, a group of three Kogia (dwarf or pygmy sperm whales) was observed about 8 NM east of Guam (Mobley, 2007). The stranding of a pygmy sperm whale in 1997 (Trianni & Tenorio, 2012), is the only other confirmed occurrence of this species in the Study Area.

3.4.1.27.3 Population and Abundance

There are no abundance estimates for pygmy sperm whale in the Study Area.

3.4.1.27.4 Predator-Prey Interactions

Pygmy sperm whales feed on cephalopods and, less often, on deep sea fishes and shrimps (Caldwell & Caldwell, 1989; Sekiguchi et al., 1992; West et al., 2009). Pygmy sperm whales are believed to generally forage near the seafloor (McAlpine, 2009).

Killer whales and white sharks are documented predators of pygmy sperm whales (Dunphy-Daly et al., 2008; Long, 1991; Tirard et al., 2010).

3.4.1.27.5 Species-Specific Threats

Based on data collected in Hawaiian waters, pygmy sperm whales are susceptible to injury or mortality from fisheries interactions (Bradford & Forney, 2014, 2017). It is assumed the fishery activities in the Study Area pose a similar threat. Given the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

3.4.1.28 Risso's Dolphin (*Grampus griseus*)

3.4.1.28.1 Status and Management

Risso's dolphin is not listed under the ESA. The stock structure for Risso's dolphin remains uncertain in the western Pacific, and Risso's dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c). Other than for waters along the U.S. West Coast, NMFS recognizes a single stock of Risso's dolphins in the Pacific in Hawaiian waters (Carretta et al., 2019c).

3.4.1.28.2 Geographic Range and Distribution

Occurrence of this species is deep open ocean waters off Hawaii and in other locations in the Pacific (Au & Perryman, 1985; Bradford et al., 2017; Leatherwood et al., 1980; Miyashita et al., 1996; Wang et al., 2001). Fishery interaction data determined the species occurrence west of the International Date Line extended as far north as 40° N, but the southern extent of the range could not be determined (Miyashita, 1993a). Aerial surveys in August 2007 covering 2,352 km of linear effort encountered a single pod of eight Risso's dolphins (Mobley, 2007). During the NMFS survey of 2010, there was a single Risso's dolphin sighting of three individuals approximately 60 NM north of FDM (Oleson & Hill, 2010b). The 2015 NMFS month-long survey of the Mariana Islands encountered Risso's dolphins only twice and in small pods with a median group size of three (Hill et al., 2018d; Oleson, 2017). The species has not been detected in any other surveys efforts in the Study Area (Fulling et al., 2011; Hill et al., 2014; Hill et al., 2017a; Hill et al., 2018b; Hill et al., 2018c; Hill et al., 2018d; Hill et al., 2019). Vocalizations from Risso's dolphins were also detected south of Guam by passive acoustic recorders aboard an underwater glider survey in 2014 (Klinck et al., 2016a).

3.4.1.28.3 Population and Abundance

There are no abundance estimates for Risso's dolphin in the Study Area.

3.4.1.28.4 Predator-Prey Interactions

Cephalopods and crustaceans are the primary prey for Risso's dolphins (Clarke, 1996), which feed mainly at night (Fernandez et al., 2017; Jefferson et al., 2015; Perrin et al., 2009). This dolphin may be preyed on by both killer whales and sharks, although there are no documented reports of predation by either (Weller, 2009).

3.4.1.28.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least one product contained Risso's dolphin meat (Baker et al., 2006a).

3.4.1.29 Rough-Toothed Dolphin (*Steno bredanensis*)

3.4.1.29.1 Status and Management

The rough-toothed dolphin is not listed under the ESA. The stock structure for rough-toothed dolphins remains uncertain in the western Pacific, and rough-toothed dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c). NMFS recognizes a single stock of rough-toothed dolphins in the Pacific in Hawaiian waters (Carretta et al., 2019c).

3.4.1.29.2 Geographic Range and Distribution

Rough-toothed dolphins were sighted twice during a 2007 survey; once as nine individuals in a mixed group of short-finned pilot whales and bottlenose dolphins, and once in a pod of nine individuals with calves present (Fulling et al., 2011). A pod of eight rough-toothed dolphins was also sighted approximately 175 km south of Guam during a 2007 aerial survey (Mobley, 2007). There were no rough-toothed dolphins identified in the broad offshore survey in 2010 (Oleson & Hill, 2010b). The species was encountered only three times during the month-long 2015 NMFS survey of the islands, twice in a group with another cetacean species (Oleson, 2017). Annual small boat surveys conducted from 2010 to 2018 have encountered rough-toothed dolphins on seven occasions, and again all but one of those encounters were in a group with other cetaceans (Hill et al., 2014; Hill et al., 2018c; Hill et al., 2018d; Hill et al., 2019). Four of the same photo-identified rough-toothed dolphins encountered in 2013 have been seen multiple times since in the same general location to the west of Saipan off CK Reef (Hill et al., 2014; Hill et al., 2017a). One group of rough-toothed dolphins was sighted in 2014, but none were encountered in surveys occurring in 2015 through 2018 (Hill et al., 2017a; Hill et al., 2018b; Hill et al., 2018c; Hill et al., 2019).

3.4.1.29.3 Population and Abundance

During the 2007 systematic line-transect survey of the Study Area, there was only one on-effort sighting of rough-toothed dolphin that was used to derive an abundance estimate of 166 animals (CV = 0.892) (Fulling et al., 2011). Given the very limited sample size (a single sighting), this estimate is considered highly uncertain. In July 2004, there was a sighting of an undetermined smaller number of rough-toothed dolphins mixed in with a school of an estimated 500–700 melon-headed whales off Rota in Sasanhayan Bay (Jefferson et al., 2006).

3.4.1.29.4 Predator-Prey Interactions

Rough-toothed dolphin prey includes fish and cephalopods. They are known to feed on large fish species, such as mahi mahi (Miyazaki & Perrin, 1994; Pitman & Stinchcomb, 2002), and have been observed feeding during the day on near-surface fishes, including flying fishes (Gannier & West, 2005). They may also prey on reef fish, as Perkins and Miller (1983) noted that parts of reef fish had been found in the stomachs of stranded rough-toothed dolphins in Hawaii, although the stomach contents of a stranded animal may not be representative of the species.

3.4.1.29.5 Species-Specific Threats

There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in Hawaii. In Hawaii from 2010 to 2014, two rough-toothed dolphins were observed injured during deep-set and shallow-set fisheries in the Exclusive Economic Zone (Bradford & Forney, 2017). Given the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

Although this species has not been documented as prey by other species, it may be subject to predation from killer whales.

3.4.1.30 Short-Finned Pilot Whale (*Globicephala macrorhynchus*)

3.4.1.30.1 Status and Management

The short-finned pilot whale is not listed under the ESA. The stock structure for short-finned pilot whales remains uncertain in the western Pacific, and short-finned pilot whales in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c). With the exception of the U.S. West Coast, NMFS recognizes a single stock of short-finned pilot whales in the Pacific in Hawaiian waters (Carretta et al., 2019c).

3.4.1.30.2 Geographic Range and Distribution

In the 2007 survey of the Mariana Islands, short-finned pilot whales were encountered five times in groups ranging in size from 5 to 43 animals (Fulling et al., 2011). During the 2010 NMFS survey there was a single sighting of 23 short-finned pilot whales in the northern portion of the Study Area (Oleson & Hill, 2010b). Closer to the islands, there have been numerous incidental sightings of short-finned pilot whales occurring between 1977 and 2013 (Uyeyama, 2014). During the Navy-funded 2010–2018 small boat surveys in the Mariana Islands, short-finned pilot whale groups were encountered on 23 occasions in a median depth of approximately 720 m and median approximate distance from shore of 5 km, including one pod of 35 individuals off Marpi Reef north of Saipan (Hill et al., 2014; Hill et al., 2017a; Hill et al., 2018b; Hill et al., 2018c; Hill et al., 2019). Satellite tag locations from one short-finned pilot whale in 2016 appeared to indicate a position inside the mouth of Apra Harbor (there were no prior or subsequent positions on that day) (Hill et al., 2017a). However, it should be considered uncertain if the animal was in Apra Harbor, due to the limited precision (error range) of even high-quality Argos satellite fixes, and in particular with regard to reduced longitudinal precision, given the Argos satellites are in polar orbits (Boyd & Brightsmith, 2013; Vincent et al., 2002). Based on the locations from the 2013 to 2016 satellite tagged individuals in the May–August timeframe, Hill et al. (2018a) argued that the combined data suggested the northwest side of Guam is a frequently used area for pilot whales during that time of the year. During the August 2018 small boat surveys off Guam, satellite tags were deployed on an additional five adult short-finned pilot whales, three at Marpi Reef and two offshore of Tinian (Hill et al., 2019). Tag durations lasted from approximately 9–128 days, with the individuals ranging from the south at Tumon Bay off Guam to as far north as the waters west of Anatahan (Hill et al., 2019). These tag locations suggest multiple areas of frequent use by pilot whales in the Mariana Islands.

3.4.1.30.3 Population and Abundance

The estimated abundance for short-finned pilot whales in the Study Area is 909 (CV = 0.677), based on sighting data from the 2007 systematic survey of the Mariana Islands (Fulling et al., 2011). Genetic samples taken during small boat surveys between 2010 and 2014 found evidence of genetic differentiation for short-finned pilot whales between the Mariana Islands, although they possess haplotypes also common in the South Pacific, North Atlantic, Indian Ocean, and off of southern Japan (Martien et al., 2014b).

3.4.1.30.4 Predator-Prey Interactions

Pilot whales feed primarily on squid but also take fish (Bernard & Reilly, 1999). They are generally well adapted to feeding on squid (Jefferson et al., 2015; Werth, 2006a, 2006b). Analysis of satellite tagging data from pilot whales in Hawaii correlated with certain environmental parameters, suggesting that the deep mesopelagic boundary community serves as prey for these whales (Abecassis et al., 2015).

Pilot whales are not generally known to prey on other marine mammals, but records from the eastern tropical Pacific suggest that the short-finned pilot whale does occasionally chase and attack, and may eat, dolphins during fishery operations (Olson, 2009; Perryman & Foster, 1980).

3.4.1.30.5 Species-Specific Threats

As discussed in Section 3.4.1.7.3 (Bycatch), entanglement risk includes fishing activities out of Japan and South Korea, with the threat of mortality from any such interaction being high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009). In nine market samples from South Korea between 2003 and 2005, molecular (DNA) evidence indicated that at least two products contained short-finned pilot whale meat (Baker et al., 2006a).

This species is not known to have any predators (Weller, 2009), although it may be subject to predation by killer whales.

3.4.1.31 Sperm Whale (*Physeter macrocephalus*)

3.4.1.31.1 Status and Management

The sperm whale is listed as endangered under the ESA, but there is no designated critical habitat for this species. The stock structure for sperm whales remains uncertain in the Pacific (Mesnick et al., 2011; Mizroch & Rice, 2013; National Marine Fisheries Service, 2015a), and sperm whales in the Study Area have not been assigned to a stock in the current Pacific SAR (Carretta et al., 2019c). Except for waters off the U.S. West Coast, NMFS recognizes two stocks of sperm whales, one in the central Pacific (in Hawaiian waters) and one in the North Pacific (in Alaskan waters) (Carretta et al., 2019c; Muto et al., 2019).

3.4.1.31.2 Geographic Range and Distribution

Based on whaling data and discovery tag movement data for the North Pacific, it has been argued that the distribution of sperm whales encompasses the entire Pacific Ocean basin, with concentrations in the arctic and subtropical areas (Ilyashenko et al., 2014; Mizroch & Rice, 2013). The Study Area is south of the locations where the majority of sperm whales were encountered during whaling (Mizroch & Rice, 2013; Townsend, 1935), although during a 1972 survey of the Ogasawara and Mariana Island regions two large groups totaling 90 sperm whales were reported (Masaki, 1972). Sperm whales have been routinely sighted in the Study Area and detected in acoustic monitoring records. Acoustic recordings in August 2013 at Pagan Island indicated the presence of sperm whales within 20 NM of the island (Tetra Tech Inc., 2014). Passive acoustic recorders detected vocalizations from sperm whales on 20 occasions to the east and south of Guam during an underwater glider survey in 2014 (Klinck et al., 2016a).

Sperm whales are highly nomadic, mobile predators with no known concentration areas in the Mariana Islands. Sightings likely represent transiting individuals and pods. Although it has been reported that sperm whales are generally found far offshore in deep water (Mizroch & Rice, 2013), sightings in the Study Area have included animals close to shore in relatively shallow water as well as in areas near steep bathymetric relief (Bangs, 2001; Fulling et al., 2011; Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2019; Uyeyama, 2014). There are two Associated Press File photographs, taken opportunistically by a local photographer during an encounter from a commercial dive boat, showing a group of three adult sperm whales and a calf on June 15, 2001, "… about four miles off the coast of the Agat Marina in Guam" (Bangs, 2001). There have been no other sperm whale calf sightings reported in the Study Area. A total of 23 sperm whale sightings and 93 acoustic encounters were made during the 2007 survey in water depths between approximately 400 and 1,000 m depth (Fulling et al., 2011; Yack et al., 2016). There were three encounters with sperm whales during the NMFS 2015 cetacean survey of the Mariana Islands (Hill et al., 2018d; Oleson, 2017). During the Navy-funded 2010–2018 small boat surveys in the Mariana Islands, a total of seven sperm whales were detected over four encounters (in 2010, 2013, 2016, and 2018) in a median depth of approximately 1,200 m and median approximate distance from shore of 12 km (Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2018d; Hill et al., 2019).

3.4.1.31.3 Population and Abundance

It is assumed the Pacific population is still recovering, given whaling by the Soviet Union from 1948 to 1979 in the North Pacific took 157,680 sperm whales (Ilyashenko et al., 2014). NMFS has reported that for the Pacific Ocean,[5] the population is estimated between 26,300 and 32,100 for the North Pacific and between 14,800 and 34,600 for the eastern tropical Pacific, while the population of the Hawaii Stock is estimated between 2,539 and 3,354 (National Marine Fisheries Service, 2015a). NMFS has not explicitly stated if the western North Pacific and the Mariana Islands are included in the range for the population of sperm whales considered the North Pacific Stock (Carretta et al., 2019c; Muto et al., 2017; Muto et al., 2018; Muto et al., 2019; National Marine Fisheries Service, 2015a), although that may be the most logical assignment for those animals in the Study Area. The most recent Alaska SAR provides that there is no current abundance data available for sperm whale of the North Pacific Stock (Muto et al., 2019).

During the 2007 systematic line-transect survey of the Mariana Islands, 11 on-effort sperm whale sightings were used to derive an abundance estimate of 705 animals (CV = 0.604) for the Study Area (Fulling et al., 2011). Passive acoustic monitoring was also conducted during the 2007 survey, and 93 acoustic encounters from vocalizing sperm whales were used to develop a habitat-based density

[5]The "Pacific Ocean" estimates provided did not address or otherwise specifically include the western Pacific Ocean that would include the Study Area.

model for this species (Yack et al., 2016). The model provided spatially explicit density estimates for the Study Area, and daily model predictions indicated that sperm whale abundance varied temporally over the period of the 2007 survey (January 15 to April 10). Average Study Area abundance derived from the habitat model was similar to the line-transect estimate based on visual sightings; 700 animals (CV = 0.436) based on a model using sounds typically produced by mature males, females, and juveniles (i.e., "regular clicks"), and 637 animals (CV = 0.447) based on a model using both the regular clicks and "slow clicks" that are only produced by mature males (Yack et al., 2016).

3.4.1.31.4 Predator-Prey Interactions

Sperm whales are known to occur in groups for both predator defense and foraging purposes. Sperm whales feed on squid, other cephalopods, and bottom-dwelling fish and invertebrates (Davis et al., 2007; Marcoux et al., 2007; Rice, 1989). False killer whales, pilot whales, and killer whales have been documented harassing and on occasion attacking sperm whales (Arnbom et al., 1987; Baird, 2009b; Palacios & Mate, 1996; Pitman et al., 2001).

3.4.1.31.5 Species-Specific Threats

Sperm whales are susceptible to injury or mortality from vessel strike (Bradford & Lyman, 2015; Carretta et al., 2016b; Carretta et al., 2017c; Fulling et al., 2017). Sperm whales in the Pacific have been documented as susceptible to entanglement and other interactions with fishing gear (Bradford & Lyman, 2015; Carretta et al., 2016b; Carretta et al., 2017c; Helker et al., 2017). Sperm whales have also been documented as having ingested marine debris, resulting in mortality (Garibaldi & Podesta, 2014; Jacobsen et al., 2010), and as with almost all marine mammals, are susceptible to disease (West et al., 2015).

3.4.1.32 Spinner Dolphin (*Stenella longirostris*)

3.4.1.32.1 Status and Management

The spinner dolphin is not listed under the ESA. The stock structure for spinner dolphins remains uncertain in the western Pacific, and spinner dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c). NMFS recognizes seven stocks of island- or atoll-associated spinner dolphin populations in the Pacific in Hawaii and American Samoa waters (Carretta et al., 2017c; Carretta et al., 2017d) (Carretta et al., 2019c), which are all at locations well to the east of the Study Area.

3.4.1.32.2 Geographic Range and Distribution

Spinner dolphins traveling among the Mariana Islands chain are expected to occur throughout the Mariana Islands, having been observed from Uracas in the north to Guam in the south (Fulling et al., 2011; Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2019; Jefferson et al., 2006; Oleson, 2017; Oleson & Hill, 2010a; Tetra Tech Inc., 2014; Trianni & Kessler, 2002; Uyeyama, 2014; Vogt, 2008). Spinner dolphins have been the most frequently encountered species during small boat reconnaissance surveys conducted in the nearshore waters of the Mariana Islands since 2010 but were uncommon offshore (Fulling et al., 2011; HDR, 2011b; HDR EOC, 2012; Hill et al., 2013a; Hill et al., 2014; Hill et al., 2015b; Hill et al., 2016b; Hill et al., 2017a; Hill et al., 2018b; Hill et al., 2018c; Hill et al., 2019; Ligon et al., 2011; National Marine Fisheries Service, 2019; Oleson, 2017; Oleson & Hill, 2010a). Previously reported spinner dolphin high-use areas nearshore at Guam include Bile Bay, Tumon Bay, Double Reef, north Agat Bay, and off Merizo (Cocos Lagoon area), where these animals congregate during the day to rest (Amesbury et al., 2001; Eldredge, 1991). More recently, high-use areas have included Agat Bay; the

Merizo channel, tucked into the several small remote bays between Merizo and Facpi Point; Piti Bay; Hagatna; Tumon Bay; and Pugua Point (Ligon et al., 2011). There have been no documented sightings within Apra Harbor. The locations where spinner dolphins have been documented resting in Agat Bay have been considered for geographic mitigation, as detailed in Appendix I (Geographic Mitigation Assessment).

During the Navy-funded 2010–2018 small boat surveys in the Mariana Islands, there were 157 encounters with pods of spinner dolphins (Hill et al., 2019). The approximate distance from shore for these encounters was 1 km (Hill et al., 2017a; Hill et al., 2018b; Hill et al., 2019). During a survey in August 2013 at Pagan Island, spinner dolphins calves and juveniles were encountered; although sighting rates were low relative to other island areas, re-sightings of four individual spinner dolphins on subsequent days were suggested to be consistent with residency patterns seen elsewhere (Tetra Tech Inc., 2014), which would be similar to behaviors seen in Hawaii (Heenehan et al., 2017b; Lammers, 2004; Marten & Psarakos, 1999; Norris et al., 1994; Tyne et al., 2015; Tyne et al., 2017).

3.4.1.32.3 Population and Abundance

Spinner dolphins were sighted only once during the 2007 broad area line-transect survey of the Mariana Islands (Fulling et al., 2011). As noted previously, spinner dolphins have been the most commonly encountered species in nearshore waters within 1 km from shore and have been encountered in group sizes of up to 124 individuals in a pod (HDR, 2011b; HDR EOC, 2012; Hill et al., 2011; Hill et al., 2013a; Hill et al., 2013b; Hill et al., 2014; Hill et al., 2015b; Hill et al., 2016b; Hill et al., 2017a; Hill et al., 2018b; Hill et al., 2019; Ligon et al., 2011; Oleson & Hill, 2010a). Genetic samples (n = 93) from spinner dolphins encountered during small boat surveys off Guam and Saipan between 2010 and 2014 suggest the population has high haplotypic diversity similar to that observed in the Society Islands of French Polynesia and that spinner dolphins around the Mariana Islands are much less isolated than those around the Hawaiian Islands (Martien et al., 2014b).

3.4.1.32.4 Predator-Prey Interactions

Spinner dolphins feed primarily on small mid-water fishes, squids, and shrimp, and dive to at least 200–300 m (Benoit-Bird & Au, 2003; Perrin & Gilpatrick, 1994). They forage primarily at night, when the mid-water community migrates toward the surface and the shore (Benoit-Bird et al., 2001; Benoit-Bird, 2004; Benoit-Bird & Au, 2009; Tyne et al., 2017). Spinner dolphins track the horizontal and vertical migrations of their prey (Benoit-Bird & Au, 2003), allowing for foraging efficiencies (Benoit-Bird et al., 2001; Benoit-Bird & Au, 2003, 2004; Benoit-Bird & Au, 2009). Foraging behavior has also been linked to lunar phases in scattering layers off of Hawaii (Benoit-Bird & Au, 2004).

3.4.1.32.5 Species-Specific Threats

There is no information available regarding marine mammal interactions with fishing activities in the Study Area, but the threat is presumed to be similar to what has been documented in Hawaii. In Hawaiian waters from 2008 to 2012 there were three observed serious injuries (leading to death) to spinner dolphins (Bradford & Lyman, 2015). Two of these injuries were fishing related, and one involved marine debris preventing the individual's mouth from opening. Given the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

Spinner dolphins are also at risk if ecotourism and whale-watching activities result in chronic disturbance in their resting habitats (Courbis & Timmel, 2008; Heenehan et al., 2016; Heenehan et al., 2017a; Tyne et al., 2014; Tyne, 2015; Tyne et al., 2015; Tyne et al., 2017; Tyne et al., 2018). Courbis (2008) found changes in spinner dolphin aerial behaviors and suggested it was likely that vessel and swimmer activity was at least synergistically involved in causing these changes, but whether the behavioral changes affected the survival and fitness of spinner dolphins remains unknown.

Spinner dolphins have stranded at Saipan (Trianni & Kessler, 2002). Spinner dolphins may be preyed on by sharks, killer whales, pygmy killer whales, and short-finned pilot whales (Perrin, 2009a).

3.4.1.33 Striped Dolphin (*Stenella coeruleoalba*)

3.4.1.33.1 Status and Management

The striped dolphin is not listed under the ESA. The stock structure for striped dolphins remains uncertain in the western Pacific, and striped dolphins in the Study Area have not been assigned to a stock in the current SAR (Carretta et al., 2019c). Other than along the U.S. West Coast, NMFS recognizes only a single stock of striped dolphins that is present within the 200-mi. Exclusive Economic Zone defining Hawaiian waters (Carretta et al., 2019c).(Carretta et al., 2017c; Carretta et al., 2017d)

3.4.1.33.2 Geographic Range and Distribution

Striped dolphins are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In the eastern tropical Pacific, striped dolphins inhabit areas with large seasonal changes in surface temperature and thermocline depth, as well as seasonal upwelling (Au & Perryman, 1985; Reilly, 1990). The observed northern limits for the species are the Sea of Japan off Hokkaido, off Washington State in the eastern Pacific, or roughly along 40° N latitude across the western and central Pacific (Reeves et al., 2002).

Prior to the 2007 survey of the Study Area (Fulling et al., 2011), striped dolphins were only known to occur in the area from two strandings, one recorded in July 1985 (Eldredge, 1991, 2003) and a second in 1993 off Saipan (Trianni & Tenorio, 2012). However, striped dolphins were sighted throughout the Study Area during the 2007 survey (Fulling et al., 2011). There was at least one sighting over the Mariana Trench, southeast of Saipan. Group sizes ranged from 7 to 44 individuals, and several sightings included calves. In early April 2010, during an oceanographic survey of waters in Micronesia and the Commonwealth of the Northern Mariana Islands, there were two striped dolphin sightings (pod sizes of 6 and 12) in waters to the south of Guam (Oleson & Hill, 2010b). Striped dolphins have not been reported during more recent non-systematic surveys in the Study Area involving small boats operating close to shore (Hill et al., 2011; Hill et al., 2013a; Hill et al., 2014; Hill et al., 2015b; Hill et al., 2017a; Hill et al., 2018b; Hill et al., 2018c; Hill et al., 2019).

3.4.1.33.3 Population and Abundance

The population of striped dolphins south of 30˚ N in the western Pacific (which would include the Study Area) was estimated to be around 52,600 dolphins (Miyashita, 1993b). Based on the 2007 survey data from the Mariana Islands sightings, there were an estimated 3,531 (CV = 0.54) striped dolphins in the survey area (Fulling et al., 2011).

3.4.1.33.4 Predator-Prey Interactions

Striped dolphins often feed in open sea or sea bottom zones along the continental slope or just beyond it in oceanic waters. Most of their prey possess light-emitting organs (lanternfishes), suggesting that striped dolphins may be feeding at great depths, possibly diving to 200–700 m, and may feed at night in order to take advantage of the deep scattering layer's diurnal vertical movements, including small mid-water fishes and squids (Archer & Perrin, 1999; Perrin et al., 1994b). This species has been documented to be preyed upon by sharks (Ross & Bass, 1971). It may also be subject to predation by killer whales.

3.4.1.33.5 Species-Specific Threats

Striped dolphins have been taken as bycatch by the tuna purse seine fishery in the eastern tropical Pacific and are susceptible to entanglement in fishing gear in other areas (Carretta et al., 2017c; Carretta et al., 2017d). There is no information on fisheries interactions or species-specific threats available for this species in the Study Area. Given the information provided in Section 3.4.1.7.3 (Bycatch), entanglement risk may include fishing activities out of Japan and South Korea (Miyashita, 1993b). The threat of mortality from any such interaction is high given the incentive created by the commercial sale of whale meat/products allowed under Japanese and South Korean law (Baker et al., 2006a; Lukoschek et al., 2009).

3.4.2 Environmental Consequences

Under the Proposed Action for this SEIS/OEIS, there have been some modifications to the quantity and type of acoustic stressors under the two action alternatives. Additionally, there is one new sub-stressor (high-energy lasers) being analyzed because of the potential to affect marine species, as detailed in Section 3.0.4.3.2.2 (High-Energy Lasers).

In the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015a), the Navy considered all potential stressors associated with ongoing military readiness in the Mariana Islands and then analyzed their potential impacts on marine mammals in the Study Area. In addition, NMFS also reviewed the Navy's analysis and detailed their findings with regard to requirements under the MMPA (80 FR 46112) and pursuant to the ESA for the Navy's Proposed Action in the Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015b).

In general, there have been no substantial changes to the activities analyzed as the Proposed Action the 2015 MITT Final EIS/OEIS that would change the conclusions reached regarding populations of marine mammals in the Study Area. Use of acoustic stressors (sonar and other transducers) and use of explosives have occurred in the Mariana Islands for decades and were last authorized by the 2015 completion of the MITT Record of Decision, MMPA Authorization, and ESA Biological Opinion. There have been no known impacts on populations of marine mammals or adverse effects to ESA-listed marine mammal species that were not otherwise previously analyzed or accounted for in the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015b), the NMFS MMPA Authorization (80 FR 46112), or the NMFS Biological Opinion pursuant to ESA (National Oceanic and Atmospheric Administration, 2015a) with regard to acoustic or explosive stressors.

In this SEIS/OEIS, the Navy has reviewed the analysis of impacts from these ongoing activities and additionally analyzed the new or changing training and testing activities as projected into the reasonably foreseeable future. The projected future actions are based on evolving operational requirements, including those associated with any anticipated new platforms or systems not previously analyzed. The Navy has compiled, thoroughly reviewed, and incorporated the best available emergent marine mammal science since 2015 that is relevant to the analysis of environmental impacts from the proposed activities as presented in the 2015 MITT Final EIS/OEIS. Where there has been no substantive or otherwise meaningful change in the action, science, or regulations, the Navy will rely on the 2015 MITT Final EIS/OEIS analysis. Where there has been substantive change in the action, science, or regulations, the information and analysis provided in this SEIS/OEIS will supplement the 2015 MITT Final EIS/OEIS to support environmental compliance with applicable environmental statutes for marine mammals (the MMPA and ESA).

The 2015 MITT Final EIS/OEIS considered all training and testing activities proposed to occur in the Study Area that may have the potential to result in the MMPA-defined take of marine mammals or to affect ESA-listed marine mammal species. The stressors applicable to marine mammals in the Study Area for this SEIS/OEIS include a new stressor (high-energy laser) and the same stressors considered in the 2015 MITT Final EIS/OEIS:

- **Acoustic** (sonar and other transducers, vessel noise, aircraft noise, weapon noise)
- **Explosives** (in-air explosions and in-water explosions)
- **Energy** (in-water electromagnetic devices, high-energy lasers)
- **Physical disturbance and strike** (vessels and in-water devices, military expended materials, seafloor devices)
- **Entanglement** (wires and cables, decelerators/parachutes)
- **Ingestion** (military expended materials – munitions, military expended materials other than munitions)
- **Secondary** (impacts on habitat, impacts on prey availability)

This section of this SEIS/OEIS evaluates how and to what degree potential impacts on marine mammals from stressors described in Section 3.0 (Introduction) may have changed since the analysis presented in the 2015 MITT Final EIS/OEIS was completed. Table 2.5-1 and Table 2.5-2 in Chapter 2 (Description of Proposed Action and Alternatives) list the proposed training and testing activities and include the number of times each activity would be conducted annually and the locations within the Study Area where the activity would typically occur under each alternative. The tables also present the same information for activities described in the 2015 MITT Final EIS/OEIS so that the proposed levels of training and testing under this SEIS/OEIS can be easily compared. The analysis in this SEIS/OEIS includes consideration of the Navy's standard operating procedures and mitigation that the Navy will implement to avoid or reduce potential impacts on marine mammals from acoustic, explosive, and physical disturbance and strike stressors. Mitigation for marine mammals has been coordinated with NMFS through the MMPA and ESA consultation processes, and is detailed in Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment) of this SEIS/OEIS.

In 2015, the Navy and NMFS determined that within the Study Area only acoustic stressors and explosive stressors could potentially result in harassment and/or the incidental taking of marine mammals from Navy training and testing activities (80 FR 46112) and that none of the other stressors would result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b).

There has been no emergent science that would necessitate changes to conclusions reached by the Navy or NMFS (as a cooperating agency) in the 2015 MITT Final EIS/OEIS regarding those other dismissed stressors as having a negligible or discountable impact on marine mammal populations or species. The 2015 conclusions have also been reaffirmed in the most recent MMPA authorizations (83 FR 66846 and 83 FR 57076) and ESA Biological Opinions (National Marine Fisheries Service, 2017, 2018a) from NMFS for many of the same Navy training and testing activities and the same species as occur in the MITT Study Area. As detailed in Chapter 2 (Description of Proposed Action and Alternatives) of this SEIS/OEIS, there are no changes to proposed training and testing activities that would necessitate re-analysis of any of the activities associated with those stressors for which NMFS has previously determined did not rise to the level of a take under MMPA. The analysis presented in this section of the SEIS/OEIS also considers standard operating procedures, which are discussed in Section 2.3.3 (Standard Operating Procedures) of this Draft SEIS/OEIS, and mitigation measures that are described in Chapter 5 (Mitigation). The Navy would implement these measures to avoid or reduce potential impacts on marine mammals from stressors associated with the proposed training and testing activities. Mitigation for marine mammals has been coordinated with NMFS through the ESA consultation process. In addition, in the Navy developed Appendix I (Geographic Mitigation Assessment), which detailed consideration of specific mitigation areas identified by the public during the scoping process. In short, Appendix I (Geographic Mitigation Assessment) contains the background information for each area being considered and lays out the methodology used by the Navy in its scientific and operational analysis for assessing and developing proposed geographic mitigation areas within the MITT Study Area to further avoid or reduce potential impacts on marine mammals in areas that may be of particular biological importance.

As presented in Section 3.0 (Introduction), since completion of the 2015 MITT Final EIS/OEIS there have been refinements made in the modeling of potential impacts from sonar and other transducers and in-water explosives. These changes have been incorporated into the re-analysis of acoustic and explosive stressors presented in this SEIS/OEIS. In addition to the new effects criteria, weighting functions, and thresholds for multiple species, new information for marine mammals includes the integration of new marine mammal density data based on new survey data (Bradford et al., 2017) and the integration of data from acoustic monitoring (Norris et al., 2017; Yack et al., 2016).

There have been no changes to the MITT Study Area, existing conditions, species life histories, or any new information available since 2015 that would otherwise substantively change the conclusions[6] presented in the 2015 MITT Final EIS/OEIS. What is new since 2015 are refinements to the Navy Acoustic Effects Model. This SEIS/OEIS, therefore, focuses on a re-analysis of potential impacts on marine mammals from acoustic stressors involving use of sonar and other transducers, and the use of in-water explosives. The following paragraphs provide details on refinements to the Navy's acoustic modeling since 2015. Most important is the information found in Section 3.4.3.4 (Summary of Monitoring and Observations During Navy Activities Since 2015) regarding scientific data gathered on marine mammals in locations where the Navy has been training and testing, which serves as an empirical basis for the marine mammal impact assessment presented in this SEIS/OEIS.

The majority of the changes in the results of the impact analyses presented in this SEIS/OEIS pursuant to requirements of the MMPA arise from changes in the model input; specifically, more accurate marine mammal density data, revised acoustic impact criteria, and more comprehensive computer modeling of predicted effects on marine mammals. These improvements are described in Section 3.0.1.2 (Navy's

[6] Conclusions in this regard refer to the findings reached by Navy and NMFS on the two previous sets of analyses for the continuation of training and testing in Study Area. NMFS has recently re-considered analysis of Navy training and testing for many of the same for actions elsewhere (83 FR 10954 and 83 FR 29872) and for a third time reaffirmed their earlier conclusions regarding Navy military readiness activities (83 FR 66846 and 83 FR 57076). The Navy and NMFS have found that there would not be significant impacts on populations of marine mammals resulting from the continuation of training and testing. Under ESA, the Proposed Action may affect certain ESA-listed marine mammal species, but were not likely to jeopardize the continued existence of the continued existence of those species (National Marine Fisheries Service, 2018a).

Quantitative Analysis). 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 2007. 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 present the potential environmental consequences based on an updated modeling methodology and the scientific observations and investigations made over 12 years of monitoring training and testing activities in the Pacific and elsewhere that are representative of the type of activities proposed in this SEIS/OEIS.

3.4.2.1 Acoustic Stressors

Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sources, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council, 2003, 2005), there are many unknowns in assessing impacts, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al., 2007; Southall et al., 2007). Many other factors besides just the received level of sound may affect an animal's reaction, such as the duration of the sound-producing activity, the animal's physical condition, prior experience with the sound, activity at the time of exposure (e.g., feeding, traveling, resting), the context of the exposure (e.g., in a semi-enclosed bay versus 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 3.0.4.7 (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 3.4.2.1.1.1, Injury). Hearing loss (Section 3.4.2.1.1.2, Hearing Loss) is a noise-induced decrease in hearing sensitivity, which can be either temporary or permanent. Masking (Section 3.4.2.1.1.4, Masking) can occur when the perception of a biologically important sound (i.e., signal) is interfered with by a second sound (i.e., noise). Physiological stress (Section 3.4.2.1.1.3, Physiological Stress) is an adaptive process that helps an animal cope with changing conditions; however, too much stress can potentially result in additional physiological effects. Behavioral response (Section 3.4.2.1.1.5, Behavioral Reactions) ranges from brief distractions to avoidance of a sound source to prolonged flight. Extreme behavioral or physiological responses can lead to stranding (Section 3.4.2.1.1.6, Stranding). Long-term consequences (Section 3.4.2.1.1.7, 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 and testing activities that generate acoustic stressors (see Chapter 5, Mitigation; and Appendix I, Geographic Mitigation Assessment).

The Navy will rely on the previous 2015 MITT Final EIS/OEIS for the analysis of vessel noise, aircraft noise, and weapon noise; new applicable and emergent science in regard to these sub-stressors is presented in the sections that follow. Due to new acoustic impact criteria, marine mammal densities, and revisions to the acoustic effects model, the analysis provided in Section 3.4.2.1.2 (Impacts from Sonar and Other Transducer Stressors) of this SEIS/OEIS supplants the 2015 MITT Final EIS/OEIS for marine mammals and changes estimated impacts for some species since the 2015 MITT Final EIS/OEIS.

3.4.2.1.1 Background

3.4.2.1.1.1 Injury

Injury (i.e., physical trauma) refers to the effects on the tissues or organs of an animal due to exposure to pressure waves. Injury due to exposure 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 any injury. Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) provides additional information on injury (i.e., physical trauma) and the framework used to analyze this potential impact.

Several mechanisms of acoustically induced tissue damage (non-auditory) have been proposed and are discussed below.

Injury Due to Sonar-Induced Acoustic Resonance

An object exposed to its resonant frequency will tend to amplify its vibration at that frequency, a phenomenon called acoustic resonance. Acoustic resonance has been proposed as a mechanism by which a sonar or sources with similar operating characteristics could damage tissues of marine mammals. In 2002, NMFS convened a panel of government and private scientists to investigate the potential for acoustic resonance to occur in marine mammals (National Oceanic and Atmospheric Administration, 2002). They modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding. The conclusions of the group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding in 2000. The frequency at which resonance was predicted to occur in the animals' lungs was 50 Hz, well below the frequencies used by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations, even at resonant frequencies, were not considered to be of sufficient amplitude to cause tissue damage, even under the unrealistic scenario in which air volumes would be undamped (unrestrained) by surrounding tissues and the amplitude of the resonant response would be greatest. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance would not occur under realistic conditions during training and testing activities, and this type of impact 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"). Bernaldo de Quirós et al. (2019) provide a recent review of theories of decompression sickness in beaked whales.

Whether marine mammals can produce deleterious gas emboli has been under debate in the scientific community (Hooker et al., 2012; Saunders et al., 2008), although various lines of evidence have been presented in support of the phenomenon. Some of these postulations are described below.

1. Analyses of bycaught animals demonstrated that nitrogen bubble formation occurs in drowned animals when they are brought to the surface (Bernaldo de Quiros et al., 2013b; Moore et al., 2009). Since gas exchange with the lungs no longer occurs once drowned, tissues become supersaturated with nitrogen due to the reduction in hydrostatic pressure near the surface. This demonstrates that the phenomenon of bubble formation is at least physically possible.
2. The presence of osteonecrosis (bone death due to reduced blood flow) in deep-diving sperm whales has been offered as evidence of impacts due to chronic nitrogen supersaturation and a lifetime of decompression insults (Moore & Early, 2004).
3. Dennison et al. (2012) investigated dolphins stranded in 2009–2010. Using ultrasound, they identified gas bubbles in kidneys of 21 of the 22 live-stranded dolphins and in the liver of two of the 22. The authors postulated that stranded animals were unable to recompress by diving and thus retained bubbles that would have otherwise re-absorbed in animals that continued to dive. However, the researchers concluded that the minor bubble formation observed could be tolerated since the majority of stranded dolphins released did not re-strand.
4. A fat embolic syndrome (out-of-place fat particles, typically in the bloodstream) was identified by Fernández et al. (2005) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals and was thought to possibly arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream.
5. Findings of gas and fat emboli in a few stranded Risso's dolphin, and in which sonar exposure was ruled out as a cause of stranding, suggested that other factors, in this case struggling with a prey item, might cause significant variations in dive behavior such that emboli formation could occur (Fernandez et al., 2017).

Only one study has attempted to find vascular bubbles in a freely diving marine mammal (Houser et al., 2009). In that study, no vascular bubbles were imaged by ultrasound in a bottlenose dolphin that repeatedly dove to a 100 m depth and maintained a dive profile meant to maximize nitrogen gas uptake. Thus, although lines of evidence suggest that marine mammals manage excessive nitrogen gas loads, the majority of the evidence for the formation of bubble and fat emboli come from stranded animals in which physiological compromise due to the stranding event is a potential confounding factor.

Researchers have examined how dive behavior affects tissue supersaturation conditions that could put an animal at risk of gas bubble embolism. An early hypothesis was that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Fernandez et al., 2005; Jepson et al., 2003). However, modeling suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer & Tyack, 2007). Instead, emboli observed in animals exposed to mid-frequency active sonar (Fernandez et al., 2005; Jepson et al., 2003) could stem from a behavioral response that involves repeated dives, shallower than the depth of lung collapse (Aguilar de Soto et al., 2006; Hooker et al., 2012; Tyack et al., 2006; Zimmer & Tyack, 2007). Longer times spent diving at mid-depths above lung collapse would allow gas exchange from the lungs to continue under high hydrostatic pressure conditions, increasing potential for supersaturation; below the depth of lung collapse, gas exchange from the lungs to the blood would likely not occur (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 Quiros 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, such as 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). The presence of osteonecrosis (bone death due to reduced blood flow) in deep-diving sperm whales has been offered as evidence of chronic supersaturation (Moore & Early, 2004). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al., 2006; Hooker et al., 2009), while the condition of supersaturation required for bubble formation in these tissues has been demonstrated in marine mammals drowned at depth as fisheries bycatch and brought to the surface (Moore et al., 2009). For beaked whale strandings associated with sonar use, one theory is that observed bubble formation might be caused by long periods of compromised blood flow caused by the stranding itself (which reduces ability to remove nitrogen from tissues) following rapid ascent dive behavior that does not allow for 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, as hypothesized by Garcia Parraga et al. (2018), mechanisms may exist that allow marine mammals to create a pulmonary shunt without the need for hydrostatic pressure-induced lung collapse, (i.e., by varying perfusion to the lung independent of lung collapse and degree of ventilation). If such a mechanism exists, then assumptions in prior gas models require reconsideration, the degree of nitrogen gas accumulation associated with dive profiles needs to be re-evaluated, and behavioral responses potentially leading to a destabilization of the relationship between pulmonary ventilation and perfusion should be considered. Costidis and Rommel (2016) suggested that gas exchange may continue to occur across the tissues of air-filled sinuses in deep-diving odontocetes below the depth of lung collapse, if hydrostatic pressures are high enough to drive gas exchange across into non-capillary veins.

If feasible, kinetic gas models would need to consider an additional gas exchange route that might be functional at great depths within the odontocetes. Other adaptations potentially mitigating and defending against deleterious nitrogen gas emboli have been proposed (Blix et al., 2013). Researchers have also considered the accumulation of carbon dioxide produced during periods of high activity by an animal, theorizing that accumulating carbon dioxide, which cannot be removed by gas exchange below the depth of lung collapse, might also facilitate the formation of bubbles in nitrogen-saturated tissues (Bernaldo de Quiros et al., 2012; Fahlman et al., 2014b). In all of these cases, the hypotheses have received little in the way of experimentation to evaluate whether or not they are supported, thus leaving many unknowns as to the predictive accuracy of modeling efforts.

The appearance of extensive bubble and fat emboli in beaked whales was unique to a small number of strandings associated with certain high-intensity sonar events; the phenomenon has not been observed to the same degree in other stranded marine mammals, including other beaked whale strandings not associated with sonar use. It is uncertain as to whether there is some more easily triggered mechanism for this phenomenon specific to beaked whales or whether the phenomenon occurs only following rapidly occurring stranding events (i.e., when whales are not capable of sufficiently decompressing). Nevertheless, based on the rarity of observations of bubble pathology, the potential for nitrogen decompression sickness, or "the bends," as a result of exposure to Navy sound sources is considered discountable.

Acoustically Induced Bubble Formation Due to Sonars

A suggested cause of injury to marine mammals is rectified diffusion (Crum & Mao, 1996), the process of increasing the size of a microscopic gas bubble by exposing it to a sound field. The process is dependent upon a number of factors, including the sound pressure level (SPL) and duration. Under this hypothesis, microscopic bubbles assumed to exist in the tissues of marine mammals may experience one of three things: (1) bubbles grow to the extent they become emboli or cause localized tissue trauma, (2) bubbles develop to the extent that a complement immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lung without negative consequence to the animal.

Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. As discussed above, repetitive diving by marine mammals can cause the blood and some tissues to become supersaturated (Ridgway & Howard, 1979). The dive patterns of some marine mammals (e.g., beaked whales) are predicted to induce greater supersaturation (Houser et al., 2001). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness.

It is unlikely that the short duration of sonar pulses would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of supersaturated tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough time for bubbles to become a problematic size. The phenomena of bubble growth due to a destabilizing exposure was shown by Crum et al. (2005) by exposing highly supersaturated ex vivo bovine tissues to a 37 kHz source at 214 dB re 1 µPa. Although bubble growth occurred under the extreme conditions created for the study, these conditions would not exist in the wild because the levels of tissue supersaturation in the study (as high as 400–700 percent) are substantially higher than model predictions for marine mammals (Fahlman et al., 2009; Fahlman et al., 2014b; Houser et al., 2001; Saunders et al., 2008), and such high exposure level would only occur in very close proximity to the most powerful sonars. 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).

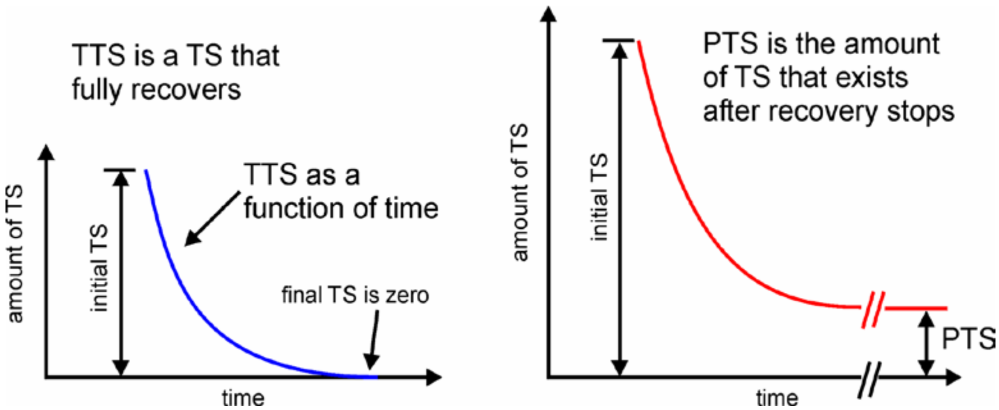
3.4.2.1.1.2 Hearing Loss

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 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 3.0.4.7 (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 (TS)—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 TS measured usually decreases with increasing recovery time—the amount of time that has elapsed since a noise exposure. If the TS 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 TS does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining TS is called a permanent threshold shift (PTS). Figure 3.4-2 shows two hypothetical TSs: 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 auditory evoked potential 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 3.4-2: 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 TS 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 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 amounts of TTS that have not resulted in PTS or injury. In other words, we do not need to know the exact functional relationship between TTS and PTS or other injury, we only need to know the upper limit for TTS before some PTS or injury is possible.

A variety of human and terrestrial mammal data indicate that threshold shifts up to 40 dB may be induced without PTS, and that 40 dB is a reasonable upper limit for allowable threshold shift to prevent PTS (e.g., Kryter et al., 1965; Miller et al., 1963; Ward et al., 1958; Ward et al., 1959; Ward, 1960). 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 et al., 2005a; Finneran, 2015; Ketten, 2000). Therefore, we assume that sound exposures sufficient to produce 40 dB of TTS measured approximately four minutes after exposure represent the limit of a non-injurious exposure (i.e., higher-level exposures have the potential to cause auditory injury). Exposures sufficient to produce a TTS of 40 dB, measured approximately four minutes after exposure, therefore represent the threshold for auditory injury. The predicted injury could consist of either hair cell damage/loss resulting in PTS or other auditory injury, such as the delayed neural degeneration identified by Kujawa and Liberman (2009) and Lin et al. (2011) that may not result in PTS.

Numerous studies have directly examined noise-induced hearing loss in marine mammals (see Finneran, 2015). In these studies, hearing thresholds were measured in marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds was then used to determine the amount of TTS at various post-exposure times. The major findings from these studies include the following:

- The method used to test hearing may affect the resulting amount of measured TTS, with neurophysiological measures producing larger amounts of TTS compared to psychophysical measures (Finneran et al., 2007; Finneran, 2015).
- The amount of TTS varies with the hearing test frequency. As the exposure SPL increases, the frequency at which the maximum TTS occurs also increases (Kastelein et al., 2014b; Kastelein et al., 2020). For high-level exposures, the maximum TTS typically occurs one-half to one octave above the exposure frequency (Finneran et al., 2007; Mooney et al., 2009a; Nachtigall et al., 2004; Popov et al., 2011; Popov et al., 2013; 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 usually increases with exposure SPL and duration and is correlated with sound exposure level (SEL), especially if the range of exposure durations is relatively small (Kastak et al., 2007; Kastelein et al., 2014b; Popov et al., 2014). As the exposure duration increases, however, the relationship between TTS and SEL begins to break down. Specifically, duration has a more significant effect on TTS than would be predicted on the basis of SEL alone (Finneran et al., 2010b; Kastak et al., 2005; Mooney et al., 2009a). This means if two exposures have the same SEL but different durations, the exposure with the longer duration (thus lower SPL) will tend to produce more TTS than the exposure with the higher SPL and shorter duration. In most acoustic impact assessments, the scenarios of interest involve shorter duration exposures than the marine mammal experimental data from which impact thresholds are derived; therefore, use of SEL tends to over-estimate the amount of TTS. Despite this, SEL continues to be used in many situations because it is relatively simple, more accurate than SPL alone, and lends itself easily to scenarios involving multiple exposures with different SPL.
- Gradual increases of TTS may not be directly observable with increasing exposure levels, before the onset of PTS (Reichmuth et al., 2019). Similarly, PTS can occur without measurable behavioral modifications (Reichmuth et al., 2019).
- The amount of TTS depends on the exposure frequency. Sounds at low frequencies, well below the region of best sensitivity, are less hazardous than those at higher frequencies, near the region of best sensitivity (Finneran & Schlundt, 2013). The onset of TTS—defined as the exposure level at which a threshold shift of 6 dB is measured approximately 4 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.
- 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., 2014b; Kastelein et al., 2015b; 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 sonar 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 shifts, regardless of the type of fatiguing sound exposure (impulsive, continuous noise band, or sinusoidal) (Kastelein et al., 2019b). 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., 2014b; Kastelein et al., 2014c; Popov et al., 2011; Popov et al., 2013; Popov et al., 2014). This means that for each doubling of recovery time, the amount of TTS will decrease by the same amount (e.g., 6 dB recovery per doubling of time).

Several recent studies have shown that certain odontocete cetaceans (toothed whales) may learn to reduce their hearing sensitivity (presumably to protect their hearing) when warned of an impending intense sound exposure (Finneran, 2018; Nachtigall & Supin, 2013, 2014, 2015; Nachtigall et al., 2016a; Nachtigall et al., 2016b; Nachtigall et al., 2016c; Nachtigall et al., 2018). The effect was first demonstrated in a false killer whale (*Pseudorca crassidens*) by Nachtigall and Supin (2013). Subsequent experiments, using similar methods, demonstrated similar conditioned hearing changes in a bottlenose dolphin (*Tursiops truncates*) (Nachtigall & Supin, 2014, 2015; Nachtigall et al., 2016c), beluga whale (*Delphinapterus leucas*) (Nachtigall et al., 2016a), and harbor porpoise (*Phocoena phocoena*) (Nachtigall et al., 2016b) Using slightly different methods, Finneran (2018) measured the time course and frequency patterns of conditioned hearing changes in two dolphins. Based on these experimental measurements with captive odontocetes, it is likely that wild odontocetes would also suppress their hearing if they could anticipate an impending, intense sound, or during a prolonged exposure (even if not anticipated). Based on the time course and duration of the conditioned hearing reduction, odontocetes participating in some previous TTS experiments could have been protecting their hearing during exposures (Finneran, 2018). A better understanding of the mechanisms responsible for the observed hearing changes is needed for proper interpretation of some existing temporary threshold shift data, particularly for considering TTS due to short duration, unpredictable exposures. No modification of analysis of auditory impacts is currently suggested, as the Phase III auditory impact thresholds are based on best available data for both impulsive and non-impulsive exposures to marine mammals.

Due to the higher exposure levels or longer exposure durations required to induce hearing loss, only a few types of human-made sound sources have the potential to cause a threshold shift to a marine mammal in the wild. These include some sonars and other transducers and impulsive sound sources such as air guns and impact pile driving, neither of which will be used in the Study Area.

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 Finneran (2016) and NMFS (2016e, 2018e). 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

TTS in mid-frequency cetaceans exposed to non-impulsive sound has been investigated in multiple studies (Finneran et al., 2005b; Finneran et al., 2010a; Finneran & Schlundt, 2013; Mooney et al., 2009a;

Mooney et al., 2009b; Nachtigall et al., 2003; Nachtigall et al., 2004; Popov et al., 2013; Popov et al., 2014; Schlundt et al., 2000) from two species, bottlenose dolphins and beluga whales. Two high-frequency cetacean species have been studied for TTS due to non-impulsive sources: the harbor porpoise (Kastelein et al., 2012b) and the finless porpoise (*Neophocaena phocaenoides*) (Popov et al., 2011). 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, 2017b), and the major findings are summarized above.

Several studies of threshold shift in marine mammals exposed to non-impulsive sounds have been published since development of the technical report. Kastelein et al. (2017b) 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 auditory evoked potentials (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 dB re 1 μPa^2s). 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, 5 minutes post-exposure. For these exposures, Phase III criteria over-estimate the observed effects (i.e., Phase III criteria predict 40 dB of TTS for SEL of 198 dB re 1 μPa^2s).

Threshold Shift due to Impulsive Sound Sources

Cetacean TTS data from impulsive sources are limited to two studies with measured TTS of 6 dB or more. Finneran et al. (2002) reported behaviorally measured TTSs of 6 and 7 dB in a beluga exposed to single impulses from a seismic water gun, and Lucke et al. (2009) reported auditory evoked potential-measured TTS of 7– 20 dB in a harbor porpoise exposed to single impulses from a seismic air gun.

In addition to these studies, a number of impulsive noise exposure studies have been conducted without behaviorally measurable TTS of 6 dB or more. The results of these studies are either consistent with the Navy Phase III criteria and thresholds (e.g., exposure levels were below those predicted to cause TTS, and TTS did not occur) or suggest that the Phase III thresholds over-estimate the potential for impact (e.g., exposure levels were above Navy Phase III TTS threshold, but TTS did not occur). The individual studies are summarized below:

Finneran et al. (2000) exposed dolphins and belugas to single impulses from an "explosion simulator," and Finneran et al. (2015) exposed three dolphins to sequences of 10 impulses from a seismic air gun (maximum cumulative SEL = 193 to 195 dB re 1 μPa^2s, 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^2s, 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^2s (weighted SEL ~144 dB re 1 μPa^2s, 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.

Kastelein et al. (2017c) measured TTS in a harbor porpoise after exposure to multiple air gun impulses. Either a single or double air gun arrangement was used. Maximum exposure peak pressure was 194/199 dB re 1 µPa for single/double air guns. Maximum cumulative, weighted SEL was 140/143 dB re 1 µPa^{2}s for ten-shot exposures of single/double air guns. Maximum TTS occurred at 4 kHz and was 3 dB/4 dB for single/double air guns.

3.4.2.1.1.3 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; New et al., 2013b; 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 effects 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, and social interactions with members of the same species 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 might 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 pronounced increase in 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). 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 acclimated to the noise exposure. Kvadsheim et al. (2010) measured the heart rate of captive hooded seals during exposure to sonar signals and found an increase in the heart rate of the seals during exposure periods versus control periods when the animals were at the surface. When the animals dove, the normal dive-related bradycardia (decrease in heart rate) was not impacted by the sonar exposure. Similarly, Thompson et al. (1998) observed a rapid but short-lived decrease in heart rates in harbor and grey seals exposed to seismic air guns (cited in Gordon et al., 2003). Williams et al. (2017a) 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 dive bradycardia persists during diving and might be enhanced in response to an acute stressor. Houser et al. (2020) measured cortisol and epinephrine obtained from 30 bottlenose dolphins exposed to simulated U.S. Navy mid-frequency sonar, and found no correlation between sound pressure level and stress hormone levels. In the same experiment (Houser et al., 2013b), behavioral responses were shown to increase in severity with increasing received sound pressure levels. These results suggest that behavioral reactions to sonar signals are not necessarily indicative of a hormonal stress response.

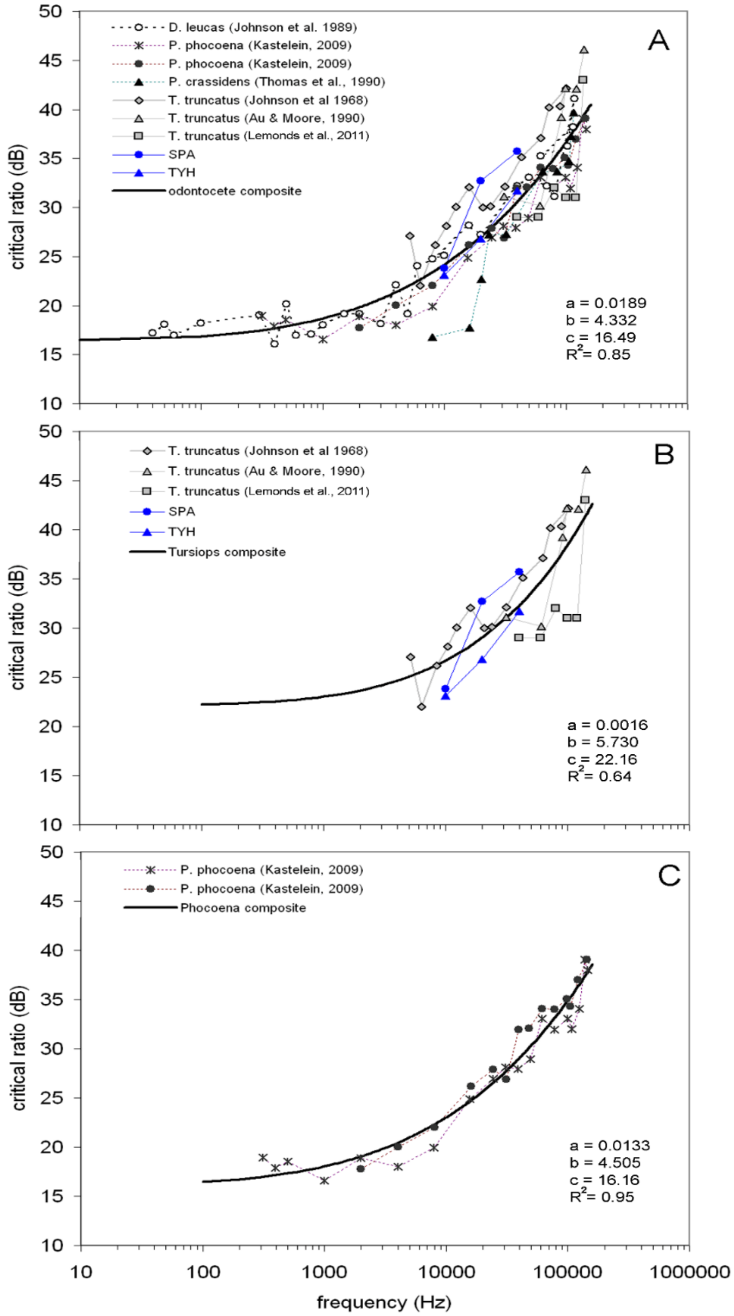
Whereas a limited amount of work has addressed the potential for acute sound exposures to produce a stress response, almost nothing is known about how chronic exposure to acoustic stressors affects stress hormones in marine mammals, particularly as it relates to survival or reproduction. In what is probably the only study of chronic noise exposure in marine mammals associating changes in a stress hormone with changes in anthropogenic noise, Rolland et al. (2012) compared the levels of cortisol metabolites in North Atlantic right whale feces collected before and after September 11, 2001. Following the events of September 11, shipping was significantly reduced in the region where fecal collections were made, and regional ocean background noise declined. Fecal cortisol metabolites significantly decreased during the period of reduced ship traffic and ocean noise (Rolland et al., 2012). Considerably more work has been conducted in an attempt to determine the potential effect of boating on smaller cetaceans, particularly killer whales (Bain, 2002; Erbe, 2002; Lusseau, 2006; Noren et al., 2009; Pirotta et al., 2015b; Rolland et al., 2012; Skarke et al., 2014; Williams et al., 2006; Williams et al., 2009; Williams et al., 2014b; Williams et al., 2014c). 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, 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 (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).

3.4.2.1.1.4 Masking

Masking occurs when one sound, the "noise," interferes with the detection, discrimination, or recognition of another sound (the "signal"). 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 3.0.4.7 (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. 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).

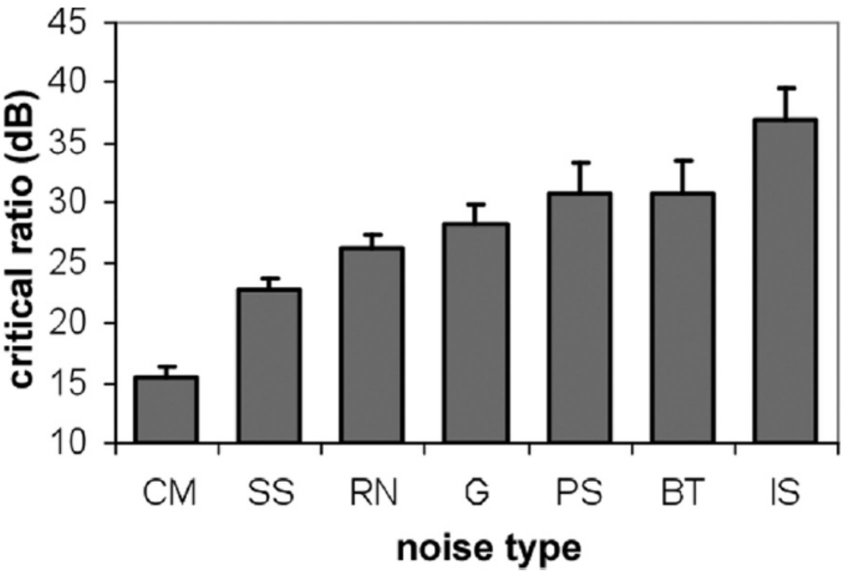
Critical ratios are the lowest signal-to-noise ratio in which detection under masking conditions occurs (Finneran & Branstetter, 2013; Johnson et al., 1989; Southall et al., 2000). When expressed in dB, critical ratios can easily be calculated by subtracting the noise level (in dB re 1 $\mu Pa^2/Hz$) from the signal level (in dB re 1 µPa) at threshold. Critical ratios have been measured for pinnipeds (Southall et al., 2000, 2003; Thomas et al., 1990a), odontocetes (see) (Au & Moore, 1990; Branstetter et al., 2017b; Johnson et al., 1989; Kastelein & Wensveen, 2008; Lemonds et al., 2011), manatees (Gaspard et al., 2012), and sea otters (Ghoul & Reichmuth, 2014). 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, which allows 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 3.4-3) depending on the noise type (Branstetter et al., 2013; Branstetter et al., 2017b; Trickey et al., 2010). Signal type (e.g., whistles, burst-pulses, sonar clicks) and spectral characteristics (e.g., frequency modulation and/or harmonics) may further influence masked detection thresholds (Branstetter et al., 2016; Cunningham et al., 2014).



Source: Branstetter et al. (2017b)

Notes: (A) Odontocete critical ratios and composite model: CR = $a[\log10(f)]^b + c$, 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. (B) *T. truncatus* critical ratios and composite model. (C) *P. phocoena* critical ratios and composite model. Parameter values for composite models are displayed in the lower right of each panel

Figure 3.4-3: 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 3.4-4: 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., 2008; Holt et al., 2011; Lesage et al., 1999; McDonald et al., 2009; Rolland et al., 2012) as well as changes in the natural acoustic environment (Dunlop et al., 2014; Helble et al., 2020). Vocal changes can be temporary, or can be persistent, as seen in the increase in starting frequency for the North Atlantic right whale upcall over the last 50 years (Tennessen & Parks, 2016). Model simulation suggests that the frequency shift resulted in increased detection ranges between right whales; the frequency shift, coupled with an increase in call intensity by 20 dB, led to a call detectability range of less than 3 km to over 9 km

(Tennessen & Parks, 2016). In some cases, these vocal changes may have fitness consequences, such as an increase in metabolic rates and oxygen consumption, as was found for bottlenose dolphins when increasing their call amplitude (Holt et al., 2015). A switch from vocal communication to physical, surface-generated sounds such as pectoral fin slapping or breaching was observed for humpback whales in the presence of increasing natural background noise levels, indicating that adaptations to masking may not be limited to vocal modifications (Dunlop et al., 2010). These changes all represent possible tactics by the sound-producing animal to reduce the impact of masking. The receiving animal can also reduce masking by using active listening strategies such as orienting to the sound source, moving to a quieter location, or reducing self-noise from hydrodynamic flow by remaining still.

Informational Masking

Much emphasis has been placed on signal detection in noise, and as a result, most masking studies and communication space models have focused on masked detection thresholds. However, from a fitness perspective, signal detection is almost meaningless without the ability to determine the sound source location and recognize what is producing the sound. Marine mammals use sound to recognize conspecifics, prey, predators, or other biologically significant sources (Branstetter et al., 2016). Masked recognition thresholds (often called informational masking) for whistle-like sounds have been measured for bottlenose dolphins (Branstetter et al., 2016), and are approximately 4 dB above detection thresholds (energetic masking) for the same signals. It should be noted that the term "threshold" typically refers to the listener's ability to detect or recognize a signal 50 percent of the time. For example, human speech communication where only 50 percent of the words are recognized would result in poor communication (Branstetter et al., 2016). Likewise, recognition of a conspecific call or the acoustic signature of a predator at only the 50 percent level could have severe negative impacts. If "quality communication" is arbitrarily set at 90 percent recognition (which may be more appropriately related to animal fitness), the output of communication space models (which are based on 50 percent detection) would likely result in a significant decrease in communication range (Branstetter et al., 2016).

Marine mammals use sound to recognize predators (Allen et al., 2014; Cummings & Thompson, 1971; Curé et al., 2015; Fish & Vania, 1971). Auditory recognition may be reduced in the presence of a masking noise, particularly if it occurs in the same frequency band. Therefore, the occurrence of masking may prevent marine mammals from responding to the acoustic cues produced by their predators. Whether this is a possibility depends on the duration of the masking and the likelihood of encountering a predator during the time that detection and recognition of predator cues are impeded. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by mammal-eating killer whales. The seals acoustically discriminate between the calls of mammal-eating and fish-eating killer whales (Deecke et al., 2002), a capability that should increase survivorship while reducing the energy required to attend to all killer whale calls. Similarly, sperm whales (Curé et al., 2016; Isojunno et al., 2016), long-finned pilot whales (Visser et al., 2016), and humpback whales (Curé et al., 2015) changed their behavior in response to killer whale vocalization playbacks; these findings indicate that some recognition of predator cues could be missed if the killer whale vocalizations were masked.

Masking by Sonar and Other Transducers

Masking only occurs in the presence of the masking noise and does not persist after the cessation of the noise. Because traditional military sonars typically have low duty cycles, relatively short duration, and narrow bandwidth that does not overlap with vocalizations for most marine mammal species, the effects of such masking would be limited when compared with continuous sources (e.g., vessel noise).

Dolphin whistles and mid-frequency active sonar are similar in frequency, so masking is possible but less likely due to the low-duty cycle of most sonars. Low-frequency active sonar could also overlap with mysticete vocalizations (e.g., minke and humpback whales). For example, in the presence of low-frequency active sonar, humpback whales were observed to increase the length of their songs (Fristrup et al., 2003; Miller et al., 2000), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar.

Newer high-duty cycle or continuous active sonars have more potential to mask vocalizations, particularly for delphinids and other mid-frequency cetaceans. These sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. Similarly, high-frequency acoustic sources such as pingers that operate at higher repetition rates (e.g., 2–10 kHz with harmonics up to 19 kHz, 76 to 77 pings per minute (Culik et al., 2001), also operate at lower source levels. While the lower source levels limit the range of impact compared to traditional systems, animals close to the sonar source are likely to experience masking on a much longer time scale than those exposed to traditional sonars. The frequency range at which high-duty cycle systems operate overlaps the vocalization frequency of many mid-frequency cetaceans. Continuous noise at the same frequency of communicative vocalizations may cause disruptions to communication, social interactions, and acoustically mediated cooperative behaviors such as foraging or reproductive activities. Similarly, because the systems are mid-frequency, there is the potential for the sonar signals to mask important environmental cues like predator vocalizations (e.g., killer whales), possibly affecting survivorship for targeted animals. While there are currently no available studies of the impacts of high-duty cycle sonars on marine mammals, masking due to these systems is likely analogous to masking produced by other continuous sources (e.g., vessel noise and low-frequency cetaceans), and would likely have similar short-term consequences, though longer in duration due to the duration of the masking noise. These may include changes to vocalization amplitude and frequency (Brumm & Slabbekoorn, 2005; Hotchkin & Parks, 2013) and behavioral impacts such as avoidance of the area and interruptions to foraging or other essential behaviors (Gordon et al., 2003). Long-term consequences could include changes to vocal behavior and vocalization structure (Foote et al., 2004; Parks et al., 2007), abandonment of habitat if masking occurs frequently enough to significantly impair communication (Brumm & Slabbekoorn, 2005), a potential decrease in survivorship if predator vocalizations are masked (Brumm & Slabbekoorn, 2005), and a potential decrease in recruitment if masking interferes with reproductive activities or mother-calf communication (Gordon et al., 2003).

Masking by Vessel Noise

Masking is more likely to occur in the presence of broadband, relatively continuous noise sources such as vessels. For example, right whales were observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al., 2007) as well as increasing the amplitude (intensity) of their calls (Parks, 2009; Parks et al., 2011). Right whales also had their communication space reduced by up to 84 percent in the presence of vessels (Clark et al., 2009). Cholewiak et al. (2018) found that right whale gunshot calls had the lowest loss of communication space in Stellwagen National Sanctuary (5 percent), while fin and humpback whales lost up to 99 percent of their communication space with increased ambient noise and shipping noise combined. Although humpback whales off Australia did not change the frequency or duration of their vocalizations in the presence of ship noise, their source levels were lower than expected based on source level changes to wind noise, potentially indicating some signal masking (Dunlop, 2016). Vessel noise decreased the 4 km of humpback whale modeled communication space (with wind noise up to 100 dB re 1 µPa) to 3 km at the same received level, and at 105 dB re 1 µPa of noise communication space decreased again to 2 km for low-frequency signals and 1 km for high-frequency signals (Dunlop, 2019). Communication space loss due to vessels in Glacier Bay National Park was estimated to be lower for singing humpback whales than for calling whales and was highest for roaring harbor seals, but synchronizing the arrival and departure times of ships into the park restored some of that communication space for the calling whales and seals (Gabriele et al., 2018). Fournet et al. (2018) found humpback whales increase their call source levels by 0.8 dB and decrease the probability of calling by 9 percent for every 1 dB increase in ambient sound, which included vessel noise.

Multiple delphinid species have also been shown to increase the minimum or maximum frequencies of their whistles in the presence of anthropogenic noise (Papale et al., 2015). More specifically, Williams et al. (2014b) found that in median noise conditions in Haro Strait, killer whales lose 62 percent of their acoustic communication space due to vessel traffic noise, and in peak traffic hours lose up to 97 percent of that space. Holt et al. (2008; 2011) 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. Dugong vocalizations were recorded in the presence of passing boats, and although the call rate, intensity, and frequency of the calls did not change, the duration of the vocalizations was increased, as was the presence of harmonics. This may indicate more energy was being used to vocalize in order to maintain the same received level (Ando-Mizobata et al., 2014). Gervaise et al. (2012) estimated that beluga whales in the St. Lawrence Marine Park had their communication space reduced to 30 percent during average vessel traffic. During peak traffic, communication space was further reduced to 15 percent. Lesage et al. (1999) found belugas in the St. Lawrence River estuary reduced overall call rates but increased the production of certain call types when ferry and small outboard motor boats were approaching. Furthermore, these belugas increased the vocalization frequency band when vessels were in close proximity. Liu et al. (2017) found that broadband shipping noise could cause masking of humpback dolphin whistles within 1.5–3 km, and masking of echolocation clicks within 0.5–1.5 km.

Masking by Impulsive Sound

Potential masking from weapon noise is likely to be similar to masking studied for other impulsive sounds such as air guns. Masking could occur in mysticetes due to the overlap between their low-frequency vocalizations and the dominant frequencies of impulsive sources; however, masking in odontocetes 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. Bowhead whales were found to increase call rates in the presence of seismic air gun noise at lower received levels (below 100 dB re: 1 µPa2s cumulative SEL), but once the received level rose above 127 dB re 1 μPa²s cumulative SEL the call rate began decreasing, and stopped altogether once received levels reached 170 dB re 1 μPa²s cumulative SEL (Blackwell et al., 2015). Nieukirk et al. (2012) recorded both seismic surveys and fin whale 20 Hz calls at various locations around the mid-Atlantic Ocean and hypothesized that distant seismic noise could mask those calls, thereby decreasing the communication range of fin whales, whose vocalizations may propagate over 400 km to reach conspecifics ((Spiesberger & Fristrup, 1990)). Two captive seals (one spotted and one ringed) were exposed to seismic air gun sounds recorded within 1 km and 30 km of an air gun survey conducted in shallow (<40 m) water. They were then tested on their ability to detect a 500 ms upsweep centered at 100 Hz at different points in the air gun pulse (start, middle, and end). Based on these results, a 100 Hz vocalization with a source level of 130 dB re 1 μPa would not be detected above a seismic survey 1 km away unless the animal was within 1–5 m, and would not be detected above a survey 30 km away beyond 46 m ((Sills et al., 2017)).

3.4.2.1.1.5 Behavioral Reactions

As discussed in Section 3.0.4.7 (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, these stimuli could also influence how or if a marine mammal responds to a sound such as the presence of predators, prey, or conspecifics. Furthermore, the response of a marine mammal to an anthropogenic sound may depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and their behavioral state (i.e., what the animal is doing and their energetic needs at the time of the exposure) (Ellison et al., 2011). The distance from the sound source and whether it is approaching or moving away can also affect the way an animal responds to a sound (Wartzok et al., 2003).

For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson et al. (1995b). Other reviews (Nowacek et al., 2007; Southall et al., 2007) addressed studies conducted since 1995 and focused on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated, and also examined the role of context. Southall et al. (2007) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels, and Southall et al. (2016) reviewed the range of experimental field studies that have been conducted to measure behavioral responses of cetaceans to sonar. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al., 2007; Southall et al., 2016). Ellison et al. (2011) outlined an approach to assessing the effects of sound on marine mammals that incorporates these contextual-based factors. They recommend considering not just the received level of sound, but also in what activity the animal is engaged, the nature and novelty of the sound (i.e., is this a new sound from the animal's perspective), and the distance between the sound source and the animal. They submit that this "exposure context," as described, greatly influences the type of behavioral response exhibited by the animal (see technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017b)). 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 active acoustic sources (e.g., pingers), vessel noise, and aircraft noise. There is 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, 2017b)).

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 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities) and Section 3.4.2.1.1.5 (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 or testing 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 5.6.1 (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 and testing activity and associated sources to assess behavioral responses (Deakos & Richlen, 2015; Henderson et al., 2016; Manzano-Roth et al., 2016; Martin et al., 2015; McCarthy et al., 2011; Mobley & Deakos, 2015; Moretti et al., 2014; Tyack et al., 2011). In addition, extensive aerial, visual, and passive acoustic monitoring have been conducted before, during, and after training events to watch for behavioral responses during training and look for injured or stranded animals after training (Falcone et al., 2017; Farak et al., 2011; HDR, 2011a; Henderson et al., 2016; Manzano-Roth et al., 2016; Norris et al., 2012b; Smultea & Mobley, 2009; Smultea et al., 2009; Trickey et al., 2015; U.S. Department of the Navy, 2011b, 2013b, 2014a, 2015b). 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 & Thomas (2015) highlighted additional research approaches that may provide further information on behavioral responses to sonars 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. There are several captive studies on some 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., 2013b; 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., 2013b; Sivle et al., 2015; Southall et al., 2019b). 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., 2013b; Sivle et al., 2015). In another study, humpback whales exposed to a 3 kHz pinger meant to act as a net alarm to prevent entanglement did not respond or change course, even when within 500 m (Harcourt et al., 2014). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives; in this case, the alarm was comprised of a mixture of signals with frequencies from 500 to 4500 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 $\mu Pa^2 s$), 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., 2013). Humpback whales in the Norwegian behavioral response study may have habituated slightly between the first and second sonar exposure (Sivle et al., 2015), and actually responded more severely to killer whale vocalization playbacks than they did to the sonar playbacks. Several humpback whales have been observed during aerial or visual surveys during Navy training events involving sonar; no avoidance or other behavioral responses were ever noted, even when the whales were observed within 5 km of a vessel with active (or possibly active) sonar and maximum received levels were estimated to be between 135 and 161 dB re 1 µPa (Mobley & Milette, 2010; Mobley, 2011; 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, 2011a). 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 (Simeone et al., 2015; U.S. Department of the Navy, 2013b), especially with an increased ping rate (Charif et al., 2015). Harris et al. (2019b) utilized acoustically generated minke whale tracks at the U.S. Navy's Pacific Missile Range Facility to statistically demonstrate changes in the spatial distribution of minke whale acoustic presence Before, During, and After surface ship mid-frequency active sonar training. The spatial distribution of probability of acoustic presence was different in the During phase compared to the Before phase, and the probability of presence at the center of ship activity for the

During phase was close to zero for both years. The After phases for both years retained lower probabilities of presence suggesting the return to baseline conditions may take more than five days. The results show a clear spatial redistribution of calling minke whales during surface ship mid-frequency active sonar training, however a limitation of passive acoustic monitoring is that one cannot conclude if the whales moved away, went silent, or a combination of the two. Two minke whales also stranded in shallow water after the U.S. Navy training event in the Bahamas in 2000, although these animals were successfully returned to deep water with no physical examinations; therefore, no final conclusions were drawn on whether the sonar led to their stranding (Filadelfo et al., 2009a; Filadelfo et al., 2009b; U.S. Department of Commerce & U.S. Department of the Navy, 2001).

Baleen whales have also been exposed to lower 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).

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 and testing 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 would 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 would 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, 2011b, 2014b; 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; Joyce et al., 2018; Manzano-Roth et al., 2016; McCarthy et al., 2011; Moretti et al., 2009; Southall et al., 2011; Southall et al., 2012; Southall et al., 2013; Southall et al., 2014; Southall et al., 2015; Tyack et al., 2011; Wensveen et al., 2019). Through analyses of these behavioral response studies, a preliminary overarching effect of greater sensitivity to most anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al., 2009).

Observed reactions by Blainville's, Cuvier's, and Baird's beaked whales to mid-frequency sonar sounds have included cessation of clicking, decline in group vocal periods, termination of foraging dives, changes in direction to avoid the sound source, slower ascent rates to the surface, longer deep and shallow dive durations, and other unusual dive behavior (Boyd et al., 2008; Defence Science and Technology Laboratory, 2007; DeRuiter et al., 2013b; Miller et al., 2015; Southall et al., 2011; Stimpert et al., 2014; Tyack et al., 2011). Similar responses have been observed in northern bottlenose whales, one of which conducted the longest and deepest dive on record for that species after the sonar exposure and continued swimming away from the source for over seven hours (Miller et al., 2015; Wensveen et al., 2019). Responses have occurred at received levels between 95 and 150 dB re 1 µPa. Many of these exposures occurred within 1–8 km of the focal animal, within a few hours of tagging the animal, and with one or more boats within a few kilometers to observe responses and record acoustic data. One Cuvier's beaked whale was also incidentally exposed to real Navy sonar located over 100 km away, and the authors did not detect similar responses at comparable received levels. Received levels from the mid-frequency active sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa, respectively, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor in the responses to the simulated sonars (DeRuiter et al., 2013b). However, in a remote environment where sonar exposure is rare, similar responses in northern bottlenose whales were detected in whales up to 28 km away from the source at modeled received levels estimated at 117–126 dB re 1 µPa with no vessel nearby (von Benda-Beckmann et al., 2019; Wensveen et al., 2019). One northern bottlenose whale did approach the ship and circle the source, then resumed foraging after the exposure, but the source level was only 122 dB re 1 µPa.

Falcone et al. (2017) modeled deep and shallow dive durations, surface interval durations, and inter-deep dive intervals of Cuvier's beaked whales against predictor values that included helicopter-dipping, mid-power mid-frequency active sonar and hull-mounted, high-power mid-frequency active sonar along with other, non-mid-frequency active sonar predictors. They found both shallow and deep dive durations to increase as the proximity to both mid- and high-powered sources decreased, and found surface intervals and inter-deep dive intervals to also increase in the presence of both types of sonars, although surface intervals shortened during periods of no mid-frequency active sonar. The responses to the mid-power mid-frequency active sonar at closer ranges were comparable to the responses to the higher SL 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). 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. (2017b) note that in normal deep dives or during fast swim speeds, beaked whales and other marine mammals use strategies to reduce their stroke rates, including leaping or wave surfing when swimming, and interspersing glides between bouts of stroking when diving. They determined that in the post-exposure dives by the tagged Cuvier's beaked whales described in DeRuiter et al. (2013b), the whales ceased gliding and swam with almost continuous strokes. This change in swim behavior was calculated to increase metabolic costs about 30.5 percent and increase the amount of energy expending on fast swim speeds from 27 to 59 percent of their overall energy budget. This repartitioning of energy was detected in the model up to 1.7 hours after the single sonar exposure. Therefore, while the overall post-exposure dive durations were similar, the metabolic energy calculated by Williams et al. (2017b) 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 mPa. The behavioral response characteristics and avoidance thresholds were comparable to those previously observed in beaked whale studies; however, they did not observe an effect of distance on behavioral response and found that onset and intensity of behavioral response were better predicted by received SPL. Joyce et al. (2019) examined modeled received sound levels, dive data, and horizontal movement of seven satellite-tagged Blainville's beaked whales before, during, and after mid-frequency active sonar training at the Atlantic Undersea Test and Evaluation Center instrumented range. They found a decline in deep dives at the onset of the training and an increase in time spent on foraging dives as individuals moved away from the range. Predicted received levels at which presumed responses were observed were comparable to those previously observed in beaked whale studies. Acoustic data indicated that vocal periods were detected on the range within 72 hours after training ended.

On Navy ranges, Blainville's beaked whales located on the range appear to move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge et al., 2009; Henderson et al., 2015; Manzano-Roth et al., 2016; McCarthy et al., 2011; Moretti et al., 2009; Tyack et al., 2011). For example, five Blainville's beaked whales that were estimated to be within 2–29 km of the AUTEC range at the onset of sonar were displaced a maximum of 28–68 km from the range after moving away from the range, although one whale approached the range during the period of active sonar (Joyce et al., 2019). However, Blainville's beaked whales remain on the range to forage throughout the rest of the year (Henderson et al., 2016), possibly indicating that this a preferred foraging habitat regardless of the effects of the noise, or it could be that there are no long-term consequences of the sonar activity. Similarly, photo-identification studies in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 40 percent having been seen in one or more prior years, with re-sightings up to seven years apart, indicating a possibly resident population on the range (Falcone et al., 2009; Falcone & Schorr, 2014).

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 four detections occurring when it was on. Beaked whales were sighted fairly equally when the echosounder was on or off, but sightings were further from the ship when the echosounder was on (Cholewiak et al., 2017). These findings indicate that the beaked whales may be avoiding the area and may cease foraging near the echosounder.

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 kilometer away from where they were vocally active during the dive, they minimize the ability of killer whales to locate them when at the surface. This may lead to a trade-off for the larger, more fit animals that could conduct longer foraging dives, such that all members of the group remain together and are better protected by this behavior. The authors further speculate that this may explain the long, slow, silent, and shallow ascents that beaked whales make when sonar occurs during a deep foraging dive. However, these hypotheses are based only on the dive behavior of tagged beaked whales, with no observations of predation attempts by killer whales, and need to be tested further to be validated. This anti-predator hypothesis was also tested by playing back killer whale vocalizations to pilot whales, sperm whales, and even other killer whales, to determine responses by both potential prey and conspecifics (Miller et al., 2011; Miller, 2012). Results varied, from no response by killer whales to an increase in group size and attraction to the source in pilot whales (Curé et al., 2012). Gotz et al. (2020) tested startle responses in bottlenose dolphins and found that these responses can occur at moderate received levels and mid-frequencies, and that the relationship between rise time and startle response was more gradual than expected in an odontocete. They therefore hypothesize that the extreme responses of beaked whales to sonar could be a form of startle response, rather than an anti-predator response.

While there has been a focus on beaked whale responses to sonar, other species have been studied during behavioral response studies as well, including pilot whales, killer whales, and sperm whales. Responses by these species have also included horizontal avoidance, reduced breathing rates, changes in behavioral state, and changes in dive behavior (Antunes et al., 2014; Isojunno et al., 2017; Isojunno et al., 2018; Isojunno et al., 2020; Miller et al., 2011; Miller, 2012; Miller et al., 2014). Additionally, separation of a killer whale calf from its group during exposure to mid-frequency sonar playback was observed (Miller et al., 2011). Received level thresholds at the onset of avoidance behavior were generally higher for pilot whales (mean 150 dB re 1 µPa) and sperm whales (mean 140 dB re 1 µPa) than killer whales (mean 129 dB re 1 µPa) (Antunes et al., 2014; Miller, 2012; Miller et al., 2014). A close examination of the tag data from the Norwegian groups showed that responses seemed to be behaviorally, signal frequency, or received sound energy mediated. For example, killer whales only changed their dive behavior when doing deep dives at the onset of 1–2 kHz sonar (sweeping across frequencies), but did not change their dive behavior if they were deep diving during 6–7 kHz sonar (sweeping across frequencies). Nor did they change their dive behavior if they were conducting shallow dives at the onset of either type of sonar. Similarly, pilot whales and sperm whales performed normal deep dives during 6–7 kHz sonar (and more deep foraging dives than during baseline for the pilot whales), while during 1–2 kHz sonar the pilot whales conducted fewer deep dives and the sperm whales performed shorter and shallower dives (Sivle et al., 2012). In addition, pilot whales were also more likely to respond to lower received levels when non-feeding than feeding during 6–7 kHz sonar exposures, but were more likely to respond at higher received levels when non-feeding during 1–2 kHz sonar exposures. Foraging time in pilot whales was reduced during the initial sonar exposure (both mid-frequency active sonar and low-frequency active sonar), with a concurrent increase in travel behavior; however, foraging increased again during subsequent exposures, potentially indicating some habituation (Isojunno et al., 2017). No reduction in foraging was observed during killer whale playbacks. Cessation of foraging appeared to occur at a lower received level of 145–150 dB re 1 µPa than had been observed previously for avoidance behavior (around 170 dB re 1 µPa; Antunes et al., 2014). Pilot whales also exhibited reduced breathing rates relative to their diving behavior when the low-frequency active sonar levels were high (reaching 180 dB re 1 µPa), but only on the first sonar exposure; on subsequent exposures their breathing rates increased (Isojunno et al., 2018), indicating a change in response tactic with additional exposures. Furthermore, pilot whales exposed to a 38 kHz downward-facing echosounder did not change their dive and foraging behavior during exposure periods, although the animals' heading variance increased and fewer deep dives were conducted (Quick et al., 2017). In contrast, killer whales were more likely to respond to either sonar type when non-feeding than when feeding (Harris et al., 2015). Sperm whales were exposed to pulsed active sonar (1-2 kHz) at moderate source levels and high source levels, as well as continuously active sonar at moderate levels for which the summed energy (SEL) equaled the summed energy of the high source level pulsed sonar (Isojunno et al., 2020). Foraging behavior did not change during exposures to moderate source level sonar, but non-foraging behavior increased during exposures to high source level sonar and to the continuous sonar, indicating that the energy of the sound (the SEL) was a better predictor of response than SPL. However, the time of day of the exposure was also an important covariate in determining the amount of non-foraging behavior, as were order effects (e.g. the SEL of the previous exposure). These results again demonstrate that the behavioral state and environment of the animal mediates the likelihood of a behavioral response, as do the characteristics (e.g., frequency, energy level) of the sound source itself. Further, the highly flexible activity time budgets observed for pilot whales, with a large amount of time spent resting at the surface, may indicate context-dependency on some behaviors, such as the presence of prey driving periods of foraging. Therefore, that time may be more easily re-allocated to missed foraging opportunities, leading to less severe population consequences of periods of reduced foraging (Isojunno et al., 2017).

Other responses during behavioral response studies included the synchronization of pilot whale surfacings with sonar pulses during one exposure, possibly as a means of mitigating the sound (Wensveen et al., 2015), and mimicry of the sonar with whistles by pilot whales (Alves et al., 2014), false killer whales (DeRuiter et al., 2013b) 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, 2013c).

In addition, killer whale sighting data from the same region in Norway as the behavioral response study was 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. (2013b; 2014; 2017) also tagged four shallow-diving odontocete species (rough-toothed dolphins, pilot whales, bottlenose dolphins, and false killer whales) in Hawaii off the Pacific Missile Range Facility before Navy training events. None of the tagged animals demonstrated a large-scale avoidance response to the sonar as they moved on or near the range, in some cases even traveling towards areas of higher noise levels, while estimated received SPLs varied from 130 to 168 dB re 1 µPa and distances from sonar sources ranged between 3.2 and 94.4 km. However, one pilot whale did have reduced dive rates (from 2.6 dives per hour before to 1.6 dives per hour during) and deeper dives (from a mean of 124 m to 268 m) during a period of sonar exposure. Baird et al. (2016) also tagged four short-finned pilot whales from both the resident island-associated population and from the pelagic population. The core range for the pelagic population was over 20 times larger than for the pelagic population, leading Baird et al. (2016) to hypothesize that that likelihood of exposure to mid-frequency active sonar, and therefore the potential for response, would be very different between the two populations. These diverse examples demonstrate that responses can be varied, are often context- and behavior-driven, and can be species and even exposure specific.

Other opportunistic observations of behavioral responses to sonar have occurred as well, although in those cases it is difficult to attribute observed responses directly to the sonar exposure, or to know exactly what form the response took. For example, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test, with transmissions centered at 57 Hz and up to 220 dB re 1 µPa (Bowles et al., 1994), although it could not be determined whether the animals ceased sound production or left the area. In May 2003, killer whales in Haro Strait, Washington, exhibited what were believed by some observers to be aberrant behaviors, during which time the USS Shoup was in the vicinity and engaged in mid-frequency active sonar operations. Sound fields modeled for the USS Shoup transmissions (Fromm, 2009; National Marine Fisheries Service, 2005; U.S. Department of the Navy, 2004) estimated a mean received SPL of approximately 169 dB re 1 µPa at the location of the killer whales at the closest point of approach between the animals and the vessel (estimated SPLs ranged from 150 to 180 dB re 1 µPa). However, attributing the observed behaviors to any one cause is problematic given there were six nearby whale watch vessels surrounding the pod, and subsequent research has demonstrated that "Southern Residents modify their behavior by increasing surface activity (breaches, tail slaps, and pectoral fin slaps) and swimming in more erratic paths when vessels are close" (National Oceanic and Atmospheric Administration, 2014). Several odontocete species, including bottlenose dolphins, Risso's dolphins, Pacific white-sided dolphins, and common dolphins have been observed near the Southern California Offshore Range during periods of mid-frequency active sonar; responses included changes in or cessation of vocalizations, changes in behavior, and departures from 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 & Schevill, 1975; Watkins et al., 1985). 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, 2011a; 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 a seasonal difference that was also observed in other years (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, that transmit sound into the acoustic environment similar to Navy sonar, 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. 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). While habituation might occur to a pinger with a single tone, it is less likely to habituate to a pinger with a mixture of signals. Additionally, sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins & Schevill, 1975). However, acoustic harassment devices used to deter marine mammals from depredating long lines or aquaculture enclosures have proven less successful. For example, Tixier et al. (2014) used a 6.5 kHz pinger with a source level of 195 dB re 1 µPa on a longline to prevent depredation by killer whales, and although two groups of killer whales fled over 700 m away during the first exposure, they began depredating again after the third and seventh exposures, indicating rapid habituation. In a review of marine mammal deterrents, Schakner & Blumstein (2013) point out that both the characteristics of deterrents and the motivation of the animal play a role in the effectiveness of acoustic harassment devices. Deterrents that are strongly aversive or simulate a predator or are otherwise predictive of a threat are more likely to be effective, unless the animal habituates to the signal or learns that there is no true threat associated with the signal. In some cases net pingers may create a "dinner bell effect," where marine mammals have learned to associate the signal with the availability of prey (Jefferson & Curry, 1996; Schakner & Blumstein, 2013). This may be why net pingers have been more successful at reducing entanglements for harbor porpoise and beaked whales since these species are not depredating from the nets but are getting entangled when foraging in the area and are unable to detect the net (Carretta et al., 2008; Schakner & Blumstein, 2013). Bowles and Anderson (2012) exposed a variety of species in captivity to novel objects, including a fishing net and anchor with line, 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., 2001; Finneran et al., 2003a; Finneran & Schlundt, 2004; Finneran et al., 2005b; 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 178–193 dB re 1 μPa; beluga whales did so at received levels of 180–196 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 would behaviorally respond 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., 2014d), 25 kHz with and without sidebands (Kastelein et al., 2015c; Kastelein et al., 2015d), 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., 2018). Responses include increased respiration rates, more jumping, or swimming further from the source, but responses were different depending on the source. For example, harbor porpoises responded to the 1−2 kHz upsweep at 123 dB re 1 μPa, but not to the downsweep or the 6−7 kHz tonal at the same level (Kastelein et al., 2014d). 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., 2014d). 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., 2018). 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., 2014a). 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 would vary across species, populations, and individuals, they are not likely to lead to long-term consequences or population-level effects.

Behavioral Reactions to Vessels Noise

Many thousands of trans-Pacific shipments to and from Asia occur as part of the global shipping transportation network and pass in proximity to the Mariana Islands and throughout the Action Area (Kaluza et al., 2010). 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 (Hatch & Wright, 2007; Hildebrand, 2005; Richardson et al., 1995b). For example, Erbe et al. (2012) estimated the maximum annual underwater SEL from vessel traffic near Seattle was 215 dB re 1 μPa^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. 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; Gende et al., 2011; Watkins, 1981). Other common responses include changes in vocalizations, call rate, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au & Green, 2000; Dunlop, 2019; Fournet et al., 2018; Machernis et al., 2018; Richter et al., 2003; Williams et al., 2002a).

The likelihood of response may be driven by the distance, speed, 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; and changes in behavior were also affected by time of day or season (Di Clemente et al., 2018). 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 1 µPa), but the physical presence of vessels was the major contributing factor to decreased social interactions (Dunlop, 2019). 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., 2009b). 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., 2009). 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 travel behavior states were likely to be maintained in the presence of tourist vessels, surface active behavior was more likely to transition to travel. Humpback whales avoided a Navy vessel by increasing their dive times and decreasing respiration rates at the surface (Smultea et al., 2009). Williamson et al. (2016) specifically looked at close approaches to humpback whales by small research boats for the purposes of tagging. They found that while dive behavior did not change for any groups, some groups did increase their speed and change their course during or right after the approach, but resumed pre-approach speed and heading shortly thereafter. Only mother-calf groups were found to increase their speed during the approach and maintain the increased speed for longer after the approach, but these groups too resumed normal swim speeds after about 40 minutes. It should be noted that there were no responses by any groups that were approached closely but with no attempts at tagging, indicating that the responses were not due to the vessel presence but to the tagging attempt. In addition, none of the observed changes in behavior were outside the normal range of swim speeds or headings for these migrating whales.

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. Based on passive acoustic recordings and in the presence of sounds from passing vessels, Melcón et al. (2012) reported that blue whales had an increased likelihood of producing certain types of calls. While humpback whale call repetition and rate has increased in association with high vessel noise (Doyle et al., 2008), a recent study with stringent inclusion criteria found that the probability of humpback whale calls decreased as vessel noise increased (Fournet et al., 2018). The amplitude of humpback whale calls did not change in the absence or presence of vessel noise. However, feeding calls increased amplitude with higher levels of any (i.e., weather or vessel) ambient noise (Fournet et al., 2018). Boat traffic has been a cause of decreased humpback song activity near Brazil (Sousa-Lima & Clark, 2008), and decreased frequency parameters of fin whale calls (Castellote et al., 2012). Bowhead whales avoided the area around icebreaker ship noise and increased their time at the surface and number of blows (Richardson et al., 1995a). Right whales increase the amplitude or frequency of their vocalizations or call at a lower rate in the presence of increased vessel noise (Parks et al., 2007; Parks et al., 2011), and these vocalization changes may persist over long periods if background noise levels remained elevated. Humpback whales increase the source levels of their calls with increased ambient noise levels that include vessel noise, but the probability of calling is also decreased when vessel noise was part of the soundscape (Fournet et al., 2018).

The long-term consequences of vessel noise are not well understood (see Section 3.4.2.1.1.7, 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 eight vessels observed within 400 m of one whale at the same time. This study found reduced surface time, fewer breaths at the surface, 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 (see Section 3.4.4.4, Physical Disturbance and Strike Stressors in the 2015 MITT Final EIS/OEIS).

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 or resting increasing and foraging and social behavior decreasing (Cecchetti et al., 2017; Clarkson et al., 2020; Meissner et al., 2015). Most studies of the behavioral reactions to vessel traffic of bottlenose dolphins have documented at least short-term changes in behavior, activities, or vocalization patterns when vessels are near, although the distinction between vessel noise and vessel movement has not been made clear (Acevedo, 1991; Arcangeli & Crosti, 2009; Berrow & Holmes, 1999; Fumagalli et al., 2018; Gregory & Rowden, 2001; Janik & Thompson, 1996; Lusseau, 2004; Marega et al., 2018; Mattson et al., 2005; Scarpaci et al., 2000). Steckenreuter (2011) found bottlenose dolphin groups to feed less, become more tightly clustered, and have more directed movement when approached to 50 m than groups approached to 150 m or approached in a controlled manner. Guerra et al. (2014) demonstrated that bottlenose dolphins subjected to chronic noise from tour boats responded to boat noise by alterations in group structure and in vocal behavior but also found the dolphins’ reactions varied depending on whether the observing research vessel was approaching or moving away from the animals being observed. This demonstrates that the influence of the sound exposure cannot be decoupled from the physical presence of a surface vessel, thus complicating interpretations of the relative contribution of each stimulus to the response. Indeed, the presence of surface vessels, their approach, and speed of approach, seemed to be significant factors in the response of the Indo-Pacific humpback dolphins (Ng & Leung, 2003).

The effects of tourism and whale watching have highly impacted killer whales, such as the Northern and Southern Resident populations. These animals are targeted by numerous small whale-watching vessels in the Pacific Northwest and, from 1998 to 2012 during the viewing season, have had an annual monthly average of nearly 20 vessels of various types within 0.5 mile 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 and 116 dB re 1 µPa. 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., 2002b; Williams et al., 2009). These short-term feeding activity disruptions may have important long-term population-level effects (Lusseau et al., 2009; Noren et al., 2009). As with other delphinids, the reaction of the killer whales to whale-watching vessels may be in response to the vessel pursuing them rather than to the noise of the vessel itself, or to the number of vessels in their proximity. Williams et al. (2014b) modeled behavioral responses of killer whales to vessel traffic by looking at their surface behavior relative to the received level of three large classes of ships. The authors found that the severity of the response was largely dependent on seasonal data (e.g., year and month) as well as the animal’s prior experience with vessels (e.g., age and sex), and the number of other vessels present, rather than the received level of the larger ships (Williams et al., 2014b). Sperm whales generally react only to vessels approaching within several hundred meters; 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).

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 to increase the pitch, frequency modulation, and length of whistling (May-Collado & Wartzok, 2008), with whistle frequency increasing in the presence of low-frequency noise and whistle frequency decreasing in the presence of high-frequency noise (Gospić & Picciulin, 2016). For example, bottlenose dolphins in Portuguese waters decrease their call rates and change the frequency parameters of whistles in the presence of boats (Luís et al., 2014), while dolphin groups with calves increase their whistle rates when tourist boats are within 200 m and when the boats increase their speed (Guerra et al., 2014). Likewise, modification of multiple vocalization parameters was shown in belugas residing in an area known for high levels of commercial traffic. These animals decreased their call rate, increased certain types of calls, and shifted upward in frequency content in the presence of small vessel noise (Lesage et al., 1999). Another study detected a measurable increase in the amplitude of their vocalizations when ships were present (Scheifele et al., 2005). Killer whales are also known to modify their calls during increased noise. For example, the source level of killer whale vocalizations was shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect) (Holt et al., 2008). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al., 2011). On the other hand, long-term modifications to vocalizations may be indicative of a learned response to chronic noise, or of a genetic or physiological shift in the populations. This type of change has been observed in killer whales off the northwestern coast of the United States between 1973 and 2003. This population increased the duration of primary calls once a threshold in observed vessel density (e.g., whale watching) was reached, which is suggested as being a long-term response to increased masking noise produced by the vessels (Foote et al., 2004).

The long-term and cumulative implications of ship sound on odontocetes is largely unknown (National Academies of Sciences Engineering and Medicine, 2017; National Marine Fisheries Service, 2007a), although some long-term consequences have been reported (Lusseau & Bejder, 2007). Repeated exposure to acoustic and other anthropogenic stimuli has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins in New Zealand responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin et al., 2008). The authors speculated that repeated interruptions of the dolphins' foraging behaviors could lead to long-term implications for the population. Bejder et al. (2006a) studied responses of bottlenose dolphins to vessel approaches and found stronger and longer lasting reactions in populations of animals that were exposed to lower levels of vessel traffic overall. The authors indicated that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Similar to mysticetes, odontocete responses to vessel noise are varied, although many odontocete species seem to be more sensitive to vessel presence and vessel noise, and these two factors are difficult to tease apart. Some species, in particular killer whales and porpoises, may be sensitized to vessels and respond at further distances and lower received levels than other delphinids. In contrast, many odontocete species also approach vessels to bow ride, indicating either that these species are less sensitive to vessels, or that the behavioral drive to bow ride supersedes any impact of the associated noise. With these broad and disparate responses, it is difficult to assess the impacts of vessel noise on odontocetes.

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 (e.g., single engine, multi engine, jet turbine), flight path (altitude, centered on the animal, off to one side, circling, level and slow), environmental factors (e.g., wind speed, sea state, cloud cover), and locations where native subsistence hunting continues and animals are more sensitive to anthropogenic impacts, including the noise from aircraft. Erbe et al. (2018) measured airplane noise levels underwater at sites about 1 and 10 km from an airport runway and found median noise levels up to 117 dB re 1 µPa and 10 kHz at the close site, and up to 91 dB re 1 µPa and 2 kHz at the more distant site; both would be audible to a number of marine mammals at those levels and frequencies. Christiansen et al. (2016b) measured the in-air and underwater noise levels of two unmanned aerial vehicles, and found that in-air the broadband source levels were around 80 dB re 20 µPa, while at a meter underwater received levels were 95–100 dB re 1 µPa when the vehicle was only 5–10 m above the surface, and were not quantifiable above ambient noise levels when the vehicle was higher. Therefore, if an animal is near the surface and the unmanned aerial vehicle is low, it may be detected, but in most cases these vehicles are operated at much higher altitudes (e.g., over 30 m) and so are not likely to be heard.

The impact of aircraft overflights is one of the least well-known sources of potential behavioral response by any species or taxonomic group, and so many generalities must be made based on the little data available. There is 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. (304.8 m) above sea level, infrequently observed at 1,500 ft. (457.2 m), and not observed at all at 2,000 ft. (609.6 m) (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., 1998; Koski et al., 2015). 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. 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., 2003; Richter et al., 2006; 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 whales 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 altitude, 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 didn't respond at all (Ramos et al., 2018).

Behavioral Reactions to Impulsive Noise

Impulsive signals (i.e., weapon noise and explosions), particularly at close range, have a rapid rise time and higher instantaneous peak pressure than other signal types, making them more likely to cause startle responses or avoidance responses. However, at long distances the rise time increases as the signal duration lengthens (similar to a "ringing" sound), making the impulsive signal more similar to a non-impulsive signal. Behavioral reactions from explosive sounds are likely to be similar to reactions studied for other impulsive sounds, such as those produced by air guns and impact pile driving. Data on behavioral responses to impulsive sound sources are limited across all marine mammal groups, with only a few studies available for mysticetes and odontocetes. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks) and typically utilize large multi-air gun arrays that fire repeatedly. While seismic data provide the best available science for assessing behavioral responses to impulsive sounds by marine mammals, it is likely that these responses represent a worst-case scenario as compared to responses to explosives used in Navy activities, which would typically consist of single impulses or a cluster of impulses, rather than long-duration, repeated impulses.

Mysticetes

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, attraction to the source, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Gordon et al., 2003; McCauley et al., 2000; Richardson et al., 1985; Southall et al., 2007). Studies have been conducted on many baleen whale species, including gray, humpback, blue, fin and bowhead whales; it is assumed that these responses are representative of all baleen whale species. The behavioral state of the whale seems to be an integral part of whether or not the animal responds and how they respond, as does the location and movement of the sound source, more than the received level of the sound.

Migratory behavior seems to lead to a higher likelihood of response, with some species demonstrating more sensitivity than others do. For example, migrating gray whales showed avoidance responses to seismic vessels at received levels between 164 and 190 dB re 1 µPa (Malme et al., 1986, 1988). Similarly, migrating humpback whales showed avoidance behavior at ranges of 5–8 km from a seismic array during observational studies and controlled exposure experiments in one Australian study (McCauley et al., 1998), and in another Australian study decreased their dive times and reduced their swimming speeds (Dunlop et al., 2015). However, when comparing received levels and behavioral responses using ramp-up versus a constant noise level of air guns, humpback whales did not change their dive behavior but did deviate from their predicted heading and decreased their swim speeds (Dunlop et al., 2016). In addition, the whales demonstrated more course deviation during the constant source trials but reduced travel speeds more in the ramp-up trials; in either case there was no dose-response relationship with the received level of the air gun noise, and similar responses were observed in control trials with vessel movement but no air guns, so some of the response was likely due to the presence of the vessel and not the received level of the air guns. When looking at the relationships between proximity, received level, and behavioral response, Dunlop et al. (2017) used responses to two different air guns and found responses occurred more towards the smaller, closer source than to the larger source at the same received level, demonstrating the importance of proximity. Responses were found to be more likely when the source was within 3 km or above 140 dB re 1 µPa, although responses were variable and some animals did not respond at those values while others responded below them. In addition, responses were generally small, with course deviations of only around 500 m, and short term (Dunlop et al., 2017). McDonald et al. (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 10 km from the seismic vessel (estimated received level 143 dB re 1 µPa peak-to-peak). Bowhead whales seem to be the most sensitive species, perhaps due to a higher overlap between bowhead whale distribution and seismic surveys in Arctic and sub-Arctic waters, as well as a recent history of being hunted. While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson et al., 1995b), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 µPa. Additionally, Malme et al. (1988) observed clear changes in diving and breathing patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 µPa. Bowhead whales may also avoid the area around seismic surveys, from 6 to 8 km (Koski and Johnson 1987, as cited in Gordon et al., 2003)out to 20 or 30 km (Richardson et al., 1999). However, work by Robertson (2014) 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).

Vocal responses to seismic surveys have been observed in a number of baleen whale species, including a cessation of calling, a shift in frequency, increases in amplitude or call rate, or a combination of these strategies. Blue whale feeding/social calls were found to increase when seismic exploration was underway, with seismic pulses at average received SELs of 131 dB re 1 $\mu Pa^2 s$ (Di Lorio & Clark, 2010), a potentially compensatory response to increased noise level. Responses by fin whales to a 10-day seismic survey in the Mediterranean Sea included possible decreased 20 Hz call production and movement of animals from the area based on lower received levels and changes in bearings (Castellote et al., 2012). However, similarly distant seismic surveys elicited no apparent vocal response from fin whales in the mid-Atlantic Ocean; instead, Nieukirk et al. (2012) hypothesized that 20 Hz calls may have been masked from the receiver by distant seismic noise. Models of humpback whale song off Angola showed significant seasonal and diel variation, but also showed a decrease in the number of singers with increasing received levels of air gun pulses (Cerchio et al., 2014). Bowhead whale calling rates decreased significantly at sites near seismic surveys (41–45 km) where median received levels were between 116 and 129 dB re 1 µPa, and did not decrease at sites further from the seismic surveys (greater than 104 km) where median received levels were 99–108 dB re 1 µPa (Blackwell et al., 2013). In fact, bowhead whale calling rates increased at the lower received levels, began decreasing at around 127 dB re 1 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 air gun pulses (Blackwell et al., 2017).

Mysticetes seem to be the most sensitive taxonomic group of marine mammals to impulsive sound sources, with possible avoidance responses occurring out to 30 km and vocal changes occurring in response to sounds over 100 km away. However, responses appear to be behaviorally mediated, with most avoidance responses occurring during migration behavior and little observed response during feeding behavior. These response patterns are likely to hold true for Navy impulsive sources; however, Navy impulsive sources would largely be stationary (e.g., explosives fired at a fixed target) and short term (on the order of hours rather than days or weeks) than were found in these studies, and so responses would likely occur in closer proximity or not at all.

Odontocetes

Few data are available on odontocete responses to impulsive sound sources, with only a few studies on responses to seismic surveys, pile driving, and construction activity available. However, odontocetes appear to be less sensitive to impulsive sound than mysticetes, with responses occurring at much closer distances. This may be due to the predominance of low-frequency sound associated with these sources that propagates long distances and overlaps with the range of best hearing for mysticetes but is below that range for odontocetes. The exception to this is the harbor porpoise, which has been shown to be highly sensitive to most sound sources, avoiding both stationary (e.g., pile driving) and moving (e.g., seismic survey vessels) impulsive sound sources out to approximately 20 km (e.g., Haelters et al., 2014; Pirotta et al., 2014). However, even this response is short-term, with porpoises returning to the area within hours after the cessation of the noise.

Madsen et al. (2006a) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic air gun surveys. Sound sources were from approximately 2 to 7 NM away from the whales, and received levels were as high as 162 dB SPL re 1 µPa (Madsen et al., 2006). The whales showed no horizontal avoidance; however, one whale rested at the water's surface for an extended period of time until air guns ceased (Miller et al., 2009). While the remaining whales continued to execute foraging dives throughout exposure, tag data suggested there may have been subtle effects of noise on foraging behavior (Miller et al., 2009). Similarly, Weir (2008) observed that seismic air gun surveys along the Angolan coast did not significantly reduce the encounter rate of sperm whales during the 10-month survey period, nor were avoidance behaviors to air gun impulsive sounds observed. In contrast, Atlantic spotted dolphins did show a significant, short-term avoidance response to air gun impulses within approximately 1 km of the source (Weir, 2008). The dolphins were observed at greater distances from the vessel when the air gun was in use, and when the air gun was not in use they readily approached the vessel to bow ride.

Captive bottlenose dolphins sometimes vocalized or were reluctant to return to the test station after exposure to single impulses from a seismic water gun (Finneran et al., 2002). When exposed to multiple impulses from a seismic air gun, some dolphins turned their heads away from the sound source just before the impulse, showing that they could anticipate the timing of the impulses and perhaps reduce the received level (Finneran et al., 2015). During construction (including the blasting of old bastions) of a bridge over a waterway commonly used by the Tampa Bay, FL, stock of bottlenose dolphins, the use of the area by females decreased while males displayed high site fidelity and continued using the area, perhaps indicating differential habitat uses between the sexes (Weaver, 2015).

A study was conducted on the response of harbor porpoises to a seismic survey using aerial surveys and C-PODs (an autonomous recording device that counts odontocete clicks); the animals appeared to have left the area of the survey and decreased their foraging activity within 5–10 km, as evidenced by both a decrease in vocalizations near the survey and an increase in vocalizations at a distance (Pirotta et al., 2014; Thompson et al., 2013). However, the animals returned within a day after the air gun operation ceased, and the decrease in occurrence over the survey period was small relative to the observed natural seasonal decrease compared to the previous year. A number of studies (Brandt et al., 2011; Dähne et al., 2014; Haelters et al., 2014; Thompson et al., 2010; Tougaard et al., 2005; Tougaard et al., 2009) also found strong avoidance responses by harbor porpoises out to 20 km during pile driving; however, all studies found that the animals returned to the area after the cessation of pile driving. When bubble curtains were deployed around pile driving, the avoidance distance appeared to be reduced to half that distance (12 km), and the response only lasted about five hours rather than a day before the animals returned to the area (Dähne et al., 2017). Kastelein et al. (2013b) exposed a captive harbor porpoise to impact pile driving sounds and found that above 136 dB re 1 µPa (zero-to-peak) the animal's respiration rates increased, and at higher levels it jumped more frequently. Bergstrom et al. (2014) found that although there was a high likelihood of acoustic disturbance during wind farm construction (including pile driving), the impact was short-term. Graham et al. (2017) assessed the occurrence of bottlenose dolphins and harbor porpoises over different area and time scales with and without impact and vibratory pile driving. While there were fewer hours with bottlenose dolphin detections and reduced detection durations within the pile driving area and increased detection durations outside the area, the effects sizes were small, and the reduced harbor porpoise encounter duration was attributed to seasonal changes outside the influence of the pile driving. However, received levels in this area were lower due to propagation effects than in the other areas described above, which may have led to the lack of or reduced response.

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.

3.4.2.1.1.6 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 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, and aging (Bradshaw et al., 2006; Culik, 2004; Geraci et al., 1999; Geraci & Lounsbury, 2005; 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., 2012; Saez et al., 2013), human activities (e.g., feeding, gunshot) (Geraci & Lounsbury, 2005; Dierauf & Gulland, 2001), and noise (Cox et al., 2006; National Research Council, 2003; Richardson et al., 1995b). 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., 2017b; Helker et al., 2019; Helker et al., 2017; National Oceanic and Atmospheric Administration, 2018d, 2019) 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). 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.

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).

Strandings and Anthropogenic Sound

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, 2016a). Several mass strandings (strandings that involve two or more individuals of the same species, excluding a single mother-calf pair) that have occurred over the past two decades have been associated with anthropogenic activities that introduced sound into the marine environment, such as naval operations and seismic surveys. U.S. Navy sonar has been identified as a contributing factor in a small number of strandings; none of these have occurred in the Study Area.

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 (Arbelo et al., 2008; Cox et al., 2006; Fernandez, 2006; U.S. Department of the Navy, 2017a), 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, 2017a). These five mass strandings resulted in about 40 known cetacean deaths consisting mostly of beaked whales with close linkages to mid-frequency active sonar activity. In these circumstances, exposure to non-impulsive acoustic energy was considered a possible indirect cause of death of the marine mammals (Cox et al., 2006). Factors that were associated with these beaked whale 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.mitteis.com). Strandings of other marine mammal species have not been as closely linked to sonar exposure, but rather, have typically been attributed to natural or other anthropogenic factors. The Navy has reviewed training requirements, standard operating procedures, and potential mitigation measures, and has implemented changes to reduce the potential for acoustic related strandings to occur in the future. Discussions of procedures associated with these and other training and testing events are presented in Chapter 5 (Mitigation).

Multiple hypotheses regarding the relationship between non-impulsive sound exposure and stranding have been proposed (see Bernaldo de Quirós et al., 2019). These range from direct impact of the sound on the physiology of the marine mammal, to behavioral reactions contributing to altered physiology (e.g., "gas and fat embolic syndrome") (Fernandez et al., 2005; Jepson et al., 2003; Jepson et al., 2005), to behaviors directly contributing to the stranding (e.g., beaching of fleeing animals). Unfortunately, without direct observation of not only the event but also the underlying process, and given the potential for artefactual evidence (e.g., chronic condition, previous injury) to complicate conclusions from the post-mortem analyses of stranded animals (Cox et al., 2006), it has not been possible to determine with certainty the exact mechanism underlying these strandings. Based on examination of the above sonar-associated strandings, Bernaldo de Quirós et al. (2019) list diagnostic features, the presence of all of which suggest gas and fat embolic syndrome for beaked whales stranded in association with sonar exposure. Bernaldo de Quirós et al. (2019) established 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; and
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.

Beaked Whale Strandings at the Mariana Islands

Although records of marine mammal strandings exist as far back as 1878 in Guam, reporting of marine mammal strandings across the Mariana Islands has only become consistent in recent years, similar to other regions, whereas sonar use has occurred in the area around the Mariana Islands for decades. Given its proximity to eastern Asia, Navy vessels equipped with sonar have been transiting and at times conducting individual and group training events with sonar in the Study Area since modern hull-mounted active sonars became standard on Navy surface ships in the mid-1960s. Furthermore, due to reductions in the size of the Navy's fleet of sonar equipped assets since WWII, coupled with improvements to passive acoustic detection technology, it is likely that there was more active sonar use from the 1960s through the late 1980s than what is currently proposed in this SEIS/OEIS.

The first recorded stranding of a beaked whale within the Mariana Islands occurred in 2007 on Guam. From 2007 through May 2020, nine recorded beaked whale stranding events have occurred in the Mariana Islands. Eight events consisted of a single animal, and one consisted of two animals. All identified beaked whales were Cuvier's beaked whales (one unknown). All but two of the stranding events occurred at Guam; the other two events, occurred on Rota and Saipan A review of Navy records indicates that sonar use occurred within 72 hours or 80 NM of four of these stranding events: two whales on Saipan in 2011, one whale on Guam in 2015, one whale on Guam in 2016 (live and pushed back to sea), and one whale on Rota in November 2019 (milling in shallow water and pushed back to sea). This means that 55 percent of beaked whale strandings in the Mariana Islands occurred when no U.S. Navy sonar was present.

A study examining the co-occurrence of beaked whale strandings and naval sonar in the Mariana Islands was recently published (Simonis et al., 2020). The study claimed a correlation ($p<0.01$) between strandings and Navy sonar; however, the study relied on incomplete or inaccurate assumptions about U.S. Navy sonar use around the Mariana Islands in its statistical analysis. The author's assessment of sonar use was largely based on publicly available press releases and news reports about joint Navy events. The author's assumed that every day of an exercise could involve the use of sonar, and that the Navy's' sonar use in the Marianas Islands was mostly limited to these joint exercises. Both of these assumptions were incorrect, as sonar use typically only occurs during brief periods of time and not on every day of an anti-submarine warfare exercise, and joint exercises make up a small fraction of Navy sonar use in this area. The majority of sonar use in the MITT Study Area is associated with unit level training and testing. Prior to the study's publication, the Navy provided information to the researchers indicating that their assumptions about sonar use in their analysis were incorrect or incomplete; therefore, their published findings may not be valid.

In discussions with NMFS following the study's publication, including NMFS researchers who participated in the Simonis et al. study, the Navy agreed to have statisticians with appropriate security clearances examine the classified sonar record around the Mariana Islands for correlation with beaked whale strandings. The Navy contracted the Center for Naval Analysis to re-evaluate the analysis conducted by Simonis et al. (2020) using the Navy's complete classified sonar record. 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 all 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, including a November 2019 stranding event on Rota that was not part of the Simonis et al dataset. Following the methods in Simonis et al. (2020), the Center for Naval Analysis conducted a Poisson distribution analysis and found that the statistical analysis yielded insufficient evidence ($p<0.10$) to claim a relationship between sonar use and beaked whale strandings in the Mariana Islands when considering the complete sonar use record.

The Center for Naval Analysis also conducted a statistical analysis specific to each island where beaked whale strandings have been observed in the Mariana Islands (Guam, Rota, and Saipan), to take into account the potential for geographically isolated sonar activities to result in strandings. This analysis similarly found no significant correlation of strandings to sonar use. For the island-specific analyses, sonar use within 80 NM (150 km) of each island was considered, a distance that is substantially greater than the farthest distance at which beaked whales have been observed to respond to sonar [see "Behavioral Reactions to Sonar and Other Transducers (Odontocetes)" in Section 3.4.2.1.1.5, Behavioral Reactions]. The finding that there is insufficient evidence supporting correlation of sonar with strandings at Rota and Saipan is based on limited data (one stranding each on both Rota and Saipan), thus has high uncertainty. The remaining seven beaked whale stranding events in the Mariana Islands occurred at Guam, providing sufficient data to find no correlation between sonar use and beaked whale strandings at this site. An unclassified summary of the Center for Naval Analysis's analysis was provided to NMFS and their scientists during the SEIS/OEIS development.

Furthermore, necropsies were conducted for a few of the strandings to attempt to determine the animal's cause of death. Necropsy examinations and high-quality tissue samples were collected from three live stranded or fresh dead individuals: from one of the whales from the August 2011 stranding on Saipan, the single whale from the March 2015 stranding on Guam, and the single whale from the January 2019 stranding on Guam. Only the animals from the 2011 and 2015 events were considered coincident with the use of Navy sonar. These three beaked whales from the Mariana Islands did not have evidence of gas bubble formation in the organs examined grossly and histologically.

Stranding response staff from the University of Hawaii conducted the examinations and compared the results to the diagnostic features of gas and fat embolic syndrome described by Bernaldo de Quiros et al. (2019). Bernaldo de Quirós et al. (2019) established that to date, strandings which have a confirmed associated with naval sonar have exhibited all seven diagnostic features. Necropsy results from the 2011 and 2015 stranded beaked whales only exhibited a few (one to three) of the diagnostic features, but not all seven, suggesting that those strandings are unlikely to be associated with sonar exposure. Additionally, a beaked whale that stranded in 2019, not coincident with sonar use, was examined and found to similarly exhibit a few of the diagnostic factors. Overall, the results of these necropsies appear to align with evidence from single beaked whale strandings that have been investigated in the Canary Islands (n=45) which stranded with no correlation in space or time with mid-frequency active sonar. These individuals had one or more diagnostic features of gas and fat embolic syndrome in beaked whales stranded in association with mid-frequency active exercises, but not all seven (Bernaldo de Quirós et al., 2019). Since 2018, the Navy has provided additional funding to NMFS's designated regional stranding responder - the University of Hawaii - to support additional necropsy efforts in the Pacific Islands region to ensure that the causes of any possible future strandings continue to be thoroughly investigated.

3.4.2.1.1.7 Long-Term Consequences

Long-term consequences to a population are determined by examining changes in the population growth rate. Physical effects that could lead to a reduction in the population growth rate include mortality or injury, which could remove animals from the reproductive pool, and permanent hearing impairment or chronic masking, which could impact navigation, foraging, predator avoidance, or communication. The long-term consequences due to individual behavioral reactions and short-term or chronic instances of physiological stress are especially difficult to predict because individual experience over time can create complex contingencies, especially for long-lived animals like marine mammals. For example, a lost reproductive opportunity could be a measurable cost to the individual, or for very small populations to the population as a whole; however, short-term costs may be recouped during the life of an otherwise healthy individual. These factors are taken into consideration when assessing risk of long-term consequences. It is more likely that any long-term consequences to an individual would be a result of costs accumulated over a season, year, or life stage due to multiple behavioral or stress responses resulting from exposure to many sound-producing activities over significant periods.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area (Wartzok et al., 2003). Highly resident or localized populations may also stay in an area of disturbance because the cost of displacement may be higher than the cost of remaining (Forney et al., 2017). Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region (Bejder et al., 2006b; Blackwell et al., 2004; Teilmann et al., 2006). Gray whales in Baja California abandoned a historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. However, whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al., 1984). Mysticetes in the northeast tended to adjust to vessel traffic over a number 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.

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 that raise uncertainties over whether a decline in the beaked whale population occurred off the U.S. West Coast between 1996 and 2014 (Barlow, 2016). Moore and Barlow (2017) have since incorporated information from the entire 1991 to 2014 time series, which suggests an increasing abundance trend and a reversal of the declining trend along the U.S. West Coast that had been noted in their previous (2013) analysis.

In addition, studies on the Atlantic Undersea Test and Evaluation Center instrumented range in the Bahamas have shown that some Blainville's beaked whales may be resident during all or part of the year in the area. Individuals may move off the range for several days during and following a sonar event, but return within a few days (Joyce et al., 2019; McCarthy et al., 2011; Tyack et al., 2011). Photo-identification studies in the Southern California 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 et al., 2009; Falcone & Schorr, 2014). These results indicate long-term residency by individuals in an intensively used Navy training and testing area, which may suggest a lack of long-term consequences as a result of exposure to Navy training and testing activities, but could also be indicative of high-value resources that exceed the cost of remaining in the area. Long-term residency does not mean there has been no impact on population growth rates, and there are no data existing on the reproductive rates of populations inhabiting the Navy range area around San Clemente Island as opposed to beaked whales from other areas. In that regard however, recent results from photo-identifications are beginning to provide critically needed calving and weaning rate data for resident animals on the Navy's Southern California range. Three adult females that had been sighted with calves in previous years were again sighted in 2016, one of these was associated with her second calf, and a fourth female that was first identified in 2015 without a calf, was sighted in 2016 with a calf (Schorr et al., 2017). Resident females documented with and without calves from year to year will provide the data for this population that can be applied to future research questions.

Research involving three tagged Cuvier's beaked whales in the Southern California 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, which can improve scientists' abilities to study these model inputs and link behavioral changes to individual life functions and ultimately population-level effects. The linkage between immediate behavioral or physiological effects to an individual due to a stressor such as sound, the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and in turn the consequences for the population have been reviewed in National Research Council (2005).

The Population Consequences of Acoustic Disturbance model (National Research Council, 2005) proposes a conceptual model for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population. In 2009, the U.S. Office of Naval Research set up a working group to transform the Population Consequences of Acoustic Disturbance framework into a mathematical model and include other stressors potentially causing disturbance in addition to noise. The model, now called Population Consequences of Disturbance, has been used for case studies involving bottlenose dolphins, North Atlantic right whales, beaked whales, southern elephant seals, California sea lions, blue whales, humpback whales, and harbor porpoise (Costa et al., 2016a; Costa et al., 2016b; Harwood & King, 2014; Hatch et al., 2012; King et al., 2015; McHuron et al., 2018; New et al., 2013a; New et al., 2013b; New et al., 2014; Pirotta et al., 2018). 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 is needed, which is 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 U.S. Navy Marine Species Monitoring Program.

Costa et al. (2016a) emphasized taking into account the size of an animal's home range, whether populations are resident and non-migratory, or if they migrate over long areas and share their feeding or breeding areas with other populations. These factors, coupled with the extent, location, and duration of a disturbance can lead to markedly different impact results. For example, Costa et al. (2016a) modeled seismic surveys with different radii of impacts on the foraging grounds of Bering Sea humpback whales, West Antarctic Peninsula humpback whales, and California Current blue whales, and used data from tagged whales to determine foraging locations and effort on those grounds. They found that for the blue whales and the West Antarctic humpback whales, less than 19 percent and 16 percent (respectively) of each population would be exposed, and less than 19 percent and 6 percent (respectively) of foraging behavior would be disturbed. This was likely due to the fact that these populations forage for krill over large areas. In contrast, the Bering Sea population of humpback whales had over 90 percent of the population exposed when the disturbance zones extended beyond 50 km, but 100 percent of their foraging time would occur during an exposure when the zone was 25 km or more. These animals forage for fish over a much smaller area, thereby having a limited range for foraging that can be disturbed. 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 percent and 15 percent greater during the migration to Baja California and China, respectively, than for the migration of eastern gray whales, and therefore this population would be more sensitive to energy lost through disturbance.

Pirotta et al. (2018) 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 return to the breeding grounds, giving birth, and lactating. They modeled this scenario with no disturbance and found 95 percent calf recruitment, under a "normal" environmental perturbation (El Niño-Southern Oscillation) there was a very small reduction in recruitment, and under an "unprecedented" environmental change, recruitment was reduced to 69 percent. An intense, localized anthropogenic disturbance was modeled (although the duration of the event was not provided); if the animals were not allowed to leave the area they did not forage and recruitment dropped to 63 percent. However, if animals could leave the area of the disturbance then there was almost no change to the recruitment rate. A weak but broader spatial disturbance, where foraging was reduced by 50 percent, caused only a small decrease in calf recruitment to 94 percent. Similarly, Hin et al. (2019) looked at the impacts of disturbance on long-finned pilot whales and found that the timing of the disturbance with seasonally-available resources is important. If a disturbance occurred during periods of low resource availability, the population-level consequences were greater than if the disturbance occurred during periods when resource levels were high.

Using the Population Consequences of Disturbance framework, modeling of the long-term consequences of exposure has been conducted for a variety of marine mammal species and stressors. Even when high and frequent exposure levels are included, few long-term consequences have been predicted. For example, De Silva et al. (2014) conducted a population viability analysis on the long-term impacts of pile driving and construction noise on harbor porpoises and bottlenose dolphins. Despite including the extreme and unlikely assumptions that 25 percent of animals that received PTS would die, and that behavioral displacement from an area would lead to breeding failure, the model only found short-term impacts on the population size and no long-term effects on population viability. Similarly, King et al. (2015) developed a Population Consequences of Disturbance framework using expert elicitation data on impacts from wind farms on harbor porpoises and, even under the worst-case scenarios, predicted less than a 0.5 percent decline in harbor porpoise populations. Nabe-Nelson et al. (2014) also modeled the impact of noise from wind farms on harbor porpoises and predicted that even when assuming a 10 percent reduction in population size if prey is impacted up to two days, the presence of ships and wind turbines did not deplete the population. In contrast, Heinis and De Jong (2015) used the Population Consequences of Disturbance framework to estimate impacts from both pile driving and seismic exploration on harbor porpoises and found a 23 percent decrease in population size over six years, with an increased risk for further reduction with additional disturbance days. These seemingly contradictory results demonstrate that refinements to models need to be investigated to improve consistency and interpretation of model results. Booth (2019) modeled the foraging behavior and known prey species and sizes and found that due to their generalist feeding behavior in most scenarios the porpoises obtained more than 100 percent of their energetic needs through typical foraging behavior, and therefore would largely be robust to short-term disturbances to foraging.

The Population Consequences of Disturbance model developed by New et al. (2013b) predicted that beaked whales require energy dense prey and high quality habitat, and that non-lethal disturbances that displace whales from that habitat could lead to long-term impacts on fecundity and survival; however, the authors were forced to use many conservative assumptions within their model since many parameters are unknown for beaked whales. As discussed above in Schorr et al. (2014), beaked whales have been tracked roaming over distances of 250 km or more, indicating that temporary displacement from a small area may not preclude finding energy dense prey or high quality habitat. Farmer et al. (2018) developed a bioenergetics framework to examine the impact of foraging disruption on body reserves of individual sperm whales. The authors examined rates of daily foraging disruption to predict the number of days to terminal starvation for various life stages, assuming exposure to seismic surveys. Mothers with calves were found to be most vulnerable to disruptions.

Another Population Consequences of Disturbance model developed in New et al. (2014) predicted elephant seal populations to be relatively robust even with a greater than 50 percent reduction in foraging trips (only a 0.4 percent population decline in the following year). McHuron et al. (2018) modeled the introduction of a generalized disturbance at different times throughout the breeding cycle of California sea lions, with the behavior response being an increase in the duration of a foraging trip by the female. Very short duration disturbances or responses led to little change, particularly if the disturbance was a single event, and changes in the timing of the event in the year had little effect. However, with even relatively short disturbances or mild responses, when a disturbance was modeled as recurring there were resulting reductions in population size and pup recruitment. Often, the effects weren't noticeable for several years, as the impacts on pup recruitment didn't affect the population until those pups were mature.

Population Consequences of Disturbance models can also be used to assess the impacts of multiple stressors. For example, Farmer et al. (2018) modeled the combined impacts of an oil spill and acoustic disturbance due to seismic airgun surveys. They found that the oil spill led to declines in the population over 10 years, and some models that included behavioral response to airguns found further declines.

However, the amount of additional population decline due to acoustic disturbance depended on the way the dose-response of the noise levels were modeled, with a single step-function leading to higher impacts than a function with multiple steps and frequency weighting. In addition, the amount of impact from both disturbances was mediated when the metric in the model that described animal resilience was changed to increase resilience to disturbance (e.g., able to make up reserves through increased foraging).

It should be noted that, in all of these models, assumptions were made and many input variables were unknown and so were estimated using available data. It is still not possible to utilize individual short-term behavioral responses to estimate long-term or population level effects.

The best assessment of long-term consequences from Navy training and testing 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 and testing 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 the Mariana Islands Range Complex. 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.

3.4.2.1.2 Impacts from Sonar and Other Transducer Stressors

Sonar and other transducers proposed for use could be used throughout the Study Area. Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of these systems are described in Section 3.0.4.1 (Acoustic Stressors). The overall use of sonar and other transducers for training and testing activities would be similar to what is currently conducted (see Tables 2.5-1 and 2.5-2 for details). Although individual activities may vary some from those previously analyzed, the overall determinations presented in the 2015 MITT Final EIS/OEIS remain valid. The quantitative analysis has been improved upon and updated since the 2015 MITT Final EIS/OEIS; therefore, the new analysis is fully presented and described in further detail in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2018b).

Sonar-induced acoustic resonance and bubble formation phenomena are very unlikely to occur under realistic conditions, as discussed in Section 3.4.2.1.1.1 (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 (Section 3.4.2.1.1.2, Hearing Loss; Section 3.4.2.1.1.3, Physiological Stress; Section 3.4.2.1.1.4, Masking; and Section 3.4.2.1.1.5, Behavioral Reactions).

3.4.2.1.2.1 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 and testing 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 on Sea Turtles and Marine Mammals), which takes into account:

- criteria and thresholds used to predict impacts from sonar and other transducers (see below);
- the density and spatial distribution of marine mammals (U.S. Department of the Navy, 2019; Watwood et al., 2018); and
- the influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation when estimating the received sound level on the animals.

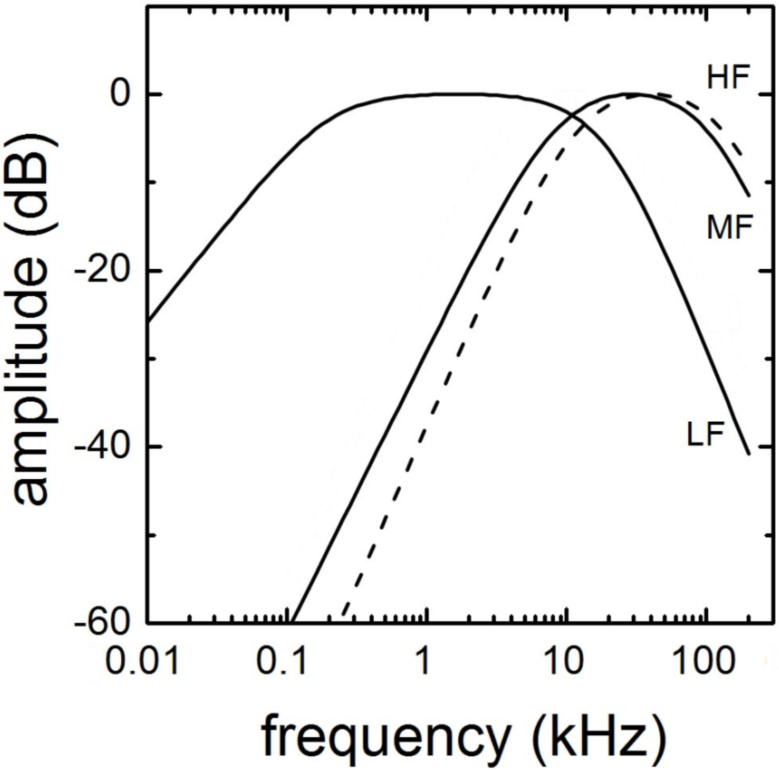
A detailed explanation of this analysis is provided in the technical report titled *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

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

Auditory Weighting Functions

See the technical report titled *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a) for detailed information on how the criteria and thresholds were derived. The marine mammal criteria and thresholds developed for that technical report were relied on by National Marine Fisheries Service in establishing guidance for assessing the effects of sound on marine mammal hearing (National Marine Fisheries Service, 2016e) and were re-affirmed in the 2018 revision (National Marine Fisheries Service, 2018e). In addition, these auditory impact criteria were recently published by Southall et al. (2019c).

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 3.4-5). 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 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.



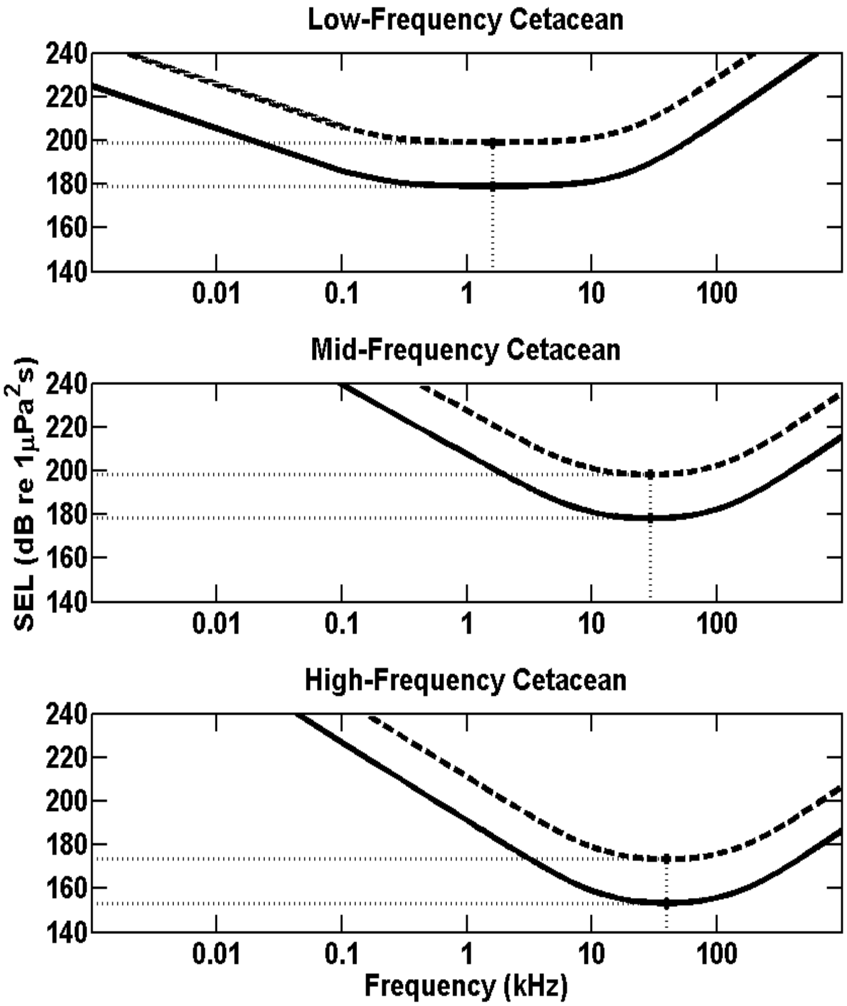
Source: For parameters used to generate the functions and more information on weighting function derivation see U.S. Department of the Navy (2017b)

Notes: HF = High-Frequency Cetacean, LF = Low-Frequency Cetacean, and MF = Mid-Frequency Cetacean

Figure 3.4-5: Navy Auditory Weighting Functions for all Species Groups

Hearing Loss from Sonar and Other Transducers

Defining the TTS and PTS exposure functions (Figure 3.4-6) 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 3.4-6: 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, 2017b). 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 and testing, 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, the National Marine Fisheries Service 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 the 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, and
- avoid area near sound source.

For the derivation of behavioral criteria, a significant duration was defined as a response that lasted for the duration of exposure or longer, regardless of how long the exposure session may have been. This assumption was made because it was not possible to tell if the behavioral responses would have continued if the exposure had continued. The costs associated with these observed behavioral reactions were not measured, so it is not possible to judge whether reactions would have risen to the level of significance as defined above, although it was conservatively assumed the case. High severity responses include those responses with immediate consequences (e.g., stranding, mother-calf separation), and were always considered significant behavioral reactions regardless of duration.

Marine mammal species were placed into behavioral criteria groups based on their known or suspected behavioral sensitivities to sound (Figure 3.4-7 through Figure 3.4-9). In most cases, these divisions are driven by taxonomic classifications (e.g., mysticetes, odontocetes). The Odontocete group combines most of the mid- and high-frequency cetaceans, without the beaked whales. These groups are combined as there are not enough data to separate them for behavioral responses.

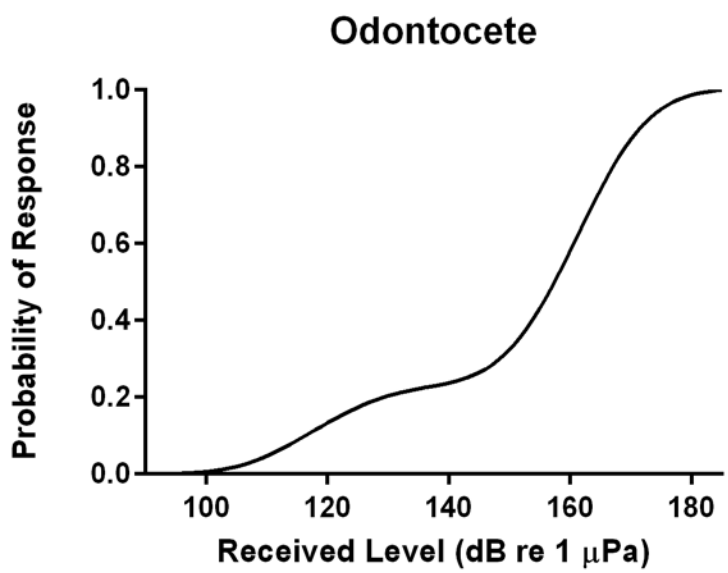


Figure 3.4-7: Behavioral Response Function for Odontocetes

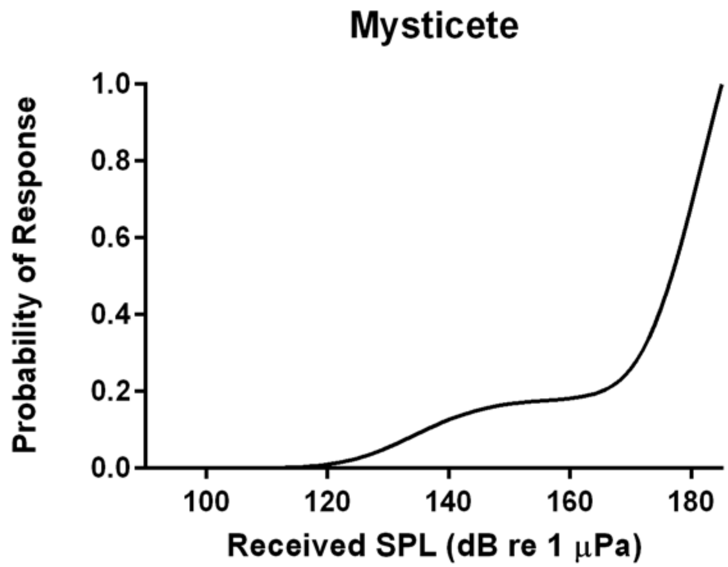


Figure 3.4-8: Behavioral Response Function for Mysticetes

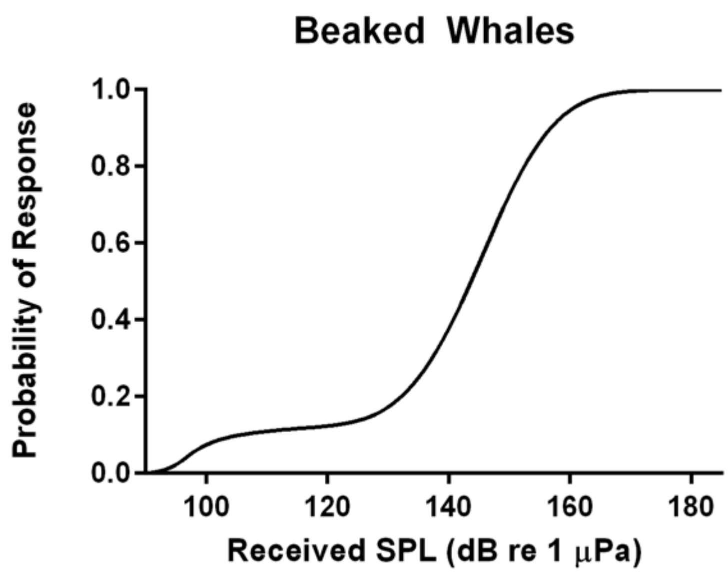


Figure 3.4-9: Behavioral Response Function for Beaked Whales

For all taxa, 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 3.4-3). 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). 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 and testing events 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 further ranges for these more intense activities.

Table 3.4-3: Cutoff Distances for Moderate Source Level, Single Platform Training and Testing 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
Mysticetes	10 km	20 km
Beaked Whales	25 km	50 km

Notes: dB re 1 µPa @ 1 m= decibels referenced to 1 micropascal at 1 meter, km = kilometer(s), 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, 2017b), the 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 3.4-10).

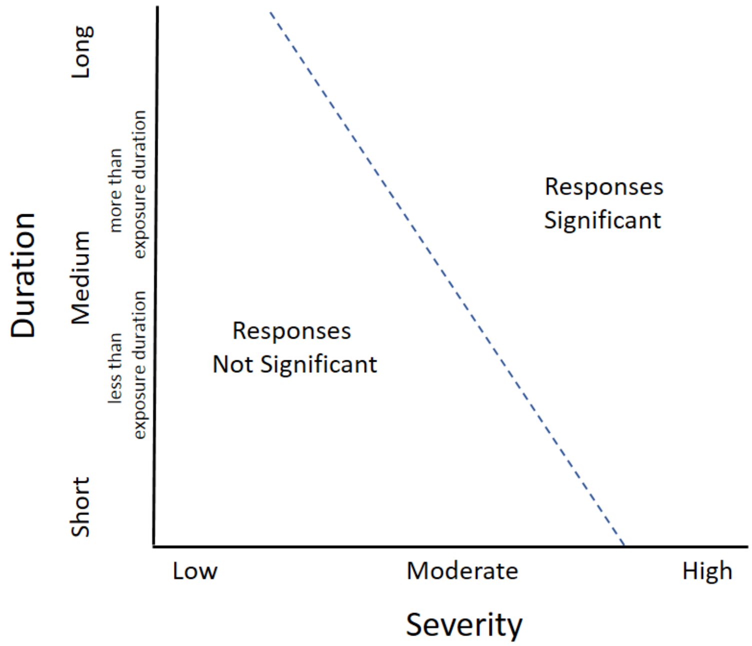


Figure 3.4-10: Relative Likelihood of a Response Being Significant Based on the Duration and Severity of Behavioral Reactions

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 3.4.2.1.1.6, 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 or testing activities.

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 that in many cases lasted 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, 2017b), 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 and Alternative 2 of the Proposed Action for training and testing. The Navy's mitigation measures are identical for both action alternatives.

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, 2018b).

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 or testing 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 or testing activity could take place are also considered, such as sea surface conditions, weather (e.g., fog or rain), and day versus night.

The Navy will also implement mitigation measures for certain active sonar activities within mitigation areas, including the Marpi Reef Mitigation Area, Chalan Kanoa Reef Mitigation Area, and Agat Bay Nearshore Mitigation Area, as described in Appendix I (Geographic Mitigation Assessment). 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.

3.4.2.1.2.2 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 to the PTS threshold for an exposure of 30 seconds are shown in Table 3.4-4 relative to the marine mammal's functional hearing group. This period (30 seconds) was chosen based on examining the maximum amount of time a marine mammal would realistically be exposed to levels that could cause the onset of PTS based on platform (e.g., ship) speed and a nominal animal swim speed of approximately 1.5 meters per second. The ranges provided in the table include the average range to PTS, as well as the range from the minimum to the maximum distance at which PTS is possible for each hearing group. Since any hull-mounted sonar, such as the SQS-53, engaged in anti-submarine warfare training would be moving at between 10 and 15 knots and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 257 m during the time between those pings (note: 10 knots is the speed used in the Navy Acoustic Effects Model). As a result, there is little overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). For all other bins (besides MF1), PTS ranges are short enough that marine mammals (with a nominal swim speed of approximately 1.5 meters per second) should be able to avoid higher sound levels capable of causing onset PTS within this 30-second period.

For all other functional hearing groups (low-frequency cetaceans and mid-frequency cetaceans), 30-second average PTS zones are substantially shorter. 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 3.4-5 through Table 3.4-9). 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.

Table 3.4-4: Range to Permanent Threshold Shift for Five Representative Sonar Systems

Hearing Group	*Approximate PTS (30 seconds) Ranges (meters)*[1]				
	Sonar bin HF4	*Sonar bin LF4*	*Sonar bin MF1*	*Sonar bin MF4*	*Sonar bin MF5*
High-frequency cetaceans	29 (22–35)	0 (0–0)	181 (180–190)	30 (30–30)	9 (8–10)
Low-frequency cetaceans	0 (0–0)	0 (0–0)	65 (65–65)	15 (15–15)	0 (0–0)
Mid-frequency cetaceans	1 (0–1)	0 (0–0)	16 (16–16)	3 (3–3)	0 (0–0)

[1] PTS ranges extend from the sonar or other transducers 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 parentheses.
Notes: HF= high-frequency, LF = low-frequency, MF = mid-frequency, PTS = permanent threshold shift

Table 3.4-5: Ranges to Temporary Threshold Shift for Sonar Bin HF4 over a Representative Range of Environments within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin HF4			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	155 (110–210)	259 (180–350)	344 (240–480)	445 (300–600)
Low-frequency cetaceans	1 (0–2)	2 (1–3)	4 (3–5)	7 (5–8)
Mid-frequency cetaceans	10 (7–12)	17 (12–21)	24 (17–30)	33 (25–40)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parenthesis.
Notes: HF = high-frequency, TTS = temporary threshold shift

Table 3.4-6: Ranges to Temporary Threshold Shift for Sonar Bin LF4 over a Representative Range of Environments within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin LF4			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Low-frequency cetaceans	3 (3–3)	4 (4–4)	6 (6–6)	9 (9–9)
Mid-frequency cetaceans	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.
Notes: LF = low-frequency, TTS = temporary threshold shift

Table 3.4-7: Ranges to Temporary Threshold Shift for Sonar Bin MF1 over a Representative Range of Environments within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)*[1]			
	Sonar Bin MF1			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	3,181 (2,025–5,025)	3,181 (2,025–5,025)	5,298 (2,275–7,775)	6,436 (2,525–9,775)
Low-frequency cetaceans	898 (850–1,025)	898 (850–1,025)	1,271 (1,025–1,525)	1,867 (1,275–3,025)
Mid-frequency cetaceans	210 (200–210)	210 (200–210)	302 (300–310)	377 (370–390)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.
Notes: Ranges for 1-sec and 30-sec periods are identical for Bin MF1 because this system nominally pings every 50 seconds; therefore, these periods encompass only a single ping.
Notes: MF = mid-frequency, TTS = temporary threshold shift

Table 3.4-8: Ranges to Temporary Threshold Shift for Sonar Bin MF4 over a Representative Range of Environments within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)[1]*			
	Sonar Bin MF4			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	232 (220–260)	454 (420–600)	601 (575–875)	878 (800–1,525)
Low-frequency cetaceans	85 (85–90)	161 (160–170)	229 (220–250)	352 (330–410)
Mid-frequency cetaceans	22 (22–22)	35 (35–35)	50 (45–50)	70 (70–70)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.
Notes: MF = mid-frequency, TTS = temporary threshold shift

Table 3.4-9: Ranges to Temporary Threshold Shift for Sonar Bin MF5 over a Representative Range of Environments within the Study Area

Hearing Group	*Approximate TTS Ranges (meters)[1]*			
	Sonar Bin MF5			
	1 second	*30 seconds*	*60 seconds*	*120 seconds*
High-frequency cetaceans	114 (110–130)	114 (110–130)	168 (150–200)	249 (210–290)
Low-frequency cetaceans	11 (10–12)	11 (10–12)	16 (16–17)	23 (23–24)
Mid-frequency cetaceans	5 (0–9)	5 (0–9)	12 (11–13)	18 (17–18)

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to suffer TTS extend from onset-PTS to the distance indicated. The average range to TTS is provided as well as the range from the estimated minimum to the maximum range to TTS in parentheses.
Notes: MF = mid-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 are shown in Table 3.4-10 through Table 3.4-14, respectively. See Section 3.4.2.1.2.1 (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 3.4-10: Ranges to a Potentially Significant Behavioral Response for Sonar Bin HF4 over a Representative Range of Environments within the Study Area

Received Level (dB re 1 µPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin HF4*		
		Odontocete	*Mysticete*	*Beaked Whale*
196	3 (2–4)	100%	100%	100%
190	8 (6–10)	100%	98%	100%
184	16 (12–20)	99%	88%	100%
178	32 (24–40)	97%	59%	100%
172	63 (45–80)	91%	30%	99%
166	120 (75–160)	78%	20%	97%
160	225 (120–310)	58%	18%	93%
154	392 (180–550)	40%	17%	83%
148	642 (280–1,275)	29%	16%	66%
142	916 (420–1,775)	25%	13%	45%
136	1,359 (625–2,525)	23%	9%	28%
130	1,821 (950–3,275)	20%	5%	18%
124	2,567 (1,275–5,025)	17%	2%	14%
118	3,457 (1,775–6,025)	12%	1%	12%
112	4,269 (2,275–7,025)	6%	0%	11%
106	5,300 (3,025–8,025)	3%	0%	11%
100	6,254 (3,775–9,275)	1%	0%	8%

Notes: dB re 1 µPa = decibels referenced to 1 micropascal, HF = high-frequency

Table 3.4-11: Ranges to a Potentially Significant Behavioral Response for Sonar Bin LF4 over a Representative Range of Environments within the Study Area

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin LF4		
		Odontocete	Mysticete	Beaked Whale
196	1 (1–1)	100%	100%	100%
190	3 (3–3)	100%	98%	100%
184	6 (6–6)	99%	88%	100%
178	12 (12–12)	97%	59%	100%
172	25 (25–25)	91%	30%	99%
166	51 (50–55)	78%	20%	97%
160	130 (130–160)	58%	18%	93%
154	272 (270–300)	40%	17%	83%
148	560 (550–675)	29%	16%	66%
142	1,048 (1,025–1,525)	25%	13%	45%
136	2,213 (1,525–4,525)	23%	9%	28%
130	4,550 (2,275–24,025)	20%	5%	18%
124	16,903 (4,025–66,275)	17%	2%	14%
118	43,256 (7,025–87,775)	12%	1%	12%
112	60,155 (7,775–100,000*)	6%	0%	11%
106	80,689 (8,775–100,000*)	3%	0%	11%
100	92,352 (9,025–100,000*)	1%	0%	8%

* Indicates maximum range to which acoustic model was run, a distance of approximately 100 km from the sound source.

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 3.4-3 for behavioral cut-off distances).

dB re 1 µPa = decibels referenced to 1 micropascal, LF = low-frequency

Table 3.4-12: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF1 over a Representative Range of Environments within the Study Area

Received Level (dB re 1 µPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin MF1*		
		Odontocete	*Mysticete*	*Beaked Whale*
196	106 (100–110)	100%	100%	100%
190	240 (240–250)	100%	98%	100%
184	501 (490–525)	99%	88%	100%
178	1,019 (975–1,025)	97%	59%	100%
172	3,275 (2,025–5,275)	91%	30%	99%
166	7,506 (2,525–11,025)	78%	20%	97%
160	15,261 (4,775–20,775)	58%	18%	93%
154	27,759 (5,525–36,525)	40%	17%	83%
148	43,166 (7,525–65,275)	29%	16%	66%
142	58,781 (8,525–73,525)	25%	13%	45%
136	71,561 (11,275–90,775)	23%	9%	28%
130	83,711 (13,025–100,000*)	20%	5%	18%
124	88,500 (23,525–100,000*)	17%	2%	14%
118	90,601 (27,025–100,000*)	12%	1%	12%
112	92,750 (27,025–100,000*)	6%	0%	11%
106	94,469 (27,025–100,000*)	3%	0%	11%
100	95,838 (27,025–100,000*)	1%	0%	8%

* Indicates maximum range to which acoustic model was run, a distance of approximately 100 km from the sound source.

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 3.4-3 for behavioral cut-off distances).

dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

Table 3.4-13: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF4 over a Representative Range of Environments within the Study Area

Received Level (dB re 1 µPa)	Mean Range (meters) with Minimum and Maximum Values in Parentheses	Probability of Behavioral Response for Sonar Bin MF4		
		Odontocete	Mysticete	Beaked Whale
196	8 (8–8)	100%	100%	100%
190	17 (17–17)	100%	98%	100%
184	35 (35–35)	99%	88%	100%
178	70 (65–70)	97%	59%	100%
172	141 (140–150)	91%	30%	99%
166	354 (330–420)	78%	20%	97%
160	773 (725–1,275)	58%	18%	93%
154	1,489 (1,025–3,275)	40%	17%	83%
148	3,106 (1,775–6,775)	29%	16%	66%
142	8,982 (3,025–18,775)	25%	13%	45%
136	15,659 (3,775–31,025)	23%	9%	28%
130	25,228 (4,775–65,775)	20%	5%	18%
124	41,778 (5,525–73,275)	17%	2%	14%
118	51,832 (6,025–89,775)	12%	1%	12%
112	62,390 (6,025–100,000*)	6%	0%	11%
106	69,235 (6,775–100,000*)	3%	0%	11%
100	73,656 (7,025–100,000*)	1%	0%	8%

* Indicates maximum range to which acoustic model was run, a distance of approximately 100 km from the sound source.

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 3.4-3 for behavioral cut-off distances).

dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

Table 3.4-14: Ranges to a Potentially Significant Behavioral Response for Sonar Bin MF5 over a Representative Range of Environments within the Study Area

Received Level (dB re 1 µPa)	*Mean Range (meters) with Minimum and Maximum Values in Parentheses*	*Probability of Behavioral Response for Sonar Bin MF5*		
		Odontocete	*Mysticete*	*Beaked Whale*
196	0 (0–0)	100%	100%	100%
190	1 (0–3)	100%	98%	100%
184	4 (0–7)	99%	88%	100%
178	14 (0–15)	97%	59%	100%
172	29 (0–30)	91%	30%	99%
166	58 (0–60)	78%	20%	97%
160	125 (0–150)	58%	18%	93%
154	284 (160–525)	40%	17%	83%
148	607 (450–1,025)	29%	16%	66%
142	1,213 (875–4,025)	25%	13%	45%
136	2,695 (1,275–7,025)	23%	9%	28%
130	6,301 (2,025–12,525)	20%	5%	18%
124	10,145 (3,025–19,525)	17%	2%	14%
118	14,359 (3,525–27,025)	12%	1%	12%
112	19,194 (3,525–37,275)	6%	0%	11%
106	24,153 (4,025–48,025)	3%	0%	11%
100	29,325 (5,025–57,775)	1%	0%	8%

Notes: Cells are shaded if the mean range value for the specified received level exceeds the distance cutoff range for a particular hearing group. Any impacts within the cutoff range for a criteria group are included in the estimated impacts. Cut-off ranges in this table are for activities with high source levels and/or multiple platforms (see Table 3.4-3 for behavioral cut-off distances).
dB re 1 µPa = decibels referenced to 1 micropascal, MF = mid-frequency

3.4.2.1.2.3 Impacts from Sonar and Other Transducers Under the Action Alternatives

Use of sonar and other transducers would typically be transient and temporary. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training and testing under Alternative 1 and 2 are described in Section 3.0.4.1 (Acoustic Stressors). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Training and Testing Activities Descriptions). The major differences between the action alternatives for the purposes of analyzing impacts on marine mammals are:

- Under Alternative 1, training and testing activities would fluctuate each year to account for the natural variation of training cycles and deployment schedules.

- Under Alternative 2, the same type and tempo of military training and testing activities would occur as Alternative 1, but there would be five Joint Multi-Strike Group Exercises (e.g., Valiant Shield) over any five-year period as compared to three under Alternative 1. Additionally, Alternative 2 contemplates three (vice two) Small Joint Coordinated anti-submarine warfare exercises (Multi-Sail/GUAMEX) per year with a 50 percent increase in associated unit-level events (e.g., Missile Exercise (Surface-to-Air). This would result in an increase of active sonar training compared to Alternative 1. There would also be an increase in the use of active sonar during certain testing events. Alternative 2 reflects the maximum number of training and testing activities that could occur within a given year, and assumes that the maximum number of Fleet exercises would occur every year.

Compared to training and testing activities that use sonar and other transducers that were previously analyzed in the 2015 MITT Final EIS/OEIS under Alternatives 1 and 2, some training and testing activities would increase, decrease, or stay the same from those currently conducted (see Table 2.5-1 and Table 2.5-2 for details). In addition, some new systems using new technologies will be tested under the action alternatives.

Major training exercises are multi-day exercises that transition across large areas and involve multiple anti-submarine warfare assets. It is important to note that, while major training exercises focus on anti-submarine warfare, there are significant periods when active anti-submarine warfare sonars are not in use. Nevertheless, behavioral reactions are assumed more likely to be significant than during other anti-submarine warfare activities due to the duration (i.e., multiple days) and scale (i.e., multiple sonar platforms) of the major training exercises. Although major training exercises tend to move to different locations as the event unfolds, some animals could be exposed multiple times over the course of a few days.

Anti-submarine warfare activities also include unit-level training and coordinated/integrated training, and anti-submarine warfare sonar systems would be active when conducting surface ship and submarine sonar maintenance. Submarine and surface ship sonar maintenance activities involve the use of a single system in a limited manner; therefore, significant reactions to maintenance are less likely than with most other anti-submarine warfare activities. Furthermore, sonar maintenance activities typically occur either pierside or within entrances to harbors where higher levels of anthropogenic activity, including elevated noise levels, already exist. Unit-level training activities typically involve the use of a single vessel or aircraft and last for only a few hours over a small area of ocean. These unit-level training and sonar maintenance activities are limited in scope and duration; therefore, significant behavioral reactions are less likely than with other anti-submarine warfare activities with greater intensity and duration. Unit-level training activities are more likely to occur close to homeports and in the same general locations each time, so resident animals could be more frequently exposed to these types of activities. Coordinated/integrated exercises involve multiple assets and can last for several days transiting across large areas of a range complex. Repeated exposures to some individual marine mammals are likely during coordinated/integrated exercises. However, due to the shorter duration and smaller footprint compared to major training exercises, impacts from these activities are less likely to be significant with the possible exception of resident animals near homeports or Navy instrumented ranges that may incur some repeated exposures.

Anti-submarine warfare testing activities are typically similar to unit-level training. Vessel evaluation testing activities also use the same anti-submarine warfare sonars on ships and submarines. Testing activities that use anti-submarine warfare sonars typically occur in water deeper than approximately 200 m and therefore out of most nearshore habitats where productivity is typically higher (i.e., more food) and many marine mammals have higher abundances. Therefore, significant reactions to anti-submarine warfare and vessel evaluation testing activities are less likely than with larger anti-submarine warfare training activities discussed. These testing activities are limited in scope and duration; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Mine warfare training activities typically involve a ship, helicopter, or unmanned vehicle using a mine-hunting sonar to locate mines. Most mine warfare sonar systems have a lower source level, higher frequency, and narrower, often downward facing beam pattern as compared to most anti-submarine warfare sonars. Significant reactions in marine mammals have not been reported due to exposure to mine warfare sonars. While individual animals could show short-term and minor responses to mine warfare sonar training activities, these reactions are very unlikely to lead to any costs or long-term consequences for individuals or populations.

Mine warfare testing activities typically involve a ship, helicopter, or unmanned vehicle testing a mine-hunting sonar system. Unmanned underwater vehicle testing also employs many of the same sonar systems as mine warfare testing and usually involves only a single sonar platform (i.e., unmanned underwater vehicle). Most of the sonar systems and other transducers used during these testing activities typically have a lower source level, higher frequency, and narrower, often downward facing beam pattern as compared to most anti-submarine warfare sonars. Significant reactions in marine mammals have not been reported due to exposure to these types of systems sonars. Animals are most likely to show short-term and minor to moderate responses to these testing activities; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Navigation and object detection activities typically employ ship and submarine-based sonar systems and other transducers to navigate and avoid underwater objects. Significant reactions in marine mammals have not been reported due to exposure to most of the sonars and other transducers typically used in these activities. Some hull-mounted anti-submarine warfare sonars (e.g., bin MF1) have a mode to look for objects in the water such as mines, but this mode uses different source characteristics as compared to the anti-submarine warfare mode. Significant behavioral reactions have not been observed in relation to hull-mounted sonars using object-detection mode; however, significant reactions may be more likely than for all other sonar systems and transducers used within these activities due to the additional presence of a moving vessel and higher source levels. Individual animals could show short-term and minor to moderate responses to these systems, although these reactions are very unlikely to lead to any costs or long-term consequences for individuals or populations.

Training and testing activities with unmanned underwater vehicles may also employ many of the same sonar systems as mine warfare testing. Most of the sonar systems and other transducers used during these activities typically have a lower source level; higher frequency; and narrower, often downward-facing beam pattern as compared to most anti-submarine warfare sonars. Significant reactions in marine mammals have not been reported due to exposure to these types of systems sonars. Animals are most likely to show short-term and minor to moderate responses to these activities; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Other testing activities include testing of individual sonar systems and other transducers for performance and acoustic signature (e.g., required pre-underway pierside sonar system checks). Most sources used during these exercises have moderate source levels between 160 and 200 dB re 1 µPa @ 1 m and are used for a limited duration, up to a few hours in most cases. Significant reactions in marine mammals have not been reported due to exposure to the sonars and other transducers typically used in these activities. Animals are most likely to show short-term and minor to moderate responses to these testing activities; therefore, many of the impacts estimated by the quantitative analysis are unlikely to rise to the level of a significant behavioral response.

Surface warfare activities require limited use of sonar or other transducers as compared to other types of activities discussed above, typically limited to the sonar targeting system of a few torpedoes. The limited scope and duration of sonar use in these activities makes significant behavioral reactions less likely than with other activities that use anti-submarine warfare sonar systems and other transducers, which are discussed above.

Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts on marine mammals from sonars and other transducers (Section 3.4.2.1.2.1, 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 and testing activities under each action alternative are shown in Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) and presented below in figures for each species of marine mammal with any estimated effects (e.g., Figure 3.4-11). The activity categories that are most likely to cause impacts and the most likely region in which impacts could occur are represented in the graphics for each species. There is a potential for impacts to occur anywhere within the Study Area where sound from sonar and the species overlap, although only regions or activity categories where 0.5 percent of the impacts or greater are estimated to occur are graphically represented below. All (i.e., grand total) estimated impacts for that species are included, regardless of region or category.

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 3.4.2.1.1.5, Behavioral Reactions). The best available science, including behavioral response studies, was used for deriving these criteria; however, many of the factors inherent in these studies that potentially increased the likelihood and severity of observed responses (e.g., close approaches by multiple vessels, tagging animals, and vectoring towards animals that have already begun avoiding the sound source) would not occur during Navy activities. Because the Navy purposely avoids approaching marine mammals, many of the behavioral responses estimated by the quantitative analysis are unlikely to occur or unlikely to rise to the severity observed during many of the behavioral response studies.

Although the statutory definition of Level B harassment for military readiness activities under the MMPA requires that the natural behavior patterns of a marine mammal be significantly altered or abandoned, the current state of science for determining those thresholds is somewhat unsettled. Therefore, in its analysis of impacts associated with acoustic sources, the Navy is adopting a conservative approach that overestimates the number of takes by Level B harassment. The responses estimated using the Navy's quantitative analysis are most likely to be moderate severity. Moderate severity responses would be considered significant if they were sustained for a duration long enough that it caused an animal to be outside of normal daily variations in feeding, reproduction, resting, migration/movement, or social cohesion. As discussed in Section 3.4.2.1.2.1 (Methods for Analyzing Impacts from Sonar and Other Transducers), the behavioral response functions used within the Navy's quantitative analysis were primarily derived from experiments using short-duration sound exposures lasting, in many cases, for less than 30 minutes. If animals exhibited moderate severity reactions for the duration of the exposure or longer, then it was conservatively assumed that the animal experienced a significant behavioral reaction. However, the experiments did not include measurements of costs to animals beyond the immediately observed reactions, and no direct correlations exist between an observed behavioral response and a cost that may result in long-term consequences. Within the Navy's quantitative analysis, many behavioral reactions are estimated from exposure to sound that may exceed an animal's behavioral threshold for only a single exposure up to several minutes. It is likely that many of the estimated behavioral reactions within the Navy's quantitative analysis would not constitute significant behavioral reactions; however, the numbers of significant verses non-significant behavioral reactions are currently impossible to predict. Consequently, there is a high likelihood that significant numbers of marine mammals exposed to acoustic sources are not significantly altering or abandoning their natural behavior patterns. As such, the overall impact of acoustic sources from military readiness activities on marine mammal species and stocks is negligible (i.e., cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stocks through effects on annual rates of recruitment or survival).

Mysticetes

Mysticetes may be exposed to sound from sonar and other transducers associated with training and testing activities. 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 3.4.1.6, 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 3.4.2.1.2 (Impacts from Sonar and Other Transducer Stressors).

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*, the quantitative analysis very likely overestimated the numbers of behavioral reactions due to the underlying nature of the data used to derive the behavioral response functions. Research shows that if mysticetes do respond they may react in a number of ways, depending on the characteristics of the sound source, their experience with the sound source, and whether they are migrating or on seasonal grounds (i.e., breeding or feeding). Behavioral reactions may include alerting, breaking off feeding dives and surfacing, or diving or swimming away. Overall, mysticetes have been observed to be more reactive to acoustic disturbance when a noise sources is located directly on their migration route. Mysticetes disturbed while migrating could pause their migration or route around the disturbance. Animals disturbed while engaged in other activities such as feeding or reproductive behaviors may be more likely to ignore or tolerate the disturbance and continue their natural behavior patterns. Therefore, behavioral reactions from mysticetes are likely to be short-term and low to moderate severity.

Some mysticetes may avoid larger activities such as a major training exercise as it moves through an area. Vessels and aircraft associated with training or testing activities are typically in transit during an event (they are not stationary) and activities typically do not use the same training locations day after day during multi-day activities. If an event otherwise focuses on a fixed location, mysticetes may avoid the location of the activity for the duration of the event. If animals are displaced, they would likely return quickly after the event subsides. It is unlikely that most mysticetes would encounter a major training exercise more than once per year. In the ocean, the use of sonar and other transducers is transient and is unlikely to expose the same population of animals repeatedly over a short period except around homeports and fixed instrumented ranges. 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 3.4.2.1.1.5, 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. 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 (Section 3.4.2.1.1.2, 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 3.4.2.1.1.4 (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. 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 less than one-third octave). These factors reduce the likelihood of sources causing significant masking in mysticetes. High-frequency sonars are typically used for mine hunting, navigation, and object detection (avoidance). High-frequency (greater than 10 kHz) sonars fall outside of the best hearing and vocalization ranges of mysticetes (see Section 3.4.1.6, 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. Masking in mysticetes due to exposure to high-frequency sonar is unlikely. Potential costs to mysticetes from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively pinging and the effect is over the moment the sound has ceased. By contrast, hearing loss lasts beyond the exposure for a period. Nevertheless, mysticetes that do experience some masking for a short period from low- or mid-frequency sonar may have their ability to communicate with conspecifics reduced, especially at further ranges. However, larger mysticetes (e.g., blue whale, fin whale, sei whale) communicate at frequencies below those of mid-frequency sonar and even most low-frequency sonars. Mysticetes that communicate at higher frequencies (e.g., minke whale) may be affected by some short-term and intermittent masking. Sounds from mid-frequency sonar could mask killer whale vocalizations making them more difficult to detect, especially at further ranges. It is unknown whether masking would affect a mysticete's ability to feed since it is unclear how or if mysticetes use sound for finding prey or feeding. A single or even a few short periods of masking, if it were to occur, to an individual mysticete per year are unlikely to have any long-term consequences for that individual.

Many activities such as submarine under ice certification and most mine hunting exercises use only high-frequency sonars that are not within mysticetes' hearing range; therefore, there were no predicted effects. Section 3.4.1.6 (Hearing and Vocalization) discusses low-frequency cetacean (i.e., mysticetes) hearing abilities.

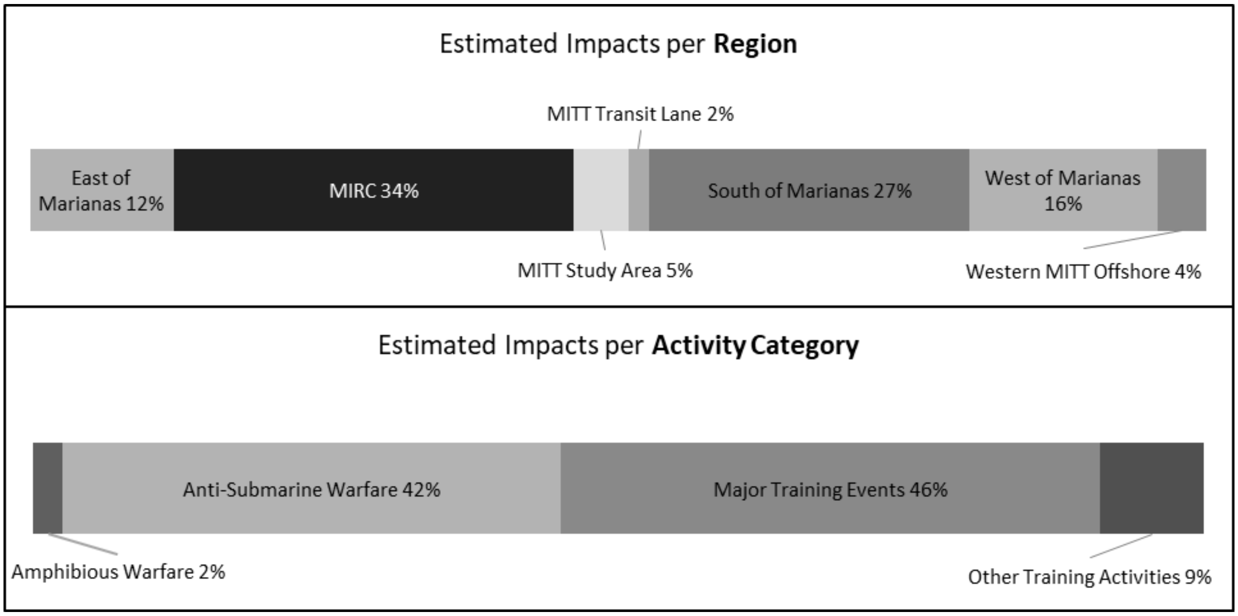
Blue Whale (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Blue whales may be exposed to sounds from sonar and other transducers associated with training and testing activities in the Study Area during the winter, when they are expected to be present (although few in number). The quantitative analysis estimates behavioral reactions and TTS during training and testing activities under Alternative 1 (Figure 3.4-11 and Table 3.4-15). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). For mysticetes, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of blue whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed blue whales.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-11: Blue Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-15: Estimated Impacts on Individual Blue Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
4	19	0

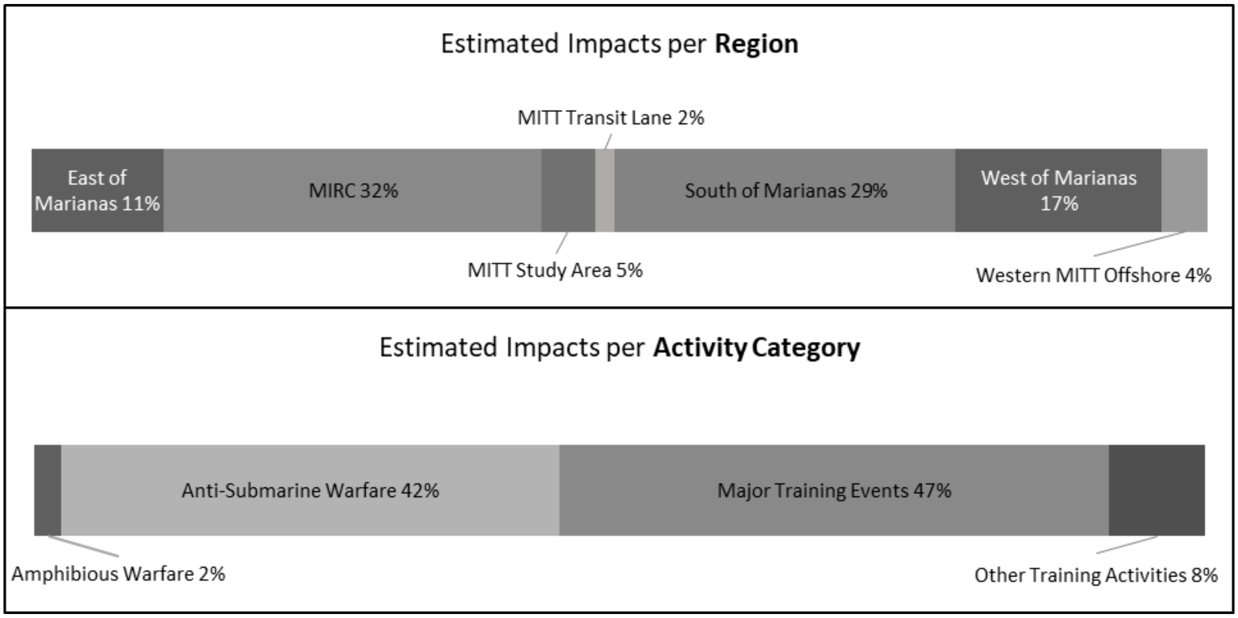
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Blue whales may be exposed to sounds from sonar and other transducers associated with training and testing activities in the Study Area during the winter, when they are expected to be present (although few in number). The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-12 and Table 3.4-16). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as Alternative 1, although the numbers of impacts would increase slightly based on the increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of blue whales incidental to those activities. The Navy is requesting 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 and testing activities as described under Alternative 2 may affect ESA-listed blue whales. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-12: Blue Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-16: Estimated Impacts on Individual Blue Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
4	20	0

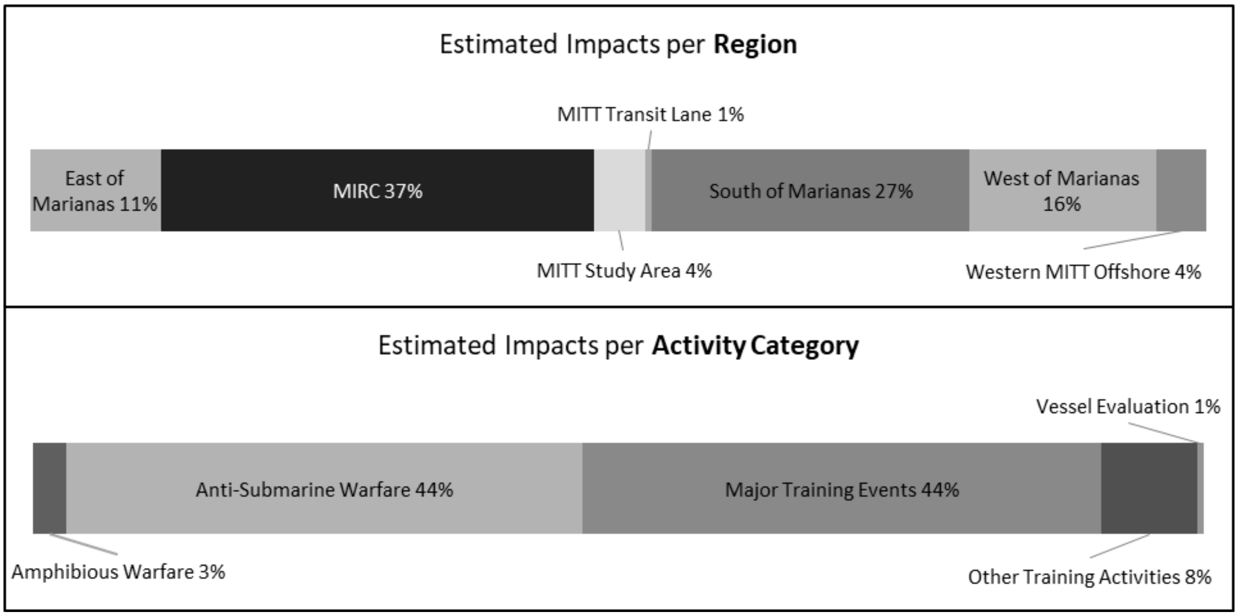
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Bryde's Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Bryde's whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-13 and Table 3.4-17). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Bryde's whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-13: Bryde's Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-17: Estimated Impacts on Individual Bryde's Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

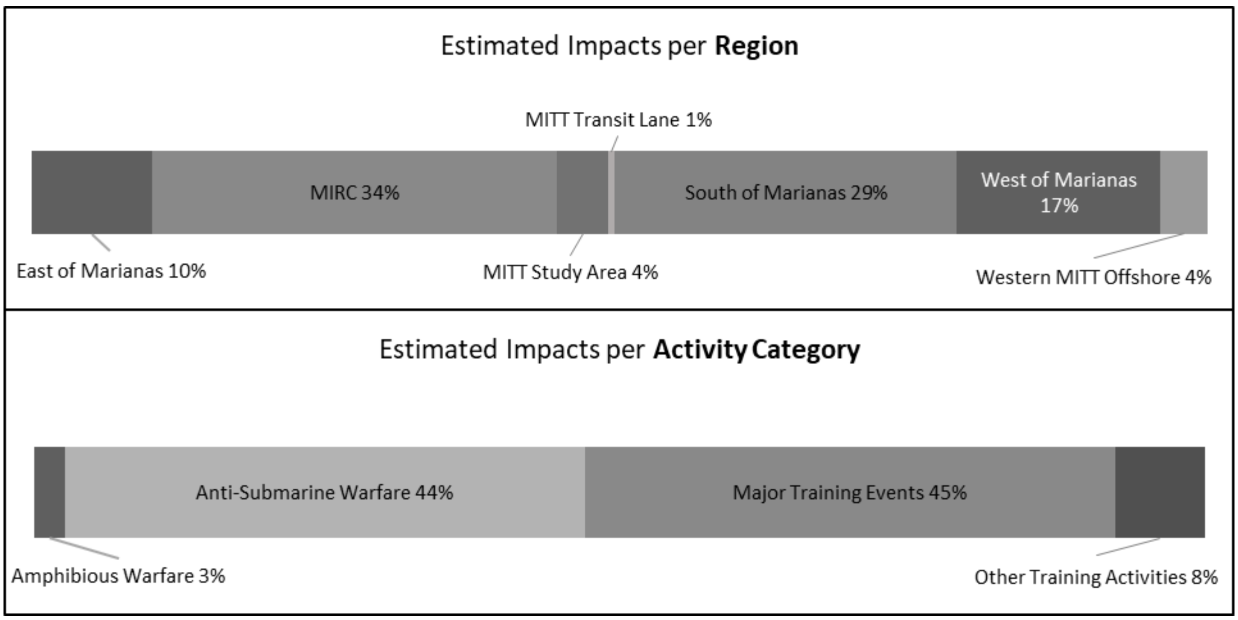
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
33	236	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Bryde's whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-14 and Table 3.4-18). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Bryde's whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-14: Bryde's Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-18: Estimated Impacts on Individual Bryde's Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
36	256	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

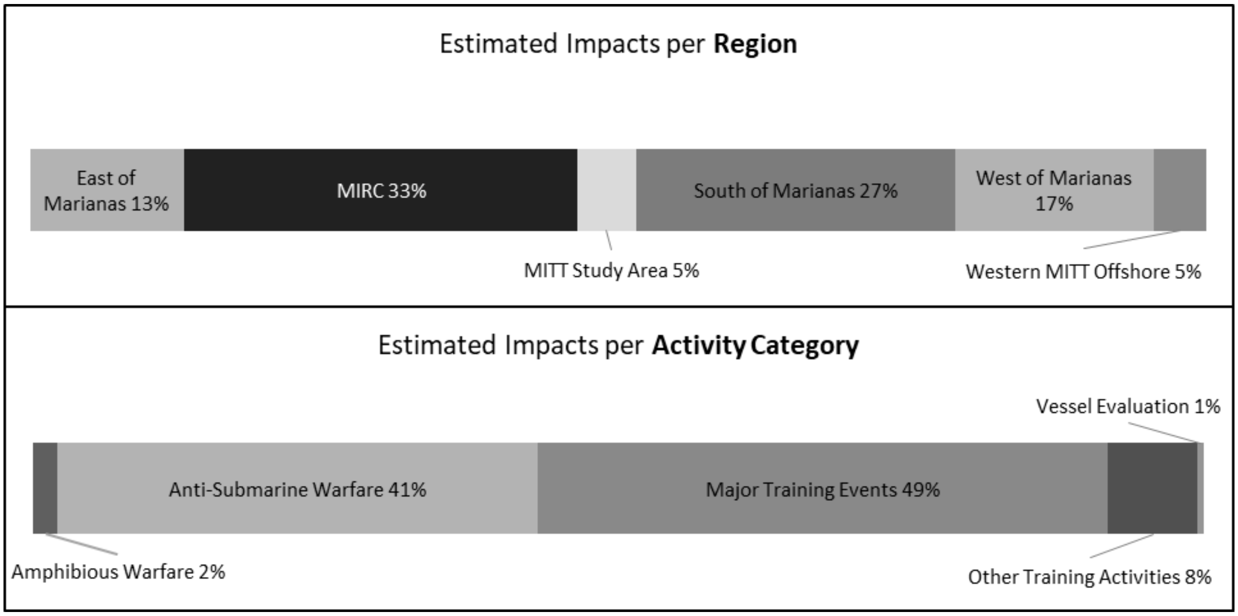
Fin Whale (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Fin whales may be exposed to sounds from sonar and other transducers associated with training and testing activities when fin whales occur in the Study Area. Based on available habitat use information, fin whales may be present in the Study Area fall through spring (U.S. Department of the Navy, 2019). The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-15 and Table 3.4-19). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of fin whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed fin whales.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-15: Fin Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-19: Estimated Impacts on Individual Fin Whale Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
4	18	0

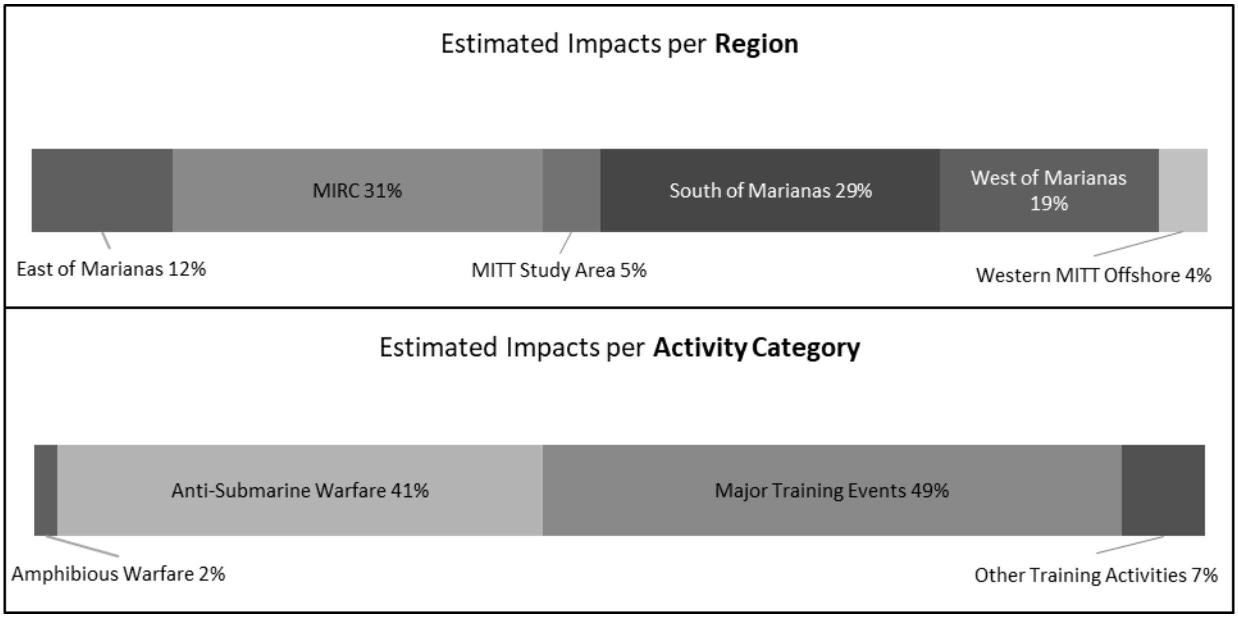
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Fin whales may be exposed to sounds from sonar and other transducers associated with training and testing activities from fall through spring, when fin whales may occur in the Study Area (U.S. Department of the Navy, 2019). The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-16 and Table 3.4-20). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of fin whales incidental to those activities. The Navy is requesting 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 and testing activities as described under Alternative 2 may affect ESA-listed fin whales. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-16: Fin Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-20: Estimated Impacts on Individual Fin Whale Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
5	20	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

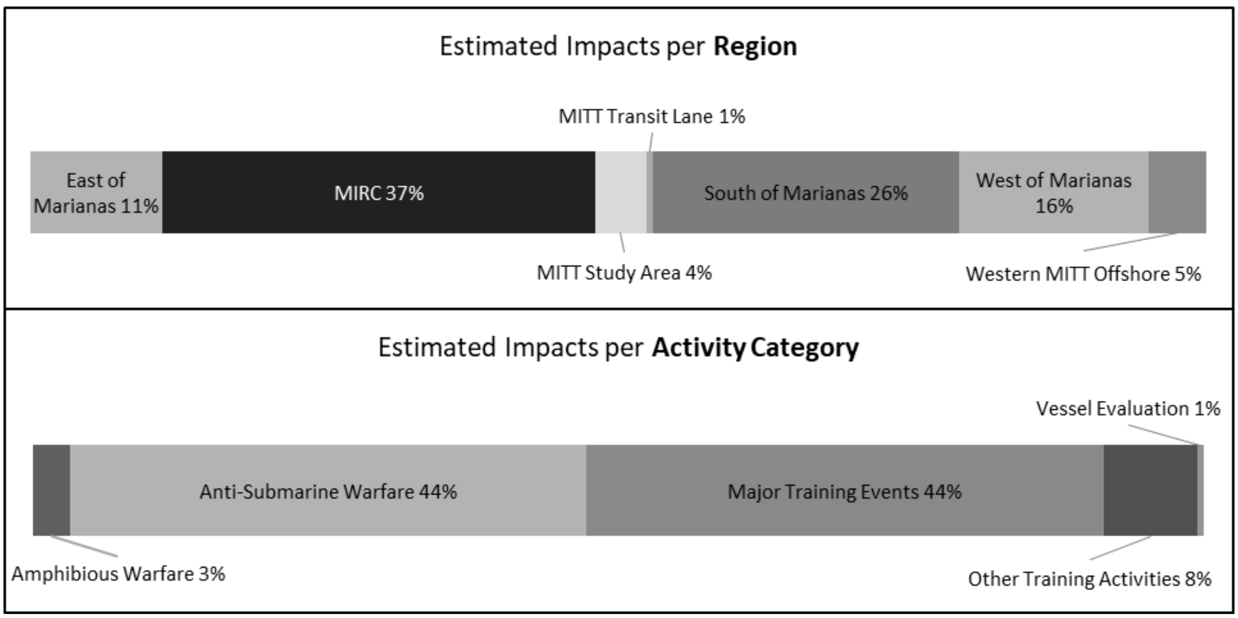
Humpback Whale (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Humpback whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-17 and Table 3.4-21). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of humpback whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed humpback whales.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-17: Humpback Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-21: Estimated Impacts on Individual Humpback Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
46	387	0

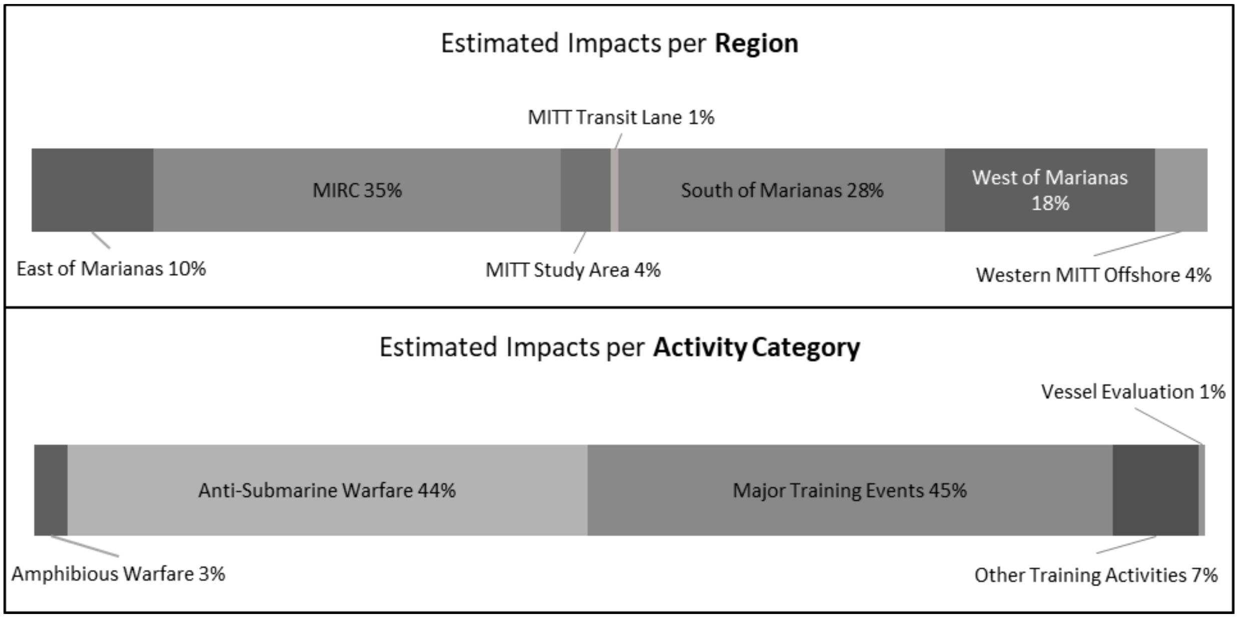
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Humpback whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-18 and Table 3.4-22). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of humpback whales incidental to those activities. The Navy is requesting 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 and testing activities as described under Alternative 2 may affect ESA-listed humpback whales. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-18: Humpback Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-22:Estimated Impacts on Individual Humpback Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
51	419	0

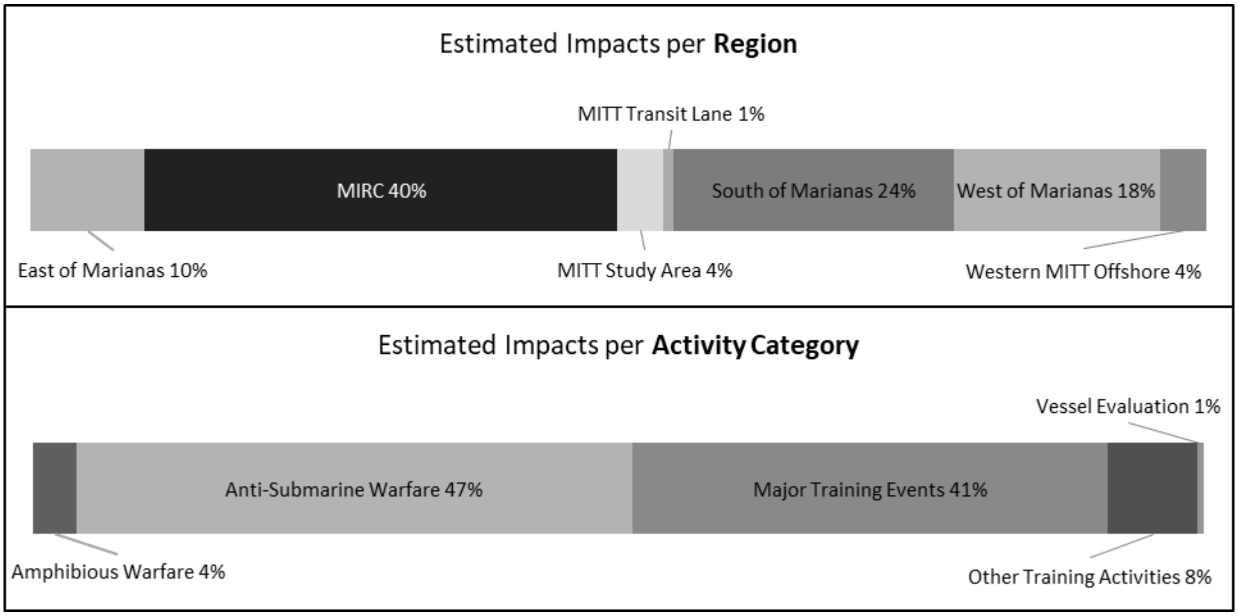
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Minke Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Minke whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-19 and Table 3.4-23). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of minke whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-19: Minke Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-23: Estimated Impacts on Individual Minke Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

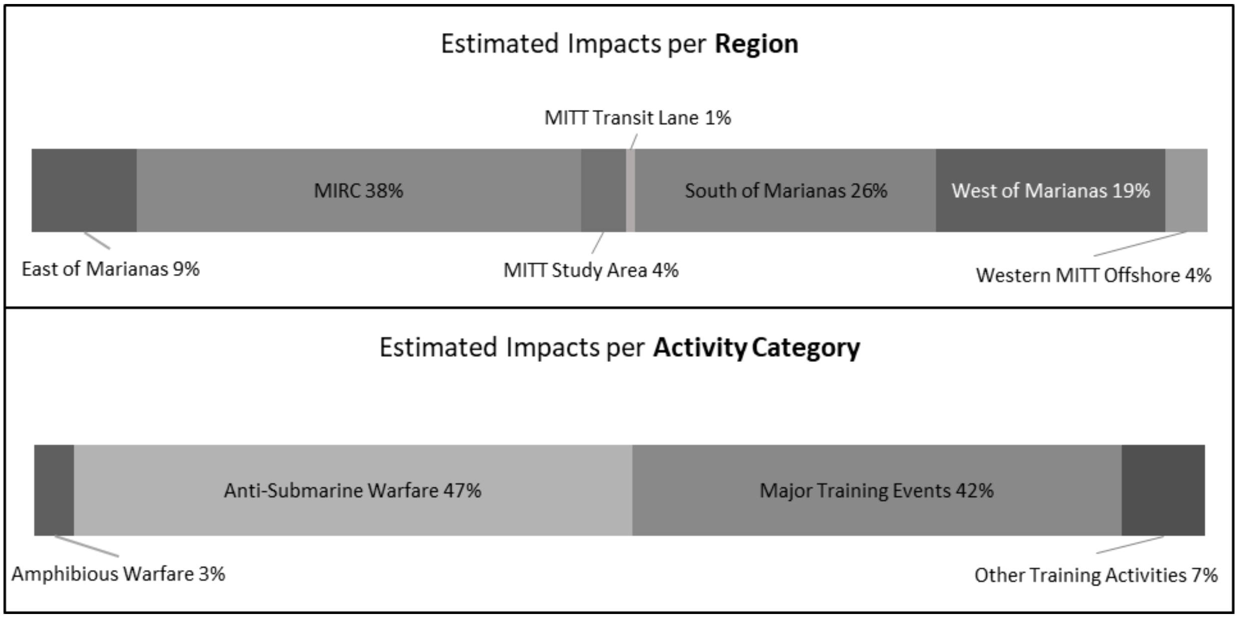
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
8	78	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Minke whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-20 and Table 3.4-24). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of minke whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-20: Minke Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-24: Estimated Impacts on Individual Minke Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
9	84	0

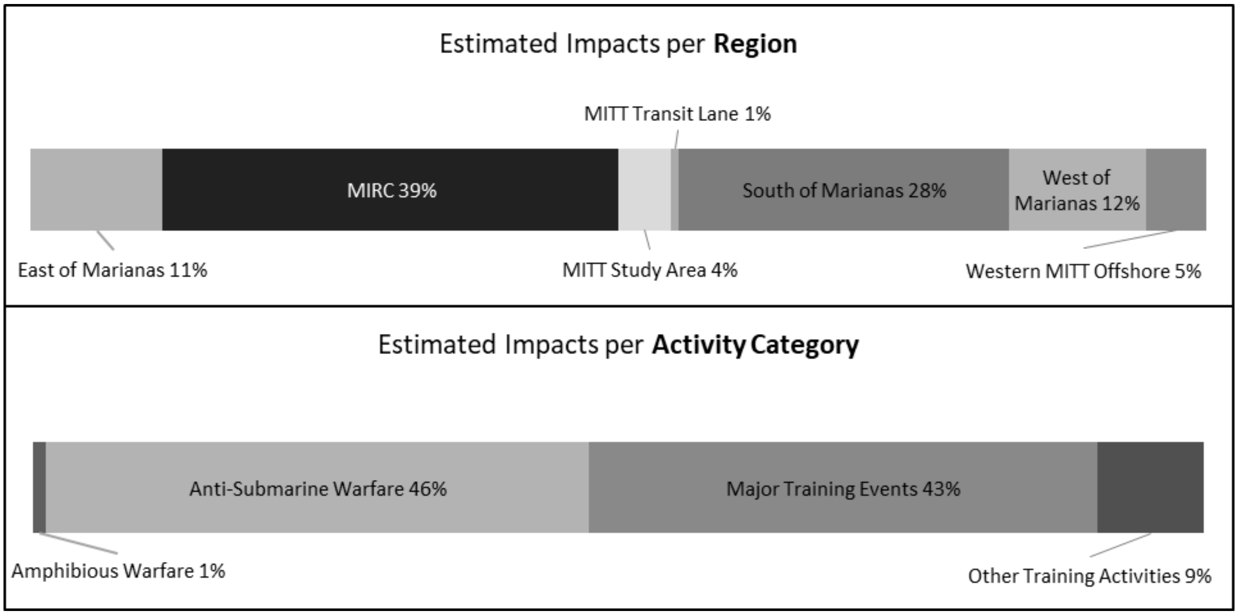
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Omura's Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Omura's whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-21 and Table 3.4-25). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Omura's whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-21: Omura's Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-25: Estimated Impacts on Individual Omura's Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

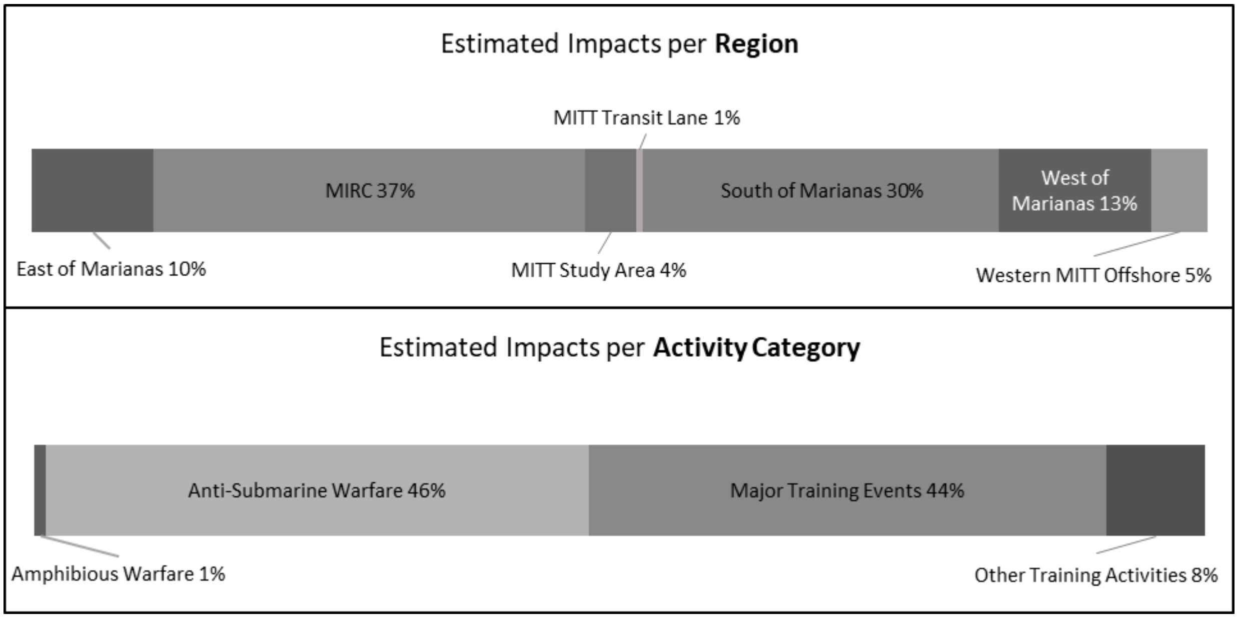
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
3	23	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Omura's whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-22 and Table 3.4-26). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Omura's whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-22: Omura's Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-26: Estimated Impacts on Individual Omura's Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
3	25	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

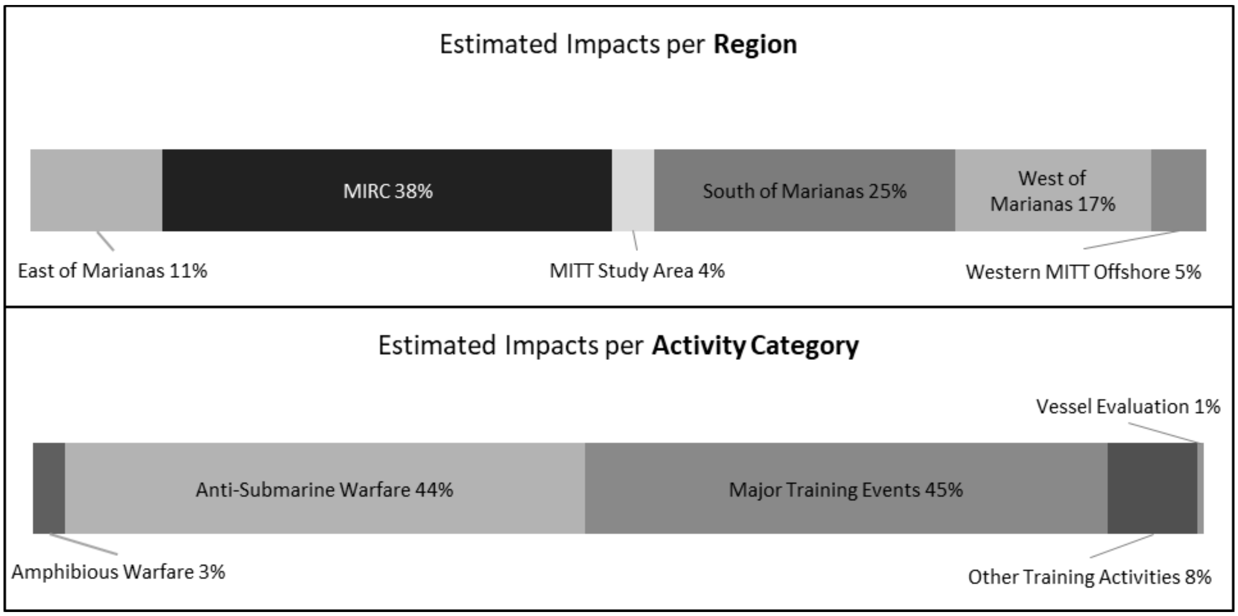
Sei Whale (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Sei whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-23 and Table 3.4-27). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of sei whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed sei whales.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-23: Sei Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-27: Estimated Impacts on Individual Sei Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
15	125	0

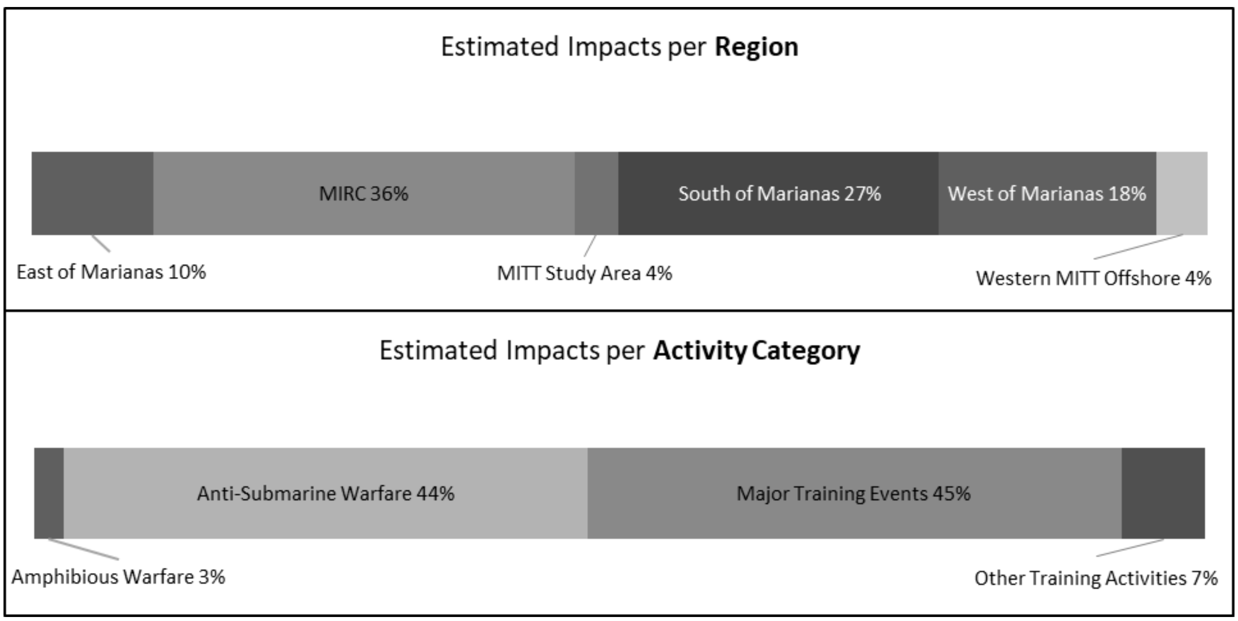
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Sei whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-24 and Table 3.4-28). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of sei whales incidental to those activities. The Navy is requesting 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 and testing activities as described under Alternative 2 may affect ESA-listed sei whales. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-24: Sei Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-28: Estimated Impacts on Individual Sei Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
17	135	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Odontocetes

Odontocetes may be exposed to sound from sonar and other transducers associated with training and testing 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 3.4.1.6, 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 3.4.2.1.2 (Impacts from Sonar and Other Transducer Stressors).

Behavioral reactions in odontocetes (except beaked whales) resulting from exposure to sonar could take place at distances of up to 20 km. Beaked whales have demonstrated a high level of sensitivity to human-made noise and activity; therefore, the quantitative analysis assumes that 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 beaked whales, as discussed above in *Assessing the Severity of Behavioral Responses from Sonar*, 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 3.4.2.1.1.5, 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 activities, which could vary in duration and intensity. Anti-submarine warfare unit-level exercises and maintenance typically last for a matter of a few hours and involves a limited amount of sonar use so significant responses would be less likely than with longer and more intense exercises (more sonar systems and vessels). Coordinated/integrated anti-submarine warfare exercises involve multiple sonar systems and can last for a period of days, making a 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 3.4.2.1.1.5, 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 activities, which could vary in duration and intensity. Anti-submarine warfare unit-level exercises and maintenance typically last for a matter of a few hours and involve a limited amount of sonar use so significant responses would be less likely than with longer and more intense exercises (more sonar systems and vessels). Coordinated/integrated anti-submarine warfare exercises involve multiple sonar systems and can last for a period of days, making significant response more likely. Some bottlenose dolphin estimated impacts could also occur due to navigation and object avoidance (detection) since these activities typically occur entering and leaving Navy homeports that overlap the distribution of coastal populations of this species. Navigation and object avoidance (detection) activities normally involve a single ship or submarine using a limited amount of sonar, therefore significant reactions are unlikely. 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 or testing 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 3.4.2.1.1.5 (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. It is unlikely that most individuals would encounter a major training exercise more than once per year due to where these activities are typically conducted. Outside of Navy instrumented ranges and homeports, the use of sonar and other transducers is transient and is unlikely to expose the same population of animals repeatedly over a short period. However, a few behavioral reactions per year from a single individual are unlikely to produce long-term consequences for that individual.

Behavioral research indicates that most odontocetes avoid sound sources at levels that would cause any temporary hearing loss (i.e., TTS) (see Section 3.4.2.1.1.5, Behavioral Reactions). TTS and even PTS is more likely for high-frequency cetaceans, such as Kogia whales, because hearing loss thresholds for these animals are lower than for all other marine mammals. These species have demonstrated a high level of sensitivity to human-made sound and activities and may avoid at further distances. This increased distance could avoid or minimize hearing loss for these species as well, especially as compared to the estimates from the quantitative analysis. Therefore, it is likely that the quantitative analysis overestimates TTS and PTS in marine mammals because it does not account for animals avoiding sound sources at closer ranges. Recovery from hearing loss begins almost immediately after the noise exposure ceases and can take a few minutes to a few days to fully recover, depending on the magnitude of the initial threshold shift. TTS would be recoverable and PTS would leave some residual hearing loss. Most TTS, if it does actually occur, would be more likely to be minor to moderate (i.e., less than 20 dB of TTS directly after the exposure) and would recover within a matter of minutes to hours. Threshold shifts do not necessarily affect all hearing frequencies equally, and typically manifest themselves at the exposure frequency or within an octave above the exposure frequency. During the period that an odontocete had hearing loss, social calls from conspecifics could be more difficult to detect or interpret. Killer whales are a primary predator of odontocetes. Some hearing loss could make killer whale calls more difficult to detect at further ranges until hearing recovers. Odontocetes use echolocation clicks to find and capture prey. These echolocation clicks and vocalizations are at frequencies above a few tens of kHz for delphinids, beaked whales, and sperm whales, and above 100 kHz for Kogia whales. Therefore, 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 3.4.2.1.1.4 (Masking). Many anti-submarine warfare sonars and countermeasures use low- and mid-frequency sonar. Most low- and mid-frequency sonar signals (i.e., sounds) are limited in their temporal, frequency, and spatial domains. The duration of most individual sounds is short, lasting up to a few seconds each. Some systems operate with higher duty cycles or nearly continuously, but typically use lower power. Nevertheless, masking may be more prevalent at closer ranges to these high-duty cycle and continuous active sonar systems. Most anti-submarine warfare activities are geographically dispersed and last for only a few hours, often with intermittent sonar use even within this period. Most anti-submarine warfare sonars also have a narrow frequency band (typically much less than one-third octave). These factors reduce the likelihood of sources causing significant masking in odontocetes due to exposure to sonar used during anti-submarine warfare activities. Odontocetes may experience some limited masking at closer ranges from high-frequency sonars and other transducers; however, the frequency band of the sonar is narrow, limiting the likelihood of masking. High-frequency sonars are typically used for mine hunting, navigation, and object detection (avoidance). Potential costs to odontocetes from masking are similar to those discussed above for mild to moderate levels of TTS, with the primary difference being that the effects of masking are only present when the sound source (i.e., sonar) is actively pinging and the effect is over the moment the sound has ceased.

Nevertheless, odontocetes that do experience some masking from sonar or other transducers may have their ability to communicate with conspecifics reduced, especially at further ranges. Sounds from mid-frequency sonar could mask killer whale vocalizations making them more difficult to detect, especially at further ranges. As discussed above for TTS, odontocetes use echolocation to find prey and navigate. The echolocation clicks of odontocetes are above the frequencies of most sonar systems, especially those used during anti-submarine warfare. 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.

Beaked Whales

Beaked whales within the Study Area include: Blainville's beaked whale, Cuvier's beaked whale, ginkgo-toothed beaked whale, and Longman's beaked whale. 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 3.4.2.1.1.5 (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 3.4.2.1.1.5, 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.

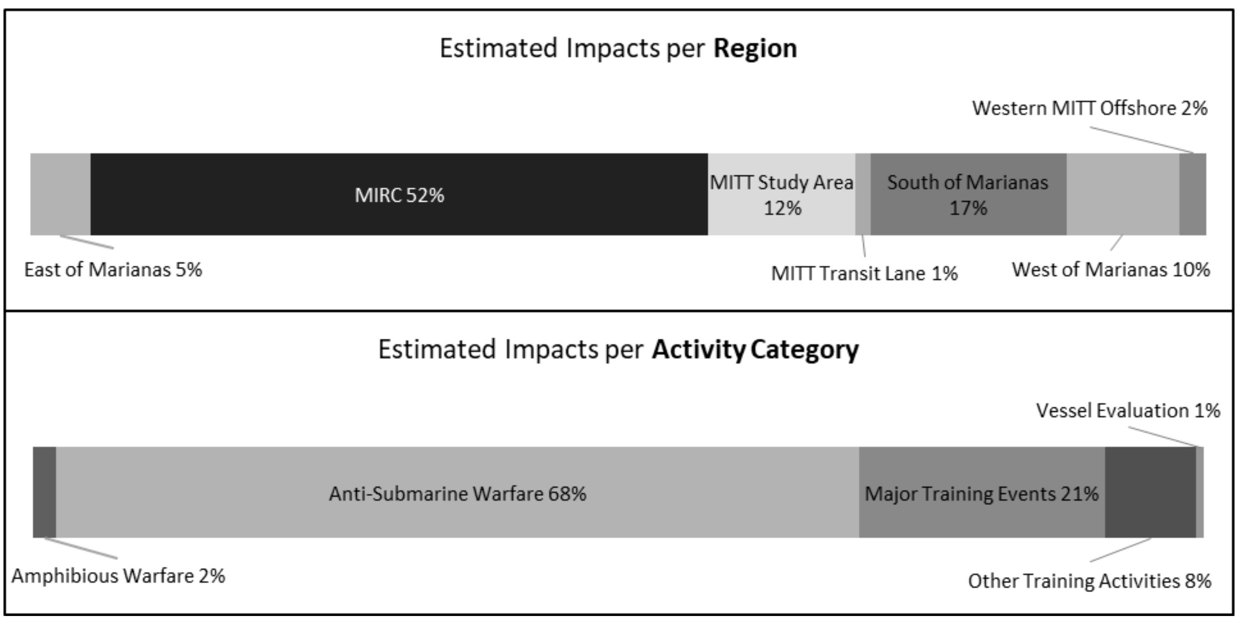
Based on the best available science, the Navy believes beaked whales that exhibit a significant behavioral reaction due to sonar and other transducers would generally not have long-term consequences for individuals or populations. However, because of a lack of scientific consensus regarding the causal 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 would result from the operation of sonar during Navy exercises within the Study Area. 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); see Section 3.4.2.1.1.6 (Stranding).

As described in Section 5.1.2.2.1 (Marine Species Research and Monitoring Programs), for this Final SEIS/OEIS, the Navy agreed to several additional research and monitoring initiatives designed to help advance the understanding of beaked whales and strandings in the MITT Study Area. The Navy will co-fund the Pacific Marine Assessment Program for Protected Species (PACMAPPS) Mariana Islands survey in spring-summer 2021 and future studies starting in 2022 to help document beaked whale occurrence, abundance, and distribution in the Mariana Islands. The Navy will also fund additional stranding response and necropsy analyses for the Pacific Islands region, and research on a framework to improve statistical stranding analysis. Collaboratively with NMFS, the Navy will fund and organize an expert panel to provide recommendations on scientific data gaps and uncertainties for further protective measure consideration to minimize potential impacts of Navy training and testing activities on beaked whales in the Mariana Islands. 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.

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Beaked whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-25 through Figure 3.4-28 and Table 3.4-29 through Table 3.4-32). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Blainville's, Cuvier's, ginkgo-toothed, and Longman's beaked whales incidental to those activities.



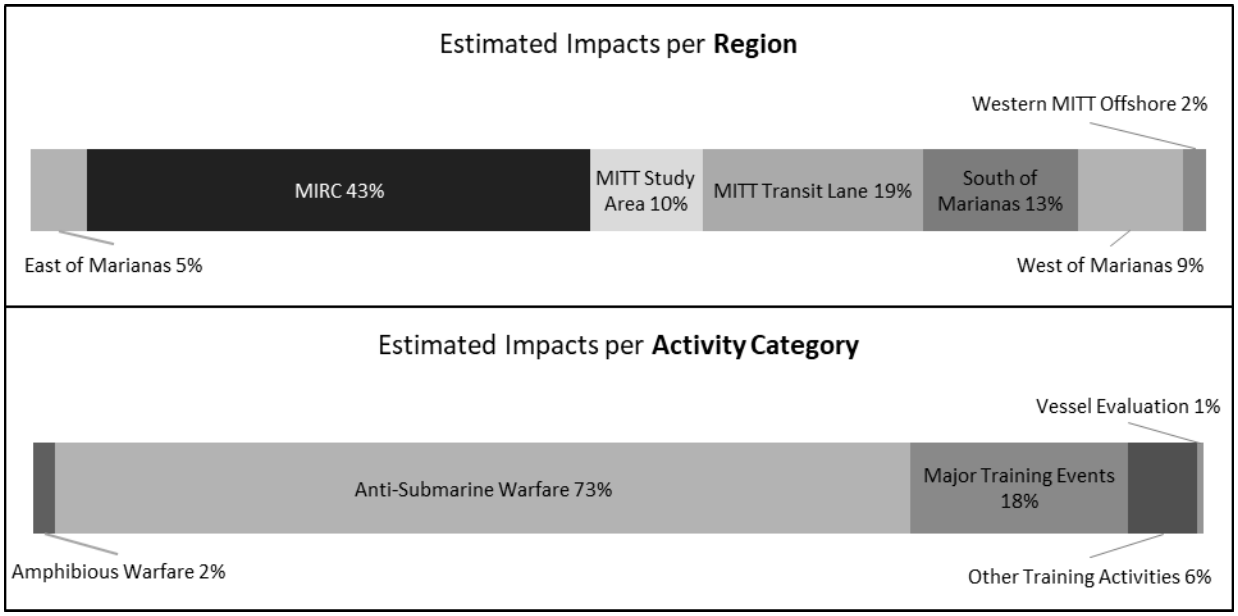
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-25: Blainville's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-29: Estimated Impacts on Individual Blainville's Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
1,557	26	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.



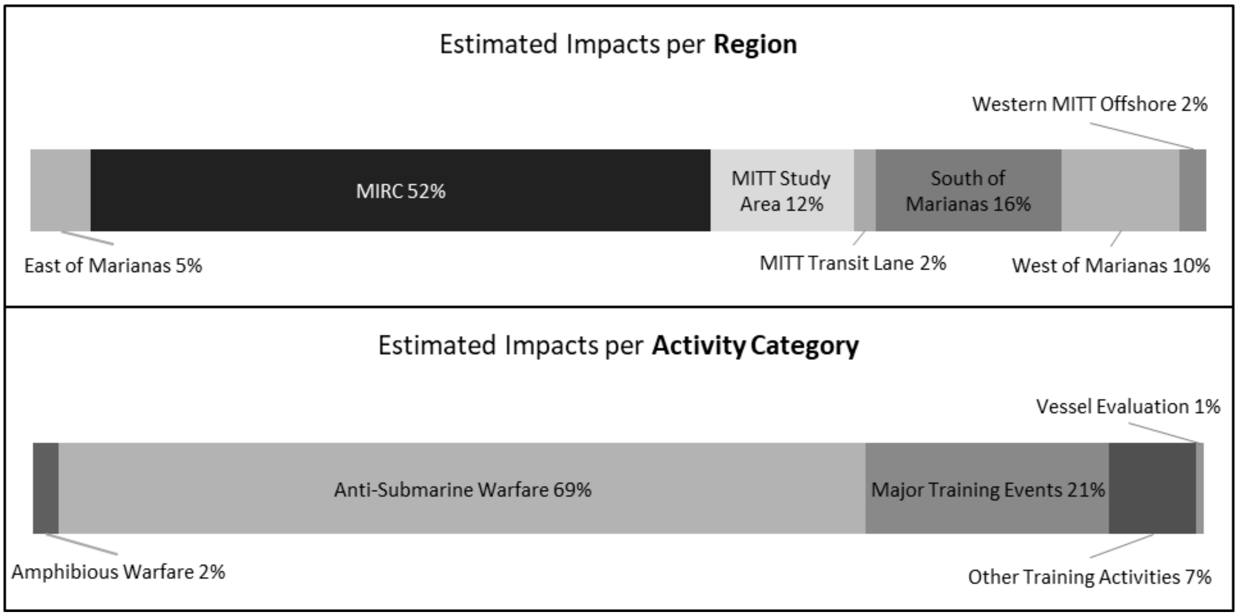
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-26: Cuvier's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-30: Estimated Impacts on Individual Cuvier's Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
600	4	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.



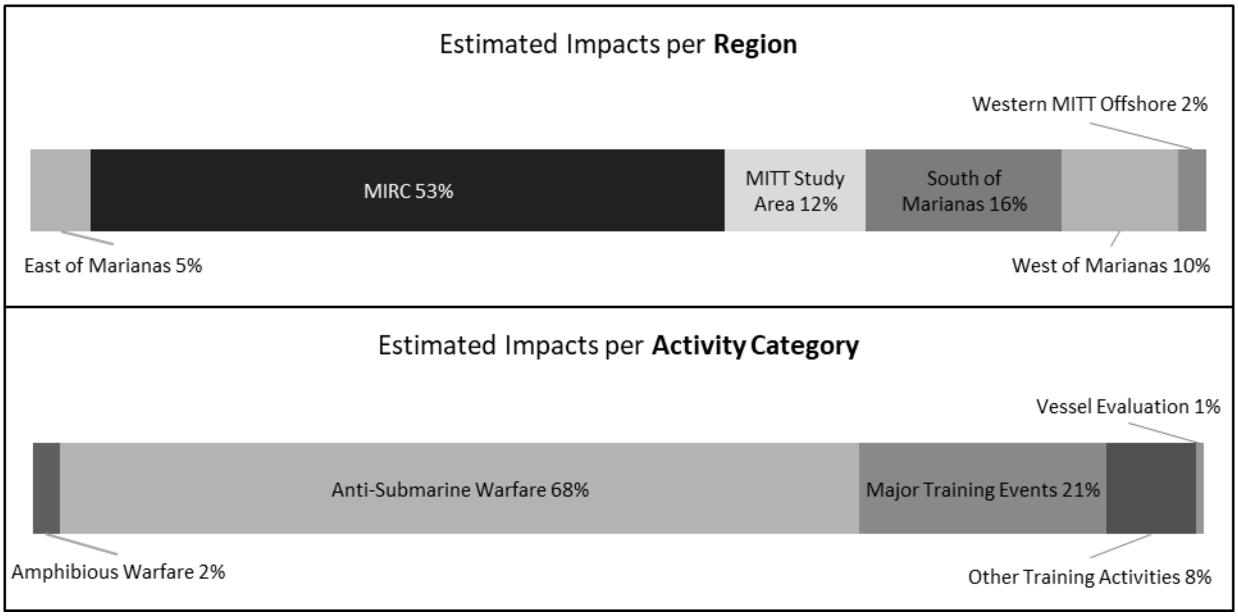
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-27: Ginkgo-Toothed Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-31: Estimated Impacts on Individual Ginkgo-Toothed Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
Behavioral	*TTS*	*PTS*
3,373	63	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-28: Longman's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-32: Estimated Impacts on Individual Longman's Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

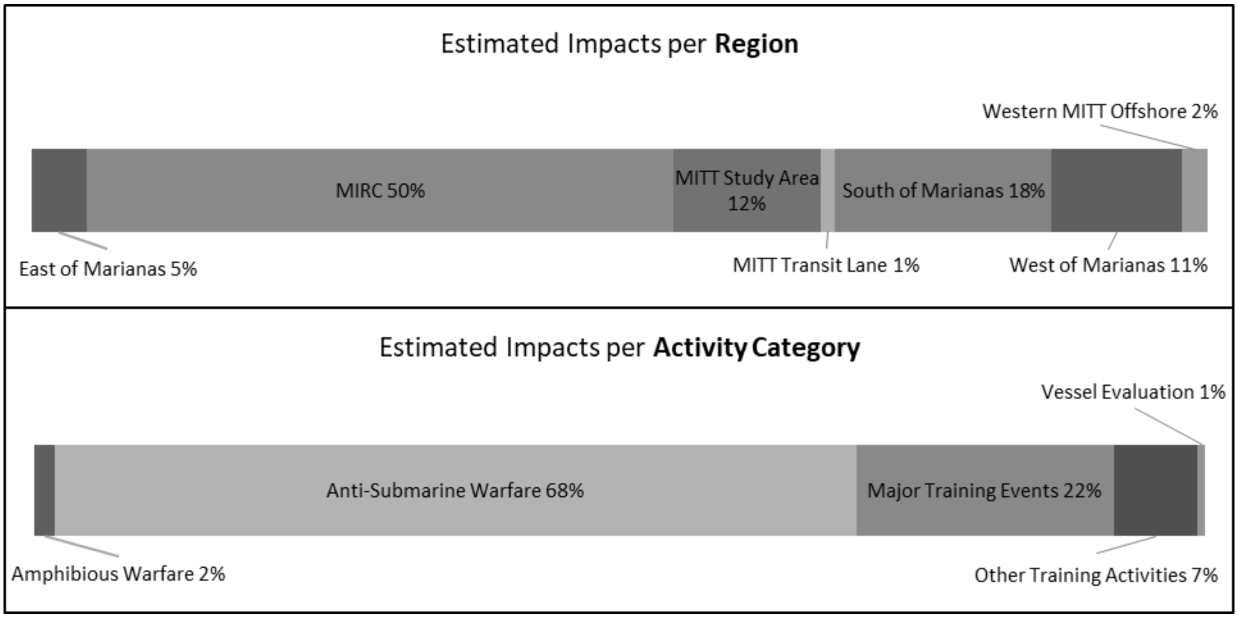
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
5,483	103	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Beaked whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-29 through Figure 3.4-32 and Table 3.4-33 through Table 3.4-36). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Blainville's, Cuvier's, ginkgo-toothed, and Longman's beaked whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



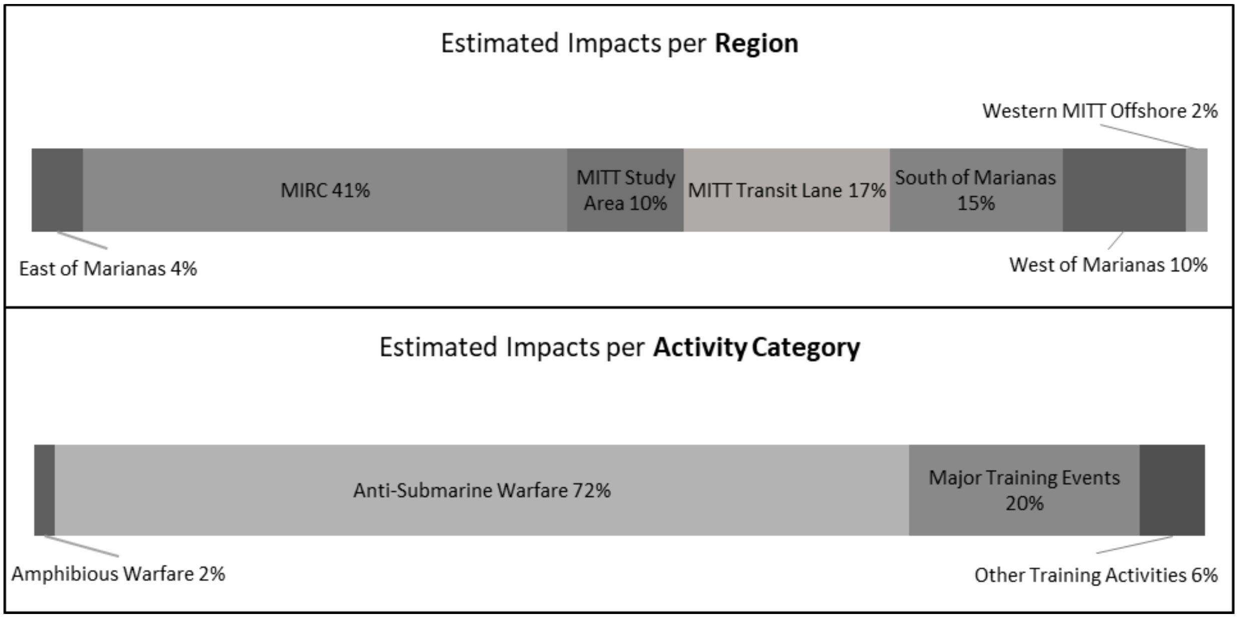
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-29: Blainville's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-33: Estimated Impacts on Individual Blainville's Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
1,691	27	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.



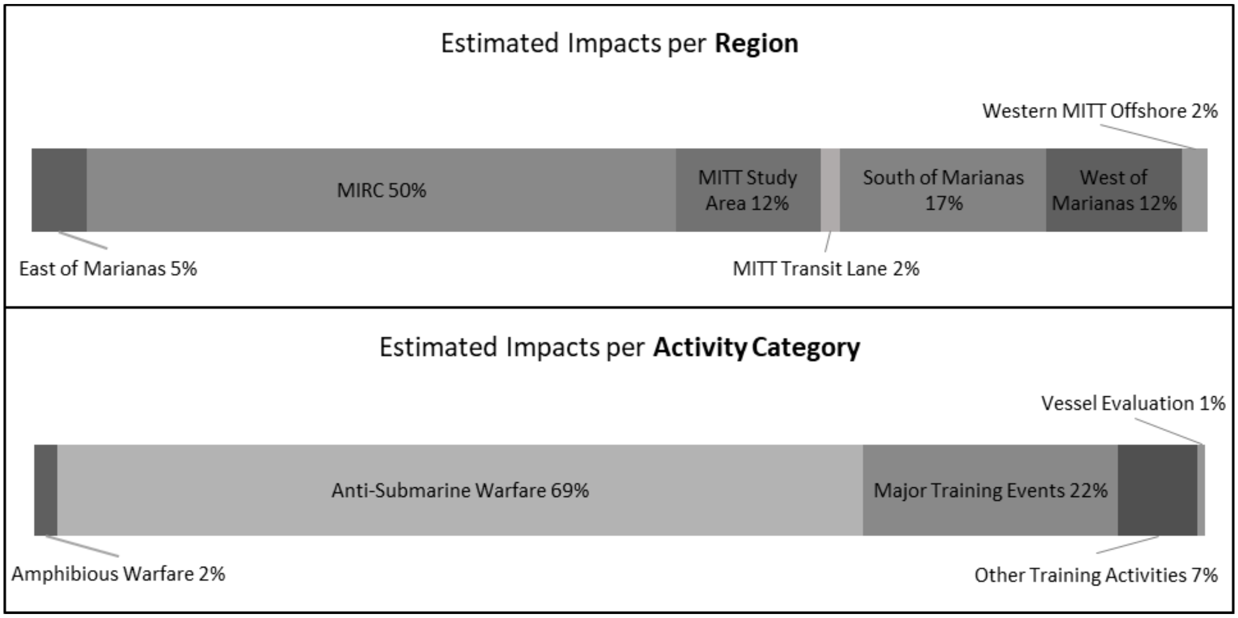
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-30: Cuvier's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-34: Estimated Impacts on Individual Cuvier's Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
642	4	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.



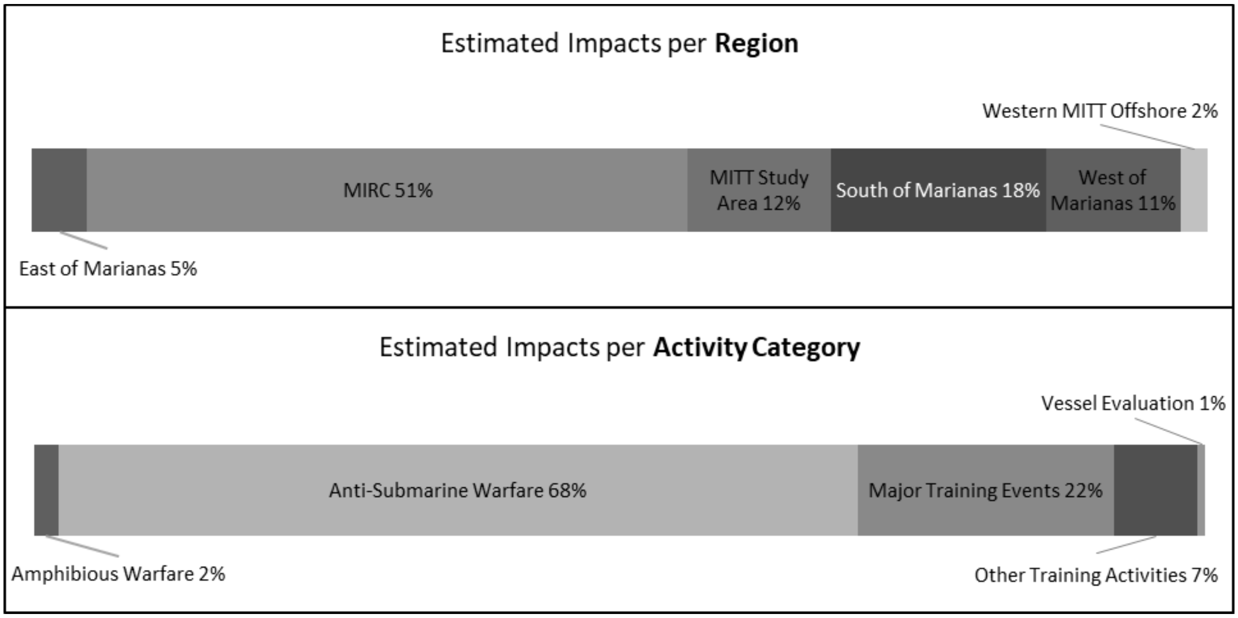
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-31: Ginkgo-Toothed Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-35: Estimated Impacts on Individual Ginkgo-Toothed Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
3,659	65	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-32: Longman's Beaked Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-36: Estimated Impacts on Individual Longman's Beaked Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
5,958	106	0

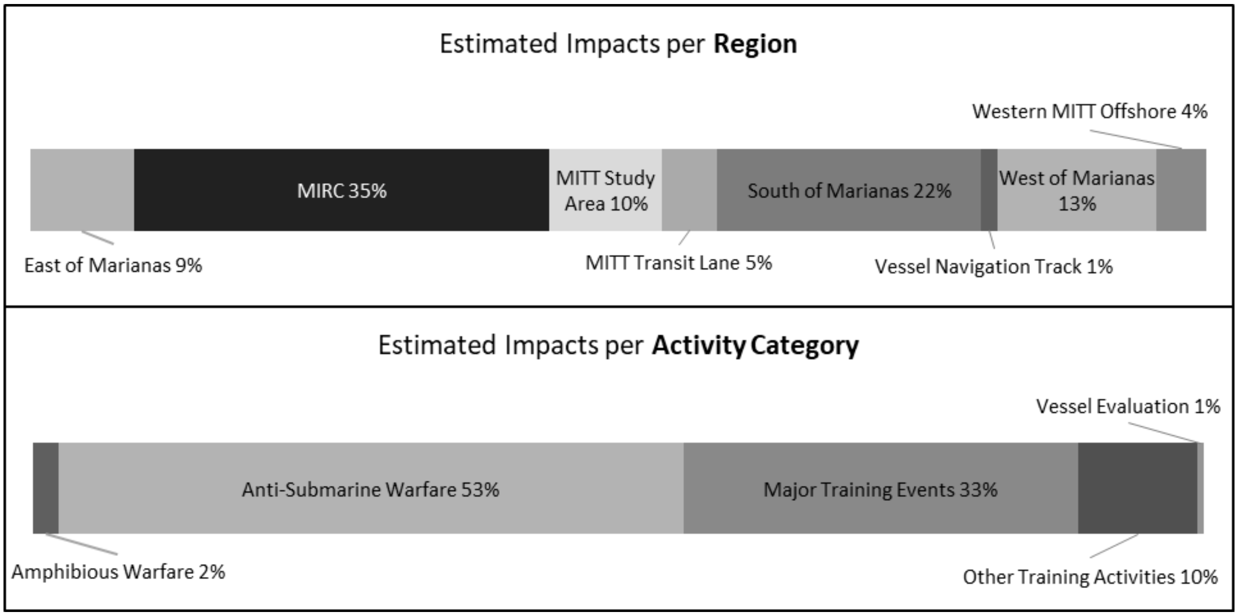
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Common Bottlenose Dolphin

<u>Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities</u>

Bottlenose dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-33 and Table 3.4-37). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of bottlenose dolphins incidental to those activities.



Note: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-33: Bottlenose Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-37: Estimated Impacts on Individual Bottlenose Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

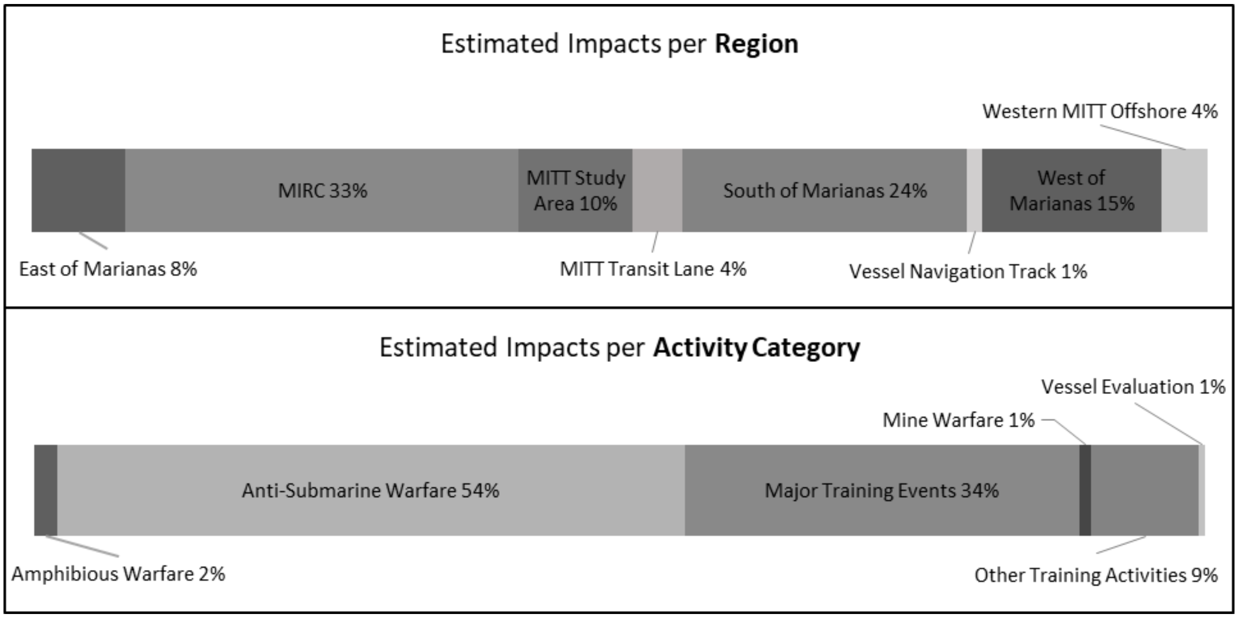
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
104	21	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Bottlenose dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-34 and Table 3.4-38). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of bottlenose dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-34: Bottlenose Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-38: Estimated Impacts on Individual Bottlenose Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
116	21	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

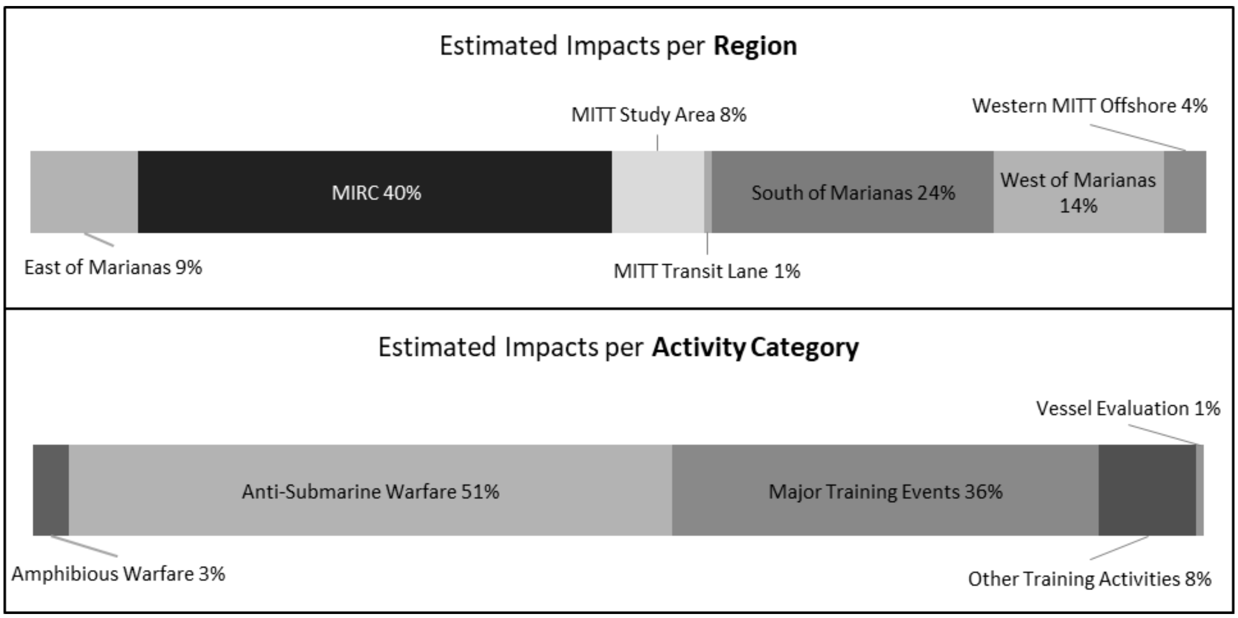
Kogia Whales

Kogia whales include two species that are often difficult to distinguish from one another: dwarf sperm whales and pygmy sperm whales; however, impacts to the populations of dwarf and pygmy sperm whales are modeled separately. TTS and PTS thresholds for high-frequency cetaceans, such as Kogia whales are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans).

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Kogia whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS under Alternative 1 during training and testing activities (Figure 3.4-35, Figure 3.4-36, Table 3.4-39, and Table 3.4-40). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any 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, a small threshold shift due to exposure to sonar is unlikely to affect the hearing range that Kogia whales rely upon. Nevertheless, PTS could have minor long-term consequences for individuals. This minor consequence for an individual is unlikely to have any long-term consequences for the species. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Kogia whales (i.e., dwarf and pygmy sperm whales) incidental to those activities.



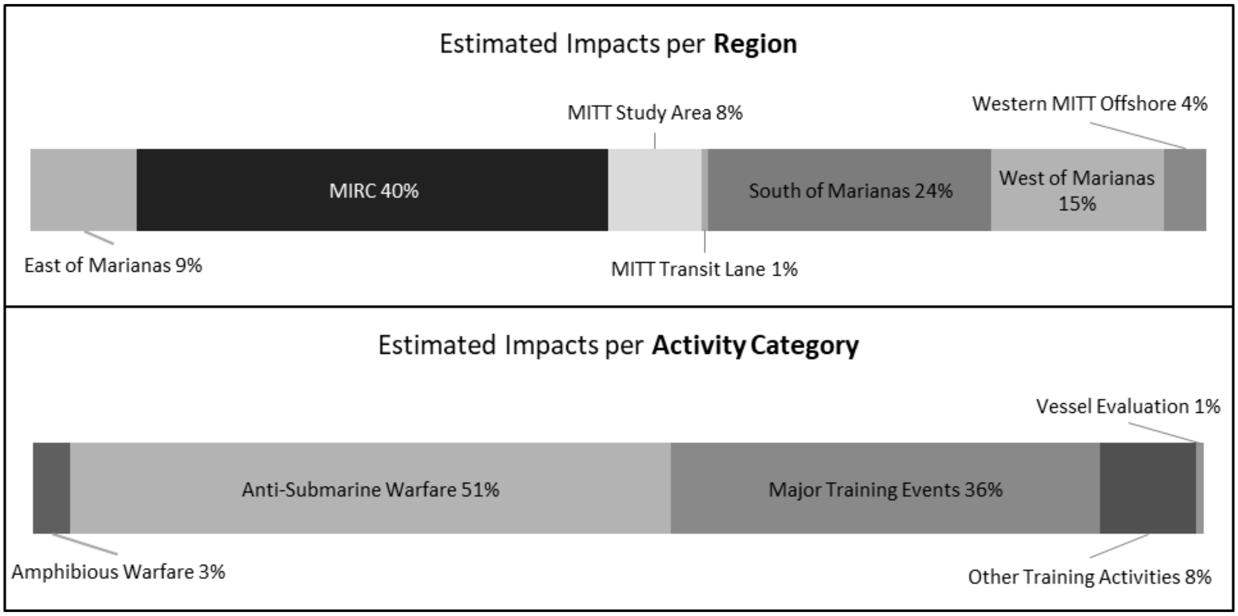
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-35: Dwarf Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-39: Estimated Impacts on Individual Dwarf Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
1,186	6,434	28

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-36: Pygmy Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-40: Estimated Impacts on Individual Pygmy Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

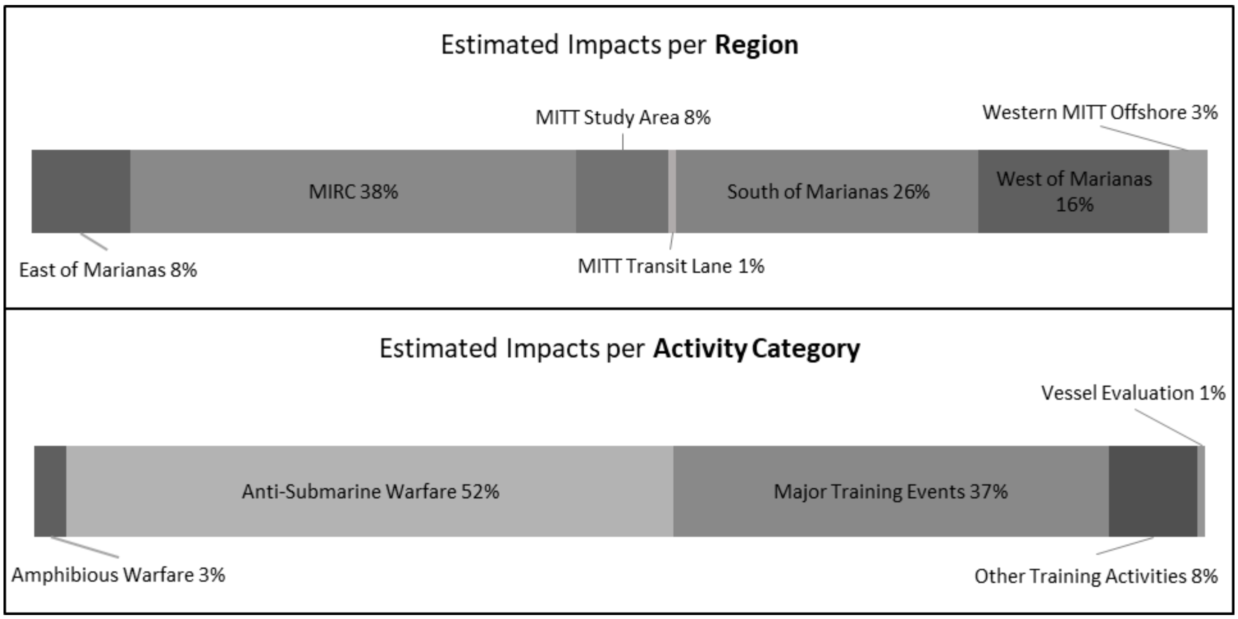
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
465	2,595	11

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Kogia whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions, TTS, and PTS under Alternative 2 during training and testing activities (Figure 3.4-37, Figure 3.4-38, Table 3.4-41, and Table 3.4-42). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Kogia whales (i.e., dwarf and pygmy sperm whales) incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



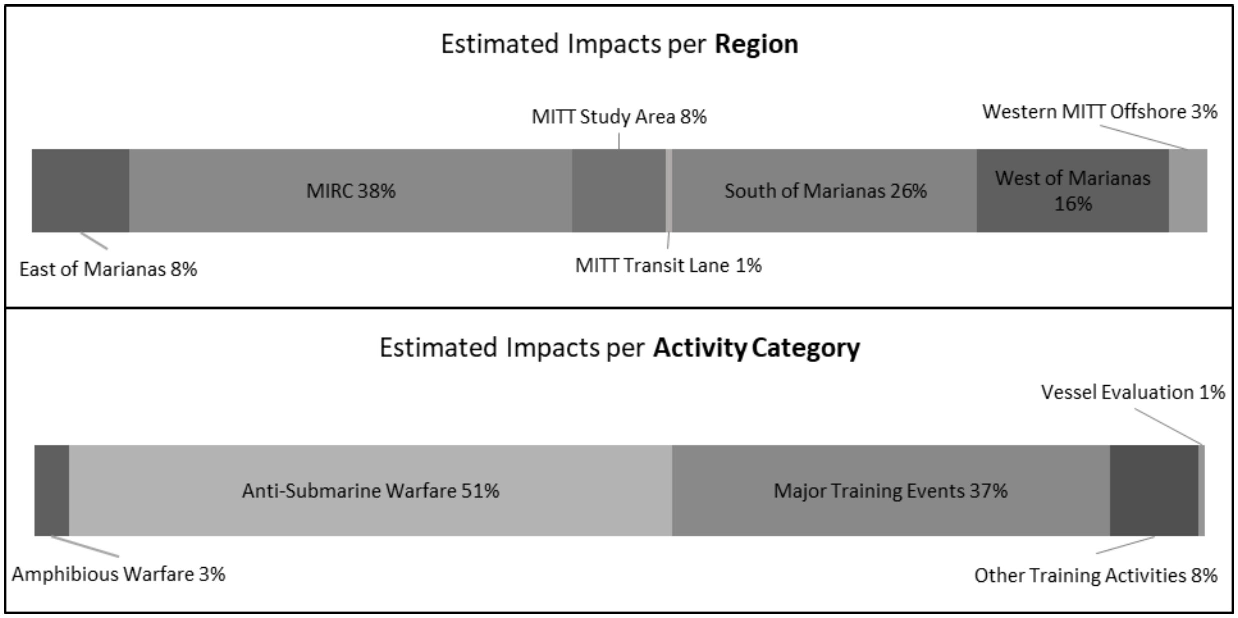
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-37: Dwarf Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-41: Estimated Impacts on Individual Dwarf Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
1,289	7,046	29

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-38: Pygmy Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-42: Estimated Impacts on Individual Pygmy Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
508	2,840	11

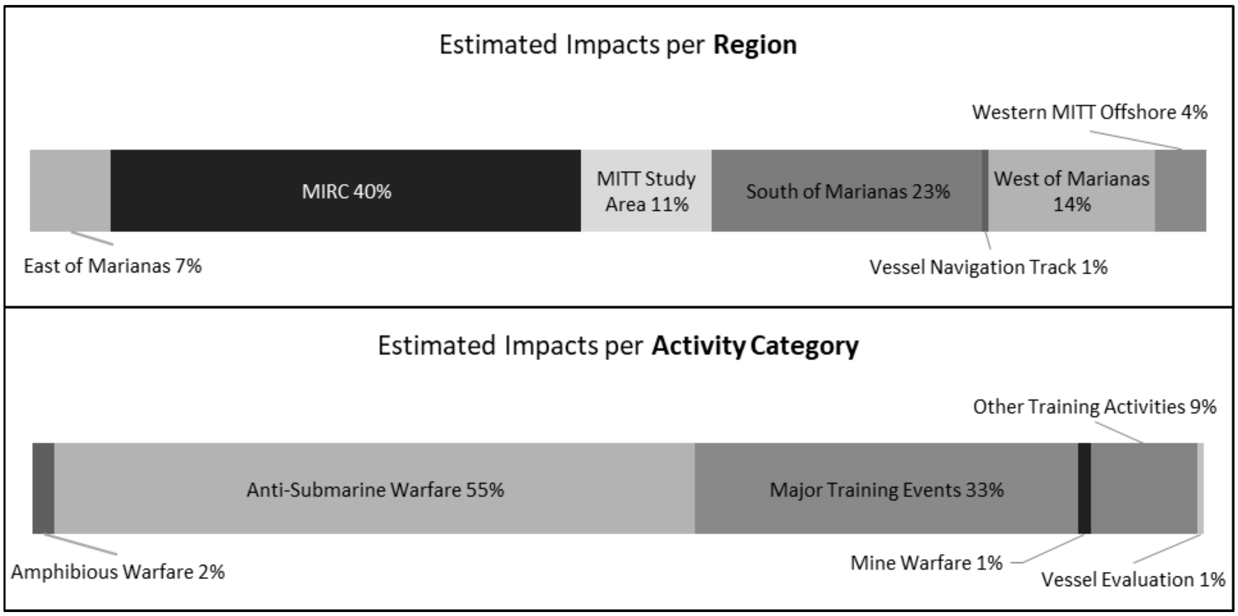
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

False Killer Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

False killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-39 and Table 3.4-43). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of false killer whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-39: False Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-43: Estimated Impacts on Individual False Killer Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

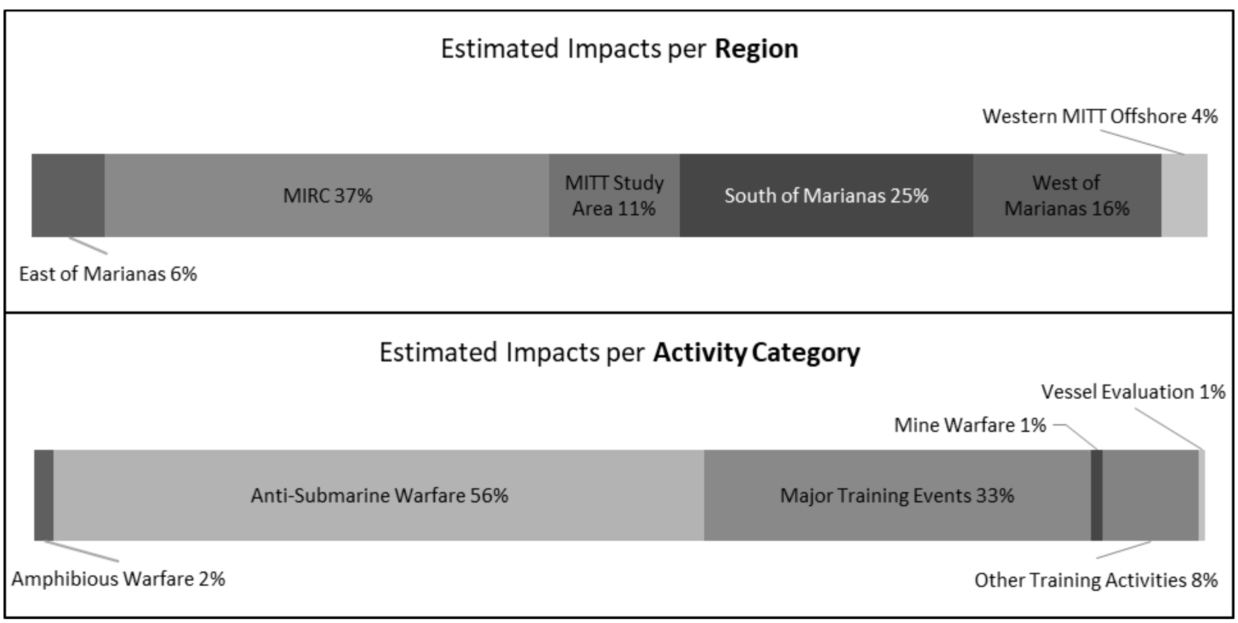
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
573	117	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

False killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-40 and Table 3.4-44). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of false killer whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-40: False Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-44: Estimated Impacts on Individual False Killer Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
641	121	0

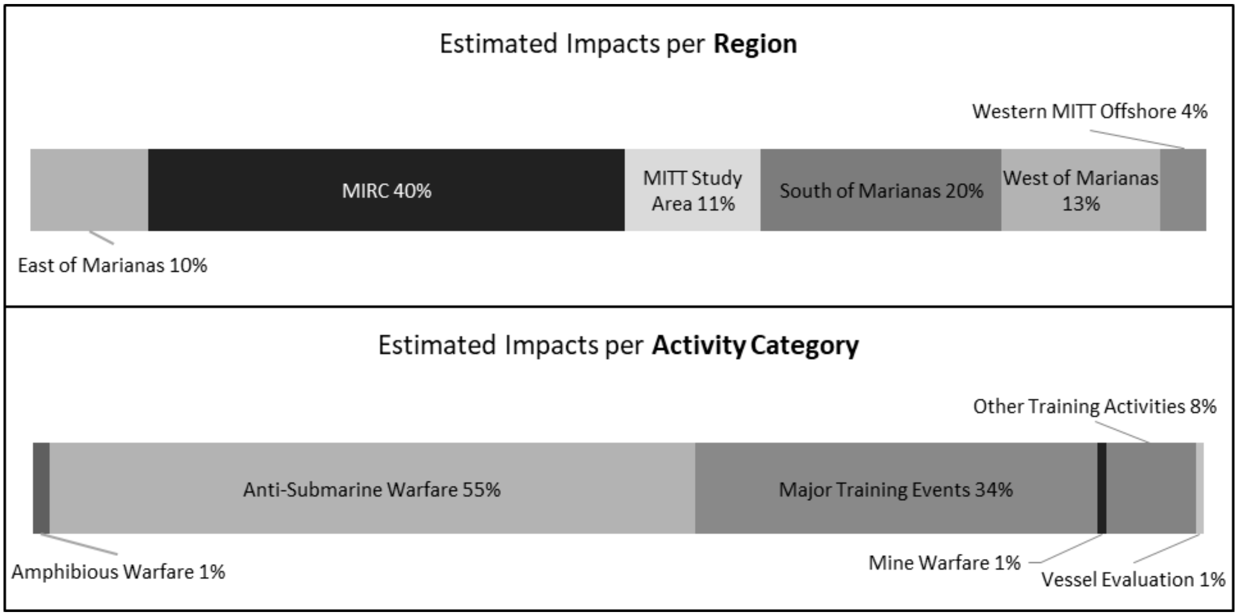
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Fraser's Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Fraser's dolphin may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-41 and Table 3.4-45). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Fraser's dolphin incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-41: Fraser's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-45: Estimated Impacts on Individual Fraser's Dolphin Impacts Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

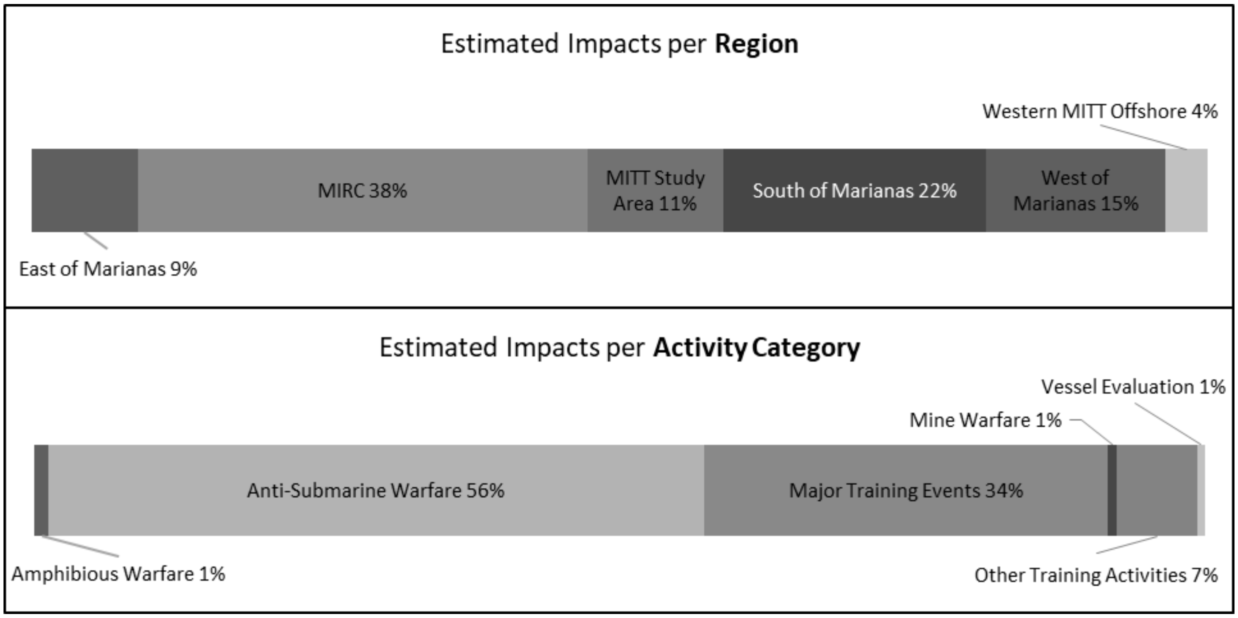
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
10,150	1,896	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Fraser's dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-42 and Table 3.4-46). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Fraser's dolphin incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-42: Fraser's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-46: Estimated Impacts on Individual Fraser's Dolphin Impacts Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
11,322	1,947	0

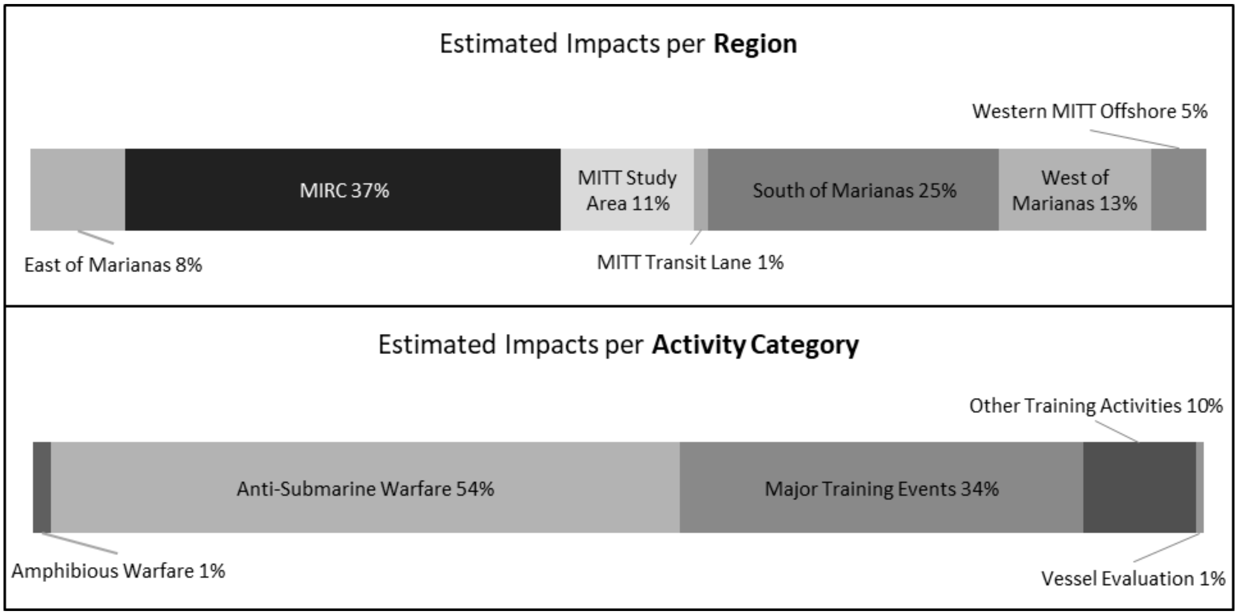
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Killer Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-43 and Table 3.4-47). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of killer whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-43: Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-47: Estimated Impacts on Individual Killer Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
32	7	0

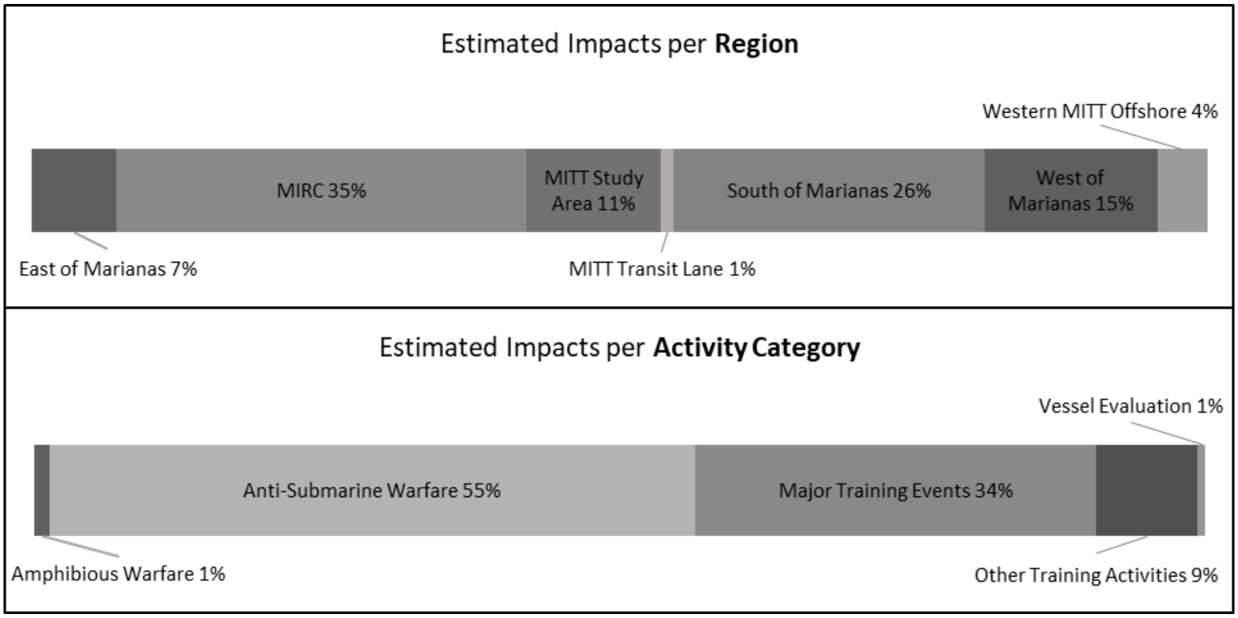
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-44 and Table 3.4-48). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers).

Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of killer whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-44: Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-48: Estimated Impacts on Individual Killer Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
36	8	0

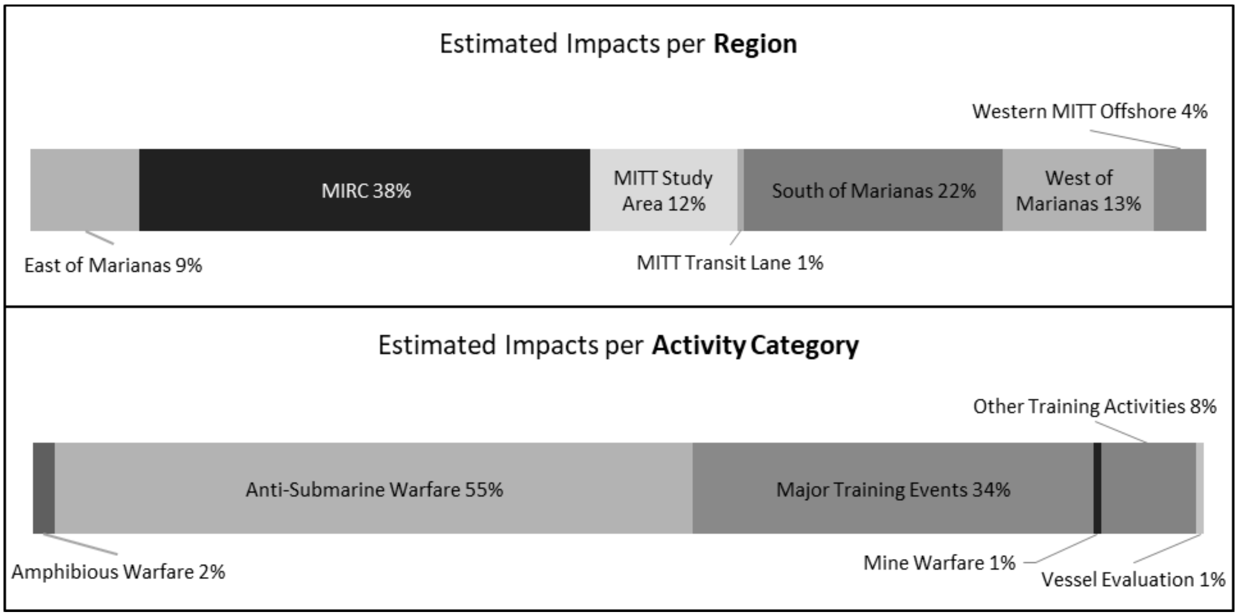
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Melon-Headed Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Melon-headed whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-45 and Table 3.4-49). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of melon-headed whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-45: Melon-Headed Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-49: Estimated Impacts on Individual Melon-Headed Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

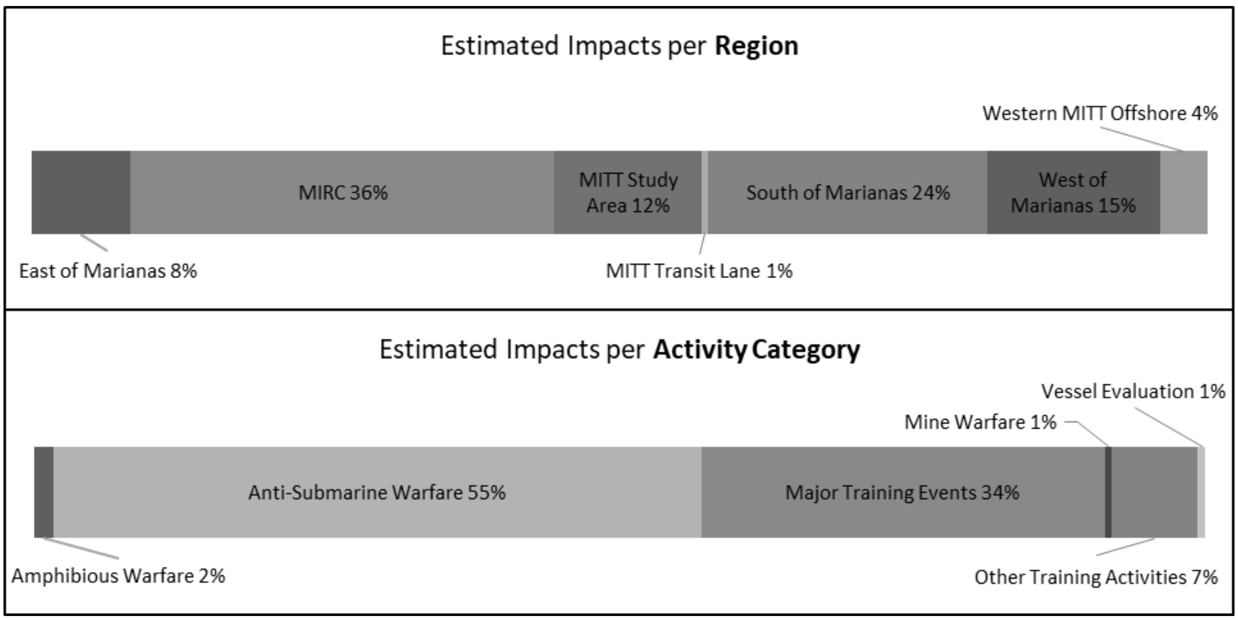
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
2,064	488	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Melon-headed whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-46 and Table 3.4-50). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of melon-headed whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-46: Melon-Headed Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-50: Estimated Impacts on Individual Melon-Headed Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
2,305	508	0

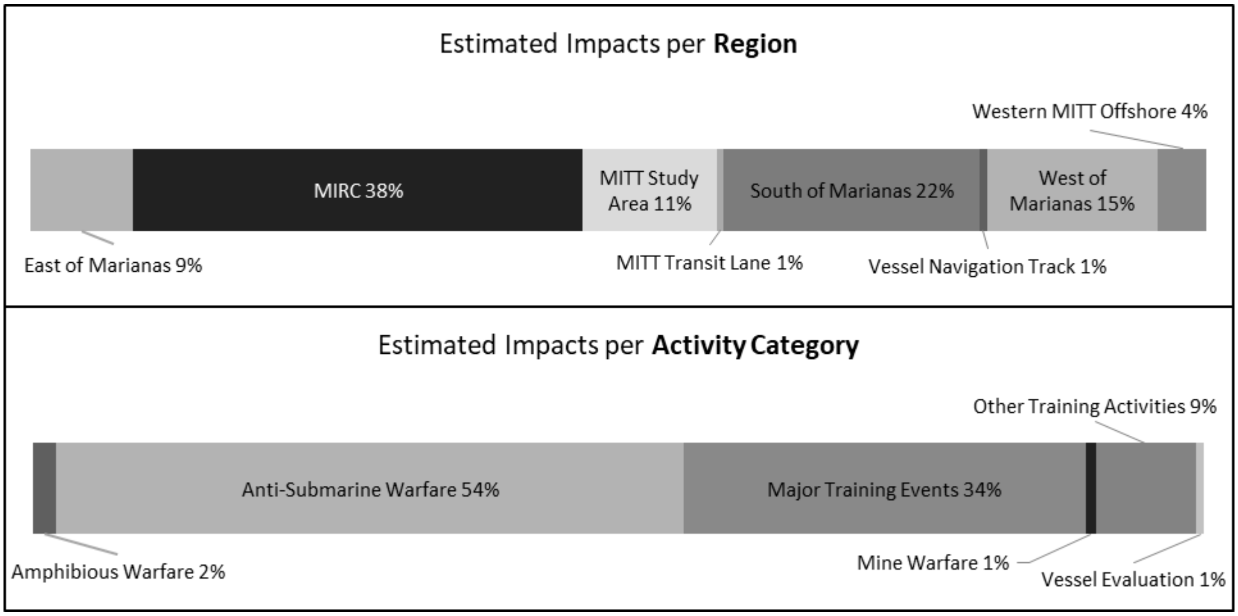
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Pantropical Spotted Dolphin

<u>Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities</u>

Pantropical spotted dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-47 and Table 3.4-51). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of pantropical spotted dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-47: Pantropical Spotted Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-51: Estimated Impacts on Individual Pantropical Spotted Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

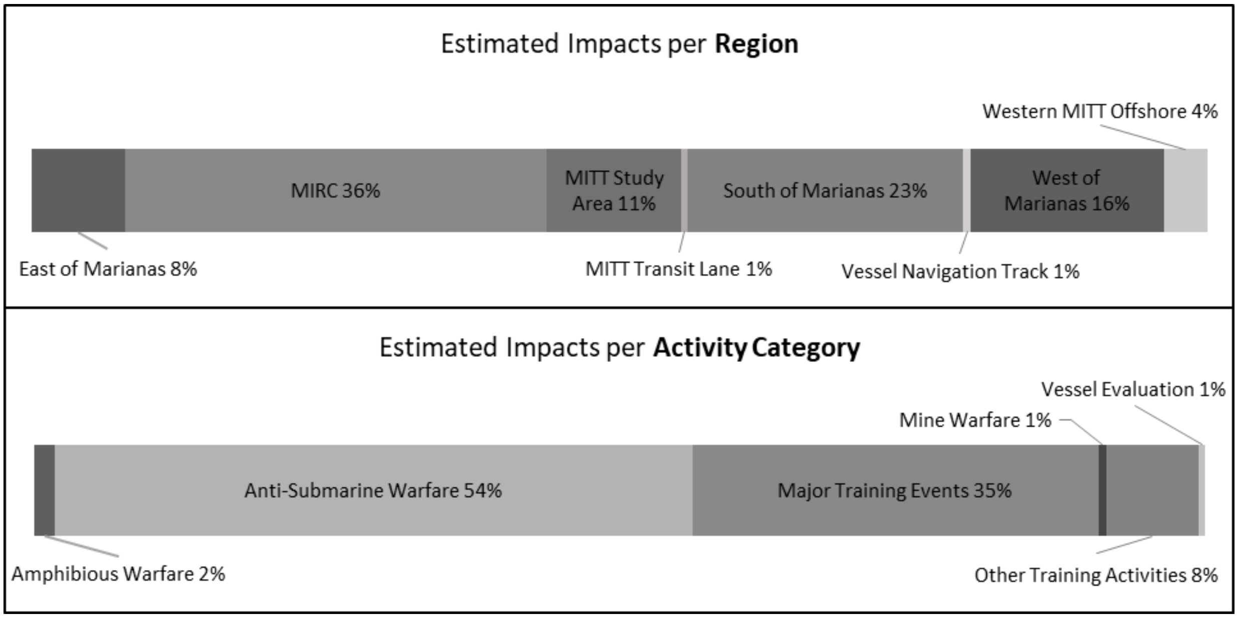
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
10,764	2,717	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Pantropical spotted dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-48 and Table 3.4-52). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of pantropical spotted dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-48: Pantropical Spotted Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-52: Estimated Impacts on Individual Pantropical Spotted Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
12,074	2,815	0

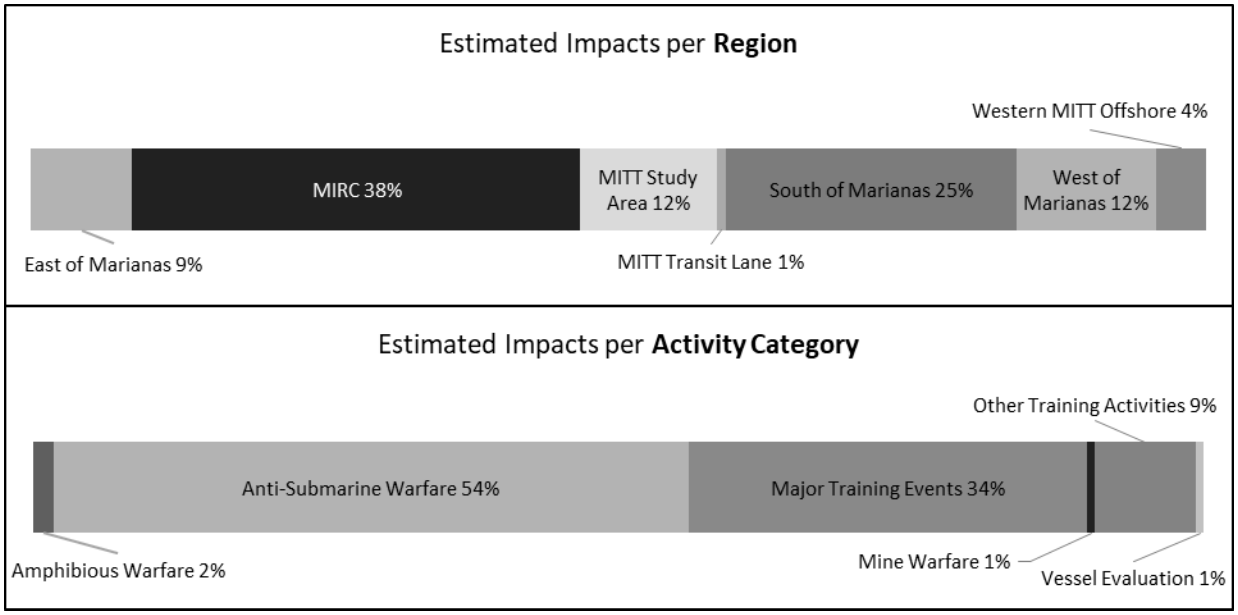
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Pygmy Killer Whale

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Pygmy killer whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-49 and Table 3.4-53). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of pygmy killer whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-49: Pygmy Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-53: Estimated Impacts on Individual Pygmy Killer Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

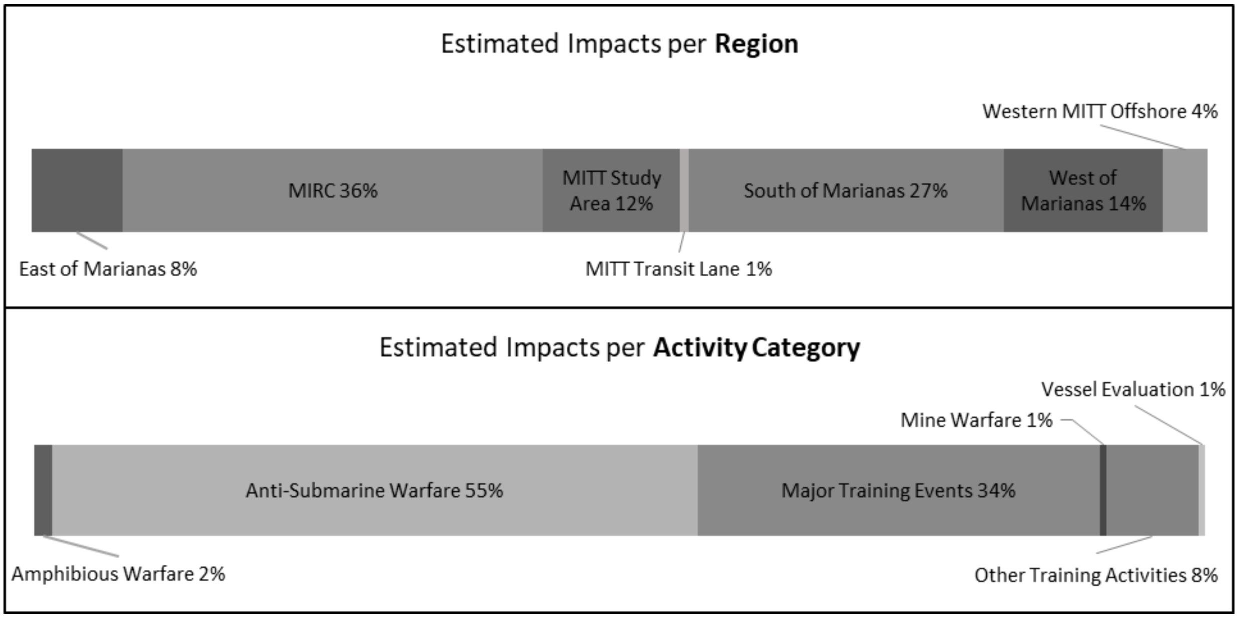
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
78	16	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Pygmy killer whale may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-50 and Table 3.4-54). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of pygmy killer whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-50: Pygmy Killer Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-54: Estimated Impacts on Individual Pygmy Killer Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
87	17	0

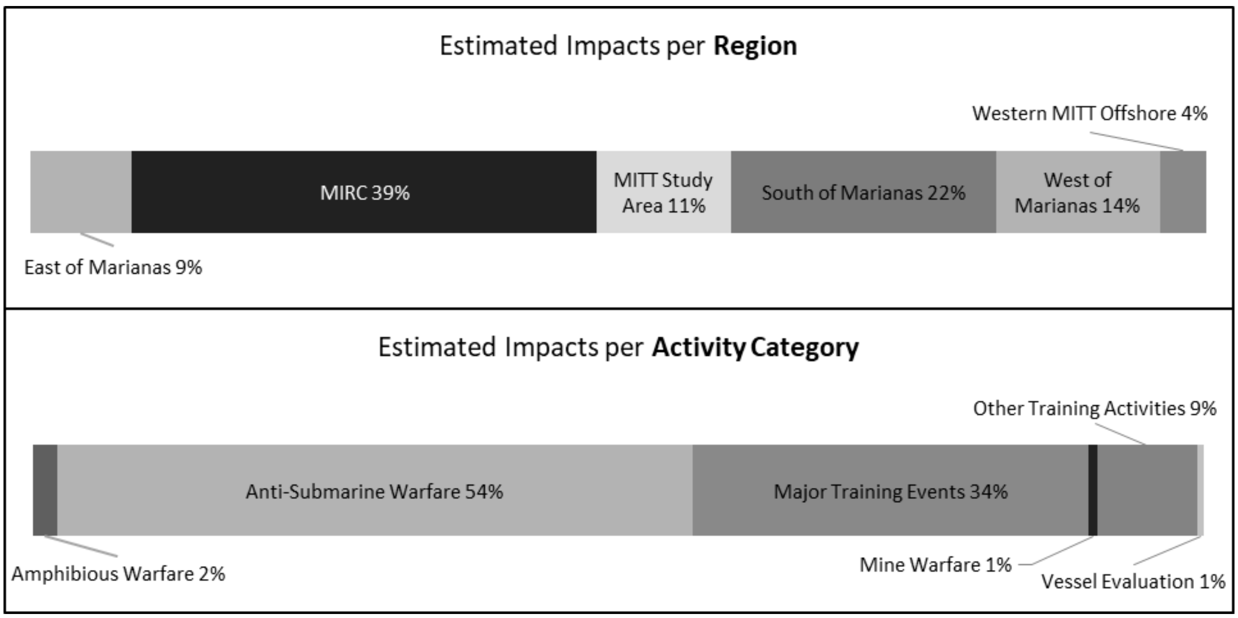
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Risso's Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Risso's dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-51 and Table 3.4-55). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of Risso's dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-51: Risso's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-55: Estimated Impacts on Individual Risso's Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

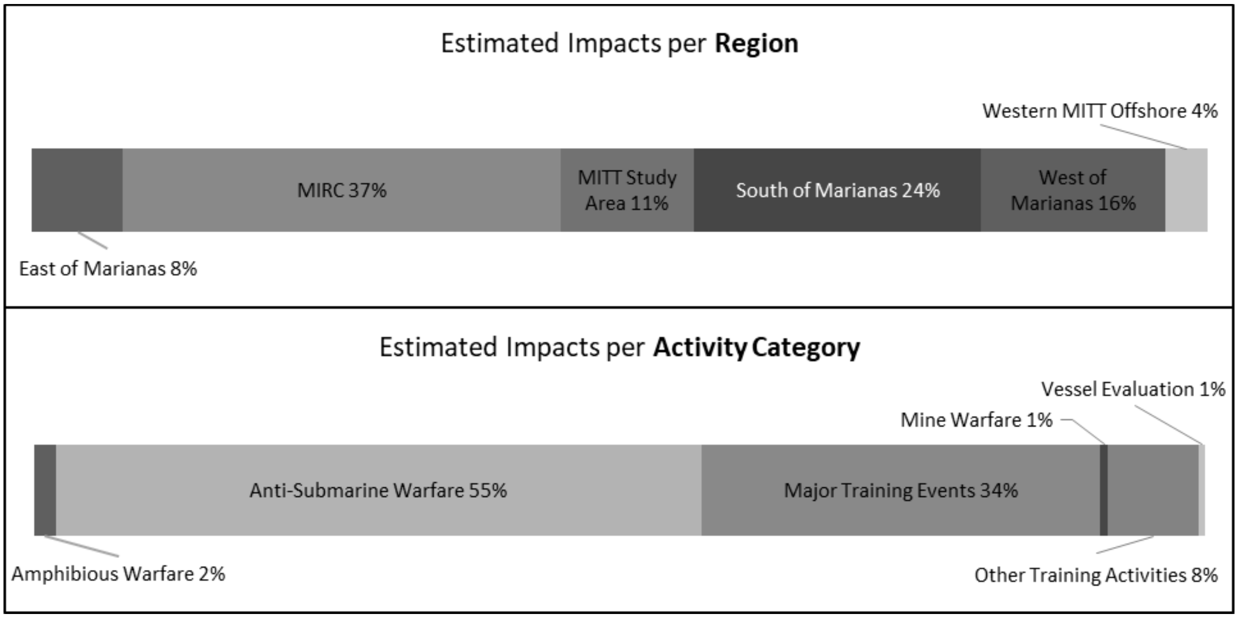
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
2,365	505	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Risso's dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-52 and Table 3.4-56). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2 versus Alternative 1.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of Risso's dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-52: Risso's Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-56: Estimated Impacts on Individual Risso's Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
2,649	519	0

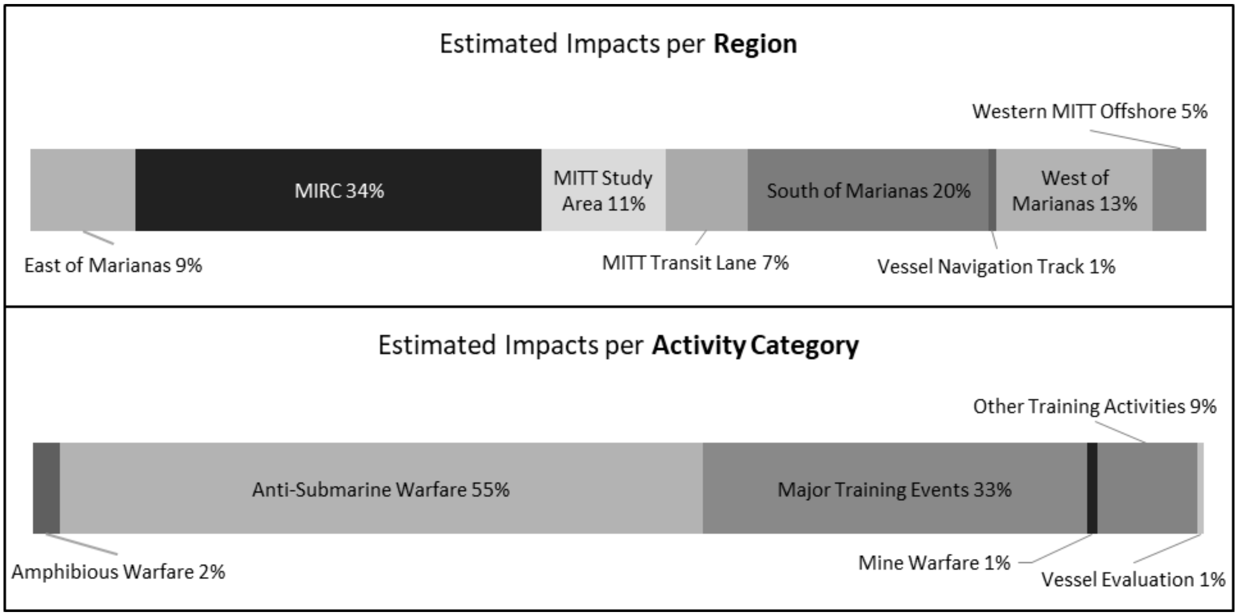
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Rough-Toothed Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Rough-toothed dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-53 and Table 3.4-57). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of rough-toothed dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-53: Rough-Toothed Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-57: Estimated Impacts on Individual Rough-Toothed Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

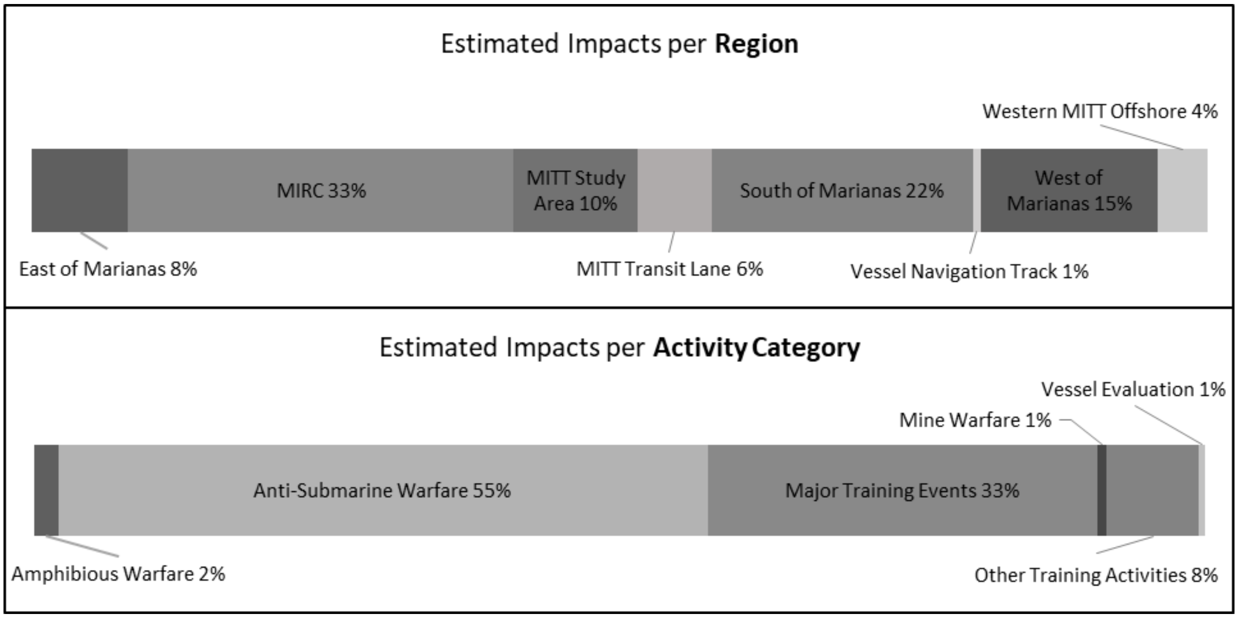
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
146	35	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Rough-toothed dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-54 and Table 3.4-58). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of rough-toothed dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-54: Rough-Toothed Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-58: Estimated Impacts on Individual Rough-Toothed Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
161	36	0

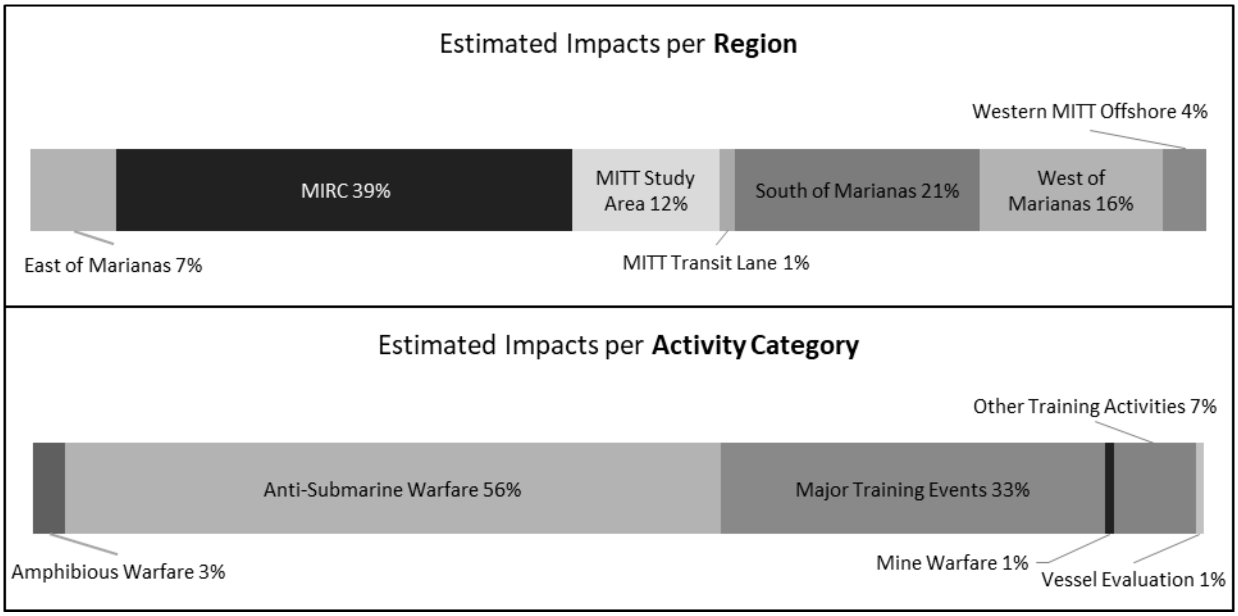
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Short-Finned Pilot Whale

<u>Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities</u>

Short-finned pilot whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-55 and Table 3.4-59). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of short-finned pilot whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-55: Short-Finned Pilot Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-59: Estimated Impacts on Individual Short-Finned Pilot Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

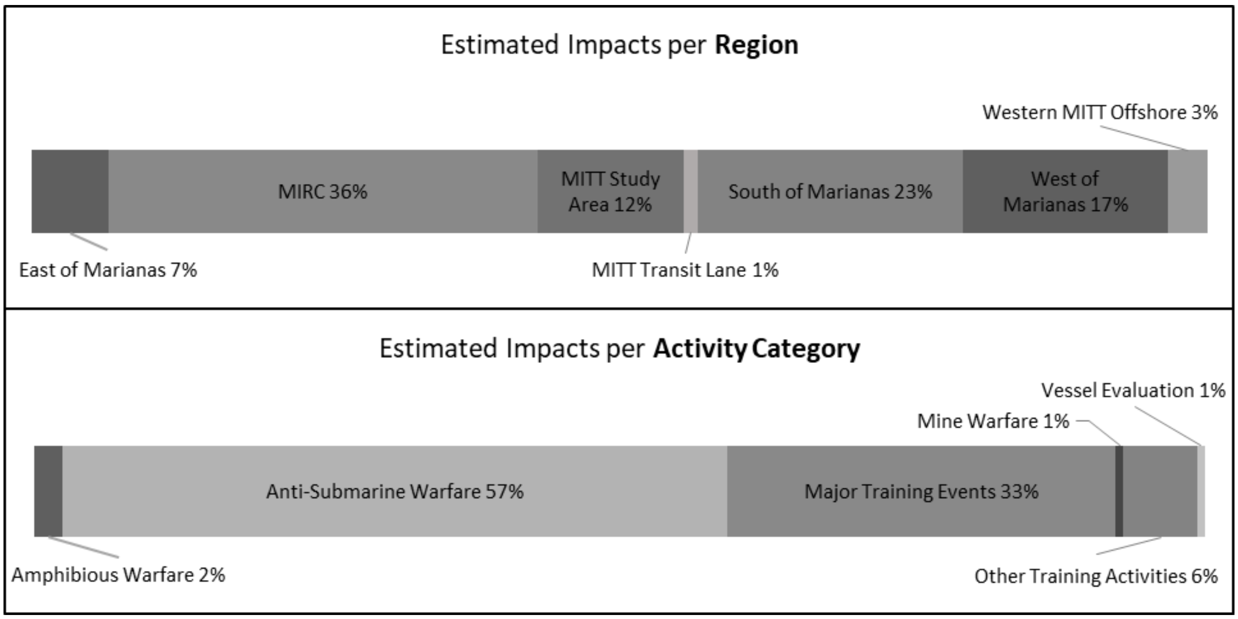
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
876	172	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Short-finned pilot whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-56 and Table 3.4-60). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of short-finned pilot whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-56: Short-Finned Pilot Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-60: Estimated Impacts on Individual Short-Finned Pilot Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
986	176	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

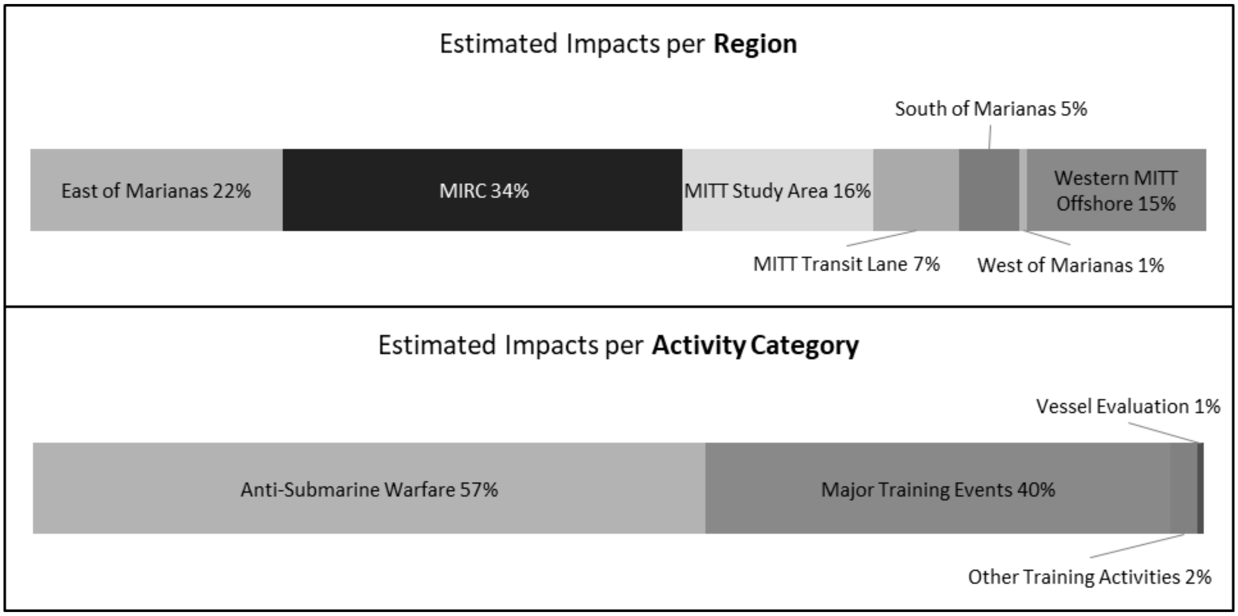
Sperm Whale (Endangered Species Act-Listed)

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Sperm whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-57 and Table 3.4-61). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of sperm whales incidental to those activities.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed sperm whales.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-57: Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-61: Estimated Impacts on Individual Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
184	11	0

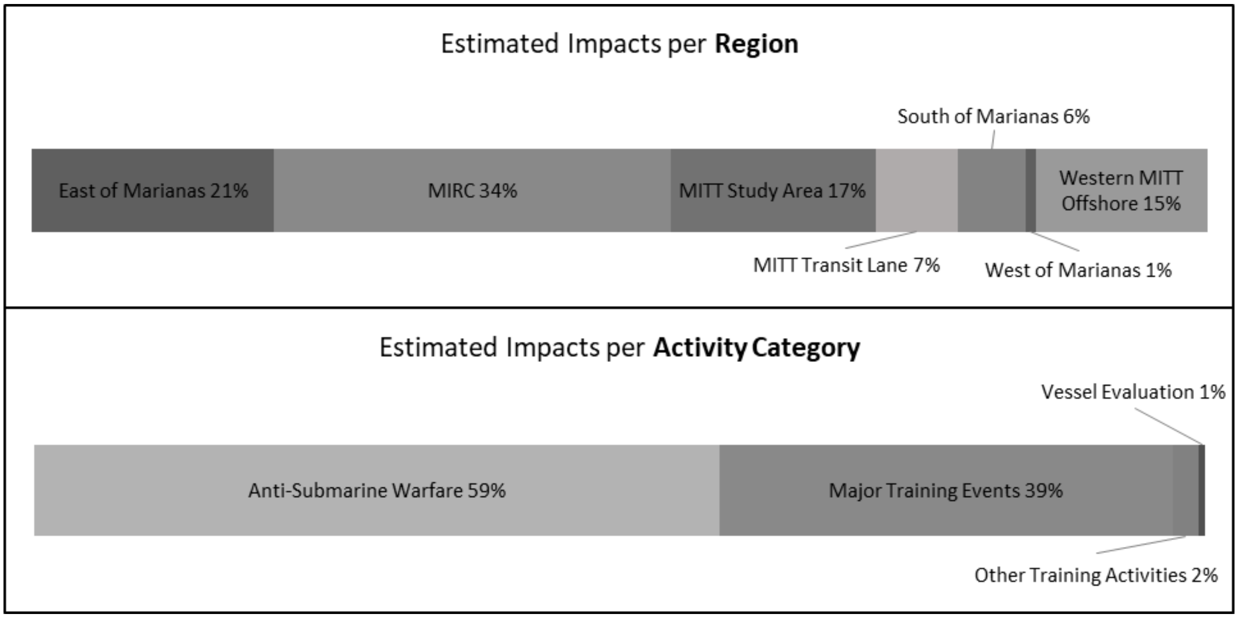
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Sperm whales may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-58 and Table 3.4-62). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of sperm whales incidental to those activities. The Navy is requesting 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 and testing activities as described under Alternative 2 may affect ESA-listed sperm whales. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-58: Sperm Whale Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-62: Estimated Impacts on Individual Sperm Whales Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
192	11	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

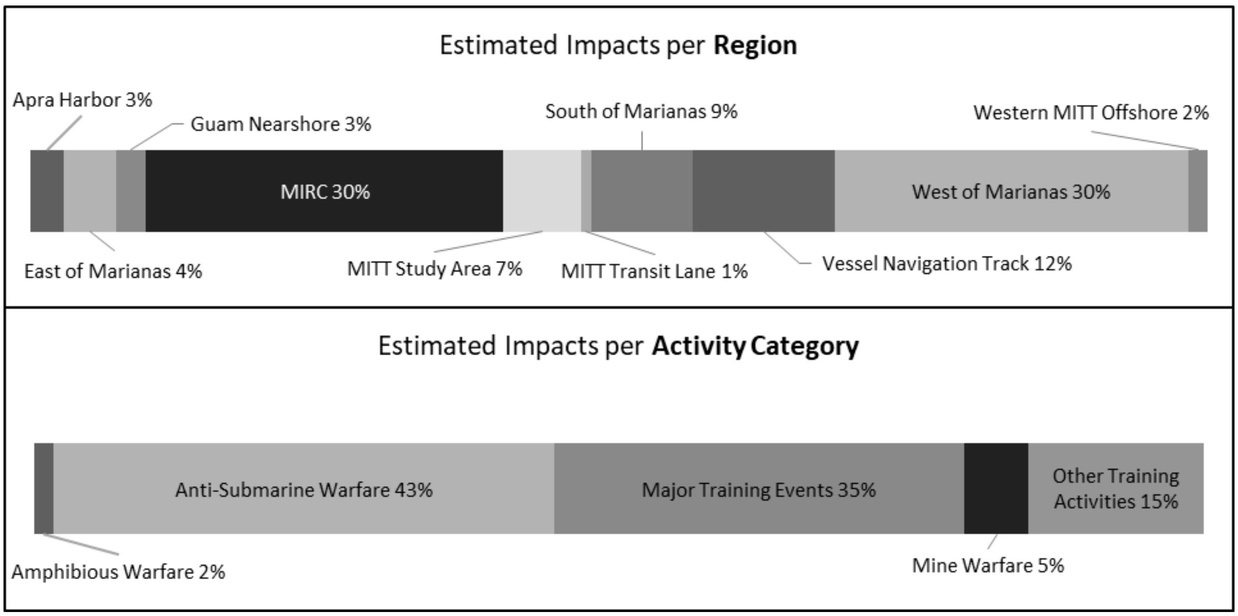
Spinner Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Spinner dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and

TTS under Alternative 1 during training and testing activities (Figure 3.4-59 and Table 3.4-63). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. In addition to procedural mitigation, the Navy will not use MF1 sonar during training and testing in the Agat Bay Nearshore Mitigation Area, where spinner dolphins have been observed resting, as described in Chapter 5 (Mitigation). Considering these factors, long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of spinner dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-59: Spinner Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-63: Estimated Impacts on Individual Spinner Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

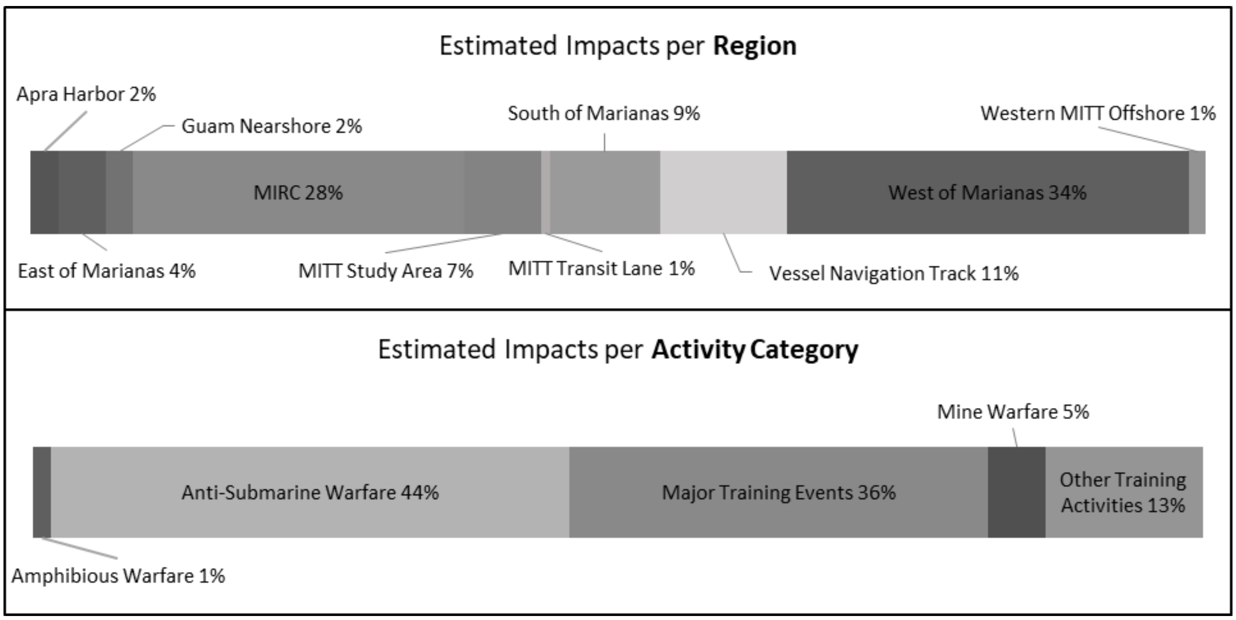
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
1,042	223	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Spinner dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-60 and Table 3.4-64). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of spinner dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-60: Spinner Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-64: Estimated Impacts on Individual Spinner Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
1,185	228	0

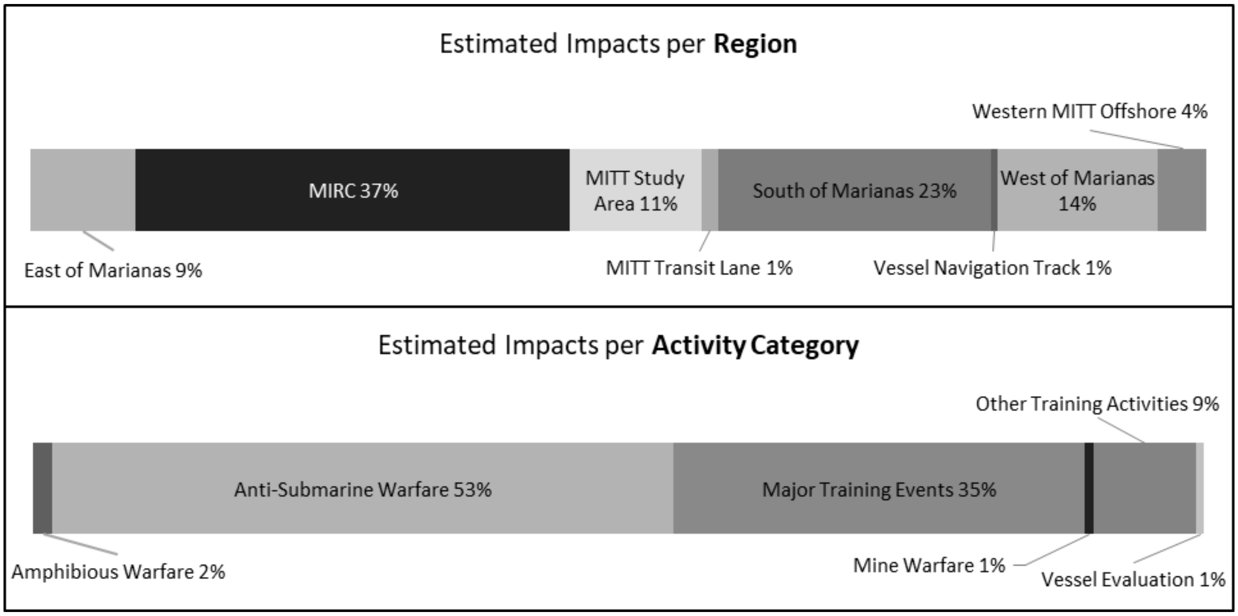
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Striped Dolphin

Impacts from Sonar and Other Transducers Under Alternative 1 for Training and Testing Activities

Striped dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 1 during training and testing activities (Figure 3.4-61 and Table 3.4-65). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 would result in the unintentional taking of striped dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-61: Striped Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

Table 3.4-65: Estimated Impacts on Individual Striped Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 1

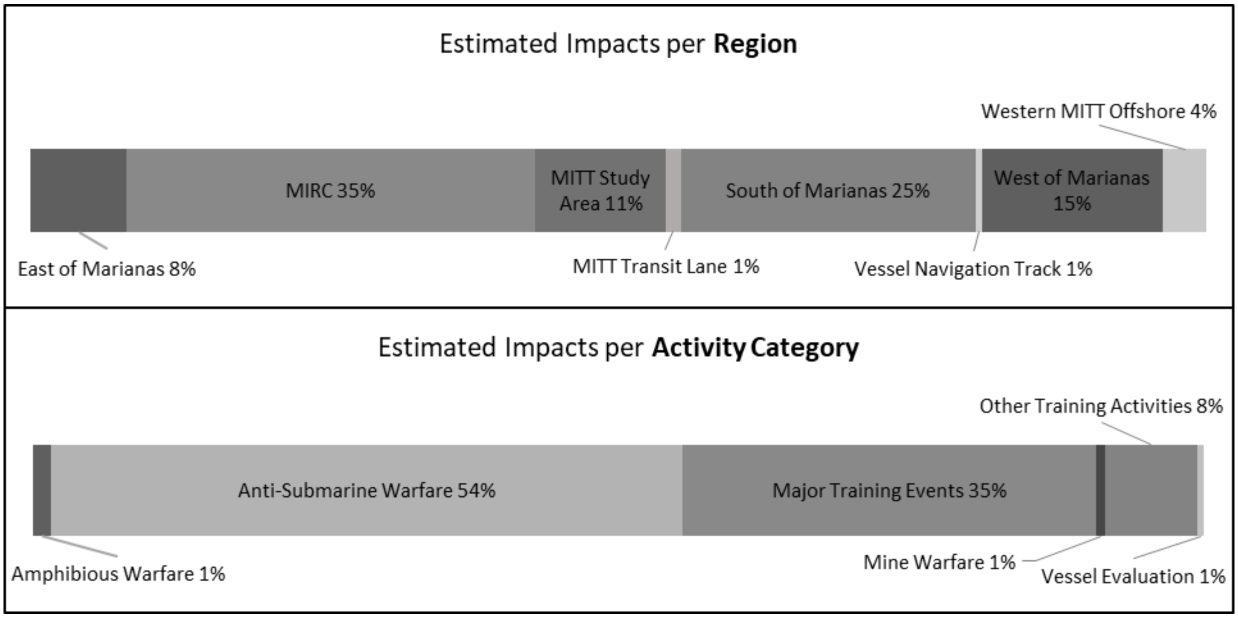
Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
2,899	723	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Sonar and Other Transducers Under Alternative 2 for Training and Testing Activities

Striped dolphins may be exposed to sounds from sonar and other transducers associated with training and testing activities throughout the year. The quantitative analysis estimates behavioral reactions and TTS under Alternative 2 during training and testing activities (Figure 3.4-62 and Table 3.4-66). Impact ranges for this species are discussed in Section 3.4.2.1.2.2 (Impact Ranges for Sonar and Other Transducers). Potential impacts under Alternative 2 from sonar and other transducers would be similar in type as for Alternative 1, although the numbers of impacts would increase slightly based on the slight increase in sonar use associated with training and testing activities under Alternative 2.

Pursuant to the MMPA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 would result in the unintentional taking of striped dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-62: Striped Dolphin Impacts Estimated per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Table 3.4-66: Estimated Impacts on Individual Striped Dolphins Within the Study Area per Year from Sonar and Other Transducers Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
Behavioral	***TTS***	***PTS***
3,255	750	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

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

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors from the use of sonar and other transducers, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that use sonar and other transducers within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from sonar and other transducers on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.1.3 Impacts from Vessel Noise

Marine mammals may be exposed to noise from vessel movement. A detailed description of the acoustic characteristics and typical sound levels of vessel noise are in Section 3.0.4.1.2 (Vessel Noise). Vessel movements involve transits to and from ports to various locations within the Study Area, including commercial ship traffic as well as recreational vessels in addition to U.S. Navy vessels. Many ongoing and proposed training and testing activities within the Study Area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels). Section 3.4.2.1.1 (Background) summarizes and synthesizes available information on behavioral reactions, masking, and physiological stress due to noise exposure, including vessel noise (Section 3.4.2.1.1.2, Hearing Loss; Section 3.4.2.1.1.3, Physiological Stress; Section 3.4.2.1.1.4, Masking; and Section 3.4.2.1.1.5, Behavioral Reactions).

Activities may vary slightly from those previously analyzed in the 2015 MITT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Table 2.5-1 and Table 2.5-2 for proposed activities under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS. 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.

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors (i.e., vessel noise) from the use of vessels, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that produce vessel noise within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from vessel noise on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

Pursuant to the MMPA, sound produced by vessel movement during training and testing activities as described under Alternative 1 and Alternative 2 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, sound produced by vessel movement during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed marine mammals. The Navy is consulting on the activities described under Alternative 2 with NMFS as required by Section 7(a)(2) of the ESA.

3.4.2.1.4 Impacts from Aircraft Noise

Marine mammals may be exposed to aircraft-generated noise throughout the Study Area. Fixed- and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area.

Tilt-rotor impacts would be similar to fixed-wing or helicopter impacts depending which mode the aircraft is in. Most of these sounds would be concentrated around airbases and fixed ranges within the range complex. Aircraft produce extensive airborne noise from either turbofan or turbojet engines. An infrequent type of aircraft noise is the sonic boom, produced when the aircraft exceeds the speed of sound. Rotary-wing aircraft produce low-frequency sound and vibration (Pepper et al., 2003). Section 3.4.2.1.1 (Background) summarizes and synthesizes available information on behavioral reactions, masking, and physiological stress due to noise exposure, including aircraft noise (Section 3.4.2.1.1.2, Hearing Loss; Section 3.4.2.1.1.3, Physiological Stress; Section 3.4.2.1.1.4, Masking; and Section 3.4.2.1.1.5, Behavioral Reactions).

A detailed description of aircraft noise as a stressor is in Section 3.0.4.1.3 (Aircraft Noise). Activities may vary slightly from those previously analyzed in the 2015 MITT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Table 2.5-1 and Table 2.5-2 for proposed training and testing activities under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors (i.e., aircraft noise) from the use of aircraft, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that produce aircraft noise within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from aircraft noise on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

Pursuant to the MMPA, aircraft noise during training and testing activities as described under Alternative1 and Alternative 2 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, aircraft noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed marine mammals. The Navy is consulting on the activities described under Alternative 2 with NMFS as required by Section 7(a)(2) of the ESA.

3.4.2.1.5 Impacts from Weapon Noise

Marine mammals may be exposed to sounds caused by the firing of weapons, objects in flight, and inert impact of non-explosive munitions on the water's surface, which are described in Section 3.0.4.1.4 (Weapon Noise). In general, these are impulsive sounds generated in close vicinity to or at the water surface, with the exception of items that are launched underwater. The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated in air by firing a gun (muzzle blast) and a crack sound due to a low amplitude shock wave generated by a supersonic projectile flying through the air. Most in-air sound would be reflected at the air-water interface.

Underwater sounds would be strongest just below the surface and directly under the firing point. Any sound that enters the water only does so within a narrow cone below the firing point or path of the projectile. Vibration from the blast propagating through a ship's hull, the sound generated by the impact of an object with the water surface, and the sound generated by launching an object underwater are other sources of impulsive sound in the water. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange.

Section 3.4.2.1.1 (Background) summarizes and synthesizes available information on behavioral reactions, masking, and physiological stress due to noise exposure, including aircraft noise (Section 3.4.2.1.1.2, Hearing Loss; Section 3.4.2.1.1.3, Physiological Stress; Section 3.4.2.1.1.4, Masking; and Section 3.4.2.1.1.5, Behavioral Reactions).

Activities may vary slightly from those previously analyzed in the 2015 MITT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Table 2.5-1 and Table 2.5-2 for proposed training and testing activities under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS. The Navy will implement mitigation measures to avoid or reduce potential impacts from weapon noise during large-caliber gunnery activities, as discussed in Section 5.3.2.2 (Weapons Firing Noise).

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur; however, weapon noise would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Under the No Action Alternative, discontinuing training and testing activities that produce weapon noise within the marine environment where training and testing activities have historically been conducted would reduce the potential for impacts from weapon noise on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

Pursuant to the MMPA, weapon noise during training and testing activities as described under Alternative 1 and Alternative 2 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, weapon noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed marine mammals. The Navy is consulting on the activities described under Alternative 2 with NMFS as required by Section 7(a)(2) of the ESA.

3.4.2.2 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 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 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). The following background section discusses what is currently known about explosive effects to marine mammals.

Due to new acoustic impact criteria, marine mammal densities, and revisions to the acoustics effects model, the analysis provided in Section 3.4.2.2.2 (Impacts from Explosive Stressors) of this SEIS/OEIS supplants the 2015 MITT Final EIS/OEIS for marine mammals and changes estimated impacts for some species since the 2015 MITT Final EIS/OEIS.

3.4.2.2.1 Background

3.4.2.2.1.1 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 3.0.4.7 (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 H (Acoustic and Explosive 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 or testing 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).

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 3.4.2.2.1.2, 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 principal 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 the 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 (psi) per millisecond (psi-ms) (40 pascals second [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 et al. (2018). 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., 2018). 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). 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 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 1147 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.

3.4.2.2.1.2 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 3.0.4.7 (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 (e.g., short duration and fast rise time) with other impulsive sounds such as those produced by air guns. General research findings regarding TTS and PTS in marine mammals, as well as findings specific to exposure to other impulsive sound sources, are discussed in Section 3.4.2.1.1.2 (Hearing Loss).

3.4.2.2.1.3 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 3.0.4.7 (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 3.4.2.1.1.3 (Physiological Stress). 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.

3.4.2.2.1.4 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 3.0.4.7 (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. Masking can lead to vocal changes (e.g., Lombard effect, increasing amplitude, or changing frequency) and behavior 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 3.4.2.1.1.4 (Masking) under Acoustic Stressors above. Potential masking from explosive sounds is likely to be similar to masking studied for other impulsive sounds such as air guns.

3.4.2.2.1.5 Behavioral Reactions

As discussed in Section 3.0.4.7 (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 post-construction. 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. Behavioral reactions from explosive sounds are likely to be similar to reactions studied for other impulsive sounds, such as those produced by air guns and impact pile driving. Data on behavioral responses to impulsive sound sources are limited across all marine mammal groups, with only a few studies available for mysticetes and odontocetes. Most data have come from seismic surveys that occur over long durations (e.g., on the order of days to weeks), and typically utilize large multi-air gun arrays that fire repeatedly. While seismic data provide the best available science for assessing behavioral responses to impulsive sounds by marine mammals, it is likely that these responses represent a worst-case scenario compared to responses to explosives used in Navy activities, which would typically consist of single impulses or a cluster of impulses, rather than long-duration, repeated impulses.

See Section 3.4.2.1.1.5 (Behavioral Reactions) under Section 3.4.2.1 (Acoustic Stressors) for a summary of information on marine mammal reactions to impulsive sounds.

3.4.2.2.1.6 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 and testing events are presented in Chapter 5 (Mitigation).

3.4.2.2.1.7 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 3.0.4.7 (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.

3.4.2.2.2 Impacts from Explosive Stressors

Marine mammals could be exposed to energy, sound, and fragments from explosions in the water and near the water surface associated with the proposed activities. Energy from an explosion is capable of causing mortality, injury, hearing loss, a behavioral response, masking, or physiological stress, depending on the level and duration of exposure.

The death of an animal would eliminate future reproductive potential, which is considered in the analysis of potential long-term consequences to the population. Exposures that result in non-auditory injuries or PTS may limit an animal's ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or impact its ability to successfully reproduce. TTS can also impair an animal's abilities, but the individual is likely to recover quickly with little significant effect.

Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds, which are within the audible range of most marine mammals, could cause behavioral reactions, masking, and elevated physiological stress. Behavioral responses can include shorter surfacings, shorter dives, fewer blows (breaths) per surfacing, longer intervals between blows, ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (National Research Council 2005). Sounds from explosives could also mask biologically important sounds; however, the duration of individual sounds is very short, reducing the likelihood of substantial auditory masking.

3.4.2.2.2.1 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 and testing 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 on Sea Turtles and Marine Mammals), which takes into account:

- criteria and thresholds used to predict impacts from explosives (see below);
- the density and spatial distribution of marine mammals (U.S. Department of the Navy, 2019; Watwood et al., 2018); 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, 2018b).

Criteria and Thresholds used to Estimate Impacts to Marine Mammals from Explosives

Mortality and Injury from Explosives

As discussed above in Section 3.4.2.2.1.1 (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 and testing activities (Table 3.4-67). The thresholds for the farthest range to effect are based on the received level at which one percent risk 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, 2017b).

Table 3.4-67: Criteria to Quantitatively Assess Non-Auditory Injury Due to Underwater Explosions

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).

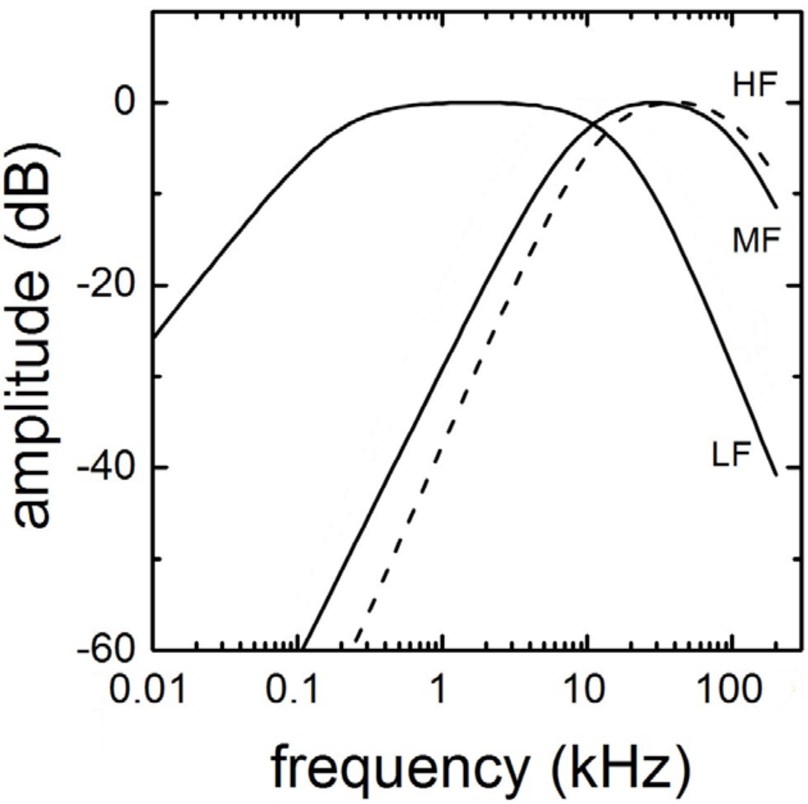
[2] Threshold for one percent risk used to assess mitigation effectiveness.

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 3.4-63). 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.

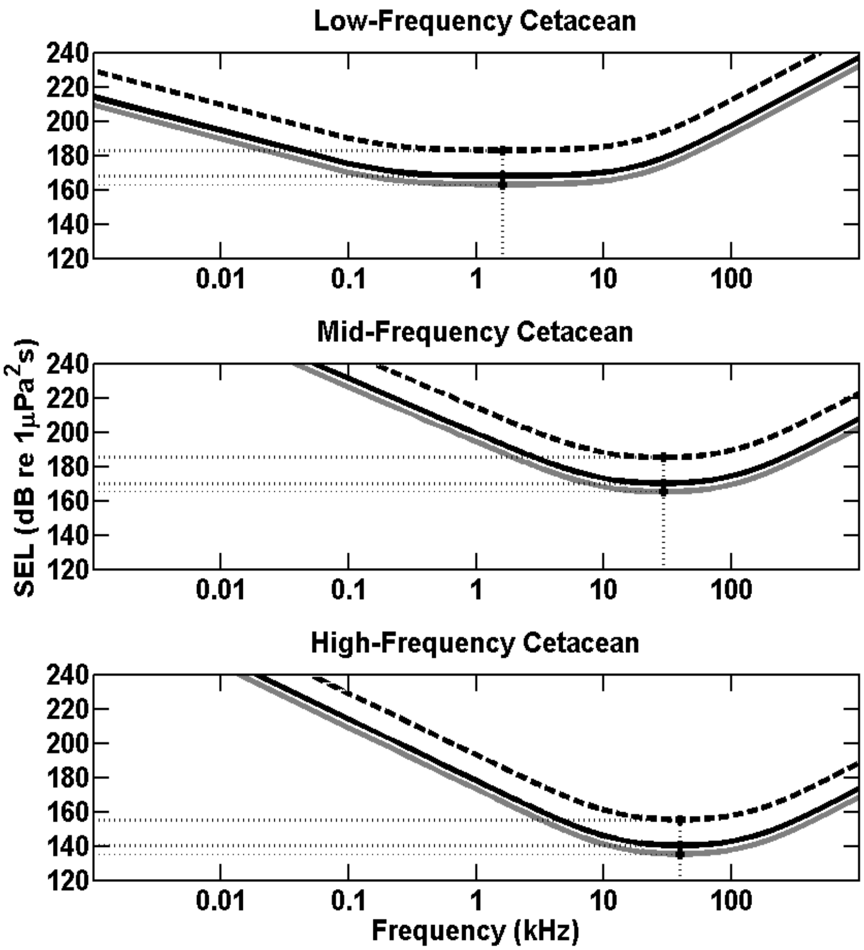


Source: See U.S. Department of the Navy (2017b) for parameters used to generate the functions and more information on weighting function derivation.
Notes: MF = mid-frequency cetacean, HF = high-frequency cetacean, LF = low-frequency cetacean

Figure 3.4-63: 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. 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 auditory evoked potential-measured TTS of 7–20 dB in a harbor porpoise exposed to single impulses from a seismic air gun. Since marine mammal PTS data from impulsive noise exposures do not exist, onset-PTS levels for all groups were estimated by adding 15 dB to the threshold for non-impulsive sources. This relationship was derived by Southall et al. (2007) from impulsive noise TTS growth rates in chinchillas. These frequency-dependent thresholds are depicted by the exposure functions for each group's range of best hearing (Figure 3.4-64). Weighted sound exposure thresholds for underwater explosive sounds used in the analysis are shown in Table 3.4-68.



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 3.4-64: Navy Phase III Behavioral, TTS, and PTS Exposure Functions for Explosives

Table 3.4-68: Navy Phase III Weighted Sound Exposure Thresholds for Underwater Explosive Sounds

Hearing Group	*Explosive Sound Source*				
	Behavior (SEL) weighted (dB)	*TTS (SEL) weighted (dB)*	*TTS (Peak SPL) unweighted (dB)*	*PTS (SEL) weighted (dB)*	*PTS (Peak SPL) unweighted (dB)*
Low-frequency Cetacean	163	168	213	183	219
Mid-frequency Cetacean	165	170	224	185	230
High-frequency Cetacean	135	140	196	155	202

Notes: dB = decibels, PTS = permanent threshold shift, SEL = sound exposure level, SPL = sound pressure level, TTS = temporary threshold shift

Behavioral Responses from Explosives

If more than one explosive event occurs within any given 24-hour period within a training or testing activity, criteria are applied to predict the number of animals that may have a behavioral reaction. For exercises with multiple explosions, the behavioral threshold used in this analysis is 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).

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). For single explosions at received sound levels below hearing loss thresholds, the most likely behavioral response is a brief alerting or orienting response. Since no further sounds follow the initial brief impulses, significant behavioral reactions would not be expected to occur. This assumption does not preclude the consideration of animals being behaviorally disturbed during single explosions if they are exposed above the TTS threshold. 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.

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). The benefits of mitigation are conservatively factored into the analysis for Alternative 1 and Alternative 2 of the Proposed Action for training and testing. The Navy's mitigation measures are identical for both action alternatives.

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. Therefore, the impact analysis quantifies the potential for procedural mitigation to reduce the risk of mortality due to exposure to explosives. 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., an explosive activity) 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, 2018b).

The impact analysis does not analyze the potential for mitigation to reduce non-auditory injury, PTS, TTS, or behavioral effects, even though mitigation would 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 mortality was estimated for each training or testing 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 or testing activity could take place are also considered, such as sea surface conditions, weather (e.g., fog or rain), and day versus night.

The Navy will also implement mitigation measures for certain explosive activities within mitigation areas, including the Marpi Reef Mitigation Area, Chalan Kanoa Reef Mitigation Area, and Agat Bay Nearshore Mitigation Area, as described in Appendix I (Geographic Mitigation Assessment). Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. The benefits of mitigation areas are discussed qualitatively in terms of the context of impact avoidance or reduction.

3.4.2.2.2.2 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 3.4.2.2.2.1, Methods for Analyzing Impacts from Explosives). The range to effects are shown for a range of explosive bins, from E1 (up to 0.25 lb. net explosive weight) to E12 (up 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 would 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 would likely be mitigated within applicable mitigation zones.

Table 3.4-69 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 3.4-70.

Table 3.4-71 through Table 3.4-76 show the minimum, average, and maximum ranges to onset of auditory and behavioral effects based on the thresholds described in Section 3.4.2.2.2.1 (Methods for Analyzing Impacts from Explosives). Ranges 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* (U.S. Department of the Navy, 2018b).

Table 3.4-69: Ranges to Non-Auditory Injury (in meters) for All Marine Mammal Hearing Groups

Bin[2]	*Range to Non-Auditory Injury (meters)*[1]
E1	12 (11–13)
E2	16 (15–16)
E3	25 (25–25)
E4	30 (30–35)
E5	40 (40–65)
E6	52 (50–60)
E8	98 (90–150)
E9	123 (120–270)
E10	155 (150–430)
E11	418 (410–420)
E12	195 (180–675)

[1] Average distance is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
Notes: All ranges to non-auditory injury within this table are driven by gastrointestinal tract injury thresholds regardless of animal mass.
[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

Table 3.4-70: Ranges to Mortality (in meters) for All Marine Mammal Hearing Groups as a Function of Animal Mass

Bin[2]	*Range to Mortality (meters) for Various Animal Mass Intervals (kg)*[1]					
	10 kg	***250 kg***	***1,000 kg***	***5,000 kg***	***25,000 kg***	***72,000 kg***
E1	3 (3–3)	1 (0–2)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
E2	4 (3–4)	2 (1–3)	1 (0–1)	0 (0–0)	0 (0–0)	0 (0–0)
E3	9 (7–10)	4 (2–8)	2 (1–2)	1 (0–1)	0 (0–0)	0 (0–0)
E4	13 (12–15)	7 (4–12)	3 (3–4)	2 (1–3)	1 (1–1)	1 (0–1)
E5	13 (12–30)	7 (4–25)	3 (2–7)	2 (1–5)	1 (1–2)	1 (0–2)
E6	16 (15–25)	9 (5–23)	4 (3–8)	3 (2–6)	1 (1–2)	1 (1–2)
E8	42 (25–65)	22 (9–50)	11 (6–19)	8 (4–13)	4 (2–6)	3 (1–5)
E9	33 (30–35)	20 (13–30)	10 (9–12)	7 (5–9)	4 (3–4)	3 (2–3)
E10	55 (40–170)	24 (16–35)	13 (11–15)	9 (7–11)	5 (4–5)	4 (3–4)
E11	206 (200–210)	98 (55–170)	44 (35–50)	30 (25–35)	16 (14–18)	12 (10–15)
E12	86 (50–270)	35 (20–210)	16 (13–19)	11 (9–13)	6 (5–6)	5 (4–5)

[1]Average distance to mortality (meters) is depicted above the minimum and maximum distances, which are in parentheses for each animal mass interval.
[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).
Note: Kg = kilogram

Table 3.4-71: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for High-Frequency Cetaceans

Range to Effects for Explosives: High-Frequency Cetaceans[1]					
Bin[2]	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***	***Range to Behavioral (meters)***
E1	0.1	1	353 (340–370)	1,303 (1,275–1,775)	2,139 (2,025–4,275)
		18	1,031 (1,025–1,275)	3,409 (2,525–8,025)	4,208 (3,025–11,525)
E2	0.1	1	431 (410–700)	1,691 (1,525–2,775)	2,550 (2,025–4,525)
		5	819 (775–1,275)	2,896 (2,275–6,775)	3,627 (2,525–10,275)
E3	0.1	1	649 (625–700)	2,439 (2,025–4,525)	3,329 (2,525–7,525)
		12	1,682 (1,525–2,275)	4,196 (3,025–11,525)	5,388 (4,525–16,275)
	18.25	1	720 (675–775)	4,214 (2,275–6,275)	7,126 (3,525–8,775)
		12	1,798 (1,525–2,775)	10,872 (4,525–13,775)	14,553 (5,525–17,775)
E4	10	2	1,365 (1,025–2,775)	7,097 (4,275–10,025)	9,939 (5,025–15,275)
	60	2	1,056 (875–2,275)	3,746 (2,775–5,775)	5,262 (3,025–7,775)
E5	0.1	20	2,926 (1,525–6,275)	6,741 (4,525–16,025)	9,161 (4,775–20,025)
	30	20	4,199 (3,025–6,275)	13,783 (8,775–17,775)	17,360 (10,525–22,775)
E6	0.1	1	1,031 (1,025–1,275)	3,693 (2,025–8,025)	4,659 (3,025–12,775)
	30	1	1,268 (1,025–1,275)	7,277 (3,775–8,775)	10,688 (5,275–12,525)
E8	0.1	1	1,790 (1,775–3,025)	4,581 (4,025–10,775)	6,028 (4,525–15,775)
	45.75	1	1,842 (1,525–2,025)	9,040 (4,525–12,775)	12,729 (5,025–18,525)
E9	0.1	1	2,343 (2,275–4,525)	5,212 (4,025–13,275)	7,573 (5,025–17,025)

Table 3.4-71: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for High-Frequency Cetaceans (continued)

Range to Effects for Explosives: High-Frequency Cetaceans[1]					
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***	***Range to Behavioral (meters)***
E10	0.1	1	2,758 (2,275–5,025)	6,209 (4,275–16,525)	8,578 (5,275–19,775)
E11	45.75	1	3,005 (2,525–3,775)	11,648 (5,025–18,775)	14,912 (6,525–24,775)
	91.4	1	3,234 (2,525–4,525)	5,772 (4,775–11,775)	7,197 (5,775–14,025)
E12	0.1	1	3,172 (3,025–6,525)	7,058 (5,025–17,025)	9,262 (6,025–21,775)
		4	4,209 (3,775–10,025)	9,817 (6,275–22,025)	12,432 (7,525–27,775)

[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. PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift
[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

Table 3.4-72: 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	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	745 (700–775)	1,275 (1,275–1,275)
E2	0.1	912 (380–975)	1,498 (725–1,525)
E3	0.1	1,525 (1,525–1,525)	2,397 (2,025–2,525)
	18.25	1,561 (1,525–2,775)	2,919 (2,775–3,525)
E4	10	2,076 (1,775–2,525)	5,565 (3,525–7,775)
	60	2,364 (1,775–4,775)	4,044 (2,025–5,275)
E5	0.1	2,267 (1,025–3,275)	3,093 (1,275–5,775)
	30	2,567 (2,275–2,775)	3,747 (3,025–5,275)

Table 3.4-72: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for High-Frequency Cetaceans (continued)

Range to Effects for Explosives: High-Frequency Cetaceans[1]			
***Bin*[2]**	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E6	0.1	2,546 (1,275–4,525)	3,356 (1,525–6,525)
	30	3,242 (2,775–3,525)	4,598 (3,525–5,275)
E8	0.1	3,458 (3,025–6,525)	4,324 (3,775–8,275)
	45.75	4,790 (4,275–6,525)	11,013 (4,775–23,775)
E9	0.1	3,870 (3,275–8,025)	4,620 (3,775–10,275)
E10	0.1	3,993 (2,525–9,275)	5,076 (2,775–16,025)
E11	45.75	8,388 (4,775–24,275)	17,386 (5,025–33,275)
	91.4	5,051 (4,025–7,525)	7,065 (4,275–26,525)
E12	0.1	4,519 (3,775–9,775)	5,678 (4,275–13,025)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses. PTS = permanent threshold shift, TTS = temporary threshold shift
[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

Table 3.4-73: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Low-Frequency Cetaceans

Range to Effects for Explosives: Low-Frequency Cetaceans[1]					
Bin[2]	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***	***Range to Behavioral (meters)***
E1	0.1	1	51 (50–55)	231 (200–250)	378 (280–410)
		18	183 (170–190)	691 (450–775)	934 (575–1,275)
E2	0.1	1	66 (65–70)	291 (220–320)	463 (330–500)
		5	134 (110–140)	543 (370–600)	769 (490–950)
E3	0.1	1	113 (110–120)	477 (330–525)	689 (440–825)
		12	327 (250–370)	952 (600–1,525)	1,240 (775–4,025)
	18.25	1	200 (200–200)	955 (925–1,000)	1,534 (1,275–1,775)
		12	625 (600–625)	5,517 (2,275–7,775)	10,299 (3,775–13,025)
E4	10	2	429 (370–600)	2,108 (1,775–2,775)	4,663 (3,025–6,025)
	60	2	367 (340–470)	1,595 (1,025–2,025)	2,468 (1,525–4,275)
E5	0.1	20	702 (380–1,275)	1,667 (850–11,025)	2,998 (1,025–19,775)
	30	20	1,794 (1,275–2,775)	8,341 (3,775–11,525)	13,946 (4,025–22,275)
E6	0.1	1	250 (190–410)	882 (480–1,775)	1,089 (625–6,525)
	30	1	495 (490–500)	2,315 (2,025–2,525)	5,446 (3,275–6,025)
E8	0.1	1	415 (270–725)	1,193 (625–4,275)	1,818 (825–8,525)
	45.75	1	952 (900–975)	6,294 (3,025–9,525)	12,263 (4,275–20,025)
E9	0.1	1	573 (320–1,025)	1,516 (725–7,275)	2,411 (950–14,275)

Table 3.4-73: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Low-Frequency Cetaceans (continued)

Range to Effects for Explosives: Low-Frequency Cetaceans[1]					
Bin[2]	*Source Depth (meters)*	*Cluster Size*	*Range to PTS (meters)*	*Range to TTS (meters)*	*Range to Behavioral (meters)*
E10	0.1	1	715 (370–1,525)	2,088 (825–28,275)	4,378 (1,025–32,275)
E11	45.75	1	1,881 (1,525–2,275)	12,425 (4,275–27,275)	23,054 (7,025–65,275)
	91.4	1	1,634 (1,275–2,525)	5,686 (3,775–11,275)	11,618 (5,525–64,275)
E12	0.1	1	790 (420–2,775)	2,698 (925–25,275)	6,032 (1,025–31,275)
		4	1,196 (575–6,025)	6,876 (1,525–31,275)	13,073 (3,775–64,275)

[1]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.
[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 3.4-74: 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	*Source Depth (meters)*	*Range to PTS (meters)*	*Range to TTS (meters)*
E1	0.1	135 (130–140)	249 (220–270)
E2	0.1	173 (120–180)	305 (180–330)
E3	0.1	292 (240–310)	499 (330–550)
	18.25	310 (310–310)	583 (550–600)
E4	10	396 (390–420)	738 (725–750)
	60	420 (380–775)	846 (575–2,025)
E5	0.1	451 (310–525)	740 (410–1,025)
	30	521 (490–600)	971 (925–1,025)

Table 3.4-74: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for Low-Frequency Cetaceans (continued)

Range to Effects for Explosives: Low-Frequency Cetaceans[1]			
Bin[2]	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E6	0.1	547 (350–700)	842 (460–1,275)
	30	622 (600–650)	1,025 (1,025–1,025)
E8	0.1	799 (450–925)	1,030 (575–1,775)
	45.75	1,025 (1,025–1,025)	1,778 (1,525–2,025)
E9	0.1	947 (500–1,275)	1,294 (675–3,025)
E10	0.1	1,032 (550–1,775)	1,388 (800–4,275)
E11	45.75	1,778 (1,525–2,025)	3,067 (2,275–11,275)
	91.4	1,676 (1,275–3,275)	2,442 (2,025–3,525)
E12	0.1	1,151 (625–2,525)	1,762 (900–5,275)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 3.4-75: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Mid-Frequency Cetaceans

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]					
Bin[2]	*Source Depth (meters)*	*Cluster Size*	*Range to PTS (meters)*	*Range to TTS (meters)*	*Range to Behavioral (meters)*
E1	0.1	1	25 (25–25)	116 (110–120)	199 (190–210)
		18	94 (90–100)	415 (390–440)	646 (525–700)
E2	0.1	1	30 (30–35)	146 (140–170)	248 (230–370)
		5	63 (60–70)	301 (280–410)	481 (430–675)
E3	0.1	1	50 (50–50)	233 (220–250)	381 (360–400)
		12	155 (150–160)	642 (525–700)	977 (700–1,025)
	18.25	1	40 (40–40)	202 (190–220)	332 (320–350)
		12	126 (120–130)	729 (675–775)	1,025 (1,025–1,025)
E4	10	2	76 (70–90)	464 (410–550)	783 (650–975)
	60	2	60 (60–60)	347 (310–675)	575 (525–900)
E5	0.1	20	290 (280–300)	1,001 (750–1,275)	1,613 (925–3,275)
	30	20	297 (240–420)	1,608 (1,275–2,775)	2,307 (2,025–2,775)
E6	0.1	1	98 (95–100)	430 (400–450)	669 (550–725)
	30	1	78 (75–80)	389 (370–410)	619 (600–650)
E8	0.1	1	162 (150–170)	665 (550–700)	982 (725–1,025)
	45.75	1	127 (120–130)	611 (600–625)	985 (950–1,025)
E9	0.1	1	215 (210–220)	866 (625–1,000)	1,218 (800–1,525)

Table 3.4-75: SEL-Based Ranges to Onset PTS, Onset TTS, and Behavioral Reaction (in meters) for Mid-Frequency Cetaceans (continued)

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]					
Bin[2]	*Source Depth (meters)*	*Cluster Size*	*Range to PTS (meters)*	*Range to TTS (meters)*	*Range to Behavioral (meters)*
E10	0.1	1	270 (250–280)	985 (700–1,275)	1,506 (875–2,525)
E11	45.75	1	241 (230–250)	1,059 (1,000–1,275)	1,874 (1,525–2,025)
	91.4	1	237 (230–270)	1,123 (900–2,025)	1,731 (1,275–2,775)
E12	0.1	1	332 (320–370)	1,196 (825–1,525)	1,766 (1,025–3,525)
		4	572 (500–600)	1,932 (1,025–4,025)	2,708 (1,275–6,775)

[1]Average distance (meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.
[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).
Notes: PTS = permanent threshold shift, SEL = sound exposure level, TTS = temporary threshold shift

Table 3.4-76: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for Mid-Frequency Cetaceans

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]			
Bin[2]	*Source Depth (meters)*	*Range to PTS (meters)*	*Range to TTS (meters)*
E1	0.1	43 (40–45)	84 (80–90)
E2	0.1	58 (55–60)	105 (95–110)
E3	0.1	98 (95–100)	183 (170–190)
	18.25	100 (100–100)	180 (180–180)
E4	10	120 (120–120)	255 (250–260)
	60	123 (120–130)	239 (230–340)
E5	0.1	155 (150–160)	288 (270–300)
	30	168 (160–190)	310 (290–350)

Table 3.4-76: Peak Pressure Based Ranges to Onset PTS and Onset TTS (in meters) for Mid-Frequency Cetaceans (continued)

Range to Effects for Explosives: Mid-Frequency Cetaceans[1]			
Bin[2]	***Source Depth (meters)***	***Range to PTS (meters)***	***Range to TTS (meters)***
E6	0.1	197 (190–210)	359 (320–400)
	30	200 (200–200)	380 (380–380)
E8	0.1	333 (310–340)	574 (440–625)
	45.75	351 (350–370)	629 (625–725)
E9	0.1	442 (370–460)	757 (500–850)
E10	0.1	546 (420–700)	939 (550–1,275)
E11	45.75	662 (650–800)	1,104 (1,025–1,275)
	91.4	748 (600–1,525)	1,353 (1,000–2,525)
E12	0.1	663 (470–725)	1,064 (625–1,275)

[1] Average distance (meters) is shown with the minimum and maximum distances due to varying propagation environments in parentheses.
[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

3.4.2.2.2.3 Impacts from Explosive Stressors Under the Action Alternatives

The following section provides a brief description of training and testing activities as they pertain to underwater and near-surface explosions under the Action Alternatives:

As described in Chapter 2 (Description of the Action and Action Area), Table 2.5-1, and Section 3.4.2.2 (Explosive Stressors), training and testing activities under the Proposed Action would use underwater detonations and explosive ordnance. Under Alternative 1, there could be fluctuation in the amount of explosives use that could occur annually, although potential impacts would be similar from year to year. The number and type (i.e., source bin) of explosives in this SEIS/OEIS compared with the totals analyzed in the 2015 MITT Final EIS/OEIS are described in Table 2.5-1 and Table 2.5-2. This comparison applies to both Alternative 1 and Alternative 2, because the number of explosives used would be almost identical under each alternative.

The number of torpedo testing events (both explosive and non-explosive) planned under Alternative 1 testing can vary slightly from year to year; however, all other training and testing activities that involve the use of explosives would remain consistent from year to year. Alternative 1 results are presented for a maximum explosive use year; however, during most years, explosive use would be less, resulting in fewer potential impacts. The numbers of activities planned under Alternative 2 are consistent from year to year and would increase slightly compared to activities planned under Alternative 1. The numbers of explosives used under each alternative are described in Section 3.0.4.2 (Explosive Stressors).

Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts on marine mammals from explosives (see Section 3.4.2.2.2.1, 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 and 2 are shown in Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Additionally, estimated numbers of potential impacts from the quantitative analysis for each species are presented below (e.g., Figure 3.4-65). The most likely regions and activity categories from which the impacts could occur are displayed in the impact graphics for each species. There is a potential for impacts to occur anywhere within the Study Area where sound and energy from explosions and the species overlap, although only regions or activity categories where 0.5 percent of the impacts, or greater, are estimated to occur are graphically represented on the impact graphics below. All (i.e., grand total) estimated impacts are also included, regardless of region or category.

Mysticetes

Mysticetes may be exposed to sound and energy from explosions associated with training and testing activities throughout the year. Explosions produce sounds that are within the hearing range of mysticetes (see Section 3.4.1.6, 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 the number of behavioral reactions and TTS in mysticetes. Impact ranges for mysticetes exposed to explosive sound and energy are discussed under low-frequency cetaceans in Section 3.4.2.2.2.2 (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 3.4.2.2.1.4 (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 Section 3.4.2.2.1.5, Behavioral Reactions), 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 3.4.2.2.1.3 (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.

Blue Whale (Endangered Species Act-Listed)

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Blue whales may be exposed to sound or energy from explosions associated with training and testing when they occur in the Study Area during the winter. The quantitative analysis estimates that any possible exposures to blue whales would not result in impacts rising to a level of take. Considering the mitigation measures that will be implemented as described in Section 2.3.4 (Mitigation Measures), and that impacts are not anticipated, long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the incidental taking of blue whales.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 1 may affect ESA-listed blue whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Blue whales may be exposed to sound or energy from explosions associated with training and testing activities when they occur in the Study Area during the winter. The quantitative analysis estimates any exposures to blue whales would not result in impacts rising to a level of take. Considering the mitigation measures that will be implemented as described in Section 2.3.4 (Mitigation Measures), and that impacts are not anticipated, long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the incidental taking of blue whales.

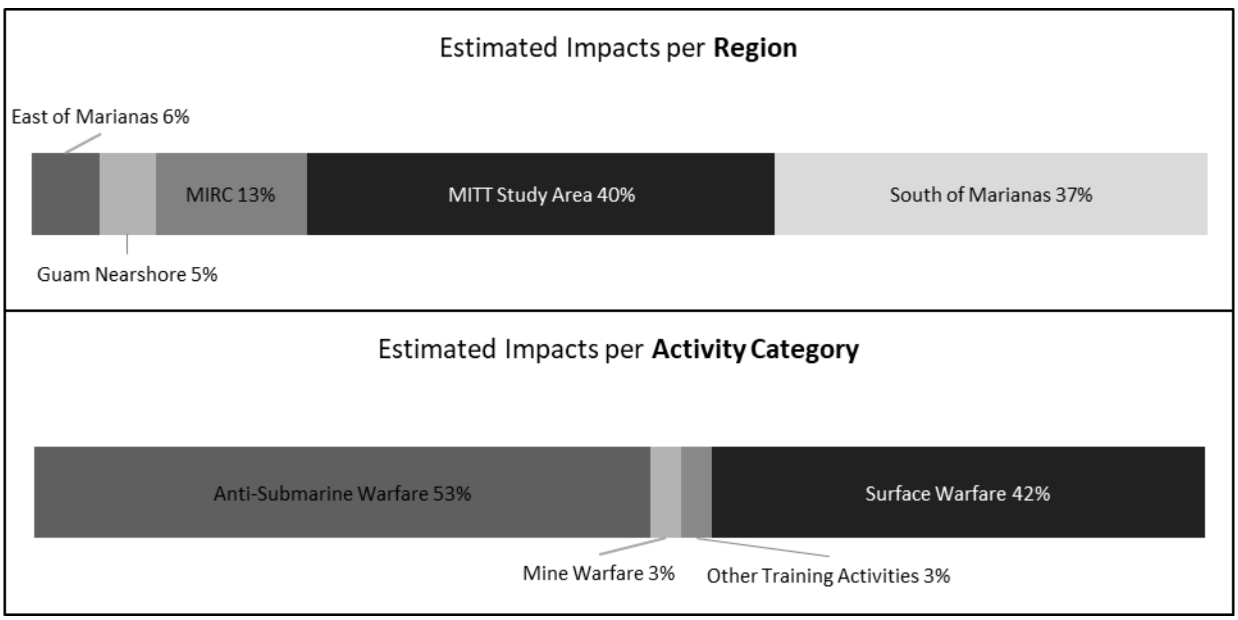
Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 2 may affect ESA-listed blue whales. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.

Bryde's Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Bryde's whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS during training and testing activities (Figure 3.4-65 and Table 3.4-77). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of Bryde's whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-65: Bryde's Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-77: Estimated Impacts on Individual Bryde's Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

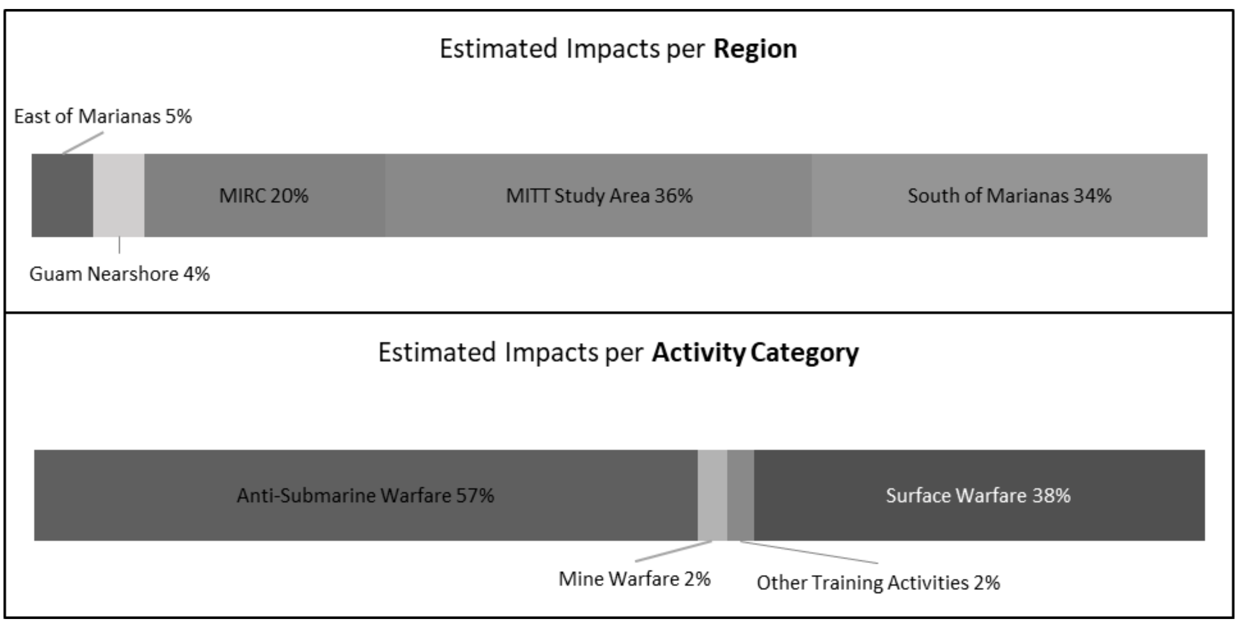
Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
3	2	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly in location and number (Figure 3.4-66 and Table 3.4-78) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities. The primary distinction is that explosive use would be consistent year to year under Alternative 2 and the total number of activities would increase slightly compared to Alternative 1.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of Bryde's whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-66: Bryde's Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-78: Estimated Impacts on Individual Bryde's Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
4	2	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Fin Whale (Endangered Species Act-Listed)

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Fin whales may be exposed to sound or energy from explosions associated with training and testing activities most likely in the winter months, when fin whales typically occur in the Study Area. The quantitative analysis estimates that any possible exposures to fin whales would not result in impacts rising to a level of take. Considering the mitigation measures that will be implemented as described in Section 2.3.4 (Mitigation Measures), and that impacts are not anticipated, long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the incidental taking of fin whales.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 1 may affect ESA-listed fin whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Fin whales may be exposed to sound or energy from explosions associated with training and testing activities, most likely in the winter months, when fin whales typically occur in the Study Area. The quantitative analysis estimates any exposures to fin whales would not result in impacts rising to a level of take. Considering the mitigation measures that will be implemented as described in Section 2.3.4 (Mitigation Measures), and that impacts are not anticipated, long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the incidental taking of fin whales.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 2 may affect ESA-listed fin whales. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.

Humpback Whale (Endangered Species Act-Listed)

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

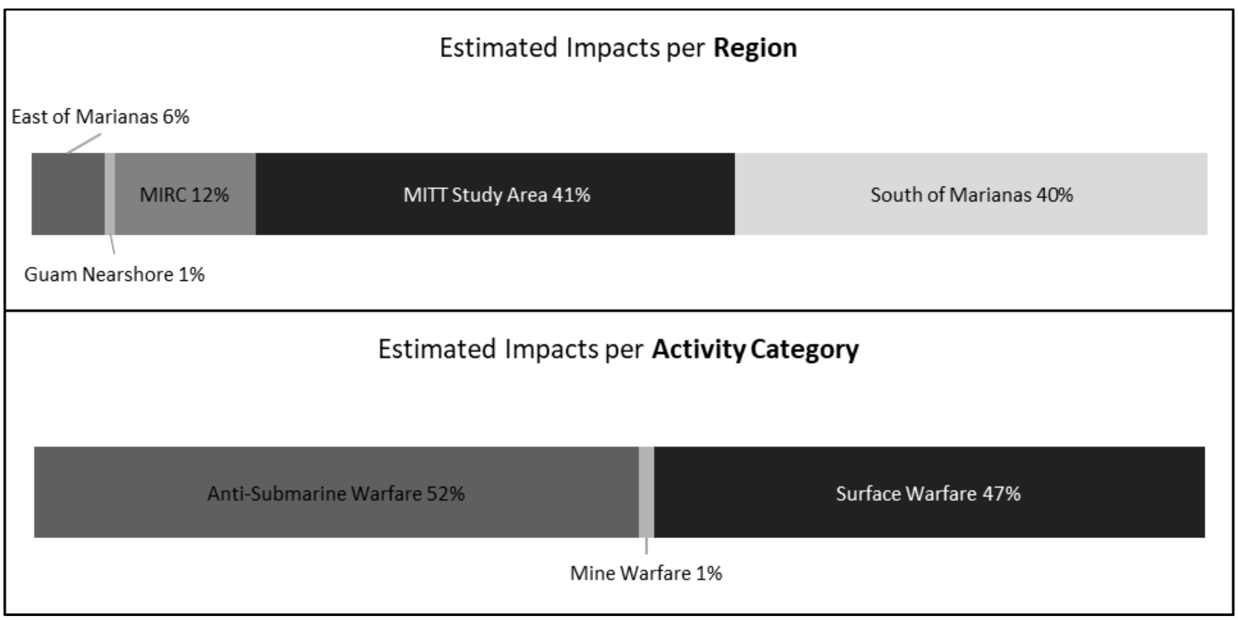
Humpback whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS during training and testing activities (Figure 3.4-67 and Table 3.4-79). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives).

In addition to procedural mitigation, the Navy will not use in-water explosives during training and testing within the Marpi Reef Mitigation Area and Chalan Kanoa Reef Mitigation Area, as described in Chapter 5 (Mitigation). These mitigation areas are designed to avoid impacts from in-water explosives on humpback whales in important reproductive habitat. Outside of these mitigation areas, Navy training and testing activities that use in-water explosives could occur year round within the Study Area, with most activities occurring in the Mariana Islands Range Complex. As discussed above, humpback whale reactions to explosions are most likely short term and mild to moderate, especially when explosions are located more than a few kilometers away and when the animals are engaged in important biological behaviors such as reproduction. Therefore, significant impacts on humpback whale reproduction behaviors from training and testing with explosives are unlikely to occur.

As described for mysticetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of humpback whales incidental to those activities.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 1 may affect ESA-listed humpback whales.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-67: Humpback Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-79: Estimated Impacts on Individual Humpback Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
6	3	0	0

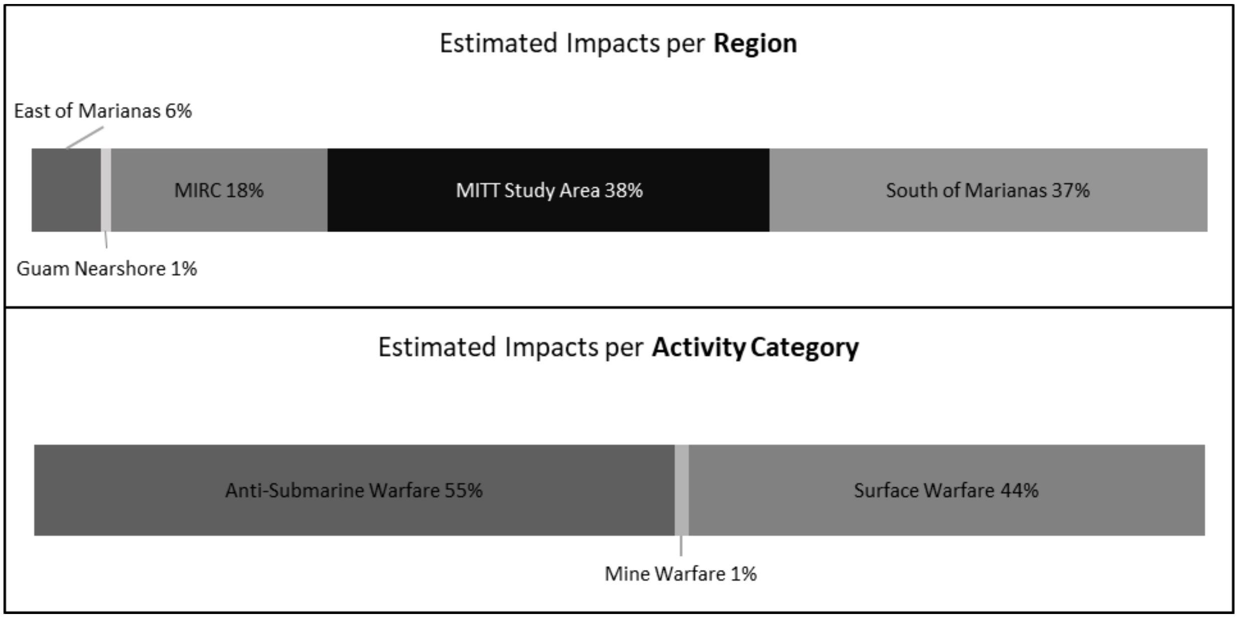
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly in location and number (Figure 3.4-68 and Table 3.4-80) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities. The primary distinction is that explosive use would be consistent year to year under Alternative 2 and the total number of activities would increase slightly compared to Alternative 1.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of humpback whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 2 may affect ESA-listed humpback whales. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-68: Humpback Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-80: Estimated Impacts on Individual Humpback Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
6	3	0	0

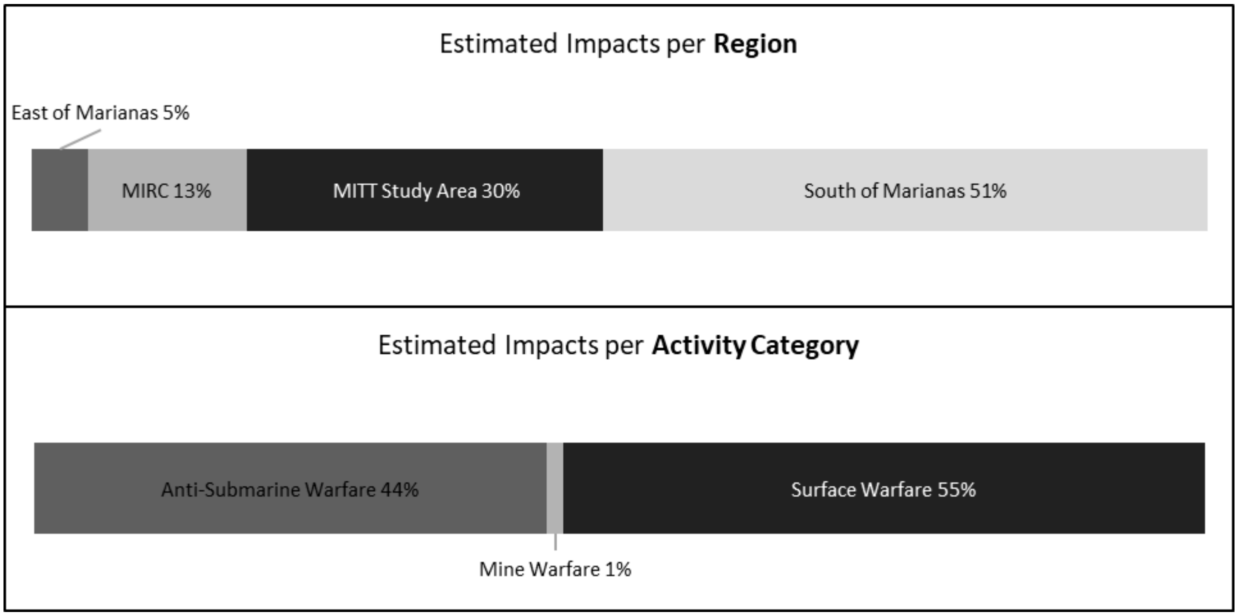
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Minke Whale

<u>Impacts from Explosives Under Alternative 1 for Training and Testing Activities</u>

Minke whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS during training and testing activities (Figure 3.4-69 and Table 3.4-81). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for mysticetes above, even a few minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of minke whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-69: Minke Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-81: Estimated Impacts on Individual Minke Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

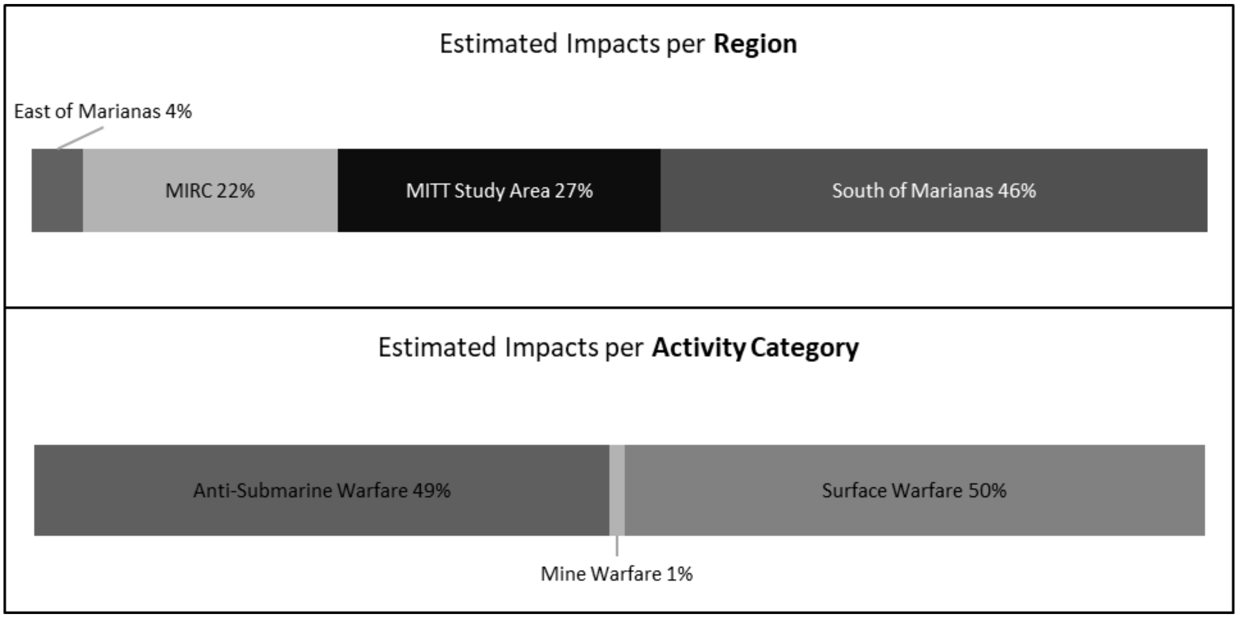
Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training with explosives would differ slightly in activity and location (Figure 3.4-70 and Table 3.4-82) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities; however, the total number of impacts would remain the same.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of minke whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-70: Minke Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-82: Estimated Impacts on Individual Minke Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Omura's Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

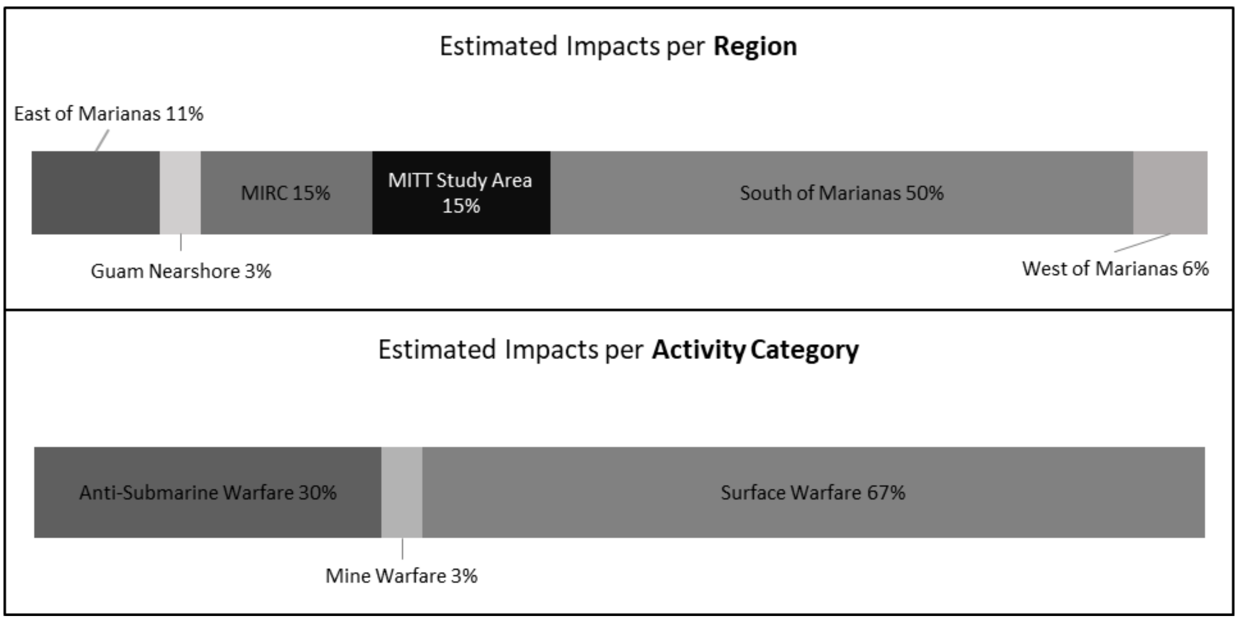
Omura's whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no Omura's whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the incidental taking of Omura's whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Omura's whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 2, estimates behavioral reactions during training and testing activities (Figure 3.4-71 and Table 3.4-83). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for mysticetes above, even a few minor to moderate behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of Omura's whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-71: Omura's Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-83: Estimated Impacts on Individual Omura's Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Alternative 2.

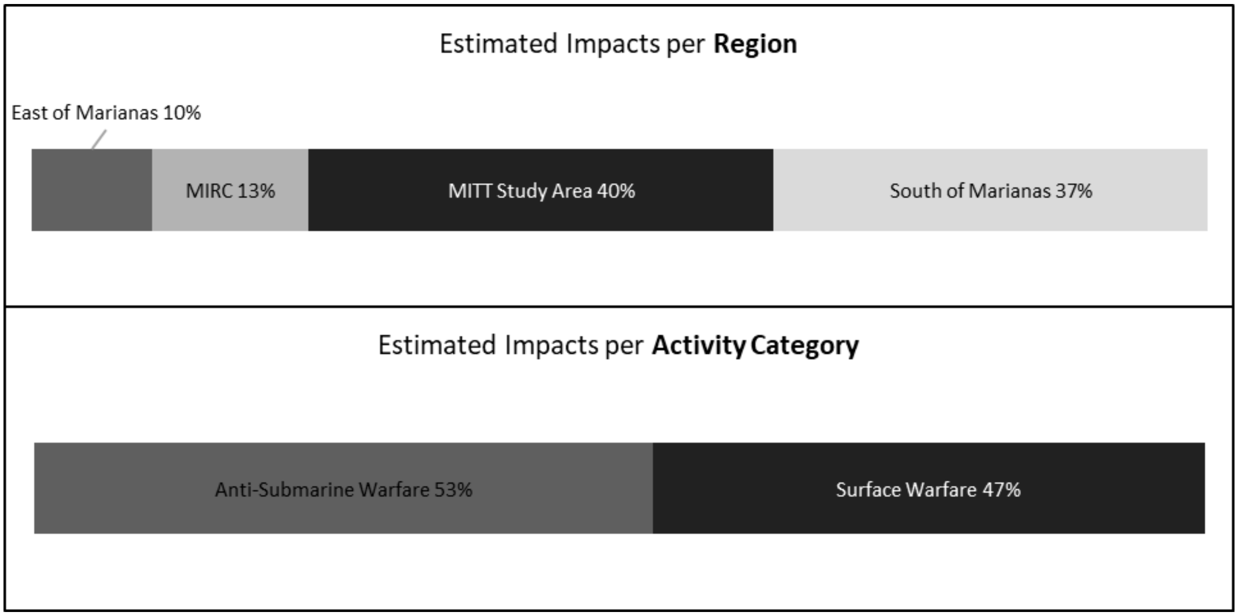
Sei Whale (Endangered Species Act-Listed)

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Sei whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS during training and testing activities (Figure 3.4-72 and Table 3.4-84). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for mysticetes above, even a few minor to moderate behavioral reactions or TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of sei whales incidental to those activities.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 1 may affect ESA-listed sei whales.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-72: Sei Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-84: Estimated Impacts on Individual Sei Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
2	1	0	0

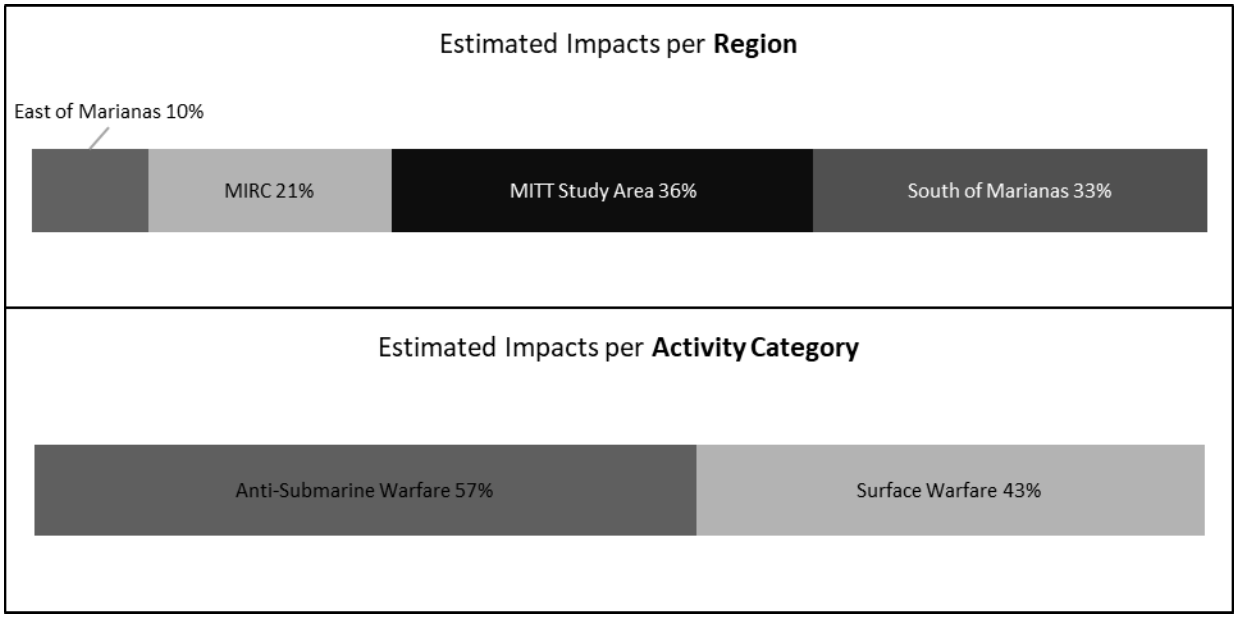
Note: Estimated impacts are based on the maximum number of activities in a given year under the Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training with explosives would differ slightly in location (Figure 3.4-73 and Table 3.4-85) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities; however, the total number of impacts would remain the same.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of sei whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.

Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 2 may affect ESA-listed sei whales. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-73: Sei Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-85: Estimated Impacts on Individual Sei Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
2	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Alternative 2.

Odontocetes

Odontocetes may be exposed to sound and energy from explosives associated with training and testing activities throughout the year. Explosions produce sounds that are within the hearing range of odontocetes (see Section 3.4.1.6, 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 3.4.2.2.2.2 (Impact Ranges for Explosives) under mid-frequency cetaceans for most species, and under high-frequency cetaceans for Kogia whales.

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. Animals that did sustain injury could have long-term consequences for that individual. 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 3.4.2.2.1.4 (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 3.4.2.2.1.5, 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 3.4.2.2.1.3 (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.

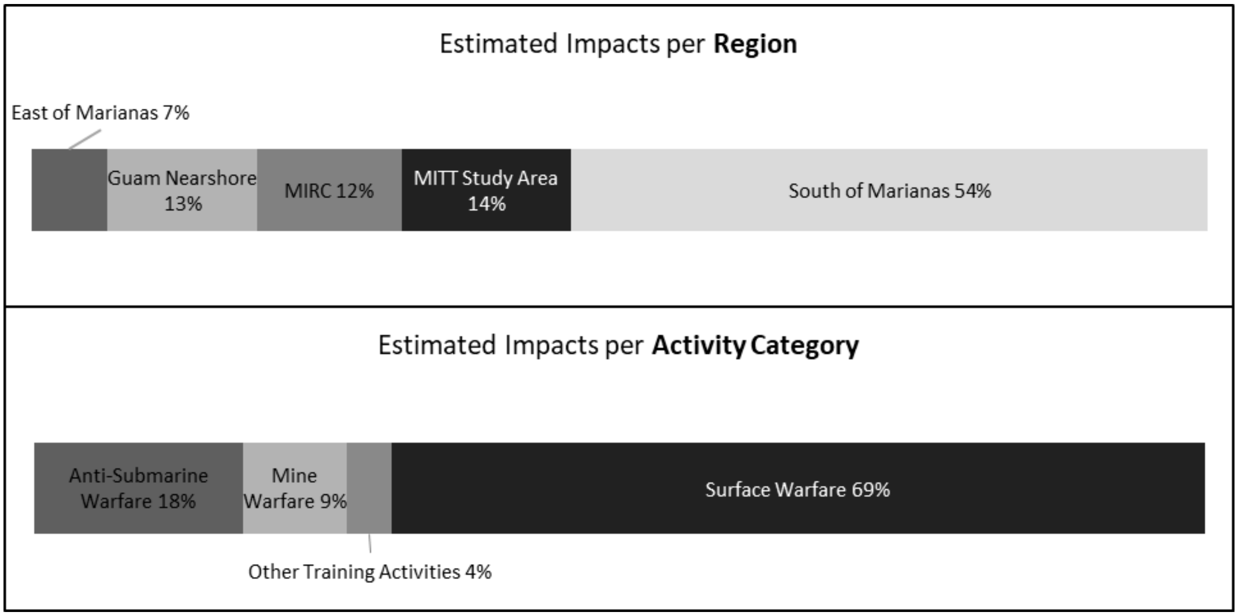
Beaked Whales

Beaked whales within the Study Area include: Blainville's beaked whale, Cuvier's beaked whale, ginkgo-toothed beaked whale, and Longman's beaked whale. Research and observations (Section 3.4.2.2.1.5, Behavioral Reactions) show that beaked whales are sensitive to human disturbance including noise from sonars, although no research on specific reactions to impulsive or explosion noise 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.

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Beaked whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS for ginkgo-toothed and Longman's beaked whales during training and testing activities (Figure 3.4-74, Figure 3.4-75, Table 3.4-86, and Table 3.4-87). Estimated impacts most years would be less based on fewer explosions. Impact ranges for these species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). No impacts are estimated for Blainville's beaked whale or Cuvier's beaked whale. As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of ginkgo-toothed and Longman's beaked whales incidental to those activities.



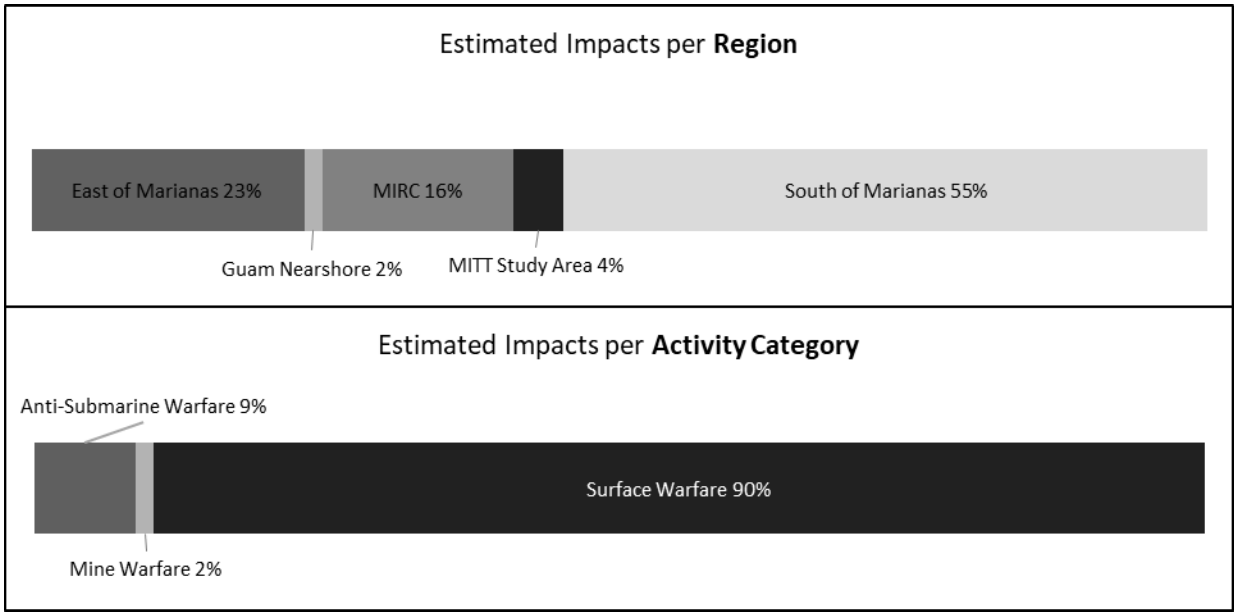
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-74: Ginkgo-Toothed Beaked Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-86: Estimated Impacts on Individual Ginkgo-Toothed Beaked Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
0	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-75: Longman's Beaked Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-87: Estimated Impacts on Individual Longman's Beaked Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

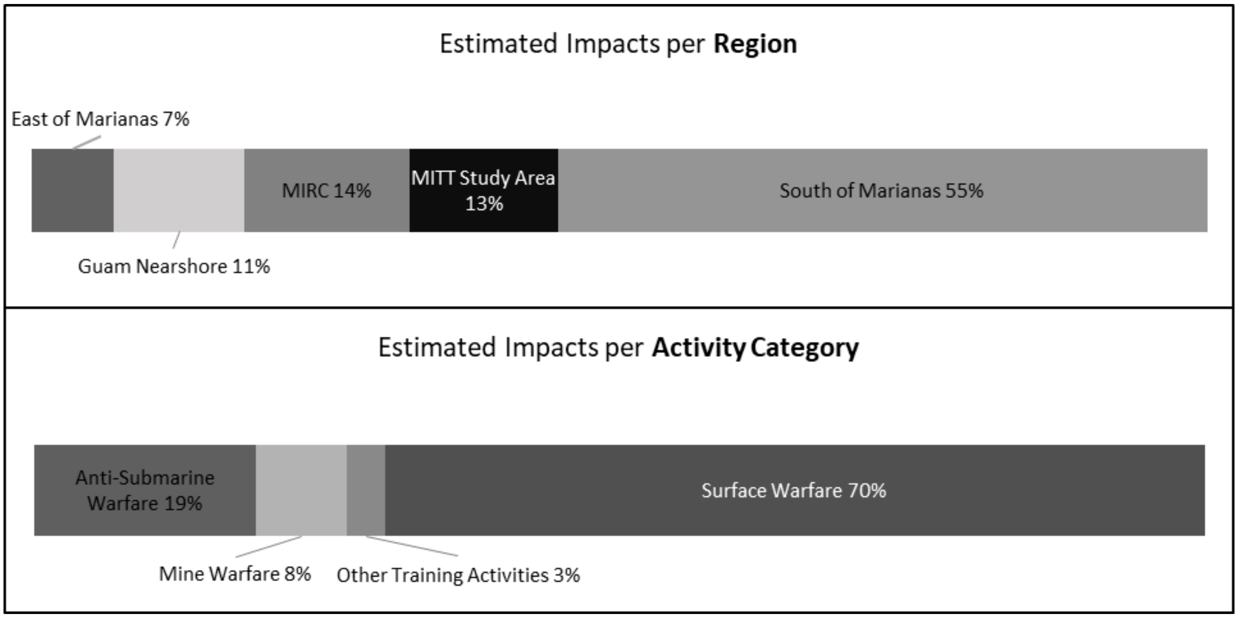
Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions and TTS for ginkgo-toothed and Longman's beaked whales. No impacts are estimated for Blainville's beaked whale or Cuvier's beaked whale. Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly in location (Figure 3.4-76, Figure 3.4-77, Table 3.4-88, and Table 3.4-89) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities; however, the total number of impacts would remain the same.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of ginkgo-toothed and Longman's beaked whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



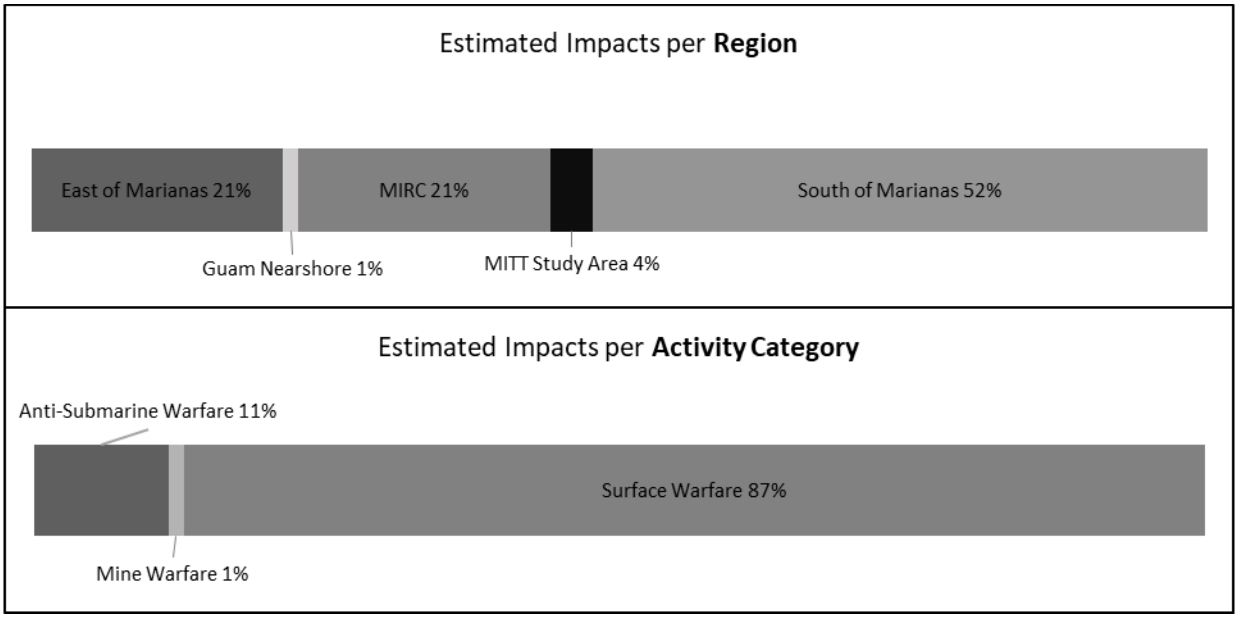
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-76: Ginkgo-Toothed Beaked Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-88: Estimated Impacts on Individual Ginkgo-Toothed Beaked Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-77: Longman's Beaked Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-89: Estimated Impacts on Individual Longman's Beaked Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Common Bottlenose Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Bottlenose dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no bottlenose dolphins would be impacted. Considering the mitigation measures that will be implemented as described in Section 2.3.4 (Mitigation Measures), and that impacts are not anticipated, long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the incidental taking of bottlenose dolphins.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Bottlenose dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no bottlenose dolphins would be impacted. Considering the mitigation measures that will be implemented as described in Section 2.3.4 (Mitigation Measures), and that impacts are not anticipated, long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the incidental taking of bottlenose dolphins.

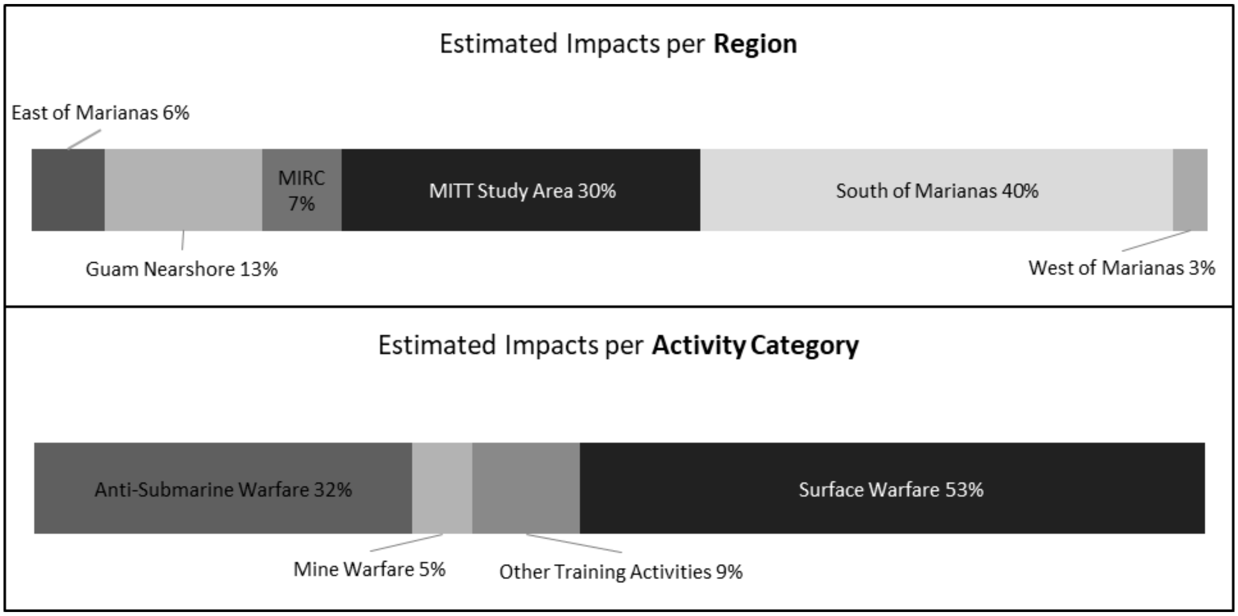
Kogia Whales

Kogia whales include two species that are often difficult to distinguish from one another: dwarf sperm whales and pygmy sperm whales; however, impacts to the populations of dwarf and pygmy sperm whales are modeled separately. TTS and PTS thresholds for high-frequency cetaceans, such as Kogia whales are lower than for all other marine mammals, which leads to a higher number of estimated hearing loss impacts relative to the number of animals exposed to the sound as compared to other hearing groups (e.g., mid-frequency cetaceans).

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Kogia whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions, TTS, and PTS during training and testing activities (Figure 3.4-78, Figure 3.4-79, Table 3.4-90, and Table 3.4-91). Estimated impacts most years would be less based on fewer explosions. Impact ranges for these species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any 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, a small threshold shift due to exposure to explosive energy and sound is unlikely to affect the hearing range that kogia species rely upon. Nevertheless, PTS could have minor long-term consequences for individuals. This minor consequence for an individual is unlikely to have any long-term consequences for the species. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of dwarf and pygmy sperm whales incidental to those activities.



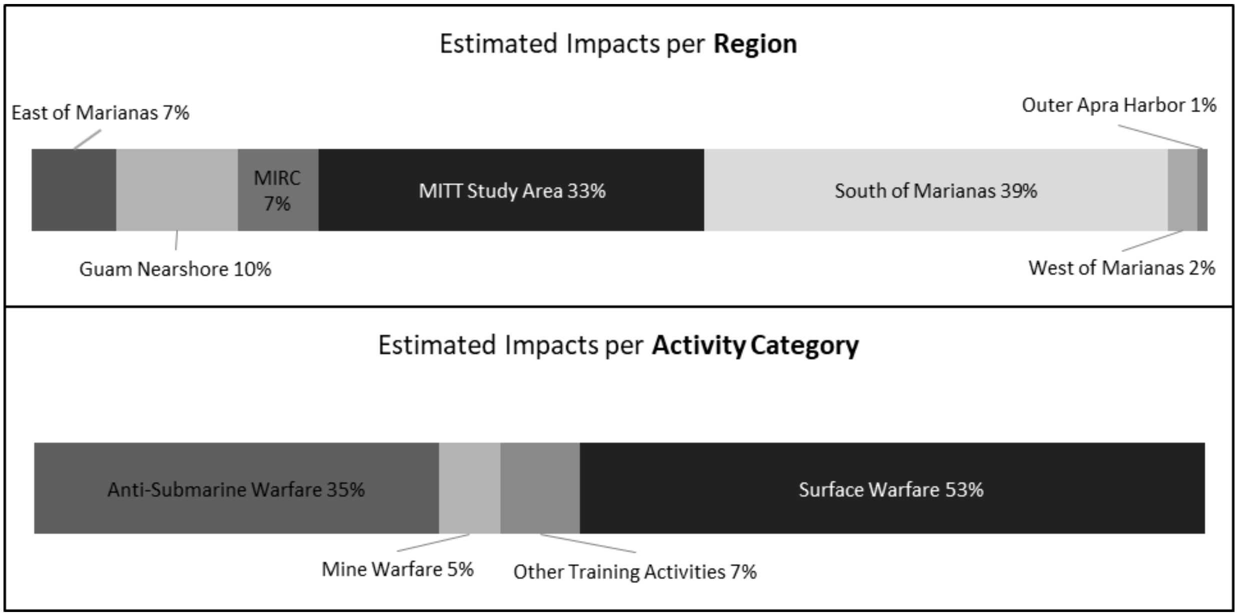
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-78: Dwarf Sperm Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-90: Estimated Impacts on Individual Dwarf Sperm Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
58	92	18	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-79: Pygmy Sperm Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-91: Estimated Impacts on Individual Pygmy Sperm Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

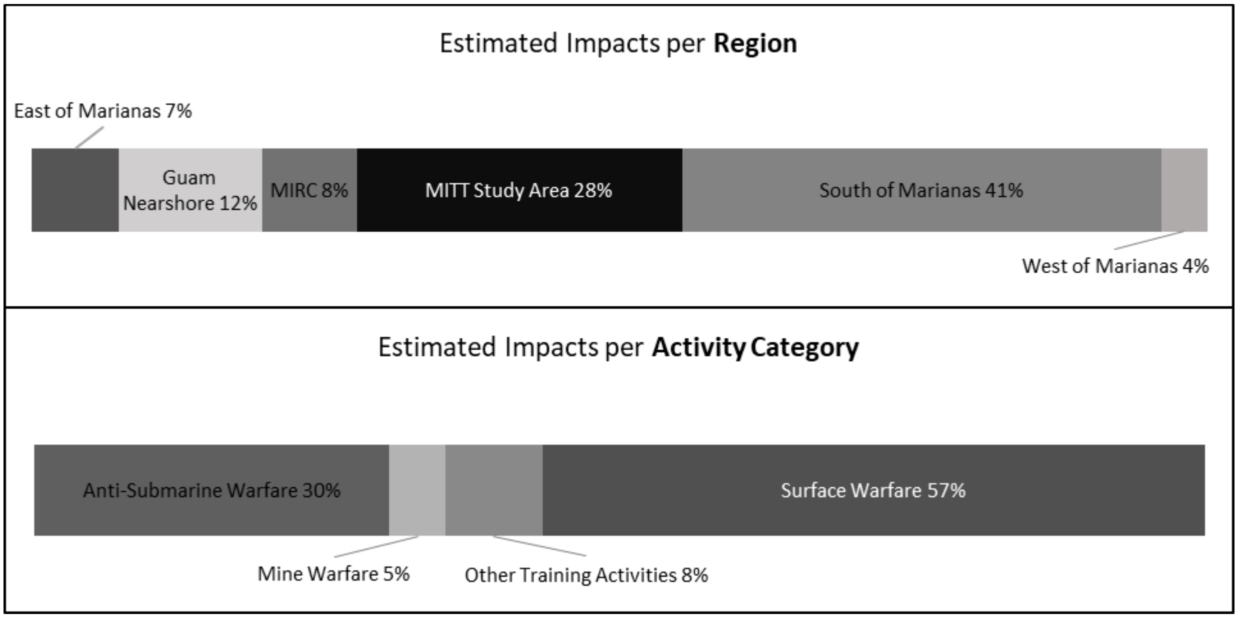
Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
23	33	8	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

<u>Impacts from Explosives Under Alternative 2 for Training and Testing Activities</u>

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly (Figure 3.4-80, Figure 3.4-81, Table 3.4-92, and Table 3.4-93) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of dwarf and pygmy sperm whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



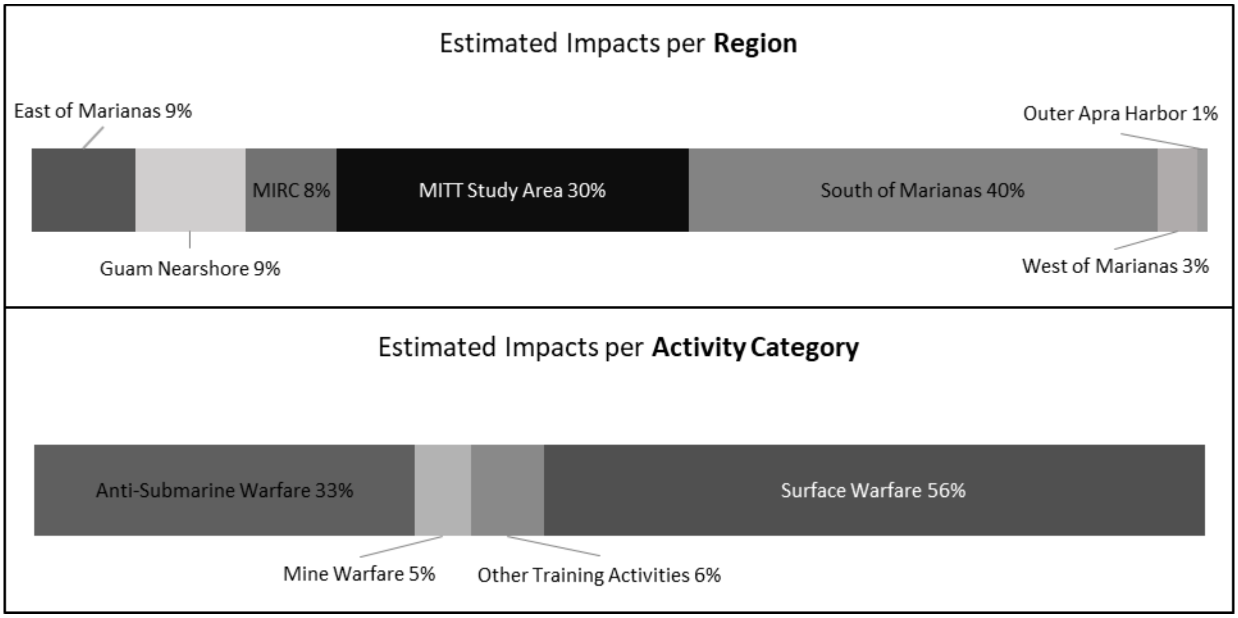
Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-80: Dwarf Sperm Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-92: Estimated Impacts on Individual Dwarf Sperm Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
64	100	21	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Alternative 2.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-81: Pygmy Sperm Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-93: Estimated Impacts on Individual Pygmy Sperm Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
25	37	8	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Alternative 2.

False Killer Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

False killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no false killer whales would be impacted. Considering the mitigation measures that will be implemented as described in Section 2.3.4 (Mitigation Measures), and that impacts are not anticipated, long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the incidental taking of false killer whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

False killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no false killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

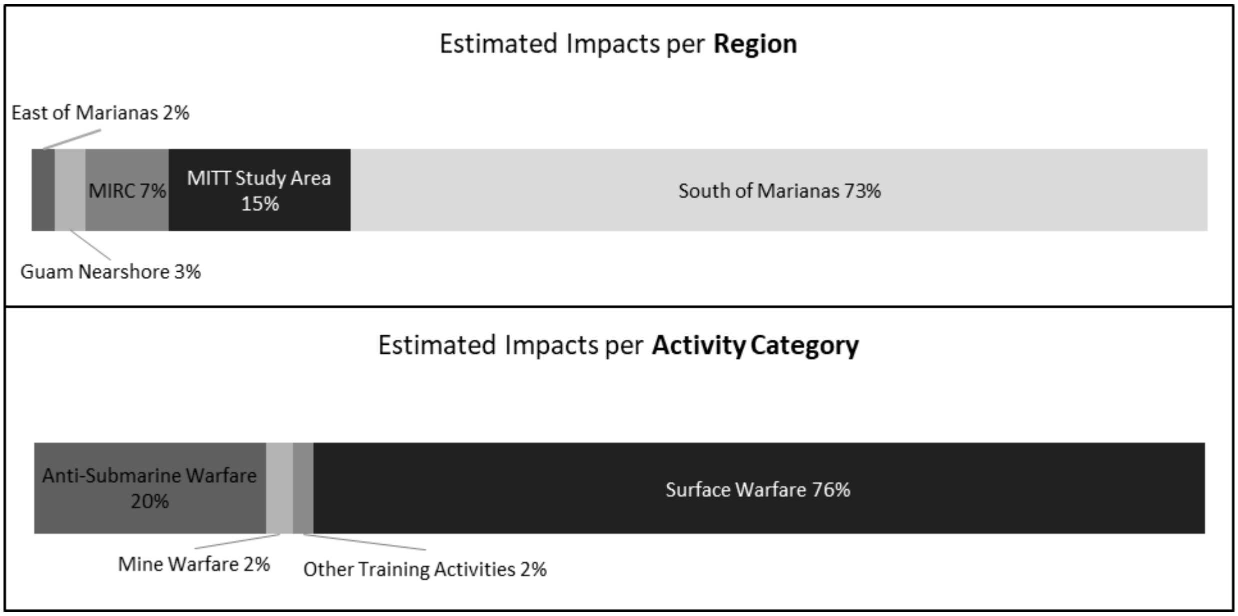
Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the incidental taking of false killer whales.

Fraser's Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Fraser's dolphin may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 1, estimates behavioral reaction, TTS, and PTS during training and testing activities (Figure 3.4-82 and Table 3.4-94). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any 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, a small threshold shift due to exposure to explosive energy and sound is unlikely to affect the hearing range that pantropical spotted dolphins rely upon. Nevertheless, PTS could have minor long-term consequences for individuals. This minor consequence for an individual is unlikely to have any long-term consequences for the species. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of Fraser's dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-82: Fraser's Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-94: Estimated Impacts on Individual Fraser's Dolphins Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

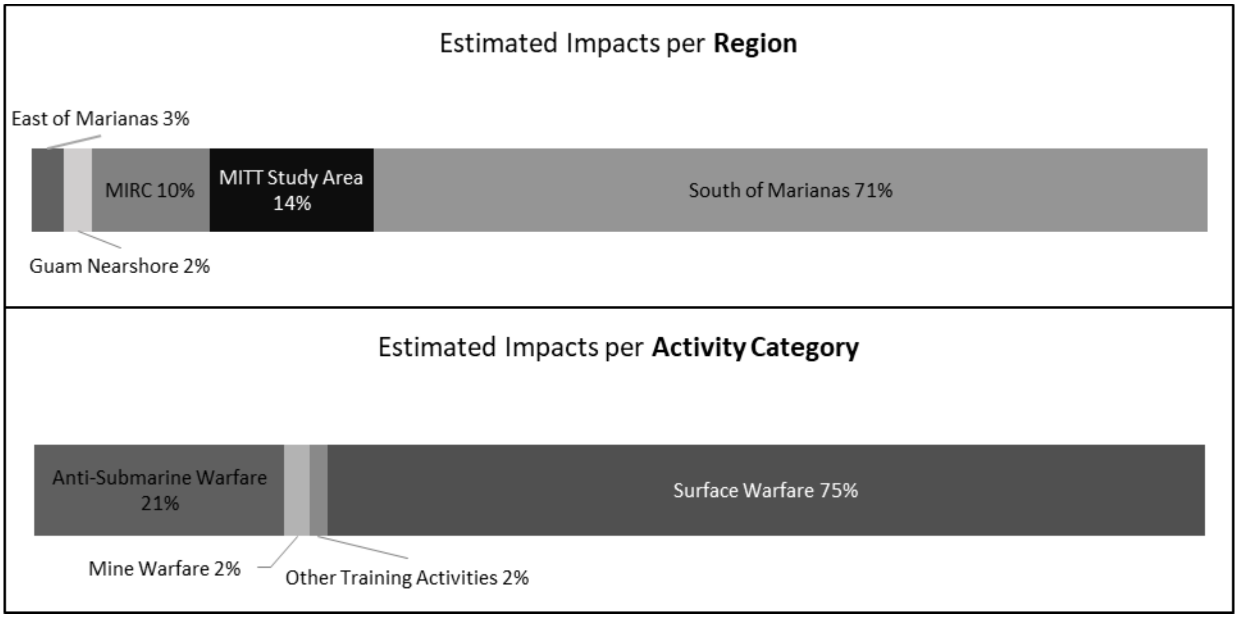
Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
4	4	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would increase slightly (Figure 3.4-83 and Table 3.4-95) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of Fraser's dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-83: Fraser's Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-95: Estimated Impacts on Individual Fraser's Dolphins Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
4	5	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under the Alternative 2.

Killer Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no killer whales would be impacted. Considering the mitigation measures that will be implemented as described in Section 2.3.4 (Mitigation Measures), and that impacts are not anticipated, long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the incidental taking of killer whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

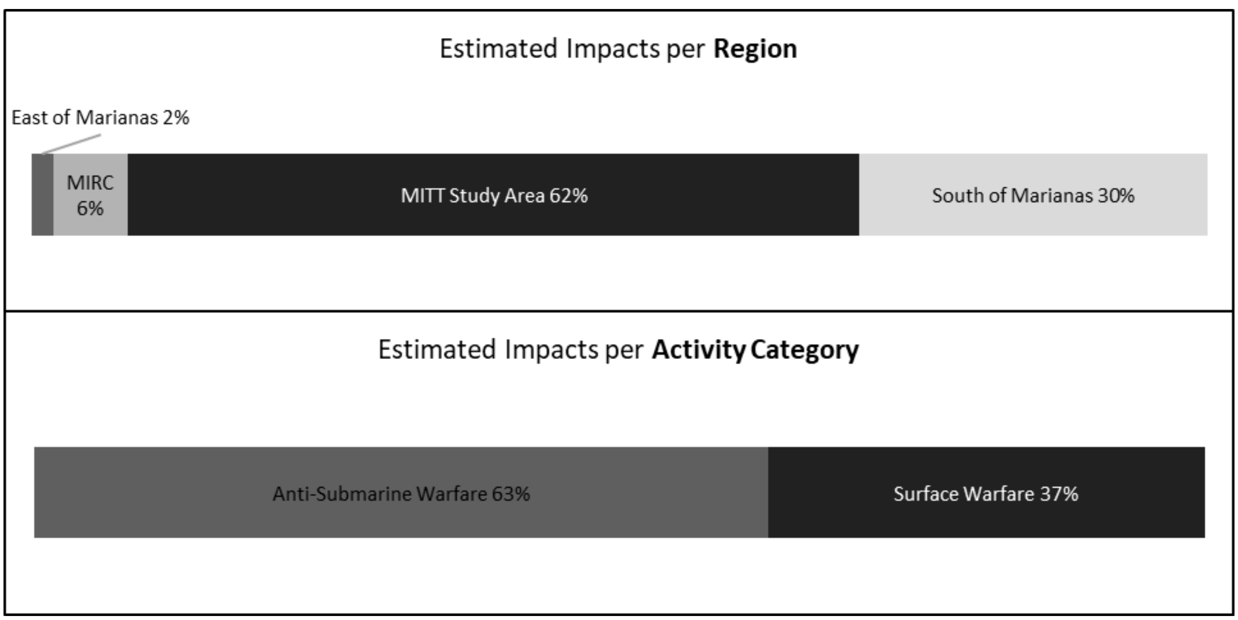
Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the incidental taking of killer whales.

Melon-Headed Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Melon-headed whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 1, estimates behavioral reaction and TTS during training and testing activities (Figure 3.4-84 and Table 3.4-96). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of melon-headed whales incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-84: Melon-Headed Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-96: Estimated Impacts on Individual Melon-Headed Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

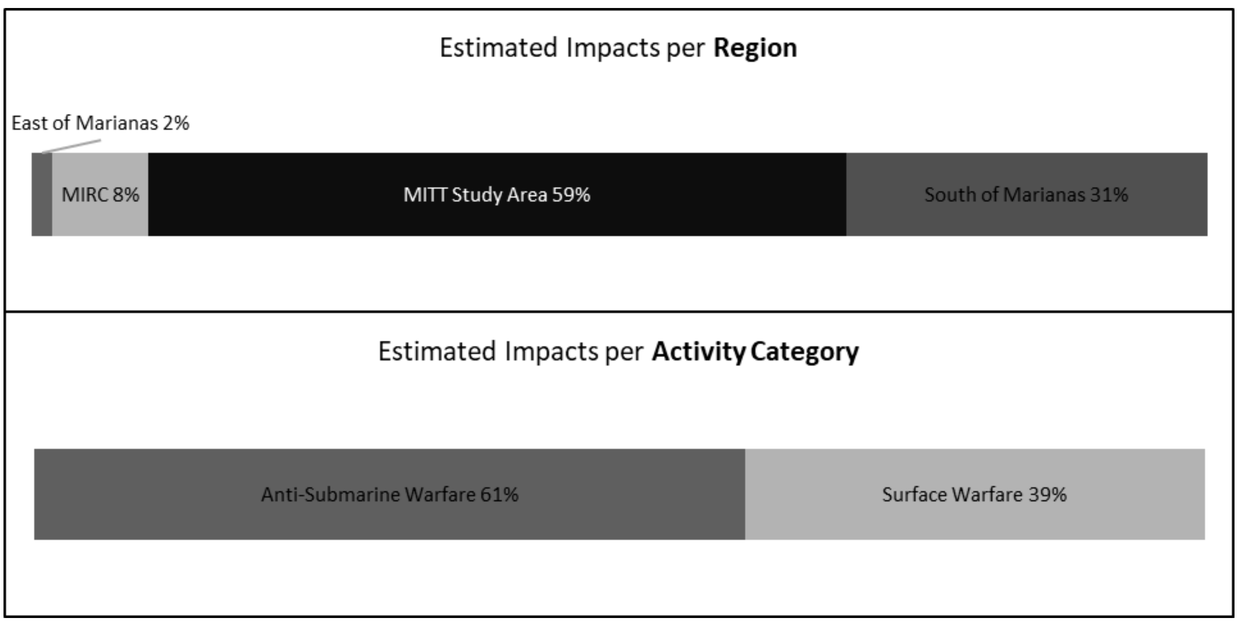
Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly by activity and location (Figure 3.4-85 and Table 3.4-97) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities; however, the total number of impacts would remain the same.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of melon-headed whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-85: Melon-Headed Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-97: Estimated Impacts on Individual Melon-Headed Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

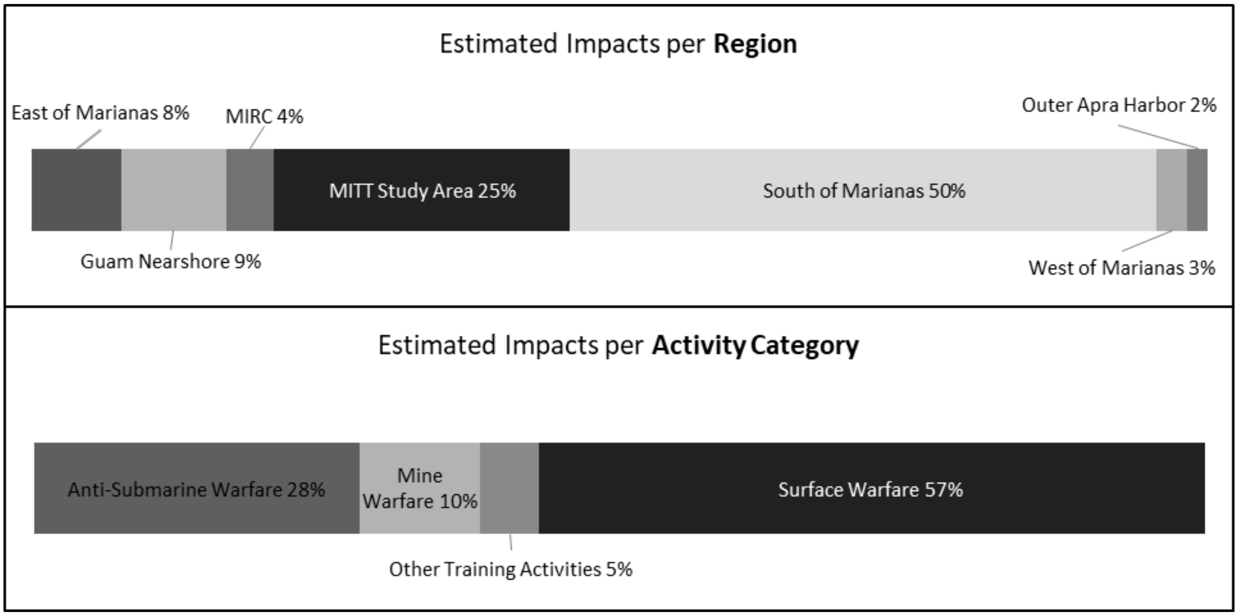
Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Pantropical Spotted Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Pantropical spotted dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosives per year under Alternative 1, estimates behavioral reactions, TTS, and PTS during training and testing activities (Figure 3.4-86 and Table 3.4-98). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any 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, a small threshold shift due to exposure to explosive energy and sound is unlikely to affect the hearing range that pantropical spotted dolphins rely upon. Nevertheless, PTS could have minor long-term consequences for individuals. This minor consequence for an individual is unlikely to have any long-term consequences for the species. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of pantropical spotted dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-86: Pantropical Spotted Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-98: Estimated Impacts on Individual Pantropical Spotted Dolphins Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

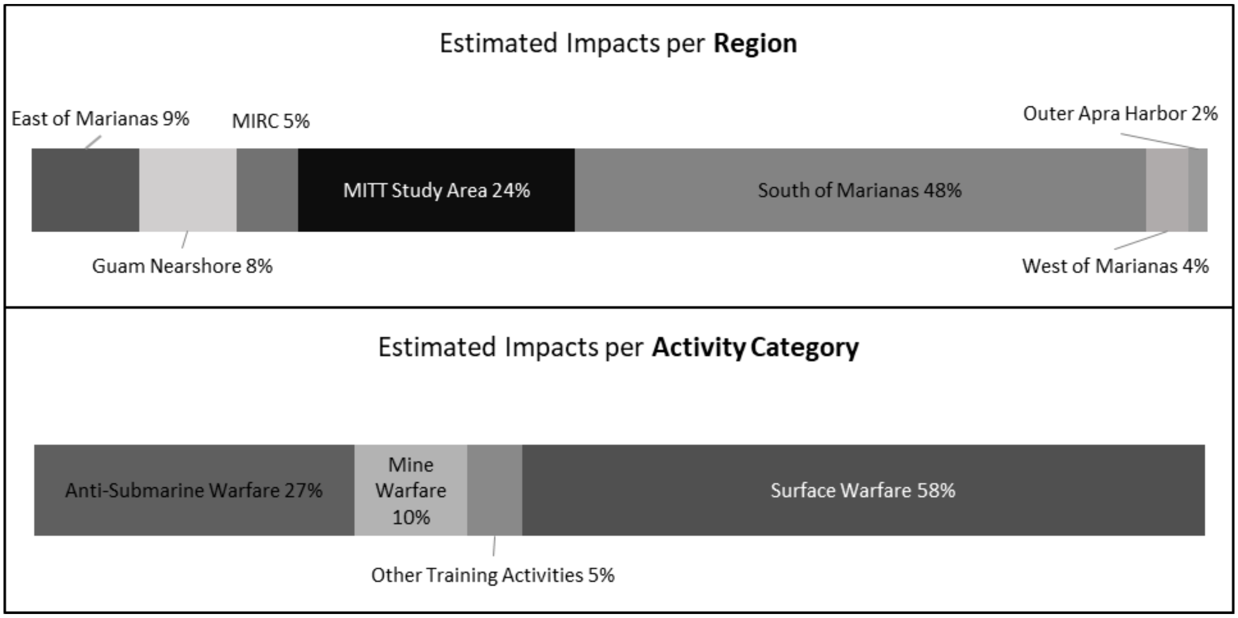
Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
4	2	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would increase slightly (Figure 3.4-87 and Table 3.4-99) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of pantropical spotted dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-87: Pantropical Spotted Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-99: Estimated Impacts on Individual Pantropical Spotted Dolphins Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
4	3	1	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Pygmy Killer Whale

<u>Impacts from Explosives Under Alternative 1 for Training and Testing Activities</u>

Pygmy killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no pygmy killer whales would be impacted. Considering the mitigation measures that will be implemented as described in Section 2.3.4 (Mitigation Measures), and that impacts are not anticipated, long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the incidental taking of pygmy killer whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Pygmy killer whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no pygmy killer whales would be impacted. Long-term consequences for individuals or the species would not be expected.

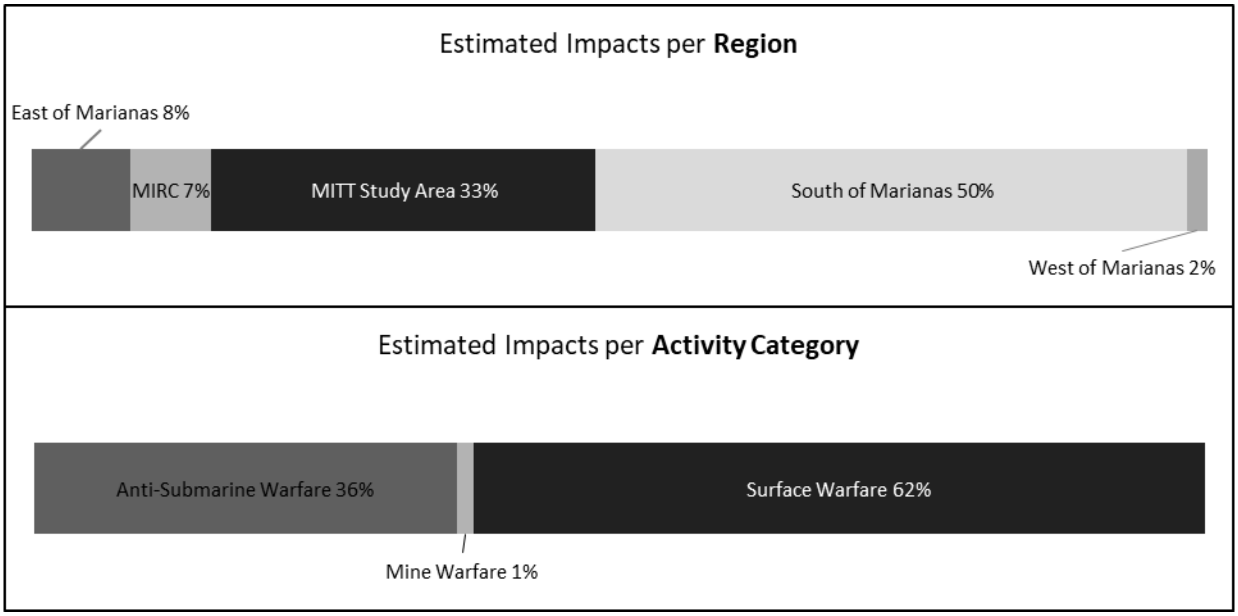
Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the incidental taking of pygmy killer whales.

Risso's Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Risso's dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 1, estimates a behavioral reaction and TTS during training and testing activities (Figure 3.4-88 and Table 3.4-100). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS or behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of Risso's dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-88: Risso's Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-100: Estimated Impacts on Individual Risso's Dolphin Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

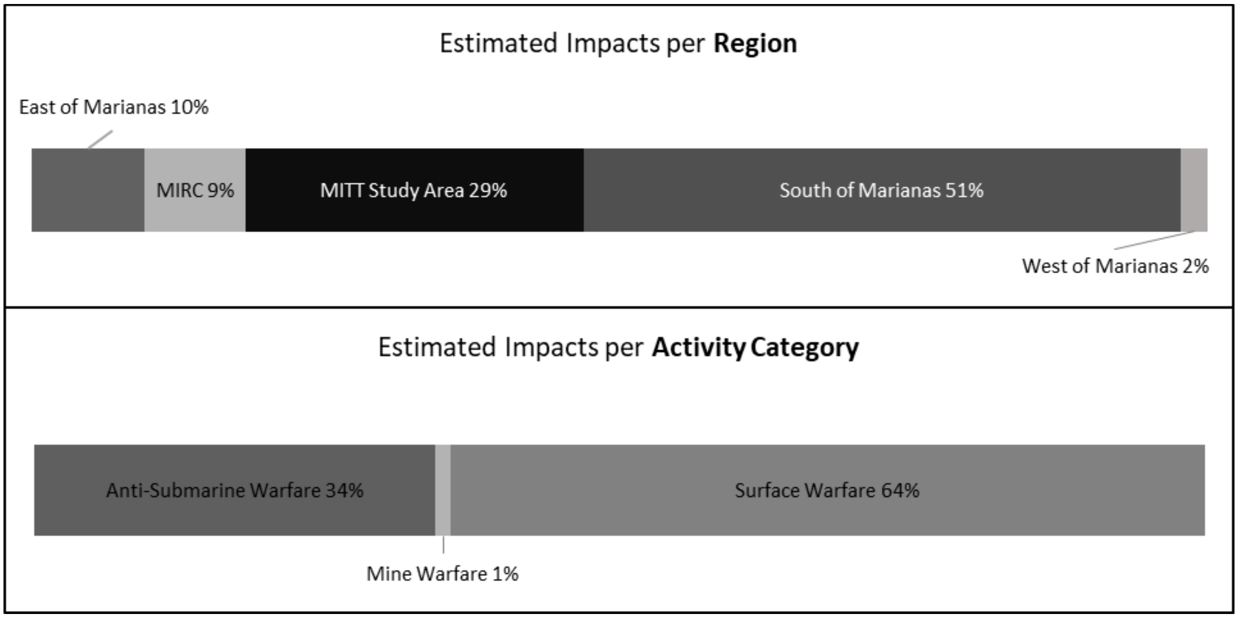
Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly (Figure 3.4-89 and Table 3.4-101) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of Risso's dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-89: Risso's Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-101: Estimated Impacts on Individual Risso's Dolphin Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Rough-Toothed Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Rough-toothed dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no rough-toothed dolphins would be impacted. Considering the mitigation measures that will be implemented as described in Section 2.3.4 (Mitigation Measures), and that impacts are not anticipated, long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the incidental taking of rough-toothed dolphins.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Rough-toothed dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no rough-toothed dolphins would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the incidental taking of rough-toothed dolphins.

Short-Finned Pilot Whale

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

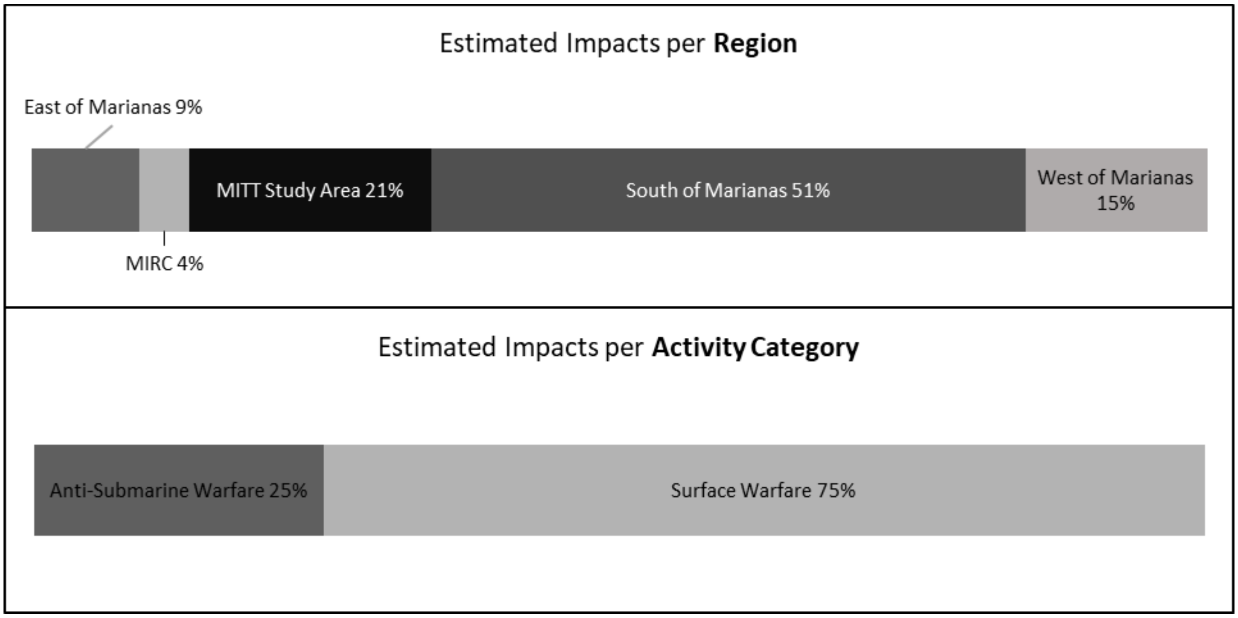
Short-finned pilot whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates that no short-finned pilot whales would be impacted. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would not result in the incidental taking of short-finned pilot whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Short-finned pilot whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 2, estimates behavioral reaction during training and testing activities (Figure 3.4-90 and Table 3.4-102). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate behavioral reactions to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of short-finned pilot whales incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-90: Short-Finned Pilot Whale Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-102: Estimated Impacts on Individual Short-Finned Pilot Whales Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	0	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Sperm Whale (Endangered Species Act-Listed)

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Sperm whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis estimates that any exposures to sperm whales would not result in impacts rising to a level of take. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing 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 and testing activities as described under Alternative 1 would not affect ESA-listed sperm whales.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Sperm whales may be exposed to sound or energy from explosions associated with training and testing activities throughout the year, although the quantitative analysis estimates any exposures to sperm whales would not result in impacts rising to a level of take. Long-term consequences for individuals or the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would not result in the incidental taking of sperm whales.

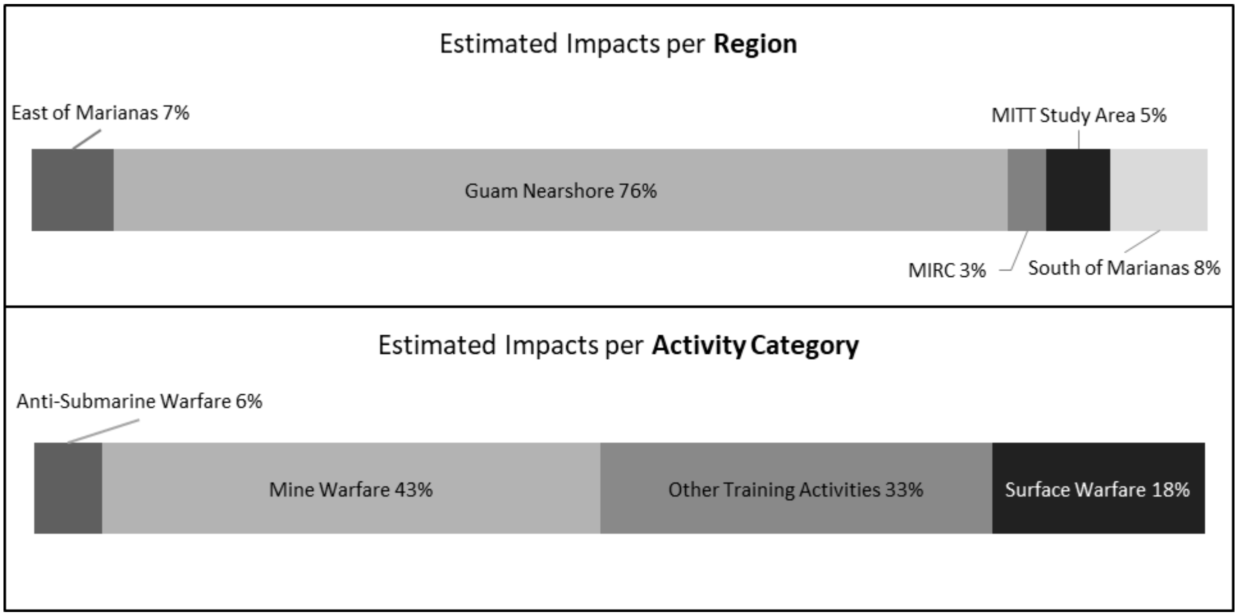
Pursuant to the ESA, the use of explosives during training and testing activities as described under Alternative 2 would not affect ESA-listed sperm whales.

Spinner Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Spinner dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 1, estimates TTS during training and testing activities (Figure 3.4-91 and Table 3.4-103). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. In addition to procedural mitigation, the Navy will not use in-water explosives during training and testing within the Agat Bay Nearshore Mitigation Area, where spinner dolphins have been observed resting, as described in Chapter 5 (Mitigation). Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of spinner dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-91: Spinner Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-103: Estimated Impacts on Individual Spinner Dolphins Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

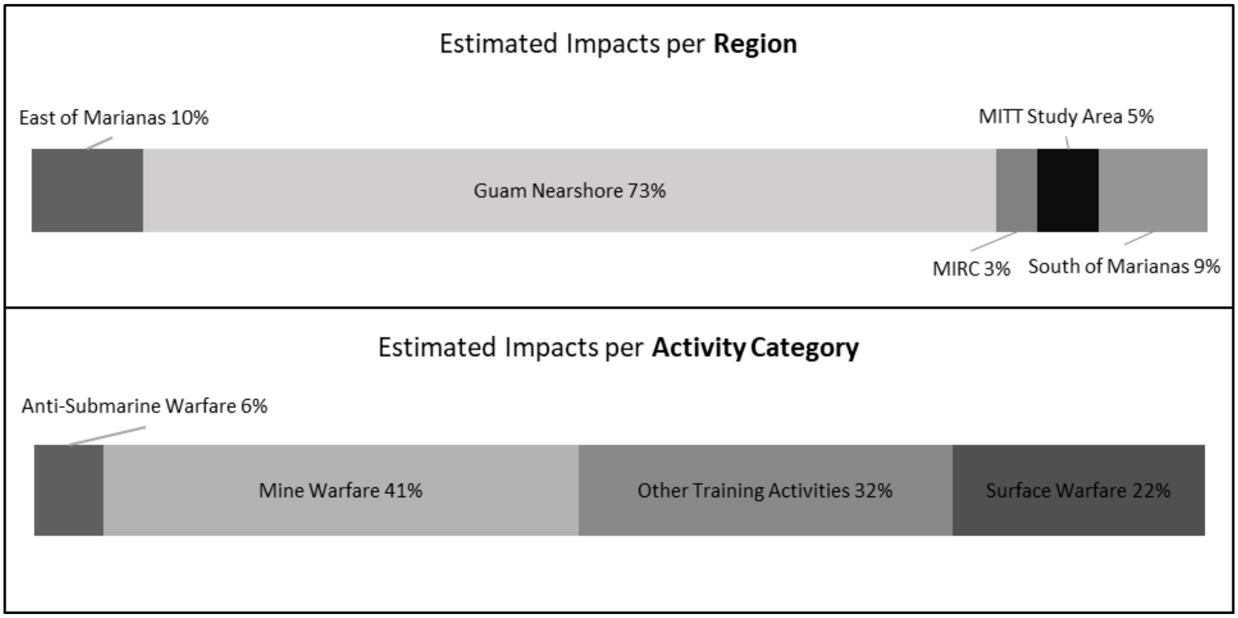
Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
0	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Spinner dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 2, estimates TTS and PTS during training and testing activities (Figure 3.4-92 and Table 3.4-104). Estimated impacts most years would be less based on fewer explosions. As described for odontocetes above, even a few minor to moderate TTS to an individual over the course of a year are unlikely to have any 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, a small threshold shift due to exposure to explosive energy and sound is unlikely to affect the hearing range that spinner dolphins rely upon. Nevertheless, PTS could have minor long-term consequences for individuals. This minor consequence for an individual is unlikely to have any long-term consequences for the species. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of spinner dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-92: Spinner Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-104: Estimated Impacts on Individual Spinner Dolphins Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
0	1	1	0

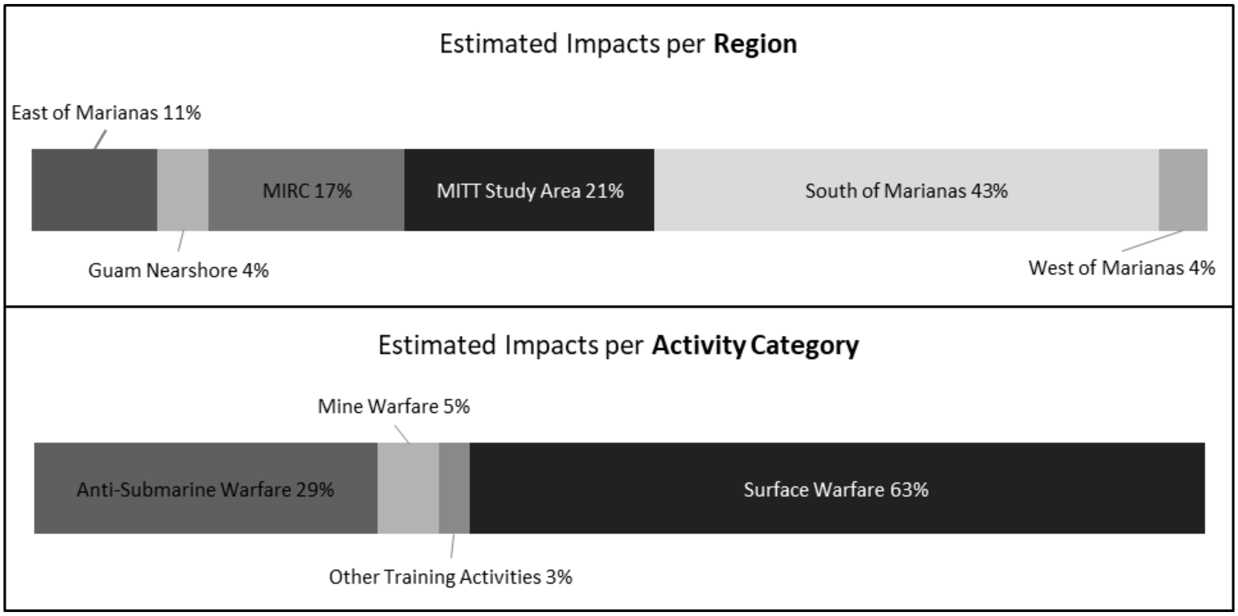
Note: Estimated impacts are based on the maximum number of activities in a given year under the Alternative 2.

Striped Dolphin

Impacts from Explosives Under Alternative 1 for Training and Testing Activities

Striped dolphins may be exposed to sound or energy from explosions associated with training and testing activities throughout the year. The quantitative analysis, using the maximum number of explosions per year under Alternative 1, estimates behavioral reaction and TTS during training and testing activities (Figure 3.4-93 and Table 3.4-105). Estimated impacts most years would be less based on fewer explosions. Impact ranges for this species are discussed in Section 3.4.2.2.2.2 (Impact Ranges for Explosives). As described for odontocetes above, even a few minor to moderate TTS or behavioral reaction to an individual over the course of a year are unlikely to have any significant costs or long-term consequences for that individual. Considering these factors and the mitigation measures that will be implemented as described in Chapter 5 (Mitigation), long-term consequences for the species would not be expected.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 1 would result in the unintentional taking of striped dolphins incidental to those activities.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-93: Striped Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.4-105: Estimated Impacts on Individual Striped Dolphins Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

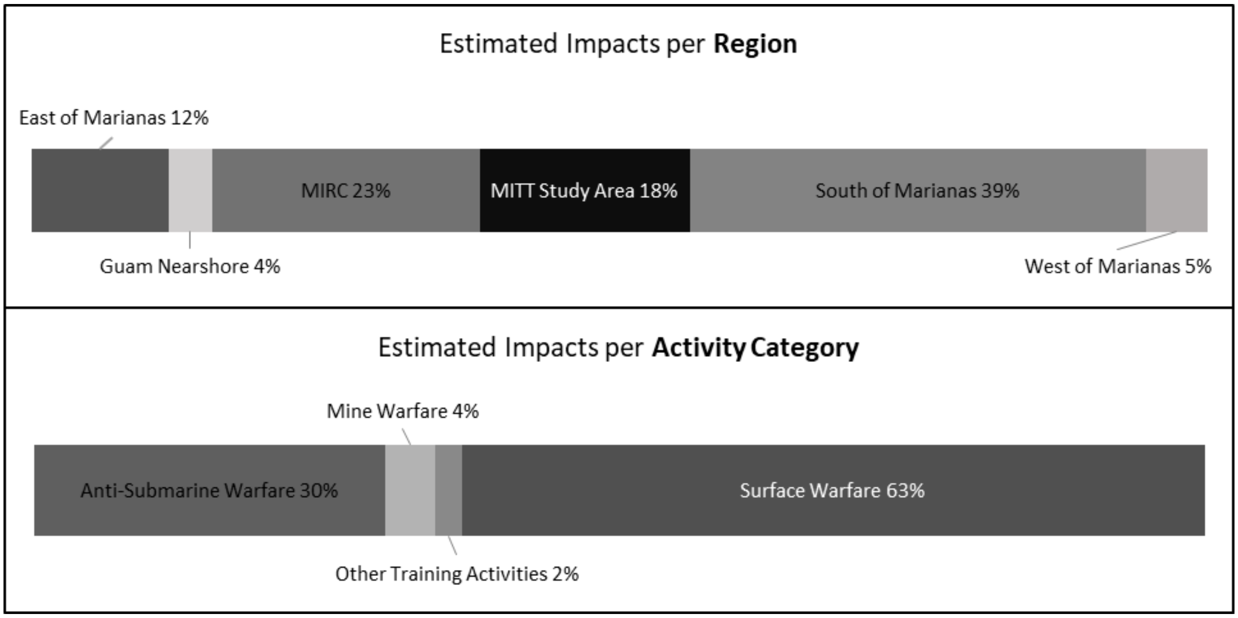
Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Impacts from Explosives Under Alternative 2 for Training and Testing Activities

Potential annual impacts under Alternative 2 from training and testing with explosives would differ slightly (Figure 3.4-94 and Table 3.4-106) compared to the impacts shown and discussed above in Impacts from Explosives Under Alternative 1 for Training and Testing Activities; however, the total number of impacts would remain the same.

Pursuant to the MMPA, the use of explosives during training and testing activities as described under Alternative 2 would result in the unintentional taking of striped dolphins incidental to those activities. The Navy is requesting authorization from NMFS as required by Section 101(a)(5)(A) of the MMPA.



Notes: (1) Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided among multiple regions or activity categories. (2) MIRC = Mariana Islands Range Complex

Figure 3.4-94: Striped Dolphin Impacts Estimated per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 2

Table 3.4-106: Estimated Impacts on Individual Striped Dolphins Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect			
Behavioral	***TTS***	***PTS***	***Injury***
1	1	0	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

3.4.2.2.2.4 Impacts from Explosive Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Explosive stressors, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that use explosives within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from explosive stressors on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.3 Energy Stressors

Energy stressors are discussed in Section 3.0.4.3 (Energy Stressors) of this SEIS/OEIS. The energy stressors that may impact marine mammals include in-water electromagnetic devices and high-energy lasers. NMFS has previously determined in documents and analyses associated with two prior Navy training and testing EIS/OEISs within the MITT Study Area that in-water electromagnetic devices would not result in harassment or the incidental taking of marine mammals (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). These determinations for this stressor were recently reaffirmed for a third time by NMFS for the same actions elsewhere (83 FR 10954, 83 FR 29872, 83 FR 66846, and 83 FR 57076). Since the 2015 MITT Final EIS/OEIS and with the increased use of undersea power cables associated with offshore energy generation, there has been renewed scientific interest in electromagnetic fields possibly affecting migrating marine mammals (Gill et al., 2014; Kremers et al., 2014; Kremers et al., 2016; Zellar et al., 2017). Horton et al. (2017) have indicated that future experiments involving empirical observation of free-ranging animals are still required for there to be sufficient evidence demonstrating causal relations between marine mammal movement decisions and environmental cues such as the earth's magnetic field. These additional scientific findings do not change in any way the rationale for the dismissal of in-water electromagnetic devices as presented in the 2015 analyses given a negligible or discountable impact on marine mammal populations or species.

The 2015 MITT Final EIS/OEIS covered the use of low-energy lasers in Section 3.0.5.2.2.3 (Lasers), but high-energy laser weapons were not part of the Proposed Action in the 2015 MITT Final EIS/OEIS. The use of high-energy lasers represents a new sub-stressor as part of an existing activity in this SEIS/OEIS. As discussed in this SEIS/OEIS, Section 3.0.4.3.2.2 (High-Energy Lasers), high-energy lasers are designed to disable surface targets, rendering them immobile. The primary concern is the potential for a marine mammal to be struck with the laser beam at or near the water's surface, where extended exposure could result in injury or death.

As described in Section 3.0.4.3.2 (Lasers), high-energy laser weapons testing activities involve evaluating the effectiveness of a high-energy laser deployed from a surface ship to create small but critical failures in potential targets from short ranges. The concern with the proposed use of high-energy lasers is the potential for a marine mammal to be exposed to the laser beam if the laser beam missed the target, if the animal was above the ocean surface, and if the animal was in the direct path of the laser beam in front of or directly behind the target. The Navy conducted statistical modeling to estimate the probability of a marine mammal being struck by a high-energy laser during training and testing activities. The probability was estimated for a location off Southern California where the density of marine mammals is generally higher than in the Study Area and where more training and testing activities using high-energy lasers are conducted. The results of the analysis showed that there is a very low probability of a direct strike by a high-energy laser on a marine mammal, and that the likelihood of a strike occurring is therefore discountable (U.S. Department of the Navy, 2017d). Given that marine mammal densities are lower in the Study Area and fewer activities using high-energy lasers would be conducted in the Study Area, it is reasonable to conclude that the probability of a direct strike is even lower than predicted off Southern California. Therefore, it is reasonable to conclude that marine mammals in the Study Area are not likely to be struck by a high-energy laser. Training and testing activities have the potential to expose marine mammals that occur within the Study Area to this energy stressor. However, given the short ranges involved in the activities involving high-energy lasers, the aim point being a surface target, the inherent precision of the weapon and its targeting system, and the fact that marine mammals spend up to 90 percent of their time under the water (Costa, 1993; Costa & Block, 2009), indicates that impacts on marine mammals from high-energy lasers should not be expected to occur.

3.4.2.3.1 Impacts from Energy Stressors Under Alternative 1

Under Alternative 1, the number of proposed training and testing activities involving the use of in-water electromagnetic devices would decrease in comparison to the 2015 MITT Final EIS/OEIS (see Table 3.0-9). These activities would occur in the same locations and in a similar manner as previously analyzed. Therefore, as stated in the 2015 MITT Final EIS/OEIS and based on the new science summarized above, impacts on marine mammals from in-water electromagnetic devices are not expected.

Under Alternative 1, there would be up to 54 activities annually that include the use of high-energy lasers (Table 3.0-10). As discussed above, impacts on marine mammals from high-energy lasers are not expected because of the very low probability of a direct strike by a high-energy laser on a marine mammal.

Impacts on marine mammals from energy stressors, including in-water electromagnetic devices and high-energy lasers, are not expected to occur under Alternative 1.

Pursuant to the MMPA, the use of in-water electromagnetic devices and high-energy lasers as described under Alternative 1 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, the use of in-water electromagnetic devices and high-energy lasers as described under Alternative 1 may affect ESA-listed marine mammals.

3.4.2.3.2 Impacts from Energy Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of proposed training and testing activities involving energy stressors would be the same as Alternative 1 for in-water electromagnetic devices (Table 3.0-9). Under Alternative 2, the use of high-energy lasers would increase as compared to Alternative 1 (Table 3.0-10). There would be no change regarding the impact conclusions for energy stressors as summarized above under Alternative 1 and as presented in the 2015 MITT Final EIS/OEIS. Therefore, impacts on marine mammals under Alternative 2 from energy stressors, including high-energy lasers, are not expected to occur.

Pursuant to the MMPA, the use of in-water electromagnetic devices and high-energy lasers as described under Alternative 2 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, the use of in-water electromagnetic devices and high-energy lasers as described under Alternative 2 may affect ESA-listed marine mammals. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.

3.4.2.3.3 Impacts from Energy Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with the Proposed Action would continue to occur. Energy stressors from the use of in-water electromagnetic devices and high-energy lasers, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that produce energy stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from energy stressors on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.4 Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors are discussed in Section 3.0.4.4 (Physical Disturbance and Strike Stressors) of this SEIS/OEIS. The physical disturbance and strike stressors that may impact marine mammals include (1) vessels and in-water devices, (2) military expended materials, and (3) seafloor devices. The annual number of activities including vessels and in-water devices, the annual number of military expended materials, and the annual number of activities including seafloor devices are shown in Table 3.0-12 through Table 3.0-17 and Table 3.0-19.

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 MITT Study Area associated with any of the proposed training or testing activities. The Navy has several standard operating procedures and mitigation measures for vessel safety that will benefit marine mammals through a reduction in the potential for vessel strike, as discussed in Section 2.3.3 (Standard Operating Procedures) and Chapter 5 (Mitigation). Based on the absence of any Navy vessel strikes associated with the Proposed Action in the Study Area, the general reduction in strike incidents Navy-wide since introduction of the Marine Species Awareness Training in 2006, and the future reduction in vessel and in-water device use in comparison to the ongoing actions (see Tables 3.0-12 and 3.0-13), the Navy does not anticipate the occurrence of future vessel strikes to marine mammals within the Study Area during training and testing activities. For these reasons, the Navy is not requesting authorization of a take by vessel strike during Navy training and testing activities in the MITT 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 of the observers on the towing platform and other standard safety measures employed when towing in-water devices. In-water devices that could pose a higher risk to marine mammals are those operated at high speeds and unmanned, such as torpedoes. The Navy reviewed torpedo design features and a large number of previous anti-submarine warfare torpedo exercises to assess the potential of torpedo strikes on marine mammals. The tactical software that guides U.S. Navy torpedoes is sophisticated and should not identify a marine mammal as a target. All training and testing torpedoes are recovered after being fired at targets and are reconfigured for re-use. Review of the exercise torpedo records indicates there has never been an impact on a marine mammal. In thousands of exercises in which torpedoes were fired or in-water devices used, there have been no recorded or reported instances of a marine mammal strike.

As part of military expended materials, small-caliber munitions are inert, are meant to be aimed at targets, and are not long-range weapons. As a result, marine mammals are extremely unlikely to be disturbed or struck by expended small-caliber munitions. There have been no known instances of a seafloor device (such as an anchor) striking a marine mammal as it was being deployed or recovered.

In short, there have been no known instances of physical disturbance or strike to any marine mammals as a result of training and testing activities prior to or since the 2015 MITT Final EIS/OEIS. As described in Section 5.3.4 (Physical Disturbance and Strike Stressors), the Navy will continue to implement mitigation measures for applicable vessel movements, towed in-water devices, and military expended materials during non-explosive activities. The mitigation measures will further avoid or reduce the already low potential for impacts on marine mammals during activities involving physical disturbance or strike stressors.

NMFS has previously determined in documents and analyses associated with two prior Navy training and testing EIS/OEISs within the MITT Study Area that physical disturbance and strike stressors would not result in harassment or the incidental taking of marine mammals (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). There has been no subsequent emergent science that would necessitate changes to these conclusions, reached in association with the 2015 MITT Final EIS/OEIS analyses, regarding physical disturbance and strike stressors being dismissed as having a negligible or discountable impact on marine mammal populations or species.

3.4.2.4.1 Impacts from Physical Disturbance and Strike Stressors Under Alternative 1

Under Alternative 1, analysis of the individual sub-stressors including the use of vessels and in-water devices, military expended materials, and seafloor devices presented in Section 3.0.4.4 (Physical Disturbance and Strike Stressors) indicates that those items having the most potential to affect marine mammals have decreased in comparison to the 2015 MITT Final EIS/OEIS (Tables 3.0-12 through 3.0-17 and Table 3.0-19). This assumes the dismissal of small-caliber munitions for the reasons noted above.

Given the reduction in physical disturbance and strike stressors for this SEIS/OEIS, the findings presented in the 2015 MITT Final EIS/OEIS, Section 3.4.4.4 (Physical Disturbance and Strike Stressors), the MMPA authorization (80 FR 46112), and the NMFS Biological Opinion, the findings associated with the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015b) remain valid.

Pursuant to the MMPA, the use of vessels and in-water devices, military expended materials, and seafloor devices under Alternative 1 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, the use of vessels and in-water devices, military expended materials, and seafloor devices as summarized above under Alternative 1 may affect ESA-listed marine mammals.

3.4.2.4.2 Impacts from Physical Disturbance and Strike Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, physical disturbance and strike stressors during training and testing activities would decrease in comparison to the 2015 (Tables 3.0-12 through 3.0-17 and Table 3.0-19) assuming the dismissal of small-caliber munitions use for the reasons noted above. Under Alternative 2, there would be additional physical disturbance and strike stressors in comparison to Alternative 1, but the conclusions remain the same. Therefore, impacts on marine mammals from physical disturbance and strike stressors are not expected to occur.

Pursuant to the MMPA, the use of vessels and in-water devices, military expended materials, and seafloor devices under Alternative 2 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, the use of vessels and in-water devices, military expended materials, and seafloor devices under Alternative 2 may affect ESA-listed marine mammals. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.

3.4.2.4.3 Impacts from Physical Disturbance and Strike Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with the Proposed Action would continue to occur. Physical disturbance and strike stressors from the use of vessels and in-water devices, military expended materials, and seafloor devices, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing training and testing activities would result in fewer activities that produce physical disturbance and strike stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from physical disturbance and strike stressors on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.5 Entanglement Stressors

Entanglement stressors are discussed in Section 3.0.4.5 (Entanglement Stressors) of this SEIS/OEIS. Entanglement stressors considered for marine mammals include (1) wires and cables, and (2) decelerators/parachutes. The annual numbers of wires and cables and decelerators/parachutes proposed under the alternatives and in comparison to current ongoing activities are presented in Tables 3.0-22 through 3.0-24. There have been no known instances of any marine mammals being entangled in wires and cables, or decelerators/parachutes associated with Navy training and testing activities prior to or since the 2015 MITT Final EIS/OEIS.

NMFS has previously determined in documents and analyses associated with two prior Navy training and testing EIS/OEISs within the MITT Study Area that entanglement stressors would not result in harassment or the incidental taking of marine mammals (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). There has been no subsequent emergent science that would necessitate changes to these conclusions, reached in association with the 2015 MITT Final EIS/OEIS analyses, regarding this stressor being dismissed as having a negligible or discountable impact on marine mammal populations or species. These determinations for this stressor were recently reaffirmed for a third time by NMFS for the same actions elsewhere (83 FR 10954 & 83 FR 29872).

3.4.2.5.1 Impacts from Entanglement Stressors Under Alternative 1

Under Alternative 1, the annual number of entanglement stressors would decrease in comparison to the current ongoing activities (Tables 3.0-22 through 3.0-24). Therefore, the analysis from the 2015 MITT Final EIS/OEIS remains valid. The analysis presented in the 2015 MITT Final EIS/OEIS (Section 3.4.4.5, Entanglement Stressors), the MMPA authorization (80 FR 46112), and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015b) determined that entanglement stressors associated with the Navy's Proposed Action can be dismissed as having a negligible or discountable impact on marine mammal populations or species.

Pursuant to the MMPA, the use of wires and cables and decelerators/parachutes as described under Alternative 1 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, the use of wires and cables and parachutes/decelerators as described under Alternative 1 may affect ESA-listed marine mammals.

3.4.2.5.2 Impacts from Entanglement Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of entanglement stressors would decrease in comparison to current ongoing activities (Tables 3.0-22 through 3.0-24). In comparison to Alternative 1, there would be a slight increase under Alternative 2 for entanglement stressors; however, the combined number of annual entanglement stressors (fiber optic cable, guidance wire, and decelerators/parachutes) decreases when compared to the 2015 MITT Final EIS/OEIS. Therefore, the analysis and conclusions presented in the 2015 MITT Final EIS/OEIS (Section 3.4.4.5, Entanglement Stressors), the MMPA authorization (80 FR 46112), and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015b) remain valid. Impacts on marine mammals from the use of entanglement stressors are not anticipated.

Pursuant to the MMPA, the use of wires and cables and decelerators/parachutes as described under Alternative 2 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, the use of wires and cables and parachutes/decelerators as described under Alternative 2 may affect ESA-listed marine mammals. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.

3.4.2.5.2.1 Impacts from Entanglement Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with the Proposed Action would continue to occur. Entanglement stressors from the use of wires and cables and decelerators/parachutes, as described above, would not be introduced into the marine environment from the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer activities that use entanglement stressors within the marine environment where Navy training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from entanglement stressors on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.6 Ingestion Stressors

Ingestion stressors are discussed in Section 3.0.4.6 (Ingestion Stressors) of this SEIS/OEIS. Types of materials that could become ingestion stressors during training and testing in the Study Area include military expended materials – munitions and military expended materials – other than munitions. The annual number of activities including military expended materials are shown in Tables 3.0-14 through 3.0-17 and Tables 3.0-25 and 3.0-26. As discussed in Section 3.4.4.6.3 (Impacts from Munitions) of the

2015 MITT Final EIS/OEIS, the number of munitions and explosive munitions fragments that an individual marine mammal could encounter would generally be low, based on the patchy distribution of both the munitions and the habitats where marine mammals forage. For the more numerous small-caliber munitions, these expended material type items are inert, small, do not resemble prey items, and end up as part of the seafloor, where they are unlikely to be encountered by most marine mammals. In addition, it is assumed for marine mammal species that may feed at the seafloor, that they would not ingest every munition or munition's fragment encountered; if a munition or munition's fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. There is evidence indicating that even ingestion of certain metal items (e.g., hooks) may not result in injury or mortality to the individual (Wells et al., 2008; West, 2016).

NMFS has previously determined in documents and analyses associated with two prior Navy training and testing EIS/OEISs within the MITT Study Area that ingestion stressors would not result in harassment or the incidental taking of marine mammals (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). There has been no subsequent emergent science that would necessitate changes to these conclusions reached in association with the 2015 MITT Final EIS/OEIS analyses regarding this stressor being dismissed as having a negligible or discountable impact on marine mammal populations or species. These determinations for this stressor were recently reaffirmed for a third time by NMFS for the same actions elsewhere (83 FR 10954 & 83 FR 29872).

3.4.2.6.1 Impacts from Ingestion Stressors Under Alternative 1

Under Alternative 1, analysis of the individual sub-stressors presented in Section 3.0.4.6 (Ingestion Stressors) indicates that those items considered ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) having the most potential to affect marine mammals have decreased (Tables 3.0-14 through 3.0.17 and Tables 3.0-25 and 3.0-26). For the reasons noted above, the Navy has determined that potential impacts from ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) would not be substantially different from the 2015 MITT Final EIS/OEIS. In the 2015 analysis of training and testing activities within the Study Area, NMFS determined that ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) would not result in harassment or the incidental taking of marine mammals activities (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). The activities expending munitions and other military expended materials analyzed in this SEIS/OEIS under Alternative 1 are not a significant change over what was analyzed in the 2015 MITT Final EIS/OEIS, and there has been no new science necessitating a revision of the 2015 conclusions in that regard. Impacts on marine mammals from ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) associated with Navy activities in the Study Area are not anticipated.

Pursuant to the MMPA, the use of military expended materials as described under Alternative 1 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, the use of military expended materials as described under Alternative 1 may affect ESA-listed marine mammals.

3.4.2.6.2 Impacts from Ingestion Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the use of military expended materials would decrease under this SEIS/OEIS in comparison to the ongoing activities, with the exception of increased small-caliber munitions use (Tables 3.0-14 through 3-17 and Tables 3.0-25 and 3.0-26). Under Alternative 2, increases as compared to Alternative 1 do not change the impact conclusions for ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) as summarized above under Alternative 1 and as presented in the 2015 MITT Final EIS/OEIS. Therefore, impacts on marine mammals from ingestion of military expended materials under Alternative 2 are not expected.

Pursuant to the MMPA, the use of military expended materials as described under Alternative 2 would not result in the incidental taking of marine mammals.

Pursuant to the ESA, the use of military expended materials as described under Alternative 2 may affect ESA-listed marine mammals. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.

3.4.2.6.3 Impacts from Ingestion Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with the Proposed Action would continue to occur. Ingestion stressors from the use of military expended materials – munitions and military expended materials – other than munitions, as described above, would not be introduced into the marine environment under the Proposed Action. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of on-going training and testing activities. Discontinuing the training and testing activities would result in fewer activities that produce ingestion stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would reduce the potential for impacts from ingestion stressors on marine mammals, but would not measurably improve the overall distribution or abundance of marine mammals.

3.4.2.7 Secondary Stressors

As discussed in Section 3.4.4.7 (Secondary Stressors) of the 2015 MITT Final EIS/OEIS, secondary stressors from training and testing activities were analyzed for potential indirect impacts on marine mammals via habitat degradation or an effect on prey availability. These stressors included (1) explosives, (2) explosive byproducts and unexploded ordnance, (3) metals, (4) chemicals, and (5) transmission of marine mammal diseases and parasites. Analyses of the potential impacts on sediments and water quality are discussed in detail in Section 3.1 (Sediments and Water Quality) of the 2015 MITT Final EIS/OEIS and in Section 3.1 (Sediments and Water Quality) of this SEIS/OEIS. NMFS has previously determined in documents and analyses associated with two prior Navy training and testing EIS/OEISs within the MITT Study Area that secondary stressors would not result in harassment or the incidental taking of marine mammals (80 FR 46112) and would not result in significant adverse impacts or jeopardize the continued existence of any ESA-listed marine mammals (National Oceanic and Atmospheric Administration, 2015b). There has been no subsequent emergent science since 2015 that would necessitate changes to the analysis of secondary stressors being dismissed as having a negligible or discountable impact on marine mammal populations or species. These determinations for secondary stressors were recently reaffirmed for a third time by NMFS for the same actions elsewhere (83 FR 10954 and 83 FR 29872).

The current analysis has concluded that the relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment, from either high-order or low-order detonations, are relatively low and readily diluted. For example, degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen & Lotufo, 2010). Any remnant undetonated components from explosives such as TNT, royal demolition explosive, and high melting explosive experience rapid biological and photochemical degradation in marine systems (Cruz-Uribe et al., 2007; Juhasz & Naidu, 2007; Pavlostathis & Jackson, 2002; Singh et al., 2009; Walker et al., 2006).

For undetonated munitions, the concentration of unexploded ordnance, explosion byproducts, metals, and other chemicals would never exceed that of a World War II dump site, where studies found minimal concentrations were detected only within a few ft. of the ordnance (Briggs et al., 2016; Edwards & Bełdowski, 2016; Edwards et al., 2016a; Edwards et al., 2016b; Kelley et al., 2016; Koide et al., 2016; University of Hawaii, 2010). Annual surveys conducted in the waters off Farallon de Medinilla from 1999 through 2012 found no evidence that the habitat had changed or been adversely impacted to a significant degree by the training activities that have been conducted there (Smith & Marx, 2016). Therefore, long-term secondary effects on marine mammal habitat or prey would be negligible.

The potential transmission of diseases or parasites from Navy marine mammals to indigenous marine mammals is highly unlikely for the following reasons: the Navy marine mammals spend a very small amount of time in the open ocean; the Navy trainers have excellent control over the animals; the Navy follows procedures for the collection and proper disposal of marine mammal waste; the Navy's marine mammals are screened and receive exceptional veterinarian care; the Navy conducts visual monitoring for indigenous marine mammals to avoid any interactions with Navy marine mammals; and the Navy has a track record of over 40 years, with zero known incidents. As described in detail in Section 3.4.4.7.5 (Transmission of Marine Mammal Diseases and Parasites) in the 2015 MITT Final EIS/OEIS, there is no scientific basis to conclude that the use of Navy marine mammals during training and testing activities would have an indirect impact on wild marine mammals.

Pursuant to the MMPA, secondary stressors from training and testing activities, as described under Alternative 1, Alternative 2, and the No Action Alternative, would not result in the incidental taking of marine mammals.

Pursuant to the ESA, secondary stressors from training and testing activities, as described under Alternative 1, Alternative 2, and the No Action Alternative, may affect ESA-listed marine mammals. The Navy is consulting with NMFS as required by Section 7(a)(2) of the ESA.

3.4.3 Summary of Potential Impacts on Marine Mammals

As described in Section 3.0.5.4 (Resource-Specific Impacts Analysis for Multiple Stressors) in the 2015 MITT Final EIS/OEIS, this section evaluates the potential for combined impacts of all the stressors from the Proposed Action. The analysis and conclusions for the potential impacts from each of the individual stressors are discussed in Section 3.4.2.1 (Acoustic Stressors) through Section 3.4.2.6 (Ingestion Stressors) and, for ESA-listed species, summarized in Section 3.4.5 (Endangered Species Act Determinations).

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 Navy presented in the 2015 MITT Final EIS/OEIS (Section 3.4.5, Summary of Impacts on Marine Mammals) and formed part of the 2015 analyses by NMFS in their MMPA authorization (80 FR 46112), and the Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015b).

Stressors associated with training and testing activities do not typically occur in isolation but rather occur in some combination. For example, mine neutralization activities include elements of acoustic, physical disturbance and strike, entanglement, 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 acoustic effects modeling, that the majority of exposures to stressors are non-lethal, 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 mine warfare event may include the use of a sound source 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, torpedoes, 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 training and testing 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 is more likely to occur at an instrumented range where training and testing activities using multiple platforms may be concentrated during a particular event. In such cases involving a relatively small area on an instrumented range, a behavioral reaction resulting in avoidance of the immediate vicinity of the activity would reduce the likelihood of exposure to additional stressors. Nevertheless, the majority of the proposed activities are unit-level training and testing activities, which are conducted in the open ocean. Unit-level events occur over a small spatial scale (one to a few square miles) and with few participants (usually one or two) or short duration (the order of a few hours or less).

Secondly, a marine mammal could be exposed to multiple training and testing activities over the course of its life; however, training and testing activities 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. However, animals with a home range intersecting an area of concentrated Navy activity have elevated exposure risks relative to animals that simply transit the area through a migratory corridor.

Multiple stressors may also have synergistic effects. For example, marine mammals that experience temporary hearing loss or injury from acoustic stressors could be more susceptible to physical disturbance and strike stressors through a decreased ability to detect and avoid threats. Marine mammals that experience behavioral and physiological consequences of ingestion stressors could be more susceptible to entanglement and physical strike stressors via malnourishment and disorientation. 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. To date, the majority of scientific investigations on this topic have been on marine mammals rather than marine mammals (Murray et al., 2020; National Academies of Sciences Engineering and Medicine, 2017). Based on current best available science, the effects of multiple synergistic stressors over time cannot be realistically or precisely modeled for marine mammals. The Navy's quantitative and qualitative analyses are consistently conservative and likely over-predict impacts on marine mammals.

Research and monitoring efforts have included before-, during-, and after-event observations and surveys; data collection through long-term studies in areas where the Navy conducts activities; 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 the types of impacts that animals may be experiencing in these areas. To date, the findings from the research and monitoring efforts and the regulatory conclusions from previous analyses by NMFS, including the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Marine Fisheries Service, 2015d; National Oceanic and Atmospheric Administration, 2015b), have been that the majority of impacts from training and testing activities are not expected to have deleterious impacts on the fitness of any individuals or long-term consequences to populations of marine mammals.

3.4.3.1 Combined Impacts of All Stressors Under Alternative 1

Although potential impacts on certain marine mammal species from training and testing activities under Alternative 1 may include injury to individuals, those injuries are not expected to lead to long-term consequences for populations. The potential impacts anticipated from Alternative 1 are summarized in Section 3.4.4 (Marine Mammal Protection Act Determinations) and Section 3.4.5 (Endangered Species Act Determinations) for each regulation applicable to marine mammals. For a discussion of cumulative impacts, see Chapter 4 (Cumulative Impacts). For a discussion of mitigation, see Chapter 5 (Mitigation). and Appendix I (Geographic Mitigation Assessment).

3.4.3.2 Combined Impacts of All Stressors Under Alternative 2 (Preferred Alternative)

As detailed previously in this section, some training and testing activities proposed under Alternative 2 would be an increase over what is proposed for Alternative 1. However, this increase is not expected to significantly increase the potential for impacts over what is analyzed for Alternative 1. The analysis presented in Section 3.4.3.1 (Combined Impacts of All Stressors Under Alternative 1) would similarly apply to Alternative 2. The combined impacts of all stressors for training and testing activities under Alternative 2 are not expected to have deleterious impacts or long-term consequences to populations of marine mammals.

3.4.3.3 Combined Impacts of All Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with the Proposed Action would continue to occur. All stressors associated with training and testing activities would not be introduced into the marine environment. Therefore, baseline conditions of the existing environment would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.4.3.4 Summary of Monitoring and Observations During Navy Activities Since 2015

As provided in detail in the 2015 MITT Final EIS/OEIS, Section 3.4.5.2 (Summary of Observations During Previous Navy Activities), the results of previous monitoring and research since 2006 taking place in and around Navy ranges and occurring before, during, and after Navy training and testing events, have been included as part of the Navy analyses as well as the analyses by NMFS in their MMPA authorization (National Oceanic and Atmospheric Administration, 2015b), and the Biological Opinion for the 2015 MITT Final EIS/OEIS (National Marine Fisheries Service, 2015c, 2017).

Since 2006, the Navy, non-Navy marine mammal scientists, and research groups and institutions have conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where the Navy has been and proposes to continue training and testing. The analysis provided in this SEIS/OEIS will be the third time Navy training and testing activities at sea have been comprehensively analyzed in the Study Area. Data collected from Navy monitoring, scientific research findings, and annual reports have been provided to NMFS; this public record is informative as part of the analysis of impacts on marine mammals in general for a variety of reasons, including species distribution, habitat use, and evaluation of potential responses to Navy activities.

Monitoring across Navy training and testing ranges is performed using a variety of methods, including visual surveys from surface vessels and aircraft; in addition, passive acoustics before, during, and after Navy activities have been conducted. The Navy also has continued to contribute to funding of basic research, including behavioral response studies specifically designed to determine the effects to marine mammals from the Navy's use of mid-frequency sonar and other transducers.

The majority of the training and testing activities Navy is proposing in the Study Area are similar if not nearly identical to activities that have been occurring in the same locations for decades. For example, the mid-frequency sonar system on the Navy's cruisers and destroyers training in the Study Area have the same sonar system components in the water as those first deployed in the 1970s. While the signal analysis and computing processes onboard these ships have been upgraded with modern technology, the sonar transducers, which put signals into the water, have not changed. For this reason, the history of past marine mammal observations, research, and monitoring remain applicable to the analysis of effects from the proposed future training and testing activities in the Study Area.

It is still the case that in the Pacific, the vast majority of scientific field work, research, and monitoring efforts have been expended in Southern California and Hawaii where Navy training and testing activities have been most concentrated. Since 2006, the Navy has been submitting exercise reports and monitoring reports to NMFS for the Navy's range complexes, including monitoring conducted before, during, and after training and testing activities. These publicly available exercise reports, monitoring reports, and the associated scientific research findings have been integrated into decisions regarding the focus for subsequent research and monitoring as determined in collaborations between Navy, NMFS, Marine Mammal Commission, and other marine resource subject matter experts using an adaptive management approach.

In the Study Area, because training and testing events are less frequent and general small in scope by comparison to other Navy areas, the majority of Navy's research effort has been focused elsewhere. Despite this, funding by the Navy has provided nearly the entirety of marine mammal science collected in the Mariana Islands. In fact, prior to Navy funding of marine mammal science, there had not been any dedicated marine mammal surveys performed in the Mariana Islands. The bulk of these Navy-funded research efforts span two primary methodologies: small-vessel surveys and bottom-moored acoustic deployments. These primary data collection methods have been supplemented by additional results from autonomous gliders acoustic survey, acoustic towed-arrays, visual survey from shore-stations, marine mammal observers on large-vessel surveys, and further analysis and collection of incidental and stranding data. Since the 2015 MITT Final EIS/OEIS, new research has continued to be funded by Navy in the Mariana Islands and has included, but is not limited to the following findings:

- The continuation of annual small vessel nearshore surveys, sightings, satellite tagging, biopsy and genetic analysis, photo-identification, and opportunistic acoustic recording off Guam, Saipan, Tinian, Rota, and Aguigan in partnership with NMFS (Hill et al., 2015b; Hill et al., 2016b; Hill et al., 2017a; Hill et al., 2018c; Hill et al., 2019). The satellite tagging and genetic analyses have resulted in the first information discovered on the movement patterns, habitat preference, and population structure of multiple odontocete species in the Study Area.
- Since 2015, the addition of a series of small vessel surveys in the winter season dedicated to humpback whales has provided new information relating to the occurrence, calving behavior, and population identity of this species (Hill et al., 2016a; Hill et al., 2017b; Hill et al., 2018c; Hill et al., 2019), which has not previously been sighted during the previous small vessel surveys in the summer or winter. This work has included sighting data, photo ID matches of individuals to other areas demonstrating migration as well as re-sights within the Mariana Islands across different years, and the collection of biopsy samples for genetic analyses of populations.
- The continued deployment of passive acoustic monitoring devices and analysis of acoustic data obtained using bottom-moored acoustic recording devices deployed by NMFS has provided information on the presence and seasonal occurrence of mysticetes, as well as the occurrence of cryptic odontocetes typically found offshore, including beaked whales and Kogia whales (Hill et al., 2015b; Hill et al., 2016a; Hill et al., 2016b; Hill et al., 2017a; Hill et al., 2018c; Munger et al., 2015; Norris et al., 2017; Oleson et al., 2015; Yack et al., 2016).
- Acoustic surveys using autonomous gliders were used to characterize the occurrence of odontocetes and mysticetes in abyssal offshore waters near Guam and Commonwealth of the Northern Mariana Islands, including species not seen in the small vessel visual survey series such as killer whales and Risso's dolphins. Analysis of collected data also provided new information on the seasonality of baleen whales, patterns of beaked whale occurrence and potential call variability, and identification of new unknown marine mammal calls (Klinck et al., 2016a; Nieukirk et al., 2016).
- Visual surveys were conducted from a shore-station at high elevation on the north shore of Guam to document the nearshore occurrence of marine mammals in waters where small vessel visual surveys are challenging due to regularly high sea states (Deakos & Richlen, 2015; Deakos et al., 2016).
- Analysis of archive data, including marine mammal sightings during Guam Department of Agriculture Division of Aquatic and Wildlife Resources aerial surveys undertaken between 1963 and 2012 (Martin et al., 2016).
- Analysis of archived acoustic towed-array data for an assessment of the abundance and density of minke whales (Norris et al., 2017), abundance and density of sperm whales (Yack et al., 2016), and the characterization of sei and humpback whale vocalizations (Norris et al., 2014).

As detailed in the 2015 MITT Final EIS/OEIS, these reporting, monitoring, and research efforts by the Navy have added to the baseline data for marine mammal species inhabiting the Study Area. In addition, subsequent research and monitoring across the Navy has continued to broaden the sample of observations regarding the general health of marine mammal populations in locations where Navy has been conducting training and testing activities for decades, which has been considered in the analysis of marine mammal impacts presented in this SEIS/OEIS in the same manner that the previous findings were used in the 2015 MITT Final EIS/OEIS, the NMFS authorization of takes under MMPA (National Oceanic and Atmospheric Administration, 2015b), and the NMFS Biological Opinion pursuant to the ESA (National Marine Fisheries Service, 2015c).

This public record of training and testing activities, monitoring, and research from across the Navy range complexes in the Pacific and Atlantic now spans more than 13 years. Given that this record involves many of the same Navy training and testing activities being considered for the Study Area, and includes all the marine mammal taxonomic families present in the Study Area, many of the same species, and perhaps some of the same populations as they seasonally migrate from other range complexes, this compendium of Navy reporting is directly applicable to the Study Area. It was the Navy's assessment in the 2015 MITT Final EIS/OEIS and that of NMFS, as reflected in their analysis of previous Navy training and testing in the Study Area (National Marine Fisheries Service, 2015c; National Oceanic and Atmospheric Administration, 2015b), that it was unlikely there would be impacts on populations of marine mammals (including whales and dolphins) having any long-term consequences as a result of the proposed continuation of training and testing in the Study Area. This assessment of likelihood is based on four indicators from areas in the eastern Pacific where Navy training and testing has been ongoing for decades: (1) evidence suggesting or documenting increases in the numbers of marine mammals present, (2) examples of documented presence and site fidelity of species and long-term residence by individual animals of some species, (3) use of training and testing areas for breeding and nursing activities, and (4) 13 years of comprehensive monitoring data indicating a lack of obvious observable effects such as direct mortalities or strandings occurring in marine mammal populations as a result of Navy training and testing activities. Consistent with the presentation in the 2015 MITT Final EIS/OEIS, the evidence to date and since 2015 continues to suggest the viability of marine mammal populations where the Navy trains and tests and does not show any direct evidence suggesting Navy training and testing has had or may have any long-term consequences to marine mammal populations. Barring any evidence to the contrary, therefore, what limited evidence there is from monitoring reports and additional other focused scientific investigations should be considered in the analysis of impacts on marine mammals. For the Study Area in particular and since the analysis in 2015, examples include

- the most current information suggesting that the ESA-listed blue whale population in the Pacific, which includes the 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., 2017d; Carretta et al., 2019c; Monnahan et al., 2015; Rockwood et al., 2017; Širović et al., 2015; Valdivia et al., 2019); and
- humpback whales continue to use Northern Mariana Islands as a winter calving area (Fulling et al., 2011; Hill et al., 2016a; Hill et al., 2017b; Hill et al., 2018b; Hill et al., 2018c; Hill et al., 2020).

To summarize and bring up to date the findings from the 2015 MITT Final EIS/OEIS, the evidence from reporting, monitoring, and research across the Pacific over more than a decade indicates that while the Proposed Action would result in harassment of marine mammals and may include injury to some individuals, these impacts are expected to be inconsequential at the level of their marine mammal populations. Monitoring of Navy training and testing will continue to confirm this expectation, as it has in the past in locations where Navy training and testing occurs. Across this past monitoring as well as the broader scientific literature, no direct evidence exists that routine Navy training and testing spanning decades has negatively impacted marine mammal populations at any Navy Range Complex or the Study Area. In particular, there is no evidence that would directly contradict the analysis in the 2015 MITT Final

EIS/OEIS or this SEIS/OEIS, such as the regular observation of strandings, injuries, or mortalities associated temporarily and spatially with Navy training and testing events.

For some of the most intensively used Navy training and testing areas, evidence such as the continued multi-year presence of long-term resident individual animals and small populations (Baird et al., 2015; Baird et al., 2016; Baird et al., 2017; Schorr et al., 2014; Schorr et al., 2018, 2019; U.S. Department of the Navy, 2017d), resident females documented with and without calves from year to year, and high abundances on the Navy ranges for some species in comparison to other off-range locations (Moore & Barlow, 2017; Schorr et al., 2018, 2019; U.S. Department of the Navy, 2017d), indicates generally healthy marine mammal populations. Therefore, based on the best available science, including data developed in exercise and monitoring reports submitted to NMFS for over a decade, long-term consequences for marine mammal populations are unlikely to result from Navy training and testing activities in the Study Area.

3.4.4 Marine Mammal Protection Act Determinations

As required by Section 101(a)(5)(A) of the MMPA, the Navy is seeking a Letter of Authorization from NMFS for the use of sonar and other transducers and explosives during Navy activities under Alternative 1 or Alternative 2 of the Proposed Action. 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, Level B harassment. Refer to Section 3.4.2.1.2 (Impacts from Sonar and Other Transducer Stressors) for details on the estimated impacts from sonar and other transducers and Section 3.4.2.2.2 (Impacts from Explosive Stressors) for impacts from explosives. Based on best available science, the Navy concludes that impacts from sonar and other transducers and from explosives to marine mammal species and stocks would result in only short-term effects on most individuals exposed and would not affect annual rates of recruitment or survival for the following reasons:

- Most acoustic exposures are within the non-injurious temporary threshold shift or behavioral effects zones (Level B harassment).
- Although the numbers presented in Appendix E (Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities) represent estimated harassment under the MMPA and they are conservative estimates (i.e., overpredictions) of harassment, primarily by behavioral disturbance.
- The Navy Acoustic Effects Model calculates harassment without taking into consideration mitigation measures, and is not indicative of a likelihood of either injury or harm. Additionally, the mitigation measures described in Chapter 5 (Mitigation) are designed to avoid or reduce sound exposure and explosive effects on marine mammals to levels below those that may cause injury and to achieve the least practicable adverse effect on marine mammal species or stocks.

Weapons noise, vessel noise, aircraft noise, the use of in-water electromagnetic devices, in-air electromagnetic devices, high-energy lasers, vessels, in-water devices, seafloor devices, wires and cables, decelerators/parachutes, and military expended materials are not expected to result in Level A or Level B harassment of any marine mammals.

3.4.5 Endangered Species Act Determinations

Pursuant to the ESA, Navy training and testing activities presented in this SEIS/OEIS may affect ESA-listed marine mammals. There is no designated critical habitat for any marine mammal species in the MITT Study Area. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA. The outcome of those consultations pursuant to ESA are described in this MITT Final SEIS/OEIS.

3.4.6 Public Comments

The public raised a number of issues during the scoping period and during public review and comment on the draft for this supplement in regard to marine mammals. Comments received from the public during the Draft SEIS/OEIS commenting period related to marine mammals are addressed in Appendix I (Public Comment Responses).

The issues are summarized in the list below.

- **Concern that there be analysis of impacts on marine mammals from various stressors associated with the Proposed Action (e.g., sonar, explosives, "chemical pollution," destruction of habitat) –** Section 3.4.2 (Environmental Consequences) analyzed potential impacts from sonar and other active acoustic stressors, explosives, electromagnetic energy, physical disturbances and strikes, entanglement, ingestion, and secondary stressors. Impacts from sonar and explosives were reanalyzed for several reasons described in Section 3.4.2.1 (Acoustic Stressors) and Section 3.4.2.2 (Explosive Stressors). The analysis of other stressors is summarized in the Section 3.4.2.3 (Energy Stressors) through Section 3.4.2.7 (Secondary Stressors) and described in detail in the 2015 MITT Final EIS/OEIS.
- **Concerns over the amount of take of marine mammals authorized –** The number and species of marine mammals exposed to sonar and explosives (the only stressors predicted to result in a "take" of a marine mammal) are presented in Section 3.4.2.1.2 (Impacts from Sonar and Other Transducer Stressors) and Section 3.4.2.2.2 (Impacts from Explosive Stressors). The vast majority of predicted impacts are behavioral reactions to sonar or explosives.
- **The analysis must address direct and cumulative impacts on marine mammals –** Direct impacts on marine mammals are addressed in the stressor sections above. A detailed analysis of impacts from acoustic and explosive stressors is provided in Section 3.4.2.1 (Acoustic Stressors) and Section 3.4.2.2 (Explosive Stressors). Impacts from other stressors are summarized in Section 3.4.2.3 (Energy Stressors) through Section 3.4.2.7 (Secondary Stressors) and described in detail in the 2015 MITT Final EIS/OEIS. Chapter 4 (Cumulative Impacts) addresses potential impacts from the Proposed Action in combination with other past, present, and future activities occurring in the Study Area. Cumulative impacts on marine mammals are likely when considering the variety of stressors (e.g., bycatch) that pose a threat to marine mammal populations. Refer to Section 3.4.1.7 (General Threats).
- **Recommendation that this SEIS/OEIS must evaluate alternatives that include temporal and habitat avoidance or time/area closures including restrictions on activities in areas biologically sensitive or important areas –** Regarding the development of alternatives considered, see Section 2.4 (Action Alternatives Development). With regard to the topic specifically, see Section 2.4.1.4 (Alternatives Including Geographic Mitigation Measures within the Study Area) for a discussion on why alternatives including these types of mitigation measures are not generally feasible. Appendix I (Geographic Mitigation Assessment) has been included in this SEIS/OEIS to further evaluate areas specifically identified in public scoping comments as areas to consider for geographic/temporal mitigation. Based on the analysis in Appendix I (Geographic Mitigation Assessment) in association with the MMPA and the ESA permitting processes, and other required regulatory consultations, consideration of geographic mitigation has been considered for implementation under both action alternatives.
- **This supplement must include analysis and description of mitigation measures implemented to reduce impacts on marine mammals –** Chapter 5 (Mitigation) provides a detailed description of mitigation measures associated with training and testing activities that would avoid or reduce potential impacts on marine mammals.

- **In-water surveys within the 3 miles around FDM should be conducted for marine mammals –** In-water surveys of marine resources within the 3 NM danger zone surrounding FDM have been conducted for more than a decade by Navy divers (see Smith and Marx (2009); Smith et al. (2013b); Smith and Marx (2016)). Research funding is allocated via the Integrated Comprehensive Monitoring Program (U.S. Department of the Navy, 2010, 2013a), which provides the overarching framework for coordination of the Navy's marine species research and monitoring efforts and serves as a planning tool to focus Navy monitoring priorities pursuant to ESA and MMPA requirements. The purpose of the Integrated Comprehensive Monitoring Program is to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of monitoring effort for each range complex based on a set of standardized objectives, regional expertise, and resource availability. Although the Integrated Comprehensive Monitoring Program does not identify specific field work or individual projects, it is designed to provide a flexible, scalable, and adaptable framework using adaptive management and strategic planning processes that periodically assess progress and reevaluate objectives. The adaptive management review process is anticipated to continue between the Navy, NMFS, and the Marine Mammal Commission through technical review meetings and ongoing discussions.
- **This supplement must include the most recently published science cetacean reports for the Mariana Archipelago –** Relevant literature published since the 2015 MITT Final EIS/OEIS has been used throughout Section 3.4 (Marine Mammals) of this SEIS/OEIS. This includes approximately 160 new references cited in the section, which were published between January 2016 and June 2018 in addition to additional emergent works of science that considered in the analysis although not necessarily cited in this section.
- **The EIS must analyze humpback whale calving areas discussed by Hill et al. (2017b) –** Section 3.4.1.11 (Humpback Whale (*Megaptera novaeangliae*)) presents the current information and references with regard to the presence of humpback whales in the Mariana Islands. Note that Hill et al. (2017b) did not identify the location specific calving areas in the Mariana Islands, but indicated, "that the Marianas are a wintering area." Subsequent to Hill et al. (2017b) and recently, scientists have confirmed the Mariana Islands as a new breeding location for humpback whales in the western North Pacific (Hill et al., 2018c; Hill et al., 2019; Hill et al., 2020; National Oceanic and Atmospheric Administration, 2018c). Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment) contain detailed discussions of potential mitigation measures that were evaluated, including temporal and geographic mitigation for areas where humpback whales have been routinely sighted as detailed in various reports (Fulling et al., 2011; Hill et al., 2015a; Hill et al., 2015b; Hill et al., 2016a; Hill et al., 2016b; Hill et al., 2017a; Hill et al., 2017b; Hill et al., 2018b; Hill et al., 2018c; Hill et al., 2019; National Marine Fisheries Service, 2019; National Oceanic and Atmospheric Administration, 2018c; Uyeyama, 2014). Based on the analysis in Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment), the MMPA and the ESA permitting processes, and other required regulatory consultations, practical science-based mitigation measures, including temporal or geographic constraints within the Study Area, would be implemented under Alternative 1 or Alternative 2.

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3.5 Sea Turtles

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3.5 Sea Turtles

3.5.1 Affected Environment

The purpose of this section is to supplement the analysis of impacts on sea turtles presented in the 2015 Mariana Islands Training and Testing (MITT) Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) with new information relevant to proposed changes in training and testing activities conducted at sea. Information presented in the 2015 MITT Final EIS/OEIS that remains valid is noted as such and referenced to the appropriate sections. Any new or updated information describing the affected environment and analysis of impacts on sea turtles associated with the Proposed Action is provided in this section. Comments received from the public during scoping related to sea turtles are addressed in Section 3.5.5 (Public Comments). Comments received from the public during the Draft Supplemental EIS (SEIS)/OEIS commenting period related to sea turtles are addressed in Appendix K (Public Comment Responses).

Only at-sea and Farallon de Medinilla (FDM) training and testing activities are subject to this SEIS/OEIS. Therefore, only effects within the nearshore and pelagic habitats for sea turtles are analyzed. The analysis of sea turtle presence and nesting on land presented in the 2015 MITT Final EIS/OEIS remains valid and continues to support these activities conducted within the Marianas.

The five sea turtle species potentially found in the Study Area are the same as those presented in the 2015 MITT Final EIS/OEIS and all are listed under the Endangered Species Act (ESA) as endangered or threatened (green sea turtle [*Chelonia mydas*], hawksbill sea turtle [*Eretmochelys imbricata*], loggerhead sea turtle [*Caretta caretta*], olive ridley sea turtle [*Lepidochelys olivacea*], and leatherback sea turtle [*Dermochelys coriacea*]). There is no critical habitat designated for sea turtle species within the Study Area. Similar to the 2015 MITT Final EIS/OEIS, this section provides an overview of the species, distribution, and occurrence of sea turtles, as well as new information released since the publication of the 2015 document. The status, presence, and nesting occurrence of sea turtles in the Study Area are listed by region in Table 3.5-1. Since the publication of the 2015 MITT Final EIS/OEIS, the National Marine Fisheries Service (NMFS) classified the global distribution of green sea turtles into distinct population segments (DPS). Within the area analyzed in this SEIS/OEIS, the endangered green sea turtle in the Mariana Islands has been determined to be part of the Central West Pacific DPS.

The Navy also reviewed the status and distribution of other pelagic reptile species, such as sea snakes, to evaluate if these species should be included in this SEIS/OEIS. There are no verified records of sea snakes in nearshore waters of the Mariana Islands. Eldredge (2003) notes that the few anecdotal reports of sea snakes are probably the result of confusion between the sea krate *Laticauda colubrina* commonly found on Palau and the snake eel *Myrichthys colubrinus*, indigenous to Guam. In the early 1970s there was a newspaper report of a yellow-bellied sea snake (*Pelamis platurus*) found on a Saipan beach (Eldredge, 2003). Sea snake occurrence in both pelagic and nearshore waters of the Study Area is extremely rare; therefore, sea snakes are not included in this SEIS/OEIS.

The 2015 MITT Final EIS/OEIS provided a general overview of sea turtle dive behavior, group size, and general threats. New information since the publication of the 2015 MITT Final EIS/OEIS is included below to better understand potential stressors and impacts on sea turtles resulting from training and testing activities.

Table 3.5-1: Endangered Species Act Status and Presence of Endangered Species Act Listed Sea Turtles in the Mariana Islands Training and Testing Study Area

Species Name and Regulatory Status				Presence in Study Area[1]	
Common Name		**Scientific Name**	**Endangered Species Act Status**	**Open Ocean/Transit Corridor**	**Coastal/Ocean**
Family Cheloniidae (hard-shelled sea turtles)					
Green sea turtle[2]	Central West Pacific DPS	*Chelonia mydas*	Endangered	Yes	Yes[3]
	East Indian-West Pacific DPS		Threatened		No
	Central North Pacific DPS		Threatened		No
Hawksbill sea turtle (throughout range)		*Eretmochelys imbricata*	Endangered	Yes	Yes[3,4]
Loggerhead sea turtle North Pacific DPS		*Caretta caretta*	Endangered[4]	Yes[5]	Yes[5]
Olive ridley sea turtle (Breeding populations on the Pacific coast of Mexico)		*Lepidochelys olivacea*	Endangered[6]	Yes[5]	Yes[5]
Family Dermochelyidae (leatherback sea turtle)					
Leatherback sea turtle (throughout range)		*Dermochelys coriacea*	Endangered	Yes[5]	Yes[5]

[1] MITT Study Area = Mariana Islands Training and Testing Study Area
[2] In 2015, NMFS published a final rule that classifies green sea turtles within the Study Area as part of the Western Pacific Distinct Population Segment. Green sea turtles within other DPS may occur within the Study Area—the East Indian-West Pacific DPS and the Central North Pacific DPS. These three DPS are analyzed individually in the section 7(a)(2) consultation between the Navy and NMFS.
[3] Indicates nesting activity within the Study Area. Only green sea turtles and hawksbill sea turtles are known to nest in the Study Area.
[4] The Northeast Atlantic Ocean, Mediterranean Sea, North Indian Ocean, North Pacific Ocean, and South Pacific Ocean Distinct Population Segments are listed as Endangered; the Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and Southwest Indian Ocean Distinct Population Segments are listed as threatened. Only loggerheads within the North Pacific Ocean DPS are within the Study Area.
[5] Species occurrence is only expected during migratory movements through the Study Area and therefore may be present, albeit at extremely low densities.
[6] Breeding populations of olive ridley sea turtles on the Pacific coast of Mexico are listed as endangered, and all other populations are listed as threatened. Both threatened and endangered populations could occur in the Study Area.

3.5.1.1 Group Size

Sea turtles are generally solitary animals, but they tend to group during migrations and mating. Because they do not show territoriality, foraging areas often overlap. New hatchlings, which often emerge from nesting beaches in groups, are solitary until they reach sexual maturity (Bolten, 2003; Bowen et al., 2004; James et al., 2005; Schroeder et al., 2003).

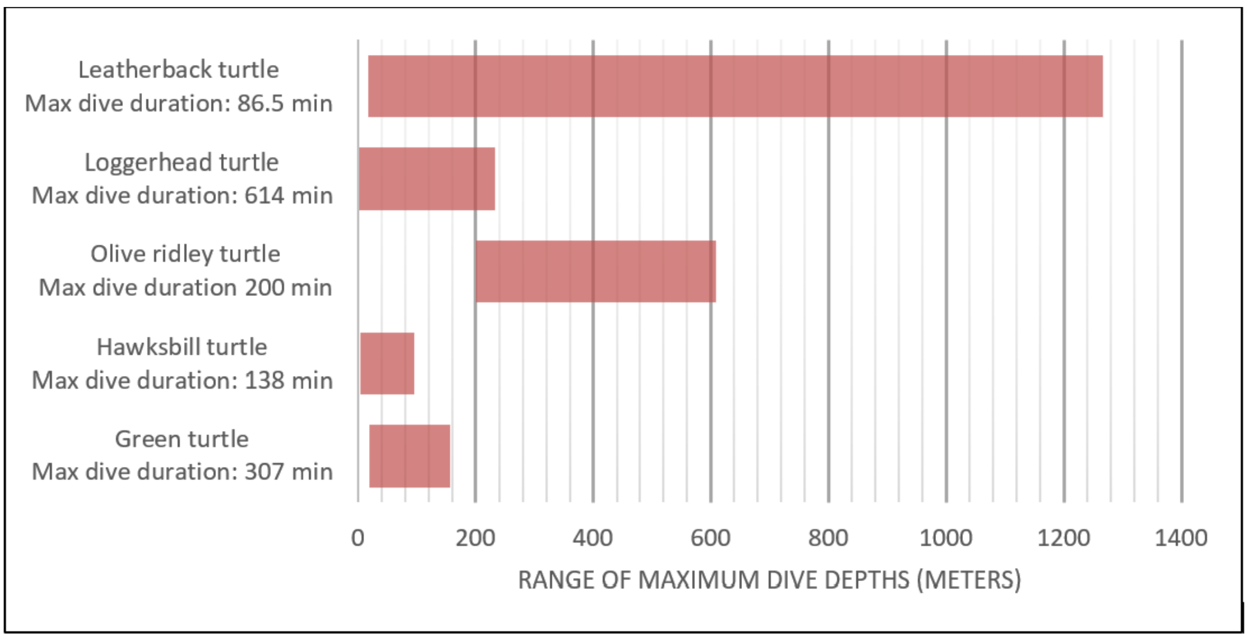
3.5.1.2 Habitat Use

Sea turtles are dependent on beaches for nesting habitat, in locations that have sand deposits that are not inundated with tides or storm events prior to hatching. In the water, sea turtle habitat use is dependent on species and corresponds to dive behavior because of foraging and migration strategies, as well as behavior state (e.g., diving deep at night for resting purposes) (Rieth et al., 2011).

3.5.1.3 Dive Behavior

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). In addition, their relative distribution through the water column is an important consideration when conducting acoustic exposure analyses. The following text briefly describes the dive behavior of each species. Dive durations are often a function of turtle size, with larger turtles being capable of diving to greater depths and for longer periods. Methods of collecting dive behavior data over the years have varied in study design, configuration of electronic tags, parameters collected in the field, and data analyses.

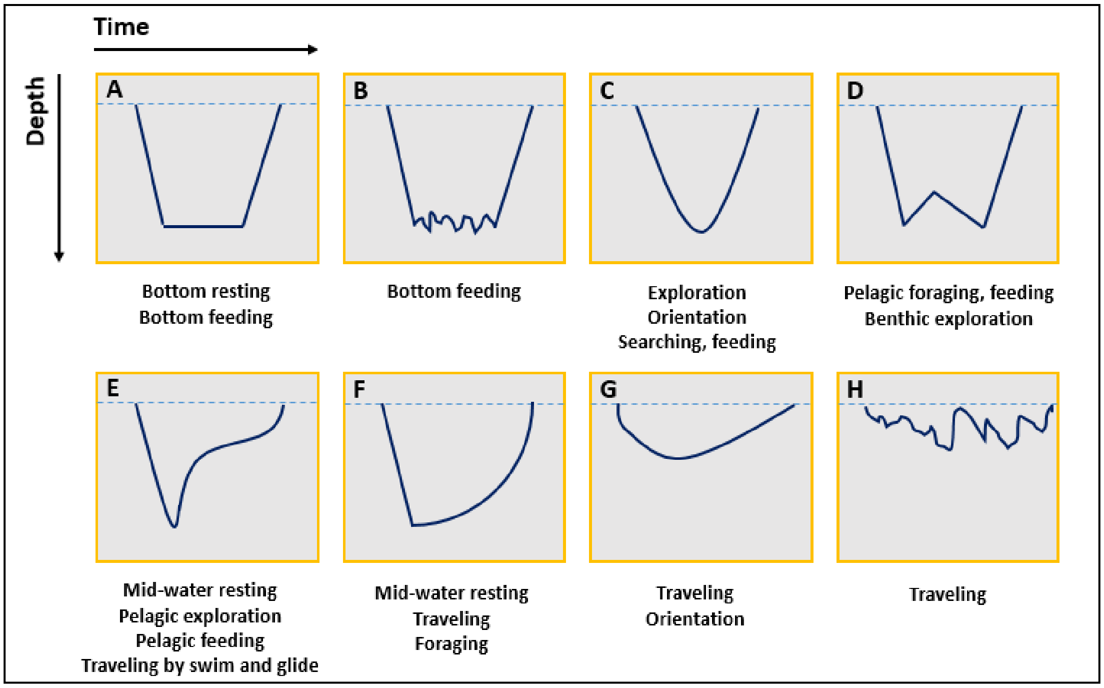
New information is available that improves the analysis for sea turtle dive behavior. Hochscheid (2014) has completed a species-specific summary for sea turtles within the Study Area that was not included in the 2015 MITT Final EIS/OEIS. Hochscheid (2014) collected data from 57 studies published between 1986 and 2013, which summarized depths and durations of dives of datasets including an overall total of 538 sea turtles. Figure 3.5-1 presents the ranges of maximum dive depths for each sea turtle species found in the Study Area. This summary is used to improve exposure analysis for stressors analyzed in Section 3.5.2 (Environmental Consequences).



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

Figure 3.5-1: Dive Depth and Duration Summaries for Sea Turtle Species

Hochscheid (2014) also collected information on generalized dive profiles, with correlations to specific activities. Generalized dive profiles compiled from 11 different studies show 8 distinct profiles tied to specific activities. These profiles and activities are shown in Figure 3.5-2.



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. (2004); Southwood et al. (1999).

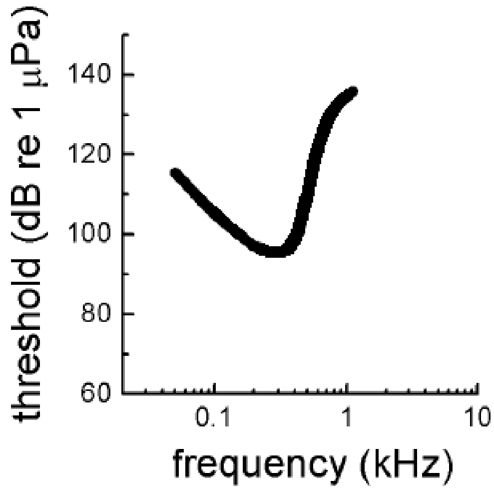
Notes: Profiles A-H, as reported in the literature and compiled by Hochscheid (2014). The depth and time arrows indicate the axis variables, but the figure does not represent true proportions of depths and durations for the various profiles. In other words, the depths can vary greatly, but behavioral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

Figure 3.5-2: Generalized Dive Profiles and Activities Described for Sea Turtles

3.5.1.4 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, with 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 U.S. Department of the Navy (Navy) developed a composite sea turtle audiogram for underwater hearing (Figure 3.5-3), 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).



Source: U.S. Department of the Navy (2017a)
Notes: dB re 1 μPa = decibels referenced to 1 micropascal, kHz = kilohertz

Figure 3.5-3: Composite Underwater 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).

Sea turtles are not known to vocalize underwater. 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 nesting female leatherback sea turtles and low-frequency pulsed and harmonic sounds by leatherback embryos in eggs and hatchlings (Ferrara et al., 2014).

3.5.1.5 General Threats

The general threats to sea turtles are described in the 2015 MITT Final EIS/OEIS. New information is available that provides a more refined understanding of how marine debris, potential invasive species introductions, and climate change can potentially threaten sea turtle species within the Study Area. Since the publication of the 2015 MITT Final EIS/OEIS, NMFS has classified green sea turtles occurring within the Mariana Islands as the Central West Pacific DPS. By doing so, the NMFS further defined threats to green sea turtles within this DPS; these threats are described below under species-specific threats for the green sea turtle. Although the information summarized below is from more recent literature since the publication of the 2015 MITT Final EIS/OEIS, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid, including the general threats to sea turtles.

3.5.1.5.1 Marine Debris

Ingestion of marine debris can cause injury or mortality to sea turtles if the debris does not pass through the digestive track. The United Nations Environment Program estimates that approximately 6.4 million tons of anthropogenic debris enters the marine environment every year (United Nations Environmental Program, 2005). This estimate, however, does not account for cataclysmic events, such as the 2011 Japanese tsunami 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 ingested various types of plastic (Mrosovsky et al., 2009), and Narazaki et al. (2013) observed a loggerhead exhibiting hunting behavior on approach to a plastic bag, possibly mistaking the bag for a jelly fish. Ingesting even small amounts of plastic can cause an obstruction in a sea turtle's digestive track and mortality (Bjorndal et al., 1994; Bjorndal, 1997), and hatchlings are at risk for ingesting small plastic fragments. Plastics absorb toxins, such as bisphenol-A (commonly known as "BPA") and phthalates, as well as heavy metals from the ocean, and can be harmful to the tissues when ingested. (Fukuoka et al., 2016; Teuten et al., 2007). Life stage and feeding preference affects 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. In 2014, Schuyler et al. (2014) reviewed 37 studies of debris ingestion by sea turtles, showing that young oceanic sea turtles are more likely to ingest debris (particularly plastic), and that green and loggerhead sea turtles were significantly more likely to ingest debris than other sea turtle species.

3.5.1.5.2 Invasive Species

Impacts on sea turtles associated with invasive species primarily concern nest predation and prey base. Some of the invasive species introduced to the larger, more populated islands in the Mariana archipelago are known nest predators (e.g., rats, feral dogs and cats, pigs, ants). Nests on populated islands are also at risk for illegal poaching (Kolinski et al., 2006). In foraging grounds, sea turtles have been shown to adapt their foraging preferences for invasive seagrass and algae. Becking et al. (2014) showed green sea turtle foraging behavior shift to consumption of *Halophila stipulacea*, a rapidly spreading seagrass in the Caribbean. In Hawaii, green sea turtles in Kaneohe Bay have modified their diets over several decades to include seven non-native species (*Acanthophora spicifera, Hypnea musciformis, Gracilaria salicornia, Eucheuma denticulatum, Gracilaria tikvahiae, Kappaphycus striatum,* and *Kappaphycus alvarezii*), with non-native algae accounting for over 60 percent of sea turtle diet (Russell & Balazs, 2015).

Since the publication of the 2015 MITT Final EIS/OEIS, the Navy has funded the *Regional Biosecurity Plan for Micronesia and Hawaii,* completed in 2015. Volume I, Appendix K of the biosecurity plan addresses general biosecurity recommendations for Guam and the Commonwealth of the Northern Mariana Islands, and Appendix M includes recommendations for U.S. Department of Defense activities (U.S. Department of the Navy, 2015d). Volume III includes a risk assessment for marine environments (U.S. Department of the Navy, 2015c), and Volume IV includes a risk assessment for potential introductions on land in terrestrial environments (U.S. Department of the Navy, 2015b). The 2015 biosecurity plan describes ongoing measures that reduce the potential for transport and introduction of invasive species resulting from military training and testing activities. Some of these species have the potential to degrade sea turtle habitats, reduce prey availability, or directly harm sea turtles. Because of the Navy's active biosecurity program, it is unlikely that training and testing activities would result in invasive species' introductions that would impact sea turtles. Therefore, invasive species are not analyzed as a new stressor in this SEIS/OEIS.

3.5.1.5.3 Climate Change

Since the publication of the MITT Final EIS/OEIS, the Navy has obtained and consolidated additional information to conceptualize the potential of climate change to threaten sea turtle species within the Study Area. Sea turtles are particularly susceptible to climate change effects because their life history, physiology, and behavior are extremely sensitive to environmental temperatures (Fuentes et al., 2013).

Climate change models predict sea level rise and increased intensity of storms and hurricanes in tropical sea turtle nesting areas (Patino-Martinez et al., 2008). These factors could significantly increase beach inundation and erosion, thus affecting water content of sea turtle nesting beaches and potentially inundating nests (Pike et al., 2015). Climate change may negatively impact turtles in multiple ways and at all life stages. These impacts may include the potential loss of nesting beaches due to sea level rise and increasingly intense storm surge (Patino-Martinez et al., 2008), feminization of turtle populations from elevated nest temperatures (and skewing populations from more males to females unless nesting shifts to northward cooler beaches) (Reneker & Kamel, 2016), decreased reproductive success (Clark & Gobler, 2016; Hawkes et al., 2006; Laloë et al., 2016; Pike, 2014), shifts in reproductive periodicity and latitudinal ranges (Birney et al., 2015; Pike, 2014), disruption of hatchling dispersal and migration, and indirect effects to food availability (Witt et al., 2010).

3.5.1.6 Green Sea Turtle (*Chelonia mydas*)

This section has been updated based on a change in the regulatory status of the green sea turtle and new information regarding trends and distributions of green sea turtles in nearshore waters of the Mariana Islands. As such, the life history and regulatory status descriptions for each sea turtle species differs in detail.

3.5.1.6.1 Status and Management

As presented in the 2015 MITT Final EIS/OEIS, green sea turtles are listed as threatened under the ESA throughout their Pacific range, except for the population that nests on the Pacific coast of Mexico (endangered). However, NMFS and United States Fish and Wildlife Service (USFWS) reclassified the species in 2016 into 11 DPSs, which maintains federal protections while providing a more tailored approach for managers to address specific threats facing different populations (see the NMFS and USFWS Final Rule published on April 6, 2016). Only the Central West Pacific DPS occurs within the Study Area. This DPS is listed as endangered under the ESA. Only this distinct population segment is discussed further in the document; however, it should be noted that minimal mixing (gene flow) may occur with other distinct population segments (Seminoff et al., 2015).

3.5.1.6.2 Habitat and Geographic Range

The habitat and geographic range of green sea turtles is described in the 2015 MITT Final EIS/OEIS. Following a review of recent literature, information on green sea turtles related to habitat and geographic range has not changed since the publication of the MITT Final EIS/OEIS. As such, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid. There is no critical habitat designated for this species in the Study Area. Seminoff et al. (2015), however, provides specific information for the Central West Pacific DPS and determined that this DPS is spatially bounded by the Asian continent to the west and north, the Solomon Islands to the south, the Marshall Islands in the east, and Palau in the west.

3.5.1.6.2.1 Population and Abundance

The population and abundance of green sea turtles is described in the 2015 MITT Final EIS/OEIS; however, new information is available for estimating abundance in waters within the Study Area. Martin et al. (2016) analyzed five decades of aerial surveys (from 1962 through 2012) to assess changes in marine megafauna on the insular coral reef ecosystem of Guam. Turtle observations (assumed to be primarily green sea turtles, but reported observations likely included some hawksbills) increased and varied spatially around Guam, with the highest densities occurring along the south, east, and north coasts, particularly in areas having low human density, reefs with coral cover, and either seagrass beds or a marine protected area. Observed individuals per survey ranged from 1.1 to 44.6 across all years. Based on this information, Martin et al. (2016) calculated a population growth rate of approximately 90 percent over the past five decades. Based on studies of in-water capture rates (where swimmers would capture and tag individual sea turtles), Martin et al. (2016) estimated that 85 percent of the sea turtles in waters off of Guam are green sea turtles, while 15 percent are hawksbill sea turtles. The Navy is currently funding in-water tagging of sea turtles in waters off of Guam, Tinian, and Saipan. Since November 2015 when tagging began, Falcone et al. (2017) report that the majority of sea turtles observed or captured (65 of 68 total sea turtles observed, or 96 percent) have been green sea turtles.

3.5.1.6.2.2 Predator-Prey Interactions

The predator-prey interactions relevant to green sea turtles are described in the 2015 MITT Final EIS/OEIS. Following a review of recent literature, information on green sea turtles related to predator-prey interactions has not changed since the publication of the 2015 MITT Final EIS/OEIS. As such, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid. When NMFS classified green sea turtles within the Central West Pacific DPS, no information on predator-prey interactions were used that were not included in the 2015 MITT Final EIS/OEIS.

3.5.1.6.2.3 Species-Specific Threats

Since the publication of the 2015 MITT Final EIS/OEIS, the NMFS has further defined threats to green sea turtles included in the Central West Pacific DPS. Damage to seagrass beds and declines in seagrass distribution can reduce foraging habitat for green sea turtles (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 1991; Seminoff et al., 2015; Williams, 1988). Green sea turtles are susceptible to the disease fibropapillomatosis, which causes tumor-like growths (fibropapillomas) resulting in reduced vision, disorientation, blindness, physical obstruction to swimming and feeding, increased susceptibility to parasites, and increased susceptibility to entanglement (Balazs, 1986; National Marine Fisheries Service & U.S. Fish and Wildlife Service, 1991; Patrício et al., 2016; Work & Balazs, 2013). The potential effects of disease and endoparasites also exist for green sea turtles found in the Central West Pacific Ocean. The loss of eggs to non-human predators is a severe problem in some areas. These predators include domestic animals, such as cats, dogs, and pigs, as well as wild species such as rats, mongoose, birds, monitor lizards, snakes, crabs, ants, and other invertebrates (Seminoff et al., 2015).

3.5.1.7 Hawksbill Sea Turtle (*Eretmochelys imbricata*)

The hawksbill sea turtle is listed as endangered under the ESA (35 Federal Register 8491). While the current listing as a single global population remains valid, data may support separating populations at least by ocean basin under the distinct population segment policy (National Marine Fisheries Service, 2013). The most recent status review was released in 2013 by the NMFS and USFWS (National Marine Fisheries Service, 2013). There is no critical habitat designated for this species in the Study Area. The regulatory status for the hawksbill sea turtle has remained unchanged since the publication of the 2015 MITT Final EIS/OEIS.

In addition, the life history information for hawksbill sea turtles occurring in nearshore and open ocean habitats within the Study Area has not changed since the publication of the 2015 MITT Final EIS/OEIS. New information is available for estimating hawksbill sea turtle population and abundance based off of five decades of aerial surveys in the nearshore waters of Guam. While Martin et al. (2016) estimated that approximately 15 percent of sea turtles observed in waters off of Guam are hawksbill sea turtles, tagging from November 2015 has revealed that only 4 percent of observed turtles are hawksbill sea turtles (Summers et al., 2017). Overall, the trend data over this time period suggests a dramatic increase in green and hawksbill sea turtle populations in waters around Guam. The Navy is currently funding in-water tagging of sea turtles in waters off of Guam, Tinian, and Saipan.

3.5.1.8 Loggerhead Sea Turtle (*Caretta caretta*)

In 2009, a status review was conducted for the loggerhead identified nine distinct population segments within the global population (Conant et al., 2009). In 2011, NMFS and USFWS listed five of these distinct population segments as endangered and kept four as threatened under the ESA. Only the North Pacific Ocean distinct population segment occurs within the Study Area; however, mixing is known to occur between other populations in the Pacific and Indian Oceans, enabling a limited amount of gene flow with other distinct population segments (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 2008). There is no critical habitat designated for this species in the Study Area. The regulatory status for the loggerhead sea turtle has remained unchanged since the publication of the 2015 MITT Final EIS/OEIS. In addition, the life history information for loggerhead sea turtles occurring in nearshore and open ocean habitats within the Study Area has not changed since the publication of the 2015 MITT Final EIS/OEIS. As such, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid.

3.5.1.9 Olive Ridley Sea Turtle (*Lepidochelys olivacea*)

Olive ridley sea turtles that nest along the Pacific coast of Mexico are listed as endangered under the ESA, while all other populations are listed under the ESA as threatened (43 Federal Register 32800). Based on genetic data, the worldwide olive ridley population is composed of four main lineages: east India, Indo-Western Pacific, Atlantic, and eastern Pacific Ocean (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 2014; Shankar et al., 2004). Most olive ridley sea turtles found within the Study Area are of the Indo-Western Pacific lineage (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 2014). There is no critical habitat designated for this species in the Study Area. The regulatory status for the olive ridley sea turtle has remained unchanged since the publication of the 2015 MITT Final EIS/OEIS.

In addition, the life history information for olive ridley sea turtles occurring in nearshore and open ocean habitats within the Study Area has not changed since the publication of the 2015 MITT Final EIS/OEIS. As such, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid.

3.5.1.10 Leatherback Sea Turtle (*Dermochelys coriacea*)

The leatherback sea turtle is listed as a single population and is classified as endangered under the ESA (35 Federal Register 8491). Recent information on population structure (through genetic studies) and distribution (through telemetry, tagging, and genetic studies) have led to an increased understanding and refinement of the global stock structure (Clark et al., 2010). There is no critical habitat designated for this species in the Study Area. The regulatory status for the leatherback sea turtle has remained unchanged since the publication of the 2015 MITT Final EIS/OEIS. In addition, the life history information for leatherback sea turtles occurring in nearshore and open ocean habitats within the Study Area has not changed since the publication of the 2015 MITT Final EIS/OEIS. As such, the information and analysis presented in the 2015 MITT Final EIS/OEIS remains valid.

3.5.2 Environmental Consequences

Under the Proposed Action for this SEIS/OEIS, there have been some modifications to the quantity and type of acoustic stressors under the two action alternatives. Additionally, one new substressor (high-energy lasers) is being analyzed because of its potential to affect marine species, as detailed in Section 3.0.4.3.2.2 (High-Energy Lasers).

In general, there have been no substantial changes to the activities analyzed as the Proposed Action in the 2015 MITT Final EIS/OEIS which would change the conclusions reached regarding populations of sea turtles in the Study Area. Acoustic stressors (sonar and other transducers) and explosives have occurred since the 2015 completion of the MITT Record of Decision and ESA Biological Opinion. There have been no known impacts on sea turtles that were not otherwise previously analyzed or accounted for in the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015a), the NMFS Biological Opinion pursuant to ESA (National Marine Fisheries Service, 2015a), or the USFWS Biological Opinion.

In this SEIS/OEIS, the Navy has reviewed the analysis of impacts from these ongoing activities and additionally analyzed the new or changing training and testing activities as projected into the reasonably foreseeable future. The projected future actions are based on evolving operational requirements, including those associated with any anticipated new platforms or systems not previously analyzed. The Navy has completed a literature review for information on sea turtles within the Study Area, which included a search for the best available science since the publication of the 2015 MITT Final EIS/OEIS. Where there has been no substantive or otherwise meaningful change in the action, science, or regulations, the Navy will rely on the previous 2015 MITT Final EIS/OEIS analysis. Where there has been substantive change in the action, science, or regulations, the information and analysis provided in in this SEIS/OEIS will supplement the 2015 MITT Final EIS/OEIS to support environmental compliance with applicable environmental statutes for sea turtles.

The stressors applicable to sea turtles in the Study Area for this SEIS/OEIS include the new stressor (high-energy lasers) and the same stressors considered in the 2015 MITT Final EIS/OEIS:

- **Acoustic** (sonar and other transducers, vessel noise, aircraft noise, and weapon noise)
- **Explosive** (in-air explosions and in-water explosions)
- **Energy** (in-water electromagnetic devices, high-energy lasers)
- **Physical disturbance and strike** (vessels and in-water devices, military expended materials, seafloor devices)
- **Entanglement** (wires and cables, decelerators/parachutes)
- **Ingestion** (military expended materials – munitions and military expended materials – other than munitions)
- **Secondary** (impacts on habitat, impacts on prey availability)

This section of this SEIS/OEIS evaluates how and to what degree potential impacts on sea turtles from stressors described in Section 3.0 (Introduction) may have changed since the analysis presented in the 2015 MITT Final EIS/OEIS was completed. Table 2.5-1 and Table 2.5-2 in Chapter 2 (Description of Proposed Action and Alternatives) list the proposed training and testing activities and include the number of times each activity would be conducted annually and the locations within the Study Area where the activity would typically occur under each alternative. The tables also present the same information for activities described in the 2015 MITT Final EIS/OEIS so that the proposed levels of training and testing under this SEIS/OEIS can be easily compared. The analysis in this SEIS/OEIS includes consideration of the Navy's standard operating procedures and mitigation that the Navy will implement to avoid or reduce potential impacts on sea turtles from acoustic, explosive, and physical disturbance and strike stressors. Mitigation for sea turtles has been coordinated with NMFS through the ESA consultation processes, and is detailed in Chapter 5 (Mitigation) and Appendix I (Geographic Mitigation Assessment) of this SEIS/OEIS.

In their biological opinion, NMFS determined that within the Study Area, only acoustic stressors and explosive stressors could potentially result in adverse effects on ESA-listed sea turtles from training and testing activities and that none of the other stressors would result in significant adverse impacts or jeopardize the continued existence of any ESA-listed sea turtle (National Oceanic and Atmospheric Administration, 2015).

The analysis presented in this section of this SEIS/OEIS also considers standard operating procedures that are described in Chapter 2 (Description of Proposed Action and Alternatives) and mitigation measures that are described in Chapter 5 (Mitigation). The Navy will implement these measures to avoid or reduce potential impacts on sea turtles from stressors associated with the proposed training and testing activities. Mitigation for sea turtles has been coordinated with NMFS through the ESA consultation process.

As presented in Section 3.0 (Introduction), since completion of the 2015 MITT Final EIS/OEIS there have been refinements made in the modeling of estimated impacts from sonar and other transduces and in-water explosives. These changes have been incorporated into the re-analysis of acoustic and explosive stressors presented in this SEIS/OEIS. In addition to the new effects criteria, weighting functions, and thresholds across multiple species, new information for sea turtles includes the integration of new sea turtle density data based on new survey data.

3.5.2.1 Acoustic Stressors

The analysis of effects to sea turtles follows the concepts outlined in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities). This section begins with a summary of relevant data regarding acoustic impacts on sea turtles in Section 3.5.2.1.1 (Background). This is followed by an analysis of estimated impacts on sea turtles due to specific Navy acoustic stressors (sonar and other transducers, vessel noise, aircraft noise, and weapon noise). Additional explanations of the acoustic terms and sound energy concepts used in this section are found in Appendix H (Acoustic and Explosive Concepts). Studies of the effects of sound on sea turtles are limited; therefore, where necessary, knowledge of impacts on other species from acoustic stressors is used to assess impacts on sea turtles.

The Navy will rely on the previous 2015 MITT Final EIS/OEIS for the analysis of vessel noise, aircraft noise, and weapon noise, and new applicable and emergent science in regard to these substressors is presented in the sections that follow. Due to new acoustic impact criteria, sea turtle densities, and acoustic effects model, the analysis provided in Section 3.5.2.1.2 (Impacts from Sonar and Other Transducers) of this SEIS/OEIS will supplant the 2015 MITT Final EIS/OEIS for sea turtles, and may result in changes to estimated impacts for some species since the 2015 MITT Final EIS/OEIS.

3.5.2.1.1 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 sea turtles potentially resulting from Navy training and testing activities. Sea turtles could be exposed to a range of impacts depending on the sound source and context of the exposure. Exposures to sound-producing activities may result in auditory or non-auditory trauma, hearing loss resulting in temporary or permanent hearing threshold shift, auditory masking, physiological stress, or changes in behavior.

3.5.2.1.1.1 Injury

The high peak pressures close to some non-explosive impulsive underwater sound sources may be injurious, although there are no reported instances of injury to sea turtles caused by these sources. A Working Group organized under the American National Standards Institute-Accredited Standards Committee S3, Subcommittee 1, Animal Bioacoustics, developed sound exposure guidelines for fish and sea turtles (Popper et al., 2014), hereafter referred to as the *ANSI Sound Exposure Guidelines*. Lacking any data on non-auditory sea turtle injuries due to sonars, the working group estimated the risk to sea turtles from low-frequency sonar to be low and mid-frequency sonar to be non-existent.

As discussed in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities, specifically Section 3.0.4.7.1, Injury), mechanisms for non-auditory injury due to acoustic exposure have been hypothesized for diving breath-hold animals. Acoustically induced bubble formation, rectified diffusion, and acoustic resonance of air cavities are considered for their similarity to pathologies observed in marine mammals stranded coincident with sonar exposures but were found to not be likely causal mechanisms (Section 3.5.2.1.1.1, Injury), and findings are applicable to sea turtles.

Nitrogen decompression due to modifications to dive behavior has never been observed in sea turtles. Sea turtles are thought to deal with nitrogen loads in their blood and other tissues, caused by gas exchange from the lungs under conditions of high ambient pressure during diving, through anatomical, behavioral, and physiological adaptations (Lutcavage & Lutz, 1997). Although diving sea turtles experience gas supersaturation, gas embolism has only been observed in sea turtles bycaught in fisheries (Garcia-Parraga et al., 2014). Therefore, nitrogen decompression due to changes in diving behavior is not considered a potential consequence to diving sea turtles.

3.5.2.1.1.2 Hearing Loss

Exposure to intense sound may result in hearing loss, typically quantified as threshold shift, which persists after cessation of the noise exposure. Threshold shift is a loss of hearing sensitivity at an affected frequency of hearing. This noise-induced hearing loss may manifest as temporary threshold shift (TTS), if hearing thresholds recover over time, or permanent threshold shift (PTS), if hearing thresholds do not recover to pre-exposure thresholds. Because studies on inducing threshold shift in sea turtles are very limited (e.g., alligator lizards: Dew et al., 1993; Henry & Mulroy, 1995), are not sufficient to estimate TTS and PTS onset thresholds, and have not been conducted on any of the sea turtles present in the Study Area, auditory threshold shift in sea turtles is considered to be consistent with general knowledge about noise-induced hearing loss described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

Because there are no data on auditory effects on sea turtles, the *ANSI Sound Exposure Guidelines* (Popper et al., 2014) do not include numeric sound exposure thresholds for auditory effects on sea turtles. Rather, the guidelines qualitatively estimate that sea turtles are less likely to incur TTS or PTS with increasing distance from various sound sources. The guidelines also suggest that data from fishes may be more relevant than data from marine mammals when estimating impacts on sea turtles, because, in general, fish hearing range is more similar to the limited hearing range of sea turtles. As shown in Section 3.5.1.4 (Hearing and Vocalization), sea turtle hearing is most sensitive around 100–400 Hz in-water, is limited over 1 kilohertz (kHz), and is much less sensitive than that of any marine mammal. Therefore, sound exposures from most mid-frequency and all high-frequency sound sources are not anticipated to affect sea turtle hearing, and sea turtles are likely only susceptible to auditory impacts when exposed to very high levels of sound within their limited hearing range.

3.5.2.1.1.3 Physiological Stress

A stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. If the magnitude and duration of the stress response is too great or too long, then it can have negative consequences to the animal (e.g., decreased immune function, decreased reproduction). Physiological stress is typically analyzed by measuring stress hormones, other biochemical markers, or vital signs. Physiological stress has been measured for sea turtles during nesting (Flower et al., 2015; Valverde et al., 1999), capture and handling (Flower et al., 2015; Gregory & Schmid, 2001), and when caught in entanglement nets (Hoopes et al., 2000; Snoddy et al., 2009) and trawls (Stabenau et al., 1991). However, the stress caused by acoustic exposure has not been studied for sea turtles. Therefore, the stress response in sea turtles in the Study Area due to acoustic exposures is considered to be consistent with general knowledge about physiological stress responses described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

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. Anthropogenic sound-producing activities have the potential to provide additional stressors beyond those that naturally occur.

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.

3.5.2.1.1.4 Masking

As described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), auditory masking occurs when one sound, distinguished as the “noise,” interferes with the detection or recognition of another sound or limits the distance over which other biologically relevant sounds, including those produced by prey, predators, or conspecifics, can be detected. Masking only occurs when the sound source is operating; therefore, direct masking effects stop immediately upon cessation of the sound-producing activity. Any sound above ambient noise and within an animal’s hearing range may potentially cause masking.

Compared to other marine animals, such as marine mammals that are highly adapted to use sound in the marine environment, sea turtle hearing is limited to lower frequencies and is less sensitive. Because sea turtles likely use their hearing to detect broadband low-frequency sounds in their environment, the potential for masking would be limited to certain similar sound exposures. Only continuous human-generated sounds that have a significant low-frequency component, are not brief in duration, and are of sufficient received level, would create a meaningful masking situation (e.g., proximate vessel noise). Other intermittent, short-duration sound sources with low-frequency components (e.g., low-frequency sonars) would have more limited potential for masking depending on duty cycle.

There is evidence that sea turtles may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al., 2013) and magnetic orientation (Avens, 2003; Putman et al., 2015). Any effect of masking may be mediated by reliance on other environmental inputs.

3.5.2.1.1.5 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 reactions may be combinations of behaviors or a sequence of behaviors. As described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), the response of a sea turtle to an anthropogenic sound would likely depend on the frequency, duration, temporal pattern, and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). Distance from the sound source and whether it is perceived as approaching or moving away may also affect the way a sea turtle responds to a sound.

Sea turtles may detect sources below 2 kHz but have limited hearing ability above 1 kHz. They likely detect most broadband sources (including vessel noise) and low-frequency sonars, so they may respond to these sources. Because auditory abilities are poor above 1 kHz, detection and consequent reaction to any mid-frequency source is unlikely.

In the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), qualitative risk factors were developed to assess the potential for sea turtles to respond to various underwater sound sources. The guidelines state that there is a low likelihood that sea turtles would respond within tens of meters of low-frequency sonars, and that it is highly unlikely that sea turtles would respond to mid-frequency sources. The risk that sea turtles would respond to other broadband sources, such as shipping, is considered high within tens of meters of the sound source, but moderate to low at farther distances.

Behavioral Reactions to Impulsive Sound Sources

There are limited studies of sea turtle responses to sounds from impulsive sound sources, and all data come from sea turtles exposed to seismic air guns, although air guns are not used during MITT training or testing activities. These exposures consist of multiple air gun shots, either in close proximity or over long durations, so it is likely that observed responses may over-estimate responses to single or short-duration impulsive exposures. Studies of responses to air guns are used to inform sea turtle responses to other impulsive sounds (e.g., some weapon noise).

O'Hara and Wilcox (1990) attempted to create a sound barrier at the end of a canal using seismic air guns. They reported that loggerhead sea turtles kept in a 300-meter by 45-meter enclosure in a 10-meter deep canal maintained a minimum standoff range of 30 meters from air guns fired simultaneously at intervals of 15 seconds with strongest sound components within the 25–1,000 Hz frequency range. McCauley et al. (2000) estimated that the received sound pressure level (SPL) at which turtles avoided sound in the O'Hara and Wilcox (1990) experiment was 175–176 decibels referenced to 1 micropascal (dB re 1 µPa).

Moein Bartol et al. (1995) investigated the use of air guns to repel juvenile loggerhead sea turtles from hopper dredges. Sound frequencies of the air guns ranged from 100 to 1,000 Hz at three source SPLs: 175, 177, and 179 dB re 1 µPa at 1 m. The turtles avoided the air guns during the initial exposures (mean range of 24 meters), but additional exposures on the same day and several days afterward did not elicit statistically significant avoidance behavior. They concluded that this was likely due to habituation.

McCauley et al. (2000) exposed a caged green and a caged loggerhead sea turtle to an approaching-departing single air gun to gauge behavioral responses. The trials showed that above a received SPL of 166 dB re 1 µPa, the turtles noticeably increased their swimming activity compared to nonoperational periods, with swimming time increasing as air gun SPLs increased during approach. Above 175 dB re 1 µPa, behavior became more erratic, possibly indicating the turtles were in an agitated state. The authors noted that the point at which the turtles showed more erratic behavior and exhibited possible agitation would be expected to approximate the point at which active avoidance to air guns would occur for unrestrained turtles.

No obvious avoidance reactions by free-ranging sea turtles, such as swimming away, were observed during a multi-month seismic survey using air gun arrays, although fewer sea turtles were observed when the seismic air guns were active than when they were inactive (Weir, 2007). The author noted that sea state and the time of day affected both air gun operations and sea turtle surface basking behavior, making it difficult to draw conclusions from the data. However, DeRuiter and Doukara (2012) noted several possible startle or avoidance reactions to a seismic air gun array in the Mediterranean by loggerhead sea turtles that had been motionlessly basking at the water surface.

Based on the limited sea turtle behavioral response data discussed above, sea turtle behavioral responses to impulsive sounds could consist of temporary avoidance, increased swim speed, or changes in depth; or no response. Based on the behavioral response severity scale developed by Southall et al. (2007), the severity of these responses can be categorized as non-existent, low, and moderate.

Behavioral Reactions to Sonar and Other Transducers

Studies of sea turtle responses to non-impulsive sounds are very limited. Lenhardt (1994) used very low frequency vibrations (< 100 Hz) coupled to a shallow tank to elicit swimming behavior responses by two loggerhead sea turtles. Watwood et al. (2016) tagged green sea turtles with acoustic transponders and monitored them using acoustic telemetry arrays in Port Canaveral, FL. Sea turtles were monitored before, during, and after a routine pier-side submarine sonar test that utilized typical source levels, signals, and duty cycle. The sea turtles did not exhibit significant long-term displacement in this study. The authors note that Port Canaveral is an urban marine habitat and that resident sea turtles may be less likely to respond than naïve populations.

According to the qualitative risk factors developed in the *ANSI Sound Exposure Guideline* technical report (Popper et al., 2014), the likelihood of sea turtles responding to low- and mid-frequency sonar is low and highly unlikely, respectively. Based on the limited sea turtle behavioral response data discussed above, sea turtle behavioral responses to non-impulsive sounds could consist of temporary avoidance, increased swim speed, or no response. Using the behavioral response severity scale developed by Southall et al. (2007), the severity of these responses can be categorized as non-existent, low, and moderate.

3.5.2.1.1.6 Long-Term Consequences

For the sea turtles present in the Study Area, long-term consequences to individuals and populations due to acoustic exposures have not been studied. Therefore, long-term consequences to sea turtles due to acoustic exposures are considered following the framework presented in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

The long-term consequences due to individual behavioral reactions and short-term (seconds to minutes) 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 sea turtles 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. For example, loggerhead sea turtles exposed to air guns with a source SPL of 179 dB re 1 µPa initially exhibited avoidance reactions. However, they may have habituated to the sound source after multiple exposures, since a habituation behavior was retained when exposures were separated by several days (Moein Bartol et al., 1995). Intermittent exposures are assumed to be less likely to have lasting consequences.

3.5.2.1.2 Impacts from Sonar and Other Transducers

The overall use of sonar and other transducers for training and testing would be similar to what is currently conducted (see Table 2.5-1 and Table 3.0-2 for details). Although individual activities may vary somewhat from those previously analyzed, the overall determinations presented in the 2015 MITT Final EIS/OEIS remain valid. In addition, some new systems using new technologies would be tested under Alternatives 1 and 2. The quantitative analysis has been updated since the 2015 MITT Final EIS/OEIS; therefore, the new analysis is fully presented and described in further detail 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, 2017b).

Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Training and Testing Activities Descriptions). Sonar and other transducers proposed for use are transient in most locations because activities that involve sonar and other transducers take place at different locations and many platforms are generally moving throughout the Study Area. Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of these systems are described in Section 3.0.4.1 (Acoustic Stressors). The activities that use sonar and other transducers are described in Appendix A (Training and Testing Activities Descriptions).

Sonar-induced acoustic resonance and bubble formation phenomena are very unlikely to occur under realistic conditions, as discussed in Section 3.5.2.1.1.1 (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.

Potential impacts considered from exposure to sonar and other transducers are hearing loss due to threshold shift (permanent or temporary), physiological stress, masking of other biologically relevant sounds, and changes in behaviors, as described in Sections 3.5.2.1.1.2 (Hearing Loss and Auditory Injury), Section 3.5.2.1.1.3 (Physiological Stress), Section 3.5.2.1.1.4 (Masking) and Section 3.5.2.1.1.5 (Behavioral Reactions).

3.5.2.1.2.1 Methods for Analyzing Impacts from Sonar and Other Transducers

The Navy performed a quantitative analysis to estimate the number of times that sea turtles could be affected by sonars and other transducers used during Navy training and testing activities. The Navy's quantitative analysis to determine impacts on sea turtles and marine mammals uses the Navy Acoustic Effects Model to produce initial estimates of the number of times these animals may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation. The steps of this quantitative analysis take into account

- criteria and thresholds used to predict impacts from sonar and other transducers (see below);
- the density and spatial distribution of sea turtles; and
- the influence of environmental parameters (e.g., temperature, depth, salinity) on sound propagation when estimating the received sound level on the animals.

A further 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).

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

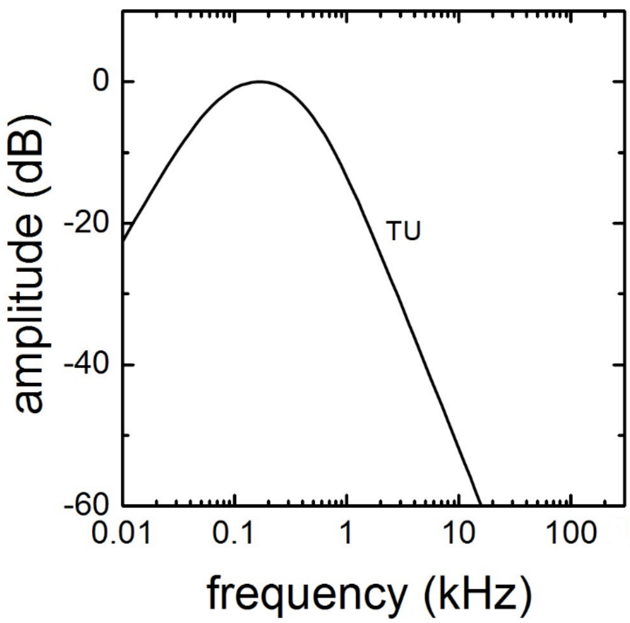
Auditory Weighting Functions

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. 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. The adjusted received sound level is referred to as a weighted received sound level.

The auditory weighting function for sea turtles is shown in Figure 3.5-4. The derivation of this weighting function is described in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a). The frequencies around the top portion of the function, where the amplitude is closest to zero, are emphasized, while the frequencies below and above this range (where amplitude declines) are de-emphasized, when summing acoustic energy received by a sea turtle.

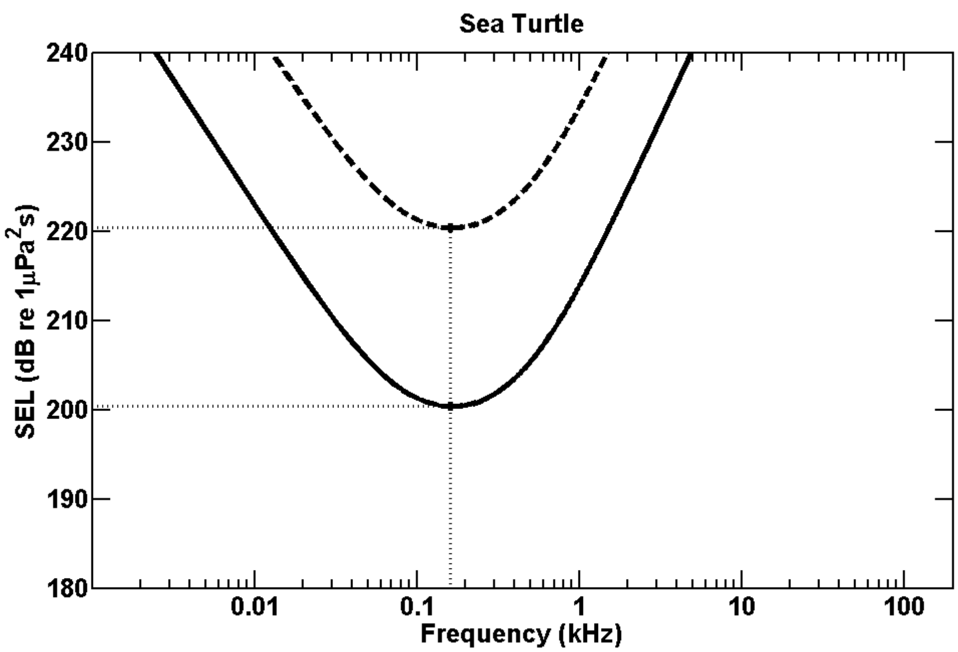
Hearing Loss from Sonar and Other Transducers

No studies of hearing loss have been conducted on sea turtles. Therefore, sea turtle susceptibility to hearing loss due to an acoustic exposure is evaluated using knowledge about sea turtle hearing abilities in combination with non-impulsive auditory effect data from other species (marine mammals and fish). This yields sea turtle exposure functions, shown in Figure 3.5-5, which are mathematical functions that relate the sound exposure levels (SELs) for onset of TTS or PTS to the frequency of the sonar sound exposure. The derivation of the sea turtle exposure functions 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).



Source: U.S. Department of the Navy (2017a)
Notes: dB = decibels, kHz = kilohertz, TU = sea turtle species group

Figure 3.5-4: Auditory Weighting Function for Sea Turtles



Source: U.S. Department of the Navy (2017a)
Notes: dB re 1 µPa2s: decibels referenced to 1 micropascal second squared, kHz = kilohertz. The solid black curve is the exposure function for TTS and the dashed black curve is the exposure function for PTS onset. Small dashed lines and asterisks indicate the SEL thresholds at the most sensitive frequency for TTS (200 dB) and PTS (220 dB).

Figure 3.5-5: TTS and PTS Exposure Functions for Sonar and Other Transducers

Accounting for Mitigation

The Navy will implement mitigation measures to avoid or reduce potential impacts from active sonar on sea turtles, as described in Section 5.3.2.1 (Active Sonar). The benefits of mitigation are conservatively factored into the analysis for Alternative 1 and Alternative 2 of the Proposed Action for training and testing. The Navy's mitigation measures are identical for both action alternatives.

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

In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, some model-estimated PTS is considered mitigated to the level of TTS. The impact 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 or testing event. The ability of Navy Lookouts to detect sea turtles in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability (such as size or surface active behavior). The behaviors and characteristics of some species may make them easier to detect. Environmental conditions under which the training or testing activity could take place are also considered such as the sea surface conditions, weather (e.g., fog or rain), and day versus night.

The Navy will also implement mitigation measures for certain active sonar activities within mitigation areas, including the Marpi Reef Mitigation Area, Chalan Kanoa Reef Mitigation Area, and Agat Bay Nearshore Mitigation Area, as described in Appendix I (Geographic Mitigation Assessment). Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. The benefits of mitigation areas are discussed qualitatively in terms of the context of impact avoidance or reduction.

3.5.2.1.2.2 Impact Ranges for Sonar and Other Transducers

Because sea turtle hearing range is limited to a narrow range of frequencies and thresholds for auditory impacts are relatively high, there are few sonar sources that could result in exposures exceeding the sea turtle TTS and PTS thresholds. The representative bin of LF4 for PTS and TTS is zero meters. Ranges would be greater (i.e., up to tens of meters) for sonars and other transducers with higher source levels (within their hearing range); however, specific ranges cannot be provided in an unclassified document.

3.5.2.1.2.3 Impacts from Sonar and Other Transducers Under the Alternative 1

Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training and testing activities under Alternative 1 are described in Section 3.0.1.2.4.1 (Sonar and Other Transducers). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Training and Testing Activities Descriptions). Low-frequency sources are operated more frequently during testing activities than during training activities. Although the general impacts from sonar and other transducers during testing would be similar in severity to those described during training, there may be slightly more impacts during testing activities as sea turtles can detect low frequency sources.

Under Alternative 1, training and testing activities would fluctuate each year to account for the natural variation of training cycles and deployment schedules. Training and testing activities, including low-frequency sonars within sea turtle hearing range (<2 kHz), could take place throughout the Study Area.

The quantitative analysis, using the number of hours of sonar and other transducers for a maximum year of training activities under Alternative 1, predicts that no sea turtles of any species are likely to be exposed to the high received levels of sound from sonars or other transducers that could cause TTS or PTS. Exposures were only modeled for green, hawksbill, leatherback, and loggerhead sea turtles in the Study Area and transit corridor. Olive ridley sea turtle presence in the Study Area is limited, and density data does not exist due to low occurrence in this region. Only a limited number of sonars and other transducers with frequencies within the range of sea turtle hearing (<2 kHz) and high source levels have the potential to cause TTS and PTS.

The *ANSI Sound Exposure Guidelines* estimate that the risk of a sea turtle responding to a low-frequency sonar (less than 1 kHz) is low regardless of proximity to the source, and that there is no risk of a sea turtle responding to a mid-frequency sonar (1–10 kHz) (Popper et al., 2014). A sea turtle could respond to sounds detected within their limited hearing range if they are close enough to the source. The few studies of sea turtle reactions to sounds, discussed in Section 3.5.2.1.1.5 (Behavioral Reactions), suggest that a behavioral response could consist of temporary avoidance, increased swim speed, or changes in depth, or that there may be no observable response. Use of sonar and other transducers would typically be transient and temporary and there is no evidence to suggest that any behavioral response would persist after a sound exposure. It is assumed that a stress response could accompany any behavioral response.

Implementation of mitigation may further reduce the already low risk of auditory impacts on sea turtles. Depending on the sonar source, mitigation includes powering down the sonar or ceasing active sonar transmission if a sea turtle is observed in the mitigation zone, as discussed in Section 3.5.2.1.2.1 (Methods for Analyzing Impacts from Sonar and Other Transducers – Accounting for Mitigation).

Although masking of biologically relevant sounds by the limited number of sonars and other transducers operated in sea turtle hearing range is possible, this may only occur in certain circumstances. Sea turtles most likely use sound to detect nearby broadband, continuous environmental sounds, such as the sounds of waves crashing on the beach. The use characteristics of low-frequency active sonars, including limited band width, beam directionality, limited beam width, relatively low source levels, low duty cycle, and limited duration of use, would both greatly limit the potential for a sea turtle to detect these sources and limit the potential for masking of broadband, continuous environmental sounds. In addition, broadband sources within sea turtle hearing range, such as countermeasures used during anti-submarine warfare, would typically be used in off-shore areas, not in near-shore areas where detection of beaches or concentrated vessel traffic is relevant.

Considering the above factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences to sea turtle individuals or populations would not be expected.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 1 may affect ESA-listed green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles.

3.5.2.1.2.4 Impacts from Sonar and Other Transducers Under Alternative 2 (Preferred Alternative)

Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. Use of sonar and other transducers would typically be transient and temporary. General categories and characteristics of sonar systems and the number of hours these sonars would be operated during training under Alternative 2 are described in Section 3.0.1.2.4.1 (Sonar and Other Transducers). Activities using sonars and other transducers would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Training and Testing Activities Descriptions). Low-frequency sources are operated more frequently during testing activities than during training activities. Although the general impacts from sonar and other transducers during testing would be similar in severity to those described during training, there may be slightly more impacts during testing activities as sea turtles can detect low frequency sources.

Under Alternative 2, the same type and tempo of training and testing activities could occur as Alternative 1, but would include five Joint multi-strike group exercises (i.e., Valiant Shield) over five years as compared to three under Alternative 1. Additionally, Alternative 2 contemplates three (vice two) small joint coordinated anti-submarine warfare exercises (Multi-Sail/Guam Exercises) per year with a 50 percent increase in associated unit-level events (e.g., missile exercise [surface-to-air]). This would result in an increase of sonar use compared to Alternative 1. There would also be an increase in the use of active sonar during certain testing events. Alternative 2 reflects the maximum number of training and testing activities that could occur within a given year, and assumes that the maximum number of Fleet exercises would occur every year.

The quantitative analysis predicts that no sea turtles of any species are likely to be exposed to the high received levels of sound from sonars or other transducers that could cause TTS or PTS during a maximum year of training activities under Alternative 2. Although there would be an increase in sonar use compared to Alternative 1, potential for and type of impacts on sea turtles would be the similar. This is because sea turtles are capable of detecting only a limited number of sonars due to their limited hearing range. Olive ridley sea turtle presence in the Study Area is limited and density data does not exist due to low occurrence in this region. Therefore, exposures were only modeled for green, hawksbill, leatherback, and loggerhead sea turtles in the Study Area and transit corridor. The NMFS's 2015 Biological Opinion (National Oceanic and Atmospheric Administration, 2015) on training and testing activities analyzed in the 2015 MITT Final EIS/OEIS considered sonars and other transducers to result in take incidental to military activities for green and hawksbill sea turtles.

Considering the above factors and the mitigation measures that would be implemented as described in Chapter 5 (Mitigation), long-term consequences to sea turtle individuals or populations would not be expected.

Pursuant to the ESA, the use of sonar and other transducers during training and testing activities as described under Alternative 2 may affect ESA-listed green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

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

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Sonar and other transducers as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer acoustic stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for acoustics stressors on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.1.3 Impacts from Vessel Noise

Sea turtles may be exposed to noise from vessel movement. A detailed description of the acoustic characteristics and typical sound levels of vessel noise is in Section 3.0.4.1.2 (Vessel Noise). Vessel movements involve transits to and from ports to various locations within the Study Area, including commercial ship traffic and recreational vessels, in addition to U.S. Navy vessels. Many ongoing and proposed training and testing activities within the Study Area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels).

Activities may vary slightly from those previously analyzed in the 2015 MITT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Tables 2.5-1 and 2.5-2 for proposed training and testing activities under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors (e.g., vessel noise) as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer acoustic stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for vessel noise impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

Pursuant to the ESA, vessel noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed green, hawksbill, leatherback, loggerhead and olive ridley sea turtles. The Navy is consulting on the activities described under Alternative 2 with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.1.4 Impacts from Aircraft Noise

Sea turtles may be exposed to aircraft-generated noise throughout the Study Area. Fixed- and rotary-wing aircraft are used during a variety of training and testing activities throughout the Study Area. Tilt-rotor impacts would be similar to fixed-wing or helicopter impacts, depending on the aircraft's mode. Most of these sounds would be concentrated around airbases and fixed ranges within the range complex. Aircraft produce extensive airborne noise from either turbofan or turbojet engines. An infrequent type of aircraft noise is the sonic boom, produced when the aircraft exceeds the speed of sound. Rotary-wing aircraft (helicopters) produce low-frequency sound and vibration (Pepper et al., 2003).

A detailed description of aircraft noise as a stressor is in Section 3.0.4.1.3 (Aircraft Noise). Activities may vary slightly from those previously analyzed in the 2015 MITT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Tables 2.5-1 and 2.5-2 for proposed training and testing activities under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS.

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors (e.g., aircraft noise) as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer acoustic stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for aircraft noise impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

Pursuant to the ESA, aircraft noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed green, hawksbill, leatherback, loggerhead and olive ridley sea turtles. The Navy is consulting on the activities described under Alternative 2 with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.1.5 Impacts from Weapon Noise

Sea turtles 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 3.0.4.1.4 (Weapon Noise). In general, these are impulsive sounds generated in close vicinity to or at the water surface, with the exception of items that are launched underwater. The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated in air by firing a gun (muzzle blast) and a crack sound due to a low-amplitude shock wave generated by a supersonic projectile flying through the air. Most in-air sound would be reflected at the air-water interface.

Underwater sounds would be strongest just below the surface and directly under the firing point. Any sound that enters the water only does so within a narrow cone below the firing point or path of the projectile. Vibration from the blast propagating through a ship's hull, the sound generated by the impact of an object with the water surface, and the sound generated by launching an object underwater are other sources of impulsive sound in the water. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange.

Activities may vary slightly from those previously analyzed in the 2015 MITT Final EIS/OEIS, but the overall determinations presented remain valid. Increases and decreases shown in Tables 2.5-1 and 2.5-2 for proposed training and testing activities under Alternative 1 and 2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS. Implementation of mitigation may further reduce the already low risk of auditory impacts on sea turtles from weapon noise during large-caliber gunnery events, as discussed in Section 5.3.2.2 (Weapons Firing Noise).

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors (e.g., weapon noise) as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer acoustic stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for weapon noise impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

Pursuant to the ESA, weapon noise during training and testing activities as described under Alternative 1 and Alternative 2 may affect ESA-listed green, hawksbill, leatherback, loggerhead and olive ridley sea turtles. The Navy is consulting on the activities described under Alternative 2 with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.2 Explosive Stressors

Explosions in the water or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. 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 sea turtles are discussed separately from other acoustic stressors, even though the analysis of explosive impacts will rely on data for sea turtle 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 H (Acoustic and Explosive Concepts).

This section begins with a summary of relevant data regarding explosive impacts on sea turtles in Section 3.5.2.2.1 (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 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), and this section follows that framework. Studies of the effects of sound and explosives on sea turtles are limited; therefore, where necessary, knowledge of impacts on other species from explosives is used to assess impacts on sea turtles.

Due to new acoustic impact criteria, sea turtle densities, and acoustics effects model, the analysis provided in Section 3.5.2.2.2 (Impacts from Explosives) of this SEIS/OEIS will supplant the 2015 MITT Final EIS/OEIS for sea turtles, and may result in changes to estimated impacts for some species since the 2015 MITT Final EIS/OEIS.

3.5.2.2.1 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 sea turtles potentially resulting from Navy training and testing activities. Sea turtles 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.

3.5.2.2.1.1 Injury

Because direct studies of explosive impacts on sea turtles have not been conducted, the below discussion of injurious effects is based on studies of other animals, generally mammals. The generalizations that can be made about in-water explosive injuries to other species should be applicable to sea turtles, with consideration of the unique anatomy of sea turtles. For example, it is unknown if the sea turtle shell may afford it some protection from internal injury.

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. However, rapid under-pressure phase caused by the negative surface-reflected pressure wave above an underwater detonation may create a zone of cavitation that may contribute to potential injury. In general, blast injury susceptibility would increase with depth, until normal lung collapse (due to increasing hydrostatic pressure) and increasing ambient pressures again reduce susceptibility.

See Appendix H (Acoustic and Explosive Concepts) for an overview of explosive propagation and an explanation of explosive effects on gas cavities.

Primary blast injury is injury that results from the compression of a body exposed to a blast wave. This 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 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 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. In this discussion, primary blast injury to auditory tissues is considered gross structural tissue injury distinct from noise-induced hearing loss, which is considered below in Section 3.5.2.2.1.2 (Hearing Loss).

Data on observed injuries to sea turtles from explosives is generally limited to animals found following explosive removal of offshore structures (Viada et al., 2008), which can attract sea turtles for feeding opportunities or shelter. Klima et al. (1988) observed a turtle mortality subsequent to an oil platform removal blast, although sufficient information was not available to determine the animal's exposure. Klima et al. (1988) also placed small sea turtles (less than 7 kilograms) at varying distances from piling detonations. Some of the turtles were immediately knocked unconscious or exhibited vasodilation over the following weeks, but others at the same exposure distance exhibited no effects.

Incidental injuries to sea turtles due to a military explosion have been documented in a few instances. In one incident, a single 1,200-pound (lb.) trinitrotoluene (TNT) underwater charge was detonated off Panama City, FL in 1981. The charge was detonated at a mid-water depth of 120 feet (ft.). Although details are limited, the following were recorded: at a distance of 500–700 ft., a 400 lb. sea turtle was killed; at 1,200 ft., a 200–300 lb. sea turtle experienced "minor" injury; and at 2,000 ft. a 200–300 lb. sea turtle was not injured (O'Keeffe & Young, 1984). In another incident, two "immature" green sea turtles (size unspecified) were found dead about 100-150 ft. away from detonation of 20 lb. of C-4 in a shallow water environment.

Results from limited experimental data suggest two explosive metrics are predictive of explosive injury: peak pressure and impulse.

Impulse as a Predictor of Explosive Injury

Without measurements of the explosive exposures in the above incidents, it is difficult to draw conclusions about what amount of explosive exposure would be injurious to sea turtles. Studies of observed in-water explosive injuries showed that terrestrial mammals were more susceptible than comparably sized fish with swim bladders (Yelverton & Richmond, 1981), and that fish with swim bladders may have increased susceptibility to swim bladder oscillation injury depending on exposure geometry (Goertner, 1978; Wiley et al., 1981). Therefore, controlled tests with a variety of terrestrial mammals (mice, rats, dogs, pigs, sheep and other species) are the best available data sources on actual injury to similar-sized animals 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 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, consistent with earlier studies of mammal exposures to underwater explosions (Clark & Ward, 1943; Greaves et al., 1943).

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 proportion of lung volume to overall body size is similar between sea turtles and terrestrial mammals, so the magnitude of lung damage in the tests may approximate the magnitude of injury to sea turtles when scaled for body size. Measurements of some shallower diving sea turtles (Hochscheid et al., 2007) show lung-to-body size ratios that are larger than terrestrial animals, whereas the lung-to-body mass ratio of the deeper diving leatherback sea turtle is smaller (Lutcavage et al., 1992). 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 kilograms) to underwater detonations, Richmond et al. (1973) reported that no blast injuries were observed when exposures were less than 6 lb. per square inch (in.) 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 adult sea turtles may be substantially larger and have respiratory structures adapted for the high pressures experienced at depth. Goertner (1982) examined how lung cavity size would affect susceptibility to blast injury by considering both size and depth in a bubble oscillation model of the lung, which is assumed to be applicable to sea turtles as well for this analysis. 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 time 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. Based on a study of green sea turtles, Berkson (1967) predicted sea turtle lung collapse would be complete around 80–160 meter depth.

Peak Pressure as a Predictor of Explosive Trauma

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 lb. psi (237 dB re 1 µPa peak) to feel like a 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.

The *ANSI Sound Exposure Guidelines* (Popper et al., 2014) recommended peak pressure guidelines for sea turtle injury from explosives. Lacking any direct data for sea turtles, these recommendations were based on fish data. Of the fish data available, the working group conservatively chose the study with the lowest peak pressures associated with fish mortality to set guidelines (Hubbs & Rechnitzer, 1952), and did not consider the Lovelace studies discussed above.

3.5.2.2.1.2 Hearing Loss

An underwater explosion produces broadband, impulsive sound that can cause noise-induced hearing loss, typically quantified as threshold shift, which persists after cessation of the noise exposure. This noise-induced hearing loss may manifest as TTS or PTS. Because studies on inducing threshold shift in sea turtles are very limited (e.g., alligator lizards: Dew et al., 1993; Henry & Mulroy, 1995) and have not been conducted on any of the sea turtles present in the Study Area, auditory threshold shift in sea turtles is considered to be consistent with general knowledge about noise-induced hearing loss described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

Little is known about how sea turtles use sound in their environment. The *ANSI Sound Exposure Guidelines* (Popper et al., 2014) do not suggest numeric sound exposure thresholds for auditory effects on sea turtles due to lack of data. Rather, the guidelines qualitatively advise that sea turtles are less likely to incur TTS or PTS with increasing distance from an explosive. The guidelines also suggest that data from fishes may be more relevant than data from marine mammals when estimating auditory impacts on sea turtles, because, in general, fish hearing range is more similar to the limited hearing range of sea turtles. As shown in Section 3.5.1.4 (Hearing and Vocalization), sea turtle hearing is most sensitive around 100–400 Hz in-water, is limited over 1 kHz, and is much less sensitive than that of any marine mammal.

3.5.2.2.1.3 Physiological Stress

A stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. If the magnitude and duration of the stress response is too great or too long, it can have negative consequences to the animal (e.g. decreased immune function, decreased reproduction). Physiological stress is typically analyzed by measuring stress hormones, other biochemical markers, or vital signs. Physiological stress has been measured for sea turtles during nesting (Flower et al., 2015; Valverde et al., 1999) and capture and handling (Flower et al., 2015; Gregory & Schmid, 2001), but the stress caused by acoustic exposure has not been studied for sea turtles. Therefore, the stress response in sea turtles in the Study Area due to acoustic exposures is considered to be consistent with general knowledge about physiological stress responses described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

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. Anthropogenic sound-producing activities have the potential to provide additional stressors beyond those that naturally occur.

Due to the limited information about acoustically induced stress responses, the Navy conservatively 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.

3.5.2.2.1.4 Masking

As described in Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities), auditory masking occurs when one sound, distinguished as the "noise," interferes with the detection or recognition of another sound or limits the distance over which other biologically relevant sounds can be detected. Masking only occurs when the sound source is operating; therefore, direct masking effects stop immediately upon cessation of the sound-producing activity. Any unwanted sound above ambient noise and within an animal's hearing range may potentially cause masking which can interfere with an animal's ability to detect, understand, or recognize biologically relevant sounds of interest.

Masking occurs in all vertebrate groups and can effectively limit the distance over which an animal can communicate and detect biologically relevant sounds. The effect of masking has not been studied for sea turtles. The potential for masking in sea turtles would be limited to certain sound exposures due to their limited hearing range to broadband low-frequency sounds and lower sensitivity to noise in the marine environment. Only continuous human-generated sounds that have a significant low-frequency component, are not of brief duration, and are of sufficient received level could create a meaningful masking situation. While explosives produce intense, broadband sounds with significant low-frequency content, these sounds are very brief with limited potential to mask relevant sounds.

There is evidence that sea turtles may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al., 2013) and magnetic orientation (Avens, 2003; Putman et al., 2015). Any effect of masking may be mediated by reliance on other environmental inputs.

3.5.2.2.1.5 Behavioral Reactions

There are no observations of behavioral reactions by sea turtles to exposure to explosive sounds. 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. Although explosive sources are more energetic than air guns, the few studies of sea turtle responses to air guns, which are not used during MITT training or testing activities, may show the types of behavioral responses that sea turtles may have towards explosives. General research findings regarding behavioral reactions from sea turtles due to exposure to impulsive sounds, such as those associated with explosions, are discussed in detail in Behavioral Reactions to Impulsive Sound Sources under Section 3.5.2.1 (Acoustic Stressors).

3.5.2.2.1.6 Long-Term Consequences

For sea turtles present in the Study Area, long-term consequences to individuals and populations due to acoustic exposures have not been studied. Therefore, long term consequences to sea turtles due to explosive exposures are considered following Section 3.0.4.7 (Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities).

Long-term consequences to a population are determined by examining changes in the population growth rate. 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, which could impact navigation. The 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 sea turtles 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. For example, loggerhead sea turtles exposed to air guns with a source SPL of 179 dB re 1 µPa initially exhibited avoidance reactions. However, they may have habituated to the sound source after multiple exposures since a habituation behavior was retained when exposures were separated by several days (Moein Bartol et al., 1995). More research is needed to better understand the long-term consequences of human-made noise on sea turtles, although intermittent exposures are assumed to be less likely to have lasting consequences.

3.5.2.2.2 Impacts from Explosives

Sea turtles could be exposed to energy, sound, and fragments from explosions in the water and near the water surface associated with the proposed activities. Energy and sound from an explosion are 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 may limit an animal's ability interpret the surrounding environment. Impairment of these abilities can decrease an individual's chance of survival or affect its ability to reproduce. Temporary threshold shift can also impair an animal's abilities, although the individual may recover quickly with little significant effect.

Overall, the locations, types, and severity of predicted impacts for the use of explosives during training and testing activities would be similar to what is currently conducted, with the addition of several new testing activities as described in Table 2.5-1. Although individual activities may vary in the number of events or ordnances some from those previously analyzed, the overall determinations presented in the 2015 MITT Final EIS/OEIS remain valid, and has been developed further under the current SEIS/EIS.

The quantitative analysis has been improved upon and updated since the 2015 MITT Final EIS/OEIS; therefore, the new analysis is fully presented and described in further detail in the technical report *Quantitative Analysis for Estimating Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2018).

3.5.2.2.2.1 Methods for Analyzing Impacts from Explosives

Potential impacts considered are mortality, injury, hearing loss due to threshold shift (permanent or temporary), masking of other biologically relevant sounds, physiological stress, and changes in behavior.

The Navy's quantitative analysis to determine impacts on sea turtles and marine mammals uses the Navy Acoustic Effects Model to produce initial estimates of the number of times these animals may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation. The steps of this quantitative analysis are described in Section 3.0.1.2 (Navy's Quantitative Analysis to Determine Impacts on Sea Turtles and Marine Mammals), which takes into account

- criteria and thresholds used to predict impacts from explosives (see below),
- the density and spatial distribution of sea turtles, 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 further detailed explanation of this analysis is provided in the technical report titled *Quantitative Analysis for Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018).

Criteria and Thresholds used to Predict Impacts on Sea Turtles from Explosives

Mortality and Injury from Explosives

As discussed above in Section 3.5.2.2.1.1 (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).

Two sets of thresholds 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 and testing activities (Table 3.5-2). The thresholds for the farthest range to effect are based on the received level at which 1 percent risk is predicted and are useful for assessing potential effects to sea turtles and marine mammals, and the range at which mitigation could be effective. 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, sea turtle populations are assumed to be 5 percent adult and 95 percent sub-adult. This adult to sub-adult population ratio is estimated from what is known about the population age structure for sea turtles. Sea turtles typically lay multiple clutches of 100 or more eggs with little parental investment and generally have low survival in early life. However, sea turtles that are able to survive past early life generally have high age-specific survival in later life.

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 3.5-2: Criteria to Quantitatively Assess Non-Auditory Injury due to Underwater Explosions

Impact Category	*Exposure Threshold*	*Threshold for Farthest Range to Effect*
Mortality[1]	$144M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s	$103M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/6}$ Pa-s
Injury[1]	$65.8\mathrm{M}^{1/3}\left(1+\frac{\mathrm{D}}{10.1}\right)^{1/6}$ Pa-s	$47.5\mathrm{M}^{1/3}\left(1+\frac{\mathrm{D}}{10.1}\right)^{1/6}$ 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 1 percent risk used to assess mitigation effectiveness.
Note: dB re 1 µPa = decibels referenced to 1 micropascal, SPL = sound pressure level, M = animal mass (kg), D = animal depth (m), and Pa-s = Pascal-second

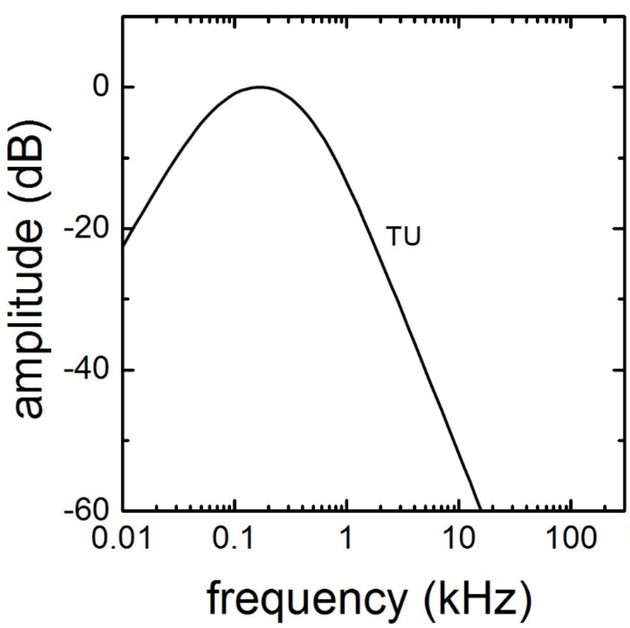
When explosive munitions (e.g., a bomb or missile) detonates, fragments of the weapon are thrown at high-velocity from the detonation point, which can injure or kill sea turtles if they are struck. Risk of fragment injury reduces exponentially with distance as the fragment density is reduced. Fragments 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.

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.

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. 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. The adjusted received sound level is referred to as a weighted received sound level.

The auditory weighting function for sea turtles is shown in Figure 3.5-6. The derivation of this weighting function is described in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017a). The frequencies around the top portion of the function, where the amplitude is closest to zero, are emphasized, while the frequencies below and above this range (where amplitude declines) are de-emphasized, when summing acoustic energy received by a sea turtle.



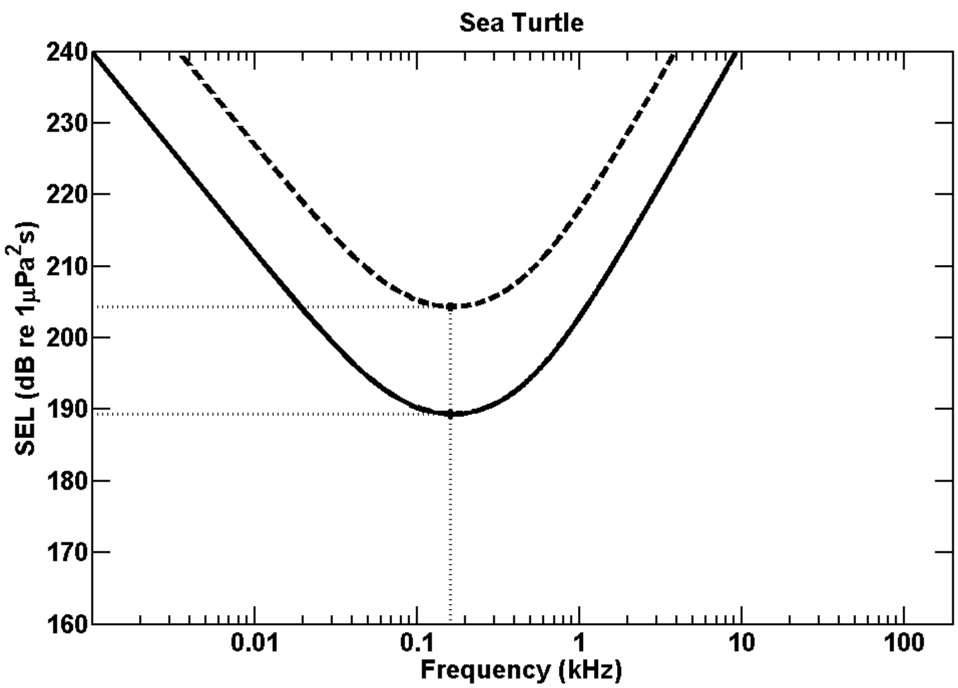
Source: U.S. Department of the Navy (2017a)
Notes: dB = decibels, kHz = kilohertz, TU = sea turtle hearing group

Figure 3.5-6: Auditory Weighting Functions for Sea Turtles

Hearing Loss from Explosives

No studies of hearing loss have been conducted on sea turtles. Therefore, sea turtle susceptibility to hearing loss due to an acoustic exposure is evaluated using knowledge about sea turtle hearing abilities in combination with non-impulsive auditory effect data from other species (marine mammals and fish). This yields sea turtle exposure functions, shown in Figure 3.5-7, which are mathematical functions that relate the SELs for onset of TTS or PTS to the frequency of the sonar sound exposure. The derivation of the sea turtle exposure functions 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).

For impulsive sounds, hearing loss in other species has also been observed to be related to the unweighted peak pressure of a received sound. Because this data does not exist for sea turtles, unweighted peak pressure thresholds for TTS and PTS were developed by applying relationships observed between impulsive peak pressure TTS thresholds and auditory sensitivity in marine mammals to sea turtles. This results in dual-metric hearing loss criteria for sea turtles for impulsive sound exposure: the SEL-based exposure functions in Figure 3.5-7 and the peak pressure thresholds in Table 3.5-3. The derivation of the sea turtle impulsive peak pressure TTS and PTS thresholds 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).



Notes: kHz = kilohertz, SEL = Sound Exposure Level, dB re 1 μPa^{2}s = decibels referenced to 1 micropascal squared second. The solid black curve is the exposure function for TTS onset and the dashed black curve is the exposure function for PTS onset. Small dashed lines and asterisks indicate the SEL thresholds and most sensitive frequency for TTS and PTS.

Figure 3.5-7: TTS and PTS Exposure Functions for Impulsive Sounds

Table 3.5-3: TTS and PTS Peak Pressure Thresholds Derived for Sea Turtles Exposed to Impulsive Sounds

Auditory Effect	*Unweighted Peak Pressure Threshold*
TTS	226 dB re 1 µPa SPL peak
PTS	232 dB re 1 µPa SPL peak

Notes: dB re 1 µPa = decibels referenced to 1 micropascal, PTS = permanent threshold shift, SPL = sound pressure level, TTS = temporary threshold shift

Accounting for Mitigation

The Navy will implement mitigation measures to avoid or reduce potential impacts from explosives on sea turtles, as described in Section 5.3.3 (Explosive Stressors). The benefits of mitigation are conservatively factored into the analysis for Alternative 1 and Alternative 2 of the Proposed Action for training and testing. The Navy's mitigation measures are identical for both action alternatives.

Procedural mitigation measures include delaying or ceasing applicable detonations when a sea turtle is observed in a mitigation zone. The mitigation zones for explosives extend beyond the respective average ranges to mortality. The mitigation zones encompass the estimated ranges to mortality for a given explosive. Therefore, the impact analysis quantifies the potential for mitigation to reduce the risk of mortality due to exposure to explosives. 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, 2017a).

In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, model-estimated mortality is considered mitigated to the level of injury. The impact 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 Navy will also implement mitigation measures for certain explosive activities within mitigation areas, including the Marpi Reef Mitigation Area, Chalan Kanoa Reef Mitigation Area, and Agat Bay Nearshore Mitigation Area, as described in Appendix I (Geographic Mitigation Assessment). Mitigation areas are designed to help avoid or reduce impacts during biologically important life processes within particularly important habitat areas. The benefits of mitigation areas are discussed qualitatively in terms of the context of impact avoidance or reduction.

3.5.2.2.2.2 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 3.5.2.2.2.1, Methods for Analyzing Impacts from Explosives). The range to effects is shown for a range of explosive bins, from E1 (up to 0.25 lb. net explosive weight) to E12 (up to 1,000 lb. net explosive weight). Ranges are determined by modeling the distance that noise from an explosion would need to propagate to reach exposure level thresholds specific to a hearing group that would cause TTS, PTS, non-auditory injury, and mortality. 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.

Table 3.5-4 shows the minimum, average, and maximum ranges due to varying propagation conditions to non-auditory injury based on the larger of the range to slight lung injury or gastrointestinal tract injury for representative animal masses ranging from 10 to 1,000 kilograms and different explosive bins ranging from 0.25 to 1,000 lb. net explosive weight. 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 3.5-5.

The following tables (Table 3.5-6 and Table 3.5-7) show the minimum, average, and maximum ranges to onset of auditory and behavioral effects based on the thresholds described in Section 3.5.2.2.2.1 (Methods for Analyzing Impacts from Explosives). Ranges 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, 2017b).

Table 3.5-4: Ranges to Non-Auditory Injury[1] (in meters) for Sea Turtles Exposed to Explosives as a Function of Animal Mass

Bin[2]	*Range to Non-Auditory Injury (meters) for Various Animal Mass Intervals (kg)[1]*		
	10 kg	*250 kg*	*1,000 kg*
E1	12 (11–13)	12 (11–13)	12 (11–13)
E2	16 (15–16)	16 (15–16)	16 (15–16)
E3	25 (25–25)	25 (25–25)	25 (25–25)
E4	30 (30–35)	30 (30–35)	30 (30–35)
E5	40 (40–65)	40 (40–50)	40 (40–50)
E6	52 (50–60)	52 (50–55)	52 (50–55)
E8	93 (90–150)	91 (90–95)	91 (90–95)
E9	123 (120–270)	123 (120–140)	123 (120–130)
E10	155 (150–420)	155 (150–240)	155 (150–160)
E11	398 (380–420)	219 (170–260)	172 (160–220)
E12	195 (190–650)	195 (190–380)	195 (190–200)

[1] Average distance (m) to non-auditory injury is depicted above the minimum and maximum distances which are in parentheses. The ranges depicted are the further of the ranges for gastrointestinal tract injury or slight lung injury for an explosive bin and animal mass interval combination.

[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

Table 3.5-5: Ranges to Mortality for Sea Turtles Exposed to Explosives as a Function of Animal Mass[1]

Bin	*Ranges to Mortality (meters) for Various Animal Mass Intervals (kg)[1]*		
	10 kg	***250 kg***	***1,000 kg***
E1	2 (2–3)	1 (0–1)	0 (0–0)
E2	4 (3–4)	1 (1–2)	1 (1–1)
E3	8 (6–9)	4 (3–6)	2 (2–2)
E4	13 (11–15)	7 (5–9)	4 (4–5)
E5	12 (11–30)	7 (5–18)	4 (4–7)
E6	15 (14–25)	9 (7–17)	5 (5–9)
E8	40 (24–65)	22 (12–40)	14 (9–21)
E9	31 (30–35)	20 (16–24)	13 (12–13)
E10	54 (40–170)	24 (20–25)	16 (15–17)
E11	194 (180–210)	96 (70–130)	53 (50–55)
E12	83 (50–260)	31 (25–90)	20 (19–20)

[1] Average distance (m) to mortality is depicted above the minimum and maximum distances which are in parentheses.
[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

Table 3.5-6: Peak Pressure Based Ranges to TTS and PTS for Sea Turtles Exposed to Explosives

Range to Effects for Explosives: Sea turtles[1]				
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	1	35 (35–35)	68 (65–70)
		18	35 (35–35)	68 (65–70)
E2	0.1	1	48 (45–50)	87 (80–90)
		5	48 (45–50)	87 (80–90)
E3	0.1	1	81 (75–85)	145 (140–150)
		12	81 (75–85)	145 (140–150)
	18.25	1	80 (80–80)	150 (150–150)
		12	80 (80–80)	150 (150–150)
E4	10	2	100 (100–100)	192 (190–200)
	60	2	101 (100–110)	194 (190–220)
E5	0.1	20	125 (120–130)	235 (230–250)
	30	20	138 (130–160)	257 (240–290)
E6	0.1	1	163 (160–170)	292 (270–320)
	30	1	160 (160–160)	300 (300–300)
E8	0.1	1	273 (260–280)	451 (370–500)
	45.75	1	281 (280–300)	527 (525–575)
E9	0.1	1	355 (320–380)	566 (440–675)

Table 3.5-6: Peak Pressure Based Ranges to TTS and PTS for Sea Turtles Exposed to Explosives (continued)

Range to Effects for Explosives: Sea turtles[1]				
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***
E10	0.1	1	432 (360–550)	690 (480–1,025)
E11	45.75	1	540 (525–625)	977 (950–1,025)
	91.4	1	558 (500–800)	1,053 (825–2,025)
E12	0.1	1	509 (410–575)	784 (550–1,025)
		4	509 (410–575)	784 (550–1,025)

[1]Average distance (m) to TTS and PTS are depicted above the minimum and maximum distances which are in parentheses. Values depict ranges to TTS and PTS based on the peak pressure metric.

[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

Table 3.5-7: SEL Based Ranges to TTS and PTS for Sea Turtles Exposed to Explosives

Range to Effects for Explosives: Sea turtles[1]				
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***
E1	0.1	1	0 (0–0)	0 (0–0)
		18	0 (0–0)	2 (2–2)
E2	0.1	1	0 (0–0)	1 (1–1)
		5	0 (0–0)	2 (2–2)
E3	0.1	1	0 (0–0)	3 (2–3)
		12	2 (1–2)	8 (8–18)
	18.25	1	3 (3–3)	17 (16–17)
		12	10 (10–10)	70 (70–70)

Table 3.5-7: SEL Based Ranges to TTS and PTS for Sea Turtles Exposed to Explosives (continued)

Range to Effects for Explosives: Sea turtles[1]				
Bin	***Source Depth (meters)***	***Cluster Size***	***Range to PTS (meters)***	***Range to TTS (meters)***
E4	10	2	7 (7–8)	52 (50–55)
	60	2	7 (7–7)	35 (35–35)
E5	0.1	20	5 (5–5)	36 (25–270)
	30	20	48 (40–65)	293 (240–400)
E6	0.1	1	2 (2–2)	10 (10–180)
	30	1	14 (14–14)	95 (95–95)
E8	0.1	1	5 (5–5)	39 (25–290)
	45.75	1	40 (40–40)	271 (270–280)
E9	0.1	1	9 (9–9)	87 (40–410)
E10	0.1	1	13 (13–270)	164 (60–1,000)
E11	45.75	1	170 (170–180)	832 (750–850)
	91.4	1	150 (150–170)	794 (750–875)
E12	0.1	1	31 (18–120)	200 (80–950)
		4	59 (30–380)	377 (140–5,025)

[1]Average distance (m) to TTS and PTS are depicted above the minimum and maximum distances which are in parentheses. Values depict ranges to TTS and PTS based on the SEL metric.
[2] Bin (net explosive weight, lb.): E1 (0.1–0.25), E2 (>0.25–0.5), E3 (>0.5–2.5), E4 (> 2.5–5), E5 (> 5–10), E6 (> 10–20), E8 (> 60–100), E9 (> 100–250), E10 (> 250–500), E11 (> 500–650), and E12 (> 650–1,000).

3.5.2.2.2.3 Presentation of Estimated Impacts from the Quantitative Analysis

The results of the analysis of potential impacts to sea turtles from explosives as described in Section 3.5.2.2.2.1 (Methods for Analyzing Impacts from Explosives) are discussed below. Estimated numbers of potential impacts from the quantitative analysis for sea turtles are presented below. The most likely regions and activity categories from which the impacts could occur are displayed in the figures. There is a potential for impacts to occur anywhere within the Study Area where sound and energy from explosives and the species overlap, although only areas or categories where 0.5 percent of the impact, or greater, are estimated to occur are graphically represented on the species-specific figures below. All (i.e., grand total) estimated impacts are included in the graphics, regardless of region or category.

The numbers of activities planned can vary slightly from year-to-year. Results are presented for a maximum explosive use year; however, during most years, explosive use would be less resulting in fewer potential impacts. The number of explosives used are described in Section 3.0.4.2 (Explosive Stressors).

Ranges to effect (see Table 3.5-4 through Table 3.5-7) were developed in the Navy Acoustic Effects Model based on the thresholds for TTS, PTS, injury, and mortality discussed above.

3.5.2.2.2.4 Impacts from Explosives Under Alternative 1

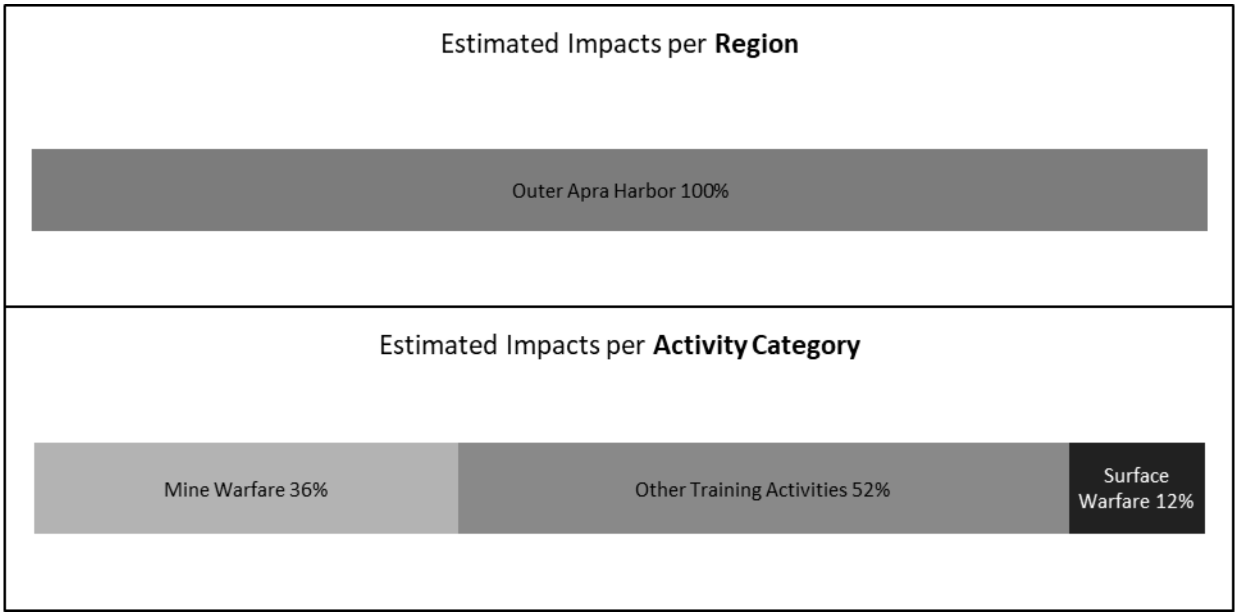
Activities using explosives would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Training and Testing Activities Descriptions). General characteristics, quantities, and net explosive weights of in-water explosives used during training and testing activities under Alternative 1 are provided in Section 3.0.4.2 (Explosive Stressors). Quantities and locations of fragment-producing explosives during training and testing activities under Alternative 1 are shown in 3.0.4.4.4 (Military Expended Materials).

Under Alternative 1, there could be fluctuation in the number of explosions that could occur annually, although potential impacts would be similar from year to year. The number of impulsive sources in this SEIS/OEIS compared with the totals analyzed in the 2015 MITT Final EIS/OEIS are described in Tables 2.5-1 and 2.5-2.

The number of torpedo testing events (both explosive and non-explosive) planned under Alternative 1 testing can vary slightly from year-to-year however all other training and testing activities would remain consistent from year-to-year. Alternative 1 results are presented for a maximum explosive use year; however, during most years, explosive use would be less resulting in fewer potential impacts, as described in Section 3.0.4.2 (Explosive Stressors).

Detonations would typically occur in waters greater than 200 ft. in depth, and greater than 3 nautical miles from shore, with the exception of existing mine warfare areas, including Outer Apra Harbor, Piti, and Agat. Section 5.3.3 (Explosive Stressors) outlines the procedural mitigation measures for explosive stressors to reduce potential impacts on biological resources.

The quantitative analysis, using a maximum year of training and testing activities, estimates that no sea turtles would be killed, however, a small number of green sea turtles would be exposed to levels of explosive sound and energy in the outer Apra Harbor that could cause TTS or PTS (Table 3.5-8). The quantitative analysis predicts that no hawksbill, leatherback, or loggerhead sea turtles are likely to be exposed to the levels of explosive sound and energy that could cause TTS or PTS during training and testing activities under Alternative 1 (for impact tables, see Appendix E, Estimated Marine Mammal and Sea Turtle Impacts from Exposure to Acoustic and Explosive Stressors Under Navy Training and Testing Activities). Olive ridley sea turtle presence in the Study Area is limited and density data does not exist due to low occurrence in this region. Therefore, exposures were only modeled for green, hawksbill, leatherback, and loggerhead sea turtles in the Study Area and transit corridor. Fractional estimated impacts per region and activity area represent the probability that the number of estimated impacts by effect would occur in a certain region or be due to a certain activity category.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided up among multiple regions or activity categories.

Figure 3.5-8: Green Sea Turtle Estimated Impacts per Year from the Maximum Number of Explosions During Training and Testing Under Alternative 1

Table 3.5-8: Estimated Impacts on Individual Green Sea Turtles Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 1

Estimated Impacts by Effect		
TTS	***PTS***	***Injury***
6	3	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 1.

Threshold shifts and injuries could reduce the fitness of an individual animal, causing a reduction in foraging success, reproduction, or increased susceptibility to predators. This reduction in fitness would be temporary for recoverable impacts, such as TTS, but there could be long-term consequences to some individuals. However, no population-level impact is expected due to the low number of estimated injuries for any sea turtle species relative to total population size. This can also be assumed for olive ridley turtles if exposed to explosions.

As discussed in Section 5.3.3 (Explosive Stressors), procedural mitigation includes ceasing explosive detonations (e.g., ceasing deployment of an explosive bomb) if a sea turtle is observed in the mitigation zone whenever and wherever applicable activities occur. In addition to this procedural mitigation, the

Navy will implement mitigation to avoid or reduce impacts from explosions on seafloor resources in mitigation areas throughout the Study Area, as described in Section 5.4.1 (Mitigation Areas for Seafloor Resources). This will further reduce the potential for impacts on sea turtles that shelter and feed on shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks.

Sea turtle hearing is less sensitive than other marine mammals, and the role of their underwater hearing is unclear. Sea turtle's limited hearing range (<2 kHz) is most likely used to detect nearby broadband, continuous environmental sounds, such as the sounds of waves crashing on the beach, that may be important for identifying their habitat. Recovery from a hearing threshold shift begins almost immediately after the noise exposure ceases. A temporary threshold shift is expected to take a few minutes to a few days, depending on the severity of the initial shift, to fully recover (U.S. Department of the Navy, 2017a). If any hearing loss remains after recovery, that remaining hearing threshold shift is permanent. Because explosions produce broadband sounds with low-frequency content, hearing loss due to explosive sound could occur across a sea turtle's very limited hearing range, reducing the distance over which relevant sounds, such as beach sounds, may be detected for the duration of the threshold shift.

Some sea turtles may behaviorally respond to the sound of an explosive. A sea turtle's behavioral response to a single detonation or explosive cluster is expected to be limited to a short-term (seconds to minutes) startle response, as the duration of noise from these events is very brief. Limited research and observations from air gun studies (See Section 3.5.2.2.2.1, Methods for Analyzing Impacts from Explosives) suggest that if sea turtles are exposed to repetitive impulsive sounds in close proximity, they may react by increasing swim speed, avoiding the source, or changing their position in the water column. There is no evidence to suggest that any behavioral response would persist beyond the sound exposure. Because the duration of most explosive events is brief, the potential for masking is low. The *ANSI Sound Exposure Guidelines* (Popper et al., 2014) consider masking to not be a concern for sea turtles exposed to explosions.

A physiological stress response is assumed to accompany any injury, hearing loss, or behavioral reaction. A stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. While the stress response is a normal function for an animal dealing with natural stressors in their environment, chronic stress responses could reduce an individual's fitness. Due to the low number of estimated impacts, it is not likely that any sea turtle would experience repeated stress responses due to explosive impacts.

Pursuant to the ESA, use of explosives during training and testing activities as described under Alternative 1 may affect ESA-listed green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles.

3.5.2.2.2.5 Impacts from Explosives Under Alternative 2 (Preferred Alternative)

Activities using explosives would be conducted as described in Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Training and Testing Activities Descriptions). General characteristics, quantities, and net explosive weights of in-water explosives used during training under Alternative 2 are provided in Section 3.0.4.2 (Explosive Stressors). Quantities and locations of fragment-producing explosives during training under Alternative 2 are shown in 3.0.4.4.4 (Military Expended Materials).

Under Alternative 2, there could be fluctuation in the amount of explosions that could occur annually, although potential impacts would be similar from year to year. The number of impulsive sources in this

SEIS/OEIS compared with the totals analyzed in the 2015 MITT Final EIS/OEIS are described in Tables 2.5-1 and 2.5-2.

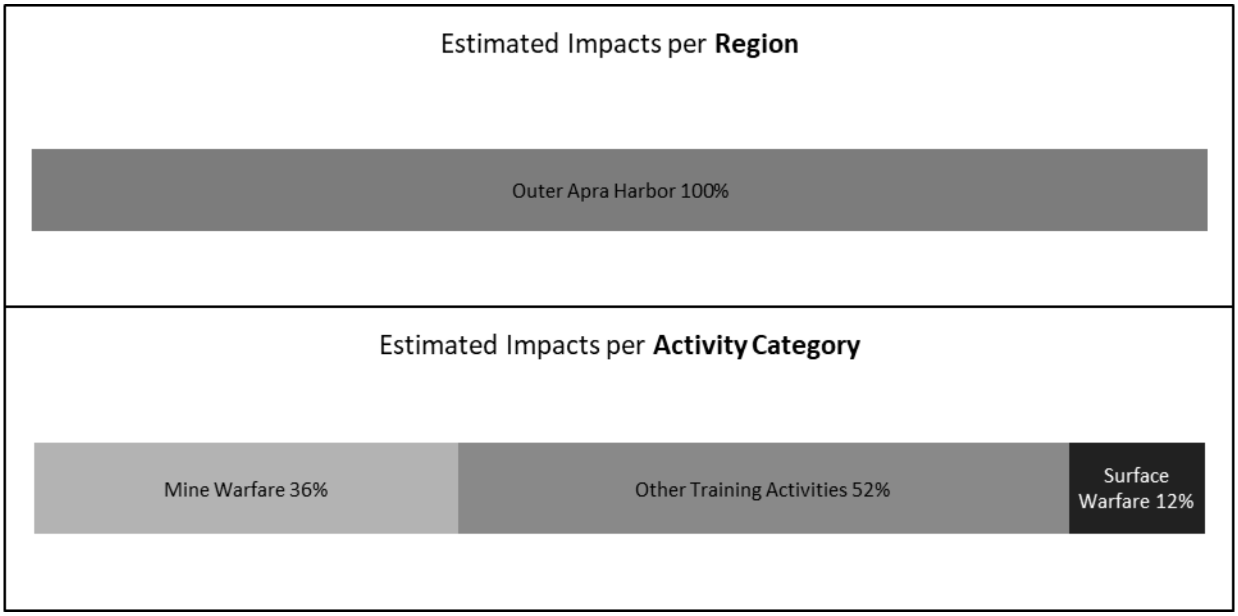
The numbers of activities planned under Alternative 2 are consistent from year-to-year and would increase slightly compared to activities planned under Alternative 1. The numbers of explosives used under each alternative are described in Section 3.0.4.2 (Explosive Stressors).

Under Alternative 2, it is possible that impacts would be slightly increased in some years, as explosive use would fluctuate. The quantitative analysis, using a maximum year of training and testing activities, estimates that no sea turtles would be killed, however, a small number of green sea turtles would be exposed to levels of explosive sound and energy in the outer Apra Harbor that could cause TTS or PTS (Table 3.5-9). The quantitative analysis predicts that no hawksbill, leatherback, or loggerhead sea turtles are likely to be exposed to the levels of explosive sound and energy that could cause TTS, PTS, or injury during training and testing activities under Alternative 2. Olive ridley sea turtle presence in the Study Area is limited and density data does not exist due to low occurrence in this region. Therefore, exposures were only modeled for green, hawksbill, leatherback, and loggerhead sea turtles in the Study Area and transit corridor. Fractional estimated impacts per region and activity area represent the probability that the number of estimated impacts by effect would occur in a certain region or be due to a certain activity category.

Threshold shifts and injuries could reduce the fitness of an individual animal, causing a reduction in foraging success, reproduction, or increased susceptibility to predators. This reduction in fitness would be temporary for recoverable impacts, such as TTS, but there could be long-term consequences to some individuals. However, no population-level impact is expected due to the low number of estimated injuries for any sea turtle species relative to total population size. This can also be assumed for olive ridley turtles exposed to explosions.

As discussed in Section 5.3.3 (Explosive Stressors), procedural mitigation includes ceasing explosive detonations (e.g., ceasing deployment of an explosive bomb) if a sea turtle is observed in the mitigation zone whenever and wherever applicable activities occur. In addition to this procedural mitigation, the Navy will implement mitigation to avoid or reduce impacts from explosions on seafloor resources in mitigation areas throughout the Study Area, as described in Section 5.4.1 (Mitigation Areas for Seafloor Resources). This would further reduce the potential for impacts on sea turtles that shelter and feed on shallow-water coral reefs, live hard bottom, artificial reefs, and shipwrecks.

Sea turtle hearing is less sensitive than other marine animals (i.e., marine mammals), and the role of their underwater hearing is unclear. Sea turtle's limited hearing range (<2 kHz) is most likely used to detect nearby broadband, continuous environmental sounds, such as the sounds of waves crashing on the beach, that may be important for identifying their habitat. Recovery from a hearing threshold shift begins almost immediately after the noise exposure ceases. A temporary threshold shift is expected to take a few minutes to a few days, depending on the severity of the initial shift, to fully recover (U.S. Department of the Navy, 2017a). If any hearing loss remains after recovery, that remaining hearing threshold shift is permanent. Because explosions produce broadband sounds with low-frequency content, hearing loss due to explosive sound could occur across a sea turtle's very limited hearing range, reducing the distance over which relevant sounds, such as beach sounds, may be detected for the duration of the threshold shift.



Note: Region and Activity Category bar charts show categories +/- 0.5 percent of the estimated impacts, which could result in a total of 98–101 percent. Estimated impacts most years would be less based on fewer explosions. The model is probabilistic and therefore a single impact could be divided up among multiple regions or activity categories.

Figure 3.5-9: Green Sea Turtle Impacts Estimated per Year from Explosions During Training and Testing Under Alternative 2

Table 3.5-9: Estimated Impacts on Individual Green Sea Turtles Within the Study Area per Year from Explosions Used During Training and Testing Under Alternative 2

Estimated Impacts by Effect		
TTS	***PTS***	***Injury***
6	3	0

Note: Estimated impacts are based on the maximum number of activities in a given year under Alternative 2.

Some sea turtles may behaviorally respond to the sound of an explosive. A sea turtle's behavioral response to a single detonation or explosive cluster is expected to be limited to a short-term (seconds to minutes) startle response, as the duration of noise from these events is very brief. Limited research and observations from air gun studies suggest that if sea turtles are exposed to repetitive impulsive sounds in close proximity, they may react by increasing swim speed, avoiding the source, or changing their position in the water column. There is no evidence to suggest that any behavioral response would persist beyond the sound exposure. Because the duration of most explosive events is brief, the potential for masking is low. The *ANSI Sound Exposure Guidelines* (Popper et al., 2014) consider masking to not be a concern for sea turtles exposed to explosions.

A physiological stress response is assumed to accompany any injury, hearing loss, or behavioral reaction. A stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. While the stress response is a normal function for an animal dealing with natural stressors in their environment, chronic stress responses could reduce an individual's fitness. Due to the low number of estimated impacts, it is not likely that any sea turtle would experience repeated stress responses due to explosive impacts.

Pursuant to the ESA, use of explosives during training and testing activities as described under Alternative 2 may affect ESA-listed green, hawksbill, leatherback, loggerhead, and olive ridley sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.2.2.6 Impacts from Explosives Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Explosives stressors (e.g., explosive shock wave and sound, explosive fragments) as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer explosive stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for explosive impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.3 Energy Stressors

This section analyzes the potential impacts of the various types of energy stressors that can occur during training and testing activities within the Study Area. This section includes analysis of the potential effects of (1) in-water electromagnetic devices, and (2) high-energy lasers on sea turtles within the Study Area. Energy stressors are discussed in Section 3.0.4.3.

Energy stressors that may impact sea turtles include in-water electromagnetic devices and high-energy lasers. With the increased use of undersea power cables associated with offshore energy generation, there has been renewed scientific interest in electromagnetic fields possibly affecting migrating marine animals (Brothers & Lohmann, 2015; Endres et al., 2016; Gill et al., 2014; Kremers et al., 2014; Kremers et al., 2016; Putman et al., 2015; Zellar et al., 2017). There is no new information that changes the basis of the conclusion. These additional scientific findings do not change in any way the rationale for the dismissal of in-water electromagnetic devices as presented in the 2015 analyses. While the number of training and testing activities using in-water electromagnetic devices would change under this SEIS/OEIS, the analysis presented in the 2015 MITT Final EIS/OEIS, Section 3.5.4.3 (Energy Stressors), and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Marine Fisheries Service, 2015b) remains valid for in-water electromagnetic devices.

High-energy laser use was not covered in the 2015 MITT Final EIS/OEIS and represents a new activity analyzed in this SEIS/OEIS. The primary concern is the potential for a sea turtle to be exposed to the laser beam at or near the water's surface, which could result in injury or death. However, sea turtles could only be exposed if the laser beam missed the target. As discussed in Section 3.0.4.3.2.2 (High-Energy Lasers), if there is a miss from a boat target, the laser beam may strike the water in the 200 meters (219 yards) to 6.5 kilometers (7,108 yards) range or more, assuming an engagement range of 200–5,000 meters. At these ranges, the low angles to the water will reflect most of the laser energy, and sea turtles would only be exposed if they were in the same exact position as the laser beam on the surface.

3.5.2.3.1 Impacts from In-Water Electromagnetic Devices Under Alternative 1

Under Alternative 1, the number of proposed training and testing activities involving the use of in-water electromagnetic devices would decrease in comparison to the 2015 MITT Final EIS/OEIS (Table 3.0-9). The activities would occur in the same locations and in a similar manner as were analyzed previously.

Therefore, impacts on sea turtles under Alternative 1 from energy stressors, including in-water electromagnetic devices, would be negligible.

Pursuant to the ESA, the use of in-water electromagnetic devices during training and testing activities as described under Alternative 1 would have no effect on ESA-listed sea turtles.

3.5.2.3.2 Impacts from In-Water Electromagnetic Devices Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of proposed training and testing activities involving the use of in-water electromagnetic devices would decrease in comparison to the 2015 MITT Final EIS/OEIS (Table 3.0-9). The activities would occur in the same locations and in a similar manner as were analyzed previously and above for Alternative 1.

Therefore, impacts on sea turtles under Alternative 2 from energy stressors, including in-water electromagnetic devices, would be negligible.

Pursuant to the ESA, the use of in-water electromagnetic devices during training and testing activities, as described under Alternative 2 would have no effect on ESA-listed sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.3.3 Impacts from In-Water Electromagnetic Devices Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Energy stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer energy stressors within the marine environment where Navy training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for energy impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.3.4 Impacts from High-Energy Lasers Under Alternative 1

Alternative 1 would introduce high-energy lasers into the Study Area, which is analyzed in this SEIS/OEIS as a new substressor not previously analyzed in the 2015 MITT Final EIS/OEIS. As stated previously, the Navy conducted statistical modeling to estimate the number of potential exposures of sea turtles to high-energy laser beams. The statistical probability and methods calculation are included in Appendix J (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures from Military Expended Materials) in this SEIS/OEIS (see Table J-2). The modeling estimated the potential direct strike exposures to a sea turtle for a worst-case scenario. Model input values include high-energy laser use data (e.g., number of high-energy laser exercises and laser beam footprint), size of the training or testing area, sea turtle density data, and animal footprint. To estimate the probability of hitting a sea turtle in a worst-case scenario (based on assumptions listed below), the impact area for all laser training and testing events was summed over one year. Finally, the sea turtle with the highest average seasonal density within the training or testing area (green sea turtles) was used in the analysis. This approach ensures that all other species with a lower density would have a lower probability of being struck by the laser.

Under Alternative 1, the modeling estimated 0.000025 annual sea turtle exposures, an extremely low estimate (see Table J-2, in Appendix J, Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures from Military Expended Materials). Based on the very low number of annual exposures, the characteristics of activities that would use high-energy lasers (e.g., short range distance from source to target, high-precision targeting, short duration of the energized beam), and likely avoidance behavior of sea turtles to other stressors (e.g., vessel or aircraft noise), there is a reasonable assurance that there is no risk to sea turtles from high-energy laser use within the Study Area, and that the risk of exposure is discountable.

Pursuant to the ESA, the use of high-energy lasers during training and testing activities as described under Alternative 1 may affect ESA-listed sea turtles.

3.5.2.3.5 Impacts from High-Energy Lasers Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of proposed activities involving the use of high-energy lasers would increase from Alternative 1 (Table 3.0-10) and the 2015 MITT Final EIS/OEIS. The increase in the number of events that use high-energy lasers is reflected in the Navy's statistical modeling of potential exposures of sea turtles with a slight increase in the model's estimates. As shown in Table J-2 in Appendix J (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures from Military Expended Materials) high-energy laser use under Alternative 2 would result in 0.000027 exposures every year. As with Alternative 1, based on the very low number of annual exposures, the characteristics of activities that would use high-energy lasers (e.g., short range distance from source to target, high-precision targeting, short duration of the energized beam), and likely avoidance behavior of sea turtles to other stressors (e.g., vessel or aircraft noise), there is a reasonable assurance that there is no risk to sea turtles from high-energy laser use within the Study Area, and that the risk of exposure is discountable.

Pursuant to the ESA, the use of in-water electromagnetic devices and high-energy lasers during training and testing activities as described under Alternative 2 may affect ESA-listed sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.3.6 Impacts from High-Energy Lasers Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Energy stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer energy stressors within the marine environment where Navy training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for energy impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.4 Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors are discussed in Section 3.0.4.4 (Physical Disturbance and Strike Stressors). Physical disturbance and strike stressors that may impact sea turtles include (1) vessels and in-water devices, (2) military expended materials, and (3) seafloor devices. The annual number of events including vessels and in-water devices, the annual number of military expended materials, and the annual number of events including seafloor devices are shown in Tables 3.0-12 through 3.0-17 and Table 3.0-19. The Navy will implement further mitigation measures to avoid or reduce potential impacts of towed in-water devices, non-explosive practice munitions, and vessel movements (see Sections 5.3.4.1 through 5.3.4.3).

There have been no known instances of physical disturbance or strike to any sea turtle in the Study Area as a result of Navy training and testing activities prior to or since the 2015 MITT Final EIS/OEIS.

3.5.2.4.1 Impacts from Physical Disturbance and Strike Stressors Under Alternative 1

Under Alternative 1, analysis of the individual substressors including the use of vessels and in-water devices, military expended materials, and seafloor devices presented in Section 3.0.4.4 (Physical Disturbance and Strike Stressors) indicates that those items having the most potential to affect sea turtles have decreased in comparison to the 2015 MITT Final EIS/OEIS (Tables 3.0-12 through 3.0-17 and Table 3.0-19). The number of small-caliber munitions would increase under Alternative 1. Small-caliber munitions are inert, are meant to be aimed at targets, and are not long-range weapons. As a result, sea turtles are extremely unlikely to be disturbed or struck by expended small-caliber munitions.

It is likely that green sea turtles within nearshore waters of western Guam and Apra Harbor would be at risk for vessel strike. During the section 7(a)(2) consultation between the Navy and NMFS, NMFS provided unpublished data to the Navy regarding green sea turtle strandings on Guam. For 2018, the only year provided by NMFS, there were three reported green sea turtle strandings attributable to vessel strikes (see Section 3.5.1.6.2.3, Species-Specific Threats). Whether these strandings were from Navy, commercial, or recreational vessels is not determinable; however, no vessel strikes for sea turtles were reported by the Navy during the reporting time period. Further, according to Apra Harbor vessel transit information included in the section 7(a)(2) consultation between the Navy and NMFS, there are more civilian vessel transits through Apra Harbor (86 percent) than Navy transits (14 percent). In areas outside the Study Area (e.g., Hawaii and Southern California), there have been recorded military vessel strikes of sea turtles. However, these are areas where the number of military vessels is much higher and training and testing activities occur more often than in the Study Area. Given the reduction in physical disturbance and strike stressors for this SEIS/OEIS, the findings presented in the 2015 MITT Final EIS/OEIS, Section 3.5.2.4 (Physical Disturbance and Strike Stressors) and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015) remain valid.

Pursuant to the ESA, the use of vessels and in-water devices, military expended materials, and seafloor devices as described under Alternative 1 may affect ESA-listed sea turtles.

3.5.2.4.2 Impacts from Physical Disturbance and Strike Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, physical disturbance and strike stressors during training and testing activities would decrease compared to the 2015 MITT Final EIS/OEIS (Tables 3.0-12 through 3.0-17 and Table 3.0-19), assuming the dismissal of small-caliber munitions use for the reasons noted above. Under Alternative 2, there would be additional physical disturbance and strike stressors in comparison to Alternative 1, but the conclusions remain the same. Therefore, the potential for strikes of sea turtles from in-water devices, military expended materials, and seafloor devices are unlikely to occur. As described above for Alternative 1, vessel strikes of sea turtles have been reported within Apra Harbor. These vessel strikes are not likely attributable to Navy activities because no vessel strikes were reported by the Navy, and the majority of vessel traffic is comprised of civilian vessels. Because vessel strike by military vessels cannot be wholly discounted, the Navy is consulting with NMFS on this stressor type and has included procedural mitigation to decrease the potential of vessel strike of sea turtles within Apra Harbor, other inshore areas, and training and testing areas at sea.

Pursuant to the ESA, the use of vessels and in-water devices, military expended materials, and seafloor devices as described under Alternative 2 may affect ESA-listed sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.4.3 Impacts from Physical Disturbance and Strike Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Physical disturbance and strike stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer physical disturbance and strike stressors within the marine environment where Navy training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for physical disturbance and strike impacts on individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.5 Entanglement Stressors

Entanglement stressors are discussed in Section 3.0.4.5. Entanglement stressors considered for sea turtles include (1) fiber optic cables and guidance wires, and (2) decelerators/parachutes. The annual number of wires and cables and decelerators/parachutes proposed under the alternatives and in comparison to current ongoing activities are presented in Tables 3.0-22 through 3.0-24. There have been no known instances of any sea turtle being entangled in wires and cables, or decelerators/ parachutes associated with training and testing activities prior to or since the 2015 MITT Final EIS/OEIS.

3.5.2.5.1 Impacts from Entanglement Stressors Under Alternative 1

Under Alternative 1, the annual number of entanglement stressors would decrease compared to the 2015 MITT Final EIS/OEIS (Tables 3.0-22 through 3.0-24). Therefore, the analysis from the 2015 MITT Final EIS/OEIS remains valid. The analysis presented in the 2015 MITT Final EIS/OEIS (Section 3.5.2.5, Entanglement Stressors) and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015) determined that impacts on sea turtles from entanglement stressors are not anticipated.

Pursuant to the ESA, the use of fiber optic cable and guidance wires and decelerators/parachutes as described under Alternative 1 may affect ESA-listed sea turtles.

3.5.2.5.2 Impacts from Entanglement Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of entanglement stressors would decrease in comparison to current ongoing activities for fiber optic cable and decelerators/parachutes but would increase for the annual number of expended guidance wire (Tables 3.0-22 through 3.0-24). In comparison to Alternative 1, there would be a slight increase under Alternative 2 for entanglement stressors; however, the combined number of annual entanglement stressors (fiber optic cable, guidance wire, and decelerators/parachutes) decreases when compared to the 2015 MITT Final EIS/OEIS. Therefore, the analysis and conclusions presented in the 2015 MITT Final EIS/OEIS (Section 3.5.2.5, Entanglement Stressors) and the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Oceanic and Atmospheric Administration, 2015) remain valid. Impacts on sea turtles from entanglement stressors are not anticipated.

Pursuant to the ESA, the use of fiber optic cable and guidance wires and decelerators/parachutes as described above under Alternative 2 may affect ESA-listed sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.5.3 Impacts from Entanglement Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Entanglement stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer entanglement stressors within the marine environment where Navy training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for entanglement of individual sea turtles, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.6 Ingestion Stressors

Ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) are discussed in Section 3.0.4.6. Types of materials that could become ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) during training and testing in the Study Area include non-explosive practice munitions (small- and medium-caliber), fragments from explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and decelerators/parachutes. The annual number of events including military expended materials are shown in Tables 3.0-14 through 3.0-17 and Tables 3.0-25 through 3.0-26. As discussed in Section 3.5.4.6.3 (Impacts from Munitions) of the 2015 MITT Final EIS/OEIS, the number of munitions and explosive munitions fragments that an individual sea turtle could encounter would generally be low, based on the patchy distribution of both the munitions and the habitats where sea turtles forage. For the more numerous small-caliber munitions, these expended material-type items are inert, small in size, do not resemble prey items, and end up as part of the seafloor, where they are unlikely to be encountered by most sea turtles. In addition, it is assumed for sea turtle species that may feed at the seafloor, that they would not ingest every munition or munition’s fragment encountered; if a munition or munition’s fragment were ingested, an animal may attempt to reject it when it realizes the item is not food.

3.5.2.6.1 Impacts from Ingestion Stressors Under Alternative 1

Under Alternative 1, analysis of the individual substressors presented in Section 3.0.4.6 (Ingestion Stressors) indicates that those items considered ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) having the most potential to affect sea turtles have decreased (Tables 3.0-14 through 3.0-17 and Tables 3.0-25 through 3.0-26). For the reasons noted above, the Navy has determined that potential impacts from ingestion stressors would not be substantially different from the 2015 MITT Final EIS/OEIS. In the 2015 analysis of training and testing activities within the Study Area, NMFS determined that ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) would not result in harassment or harm of sea turtles or jeopardize the continued existence of any sea turtle species (National Oceanic and Atmospheric Administration, 2015). The activities expending munitions and other military expended materials analyzed in this SEIS/OEIS under Alternative 1 are not a significant change over what was analyzed in the 2015 MITT Final EIS/OEIS, and there has been no new science necessitating a revision of the 2015 conclusions in that regard. Impacts on sea turtles from ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) in the Study Area are not anticipated.

Pursuant to the ESA, the use of munitions and other military expended materials as described under Alternative 1 may affect ESA-listed sea turtles.

3.5.2.6.2 Impacts from Ingestion Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, of the number of military expended materials would decrease compared to the 2015 MITT Final EIS/OEIS, with the exception of increased use of small-caliber munitions (Tables 3.0-14 through 3.0-17 and Tables 3.0-25 through 3.0-26). Under Alternative 2, increases as compared to Alternative 1 do not change the impact conclusions for ingestion stressors (military expended materials – munitions and military expended materials – other than munitions) as summarized above under Alternative 1 and as presented in the 2015 MITT Final EIS/OEIS. Therefore, impacts on sea turtles from ingestion of military expended materials under Alternative 2 are not expected.

Pursuant to the ESA, the use of munitions and other military expended materials as described under Alternative 2 may affect ESA-listed sea turtles. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA.

3.5.2.6.3 Impacts from Ingestion Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Ingestion stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer ingestion stressors within the marine environment where Navy training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for individual sea turtles to ingest items expended during training and testing activities, but would not measurably improve the status of sea turtle populations or subpopulations.

3.5.2.7 Secondary Stressors

As discussed in Section 3.5.3.6 (Secondary Stressors) of the 2015 MITT Final EIS/OEIS, secondary stressors from training and testing activities could pose indirect impacts on sea turtles via habitat degradation or an effect on prey availability. These stressors include (1) explosives, (2) explosive byproducts and unexploded ordnance, (3) metals, and (4) chemicals. Analyses of the potential impacts on sediments and water quality from the proposed training and testing activities are discussed in detail in Section 3.1 (Sediments and Water Quality) of the 2015 MITT Final EIS/OEIS. The analysis of explosives, explosive byproducts, metals, chemicals, and the transmission of diseases and parasites and their potential to indirectly impact sea turtles has not appreciably changed and is presented in detail in Section 3.5.4.7 (Secondary Stressors) of the 2015 MITT Final EIS/OEIS.

The analysis concluded that the relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment, from either high-order or low-order detonations, are relatively low and readily diluted. Given that the concentration of unexploded ordnance, explosion byproducts, metals, and other chemicals would never exceed that of a World War II dump site where minimal concentrations were detected only within a few feet of the ordnance (Briggs et al., 2016; Edwards et al., 2016; Kelley et al., 2016; Smith & Marx, 2016), indirect impacts on sea turtles from the Proposed Action would be negligible and would have no long-term effect on habitat or prey.

3.5.3 Summary of Potential Impacts on Sea Turtles

As described in Section 3.0.5.4 (Resource-Specific Impacts Analysis for Multiple Stressors) in the 2015 MITT Final EIS/OEIS, this section evaluates the potential for combined impacts of all the stressors from the Proposed Action. The analysis and conclusions for the potential impacts from each of the individual stressors are discussed in Section 3.5.2.1 (Acoustic Stressors) through Section 3.5.2.6 (Ingestion Stressors) and, for ESA-listed species, summarized in Section 3.5.4 (Endangered Species Act Determinations).

There are generally two ways that a sea turtle could be exposed to multiple stressors. The first would be if a sea turtle were exposed to multiple sources of stress from a single event or activity within a single event (e.g., a mine warfare event may include the use of a sound source 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, torpedoes, aircraft) that may produce one or more stressors; therefore, it is likely that if a sea turtle 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 training and testing activities, and behavioral avoidance exhibited by many sea turtle species, it is very unlikely that a sea turtle would remain in the potential impact range of multiple sources or sequential events. Exposure to multiple stressors is more likely to occur at an instrumented range where training and testing activities using multiple platforms may be concentrated during a particular event. In such cases involving a relatively small area on an instrumented range, a behavioral reaction resulting in avoidance of the immediate vicinity of the activity would reduce the likelihood of exposure to additional stressors. Nevertheless, the majority of the proposed activities are unit-level training and testing activities, which are conducted in the open ocean. Unit-level events occur over a small spatial scale (one to a few square miles) and with few participants (usually one or two) or short duration (the order of a few hours or less).

Secondly, a sea turtle could be exposed to multiple training and testing activities over the course of its life; however, training and testing activities are generally separated in space and time in such a way that it would be unlikely that any individual sea turtle would be exposed to stressors from multiple activities within a short timeframe. However, animals with a home range intersecting an area of concentrated Navy activity have elevated exposure risks relative to animals that simply transit the area through a migratory corridor.

Multiple stressors may also have synergistic effects. For example, sea turtles that experience temporary hearing loss or injury from acoustic stressors could be more susceptible to physical disturbance and strike stressors through a decreased ability to detect and avoid threats. Sea turtles that experience behavioral and physiological consequences of ingestion stressors could be more susceptible to entanglement and physical strike stressors via malnourishment and disorientation. 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. To date, the majority of scientific investigations on this topic have been on marine mammals rather than sea turtles (Murray et al., 2020; National Academies of Sciences Engineering and Medicine, 2017). Based on current best available science, the effects of multiple synergistic stressors over time cannot be realistically or precisely modeled for sea turtles. The Navy's quantitative and qualitative analyses are consistently conservative and likely over-predict impacts on sea turtles.

Research and monitoring efforts have included before-, during-, and after-event observations and surveys; data collection through long-term studies in areas where the Navy conducts activities; 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 the types of impacts that animals may be experiencing in these areas. To date, the findings from the research and monitoring efforts and the regulatory conclusions from previous analyses by NMFS, including the NMFS Biological Opinion for the 2015 MITT Final EIS/OEIS (National Marine Fisheries Service, 2015b), have been that the majority of impacts from training and testing activities are not expected to have deleterious impacts on the fitness of any individuals or long-term consequences to populations of sea turtles.

3.5.4 Endangered Species Act Determination

Pursuant to the ESA, Navy training and testing activities presented in this SEIS/OEIS may affect ESA-listed sea turtles. There is no designated critical habitat for any sea turtle species in the MITT Study Area. The Navy is consulting with NMFS as required by section 7(a)(2) of the ESA, with training and testing activities described under Alternative 2 in this SEIS/OEIS as the action description in the consultation process. The outcome of those consultations pursuant to the ESA are described in this MITT Final SEIS/OEIS.

3.5.5 Public Comments

The public raised a number of issues during the scoping period in regard to Sea Turtles. The issues are summarized in the list below. Comments received from the public during the Draft SEIS/OEIS commenting period related to sea turtles are addressed in Appendix K (Public Comment Responses).

- **Lack of sea turtle information in waters surrounding FDM –** One commenter noted a lack of studies documenting the condition of sea turtles in waters surrounding FDM. Multi-year dive studies conducted by Smith and Marx (2016) have reported roughly comparable numbers of sea turtles (only green sea turtles and hawksbill sea turtles have been observed in waters surrounding FDM) during every survey between 1999 and 2012. None of the specimens seen by the authors had any visible fibropapilloma tumors, barnacles, lesions, or other visible abnormalities. The number of sea turtle sightings during each dive session was low, ranging from 0.13 to 0.36 per biologist per dive in each year. For comparative purposes, some study sites off Oahu, Hawaii which have been surveyed since 1999 by the authors have averaged more than 10 sea turtles sighted per dive during all seasons. This equates to 28 times higher than the FDM densities. The precipitous sea cliffs, lack of suitable haulout sites or beaches preclude nesting or basking at FDM. In addition, Smith and Marx (2016) noted that no sea turtle remains, such as carapace or bone fragments, have ever been sighted or reported at FDM (the authors have encountered such remains at various locations in the Bahamas, Cayman Islands, Hawaiian Islands and Malaysia, which support resident sea turtle populations). In summary, sea turtles around FDM probably represent transient individuals and not a resident population. Although waters surrounding FDM likely maintain healthy foraging grounds for transient turtles, they do not congregate in high concentrations in these waters.

- **Habitat, prey availability, and overall health of sea turtles –** The Navy received comments expressing concerns over impacts on the general marine environment from military training and testing activities. The Navy has included a detailed summary of recent published studies that describe multi-year dive studies conducted by Smith and Marx (2016), which provide an indication of habitat quality in waters surrounding a location of concentrated and intensive military activities. The results of these surveys are included in Section 3.1.1.1.4 (Farallon de Medinilla) of this SEIS/OEIS. Throughout all dive surveys, the coral fauna at FDM were observed to be healthy and robust, which suggests healthy foraging habitats for sea turtles. The nearshore physical environment and basic habitat types at FDM have remained unchanged over the 13 years of survey activity. These conclusions are based on (1) a limited amount of physical damage, (2) very low levels of partial mortality and disease (less than 1 percent of all species observed), (3) absence of excessive mucus production, (4) good coral recruitment, (5) complete recovery by 2012 of the 2007 bleaching event, and (6) a limited number of macrobioeroders and an absence of invasive crown of thorns starfish (*Acanthaster planci*). These factors suggest that potential impacts from training and testing activities are not sufficient as to adversely impact water quality, substantiated by repeated dive surveys discussed above (Smith & Marx, 2016), and thereby reduce habitat quality for sea turtle populations.

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3.6 Marine Birds

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3.6 Marine Birds

The purpose of this section is to supplement the analysis of impacts on marine birds presented in the 2015 Mariana Islands Training and Testing (MITT) Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) with new information relevant to proposed changes in training and testing activities conducted at sea and on Farallon de Medinilla (FDM). Information presented in the 2015 MITT Final EIS/OEIS that remains valid is noted as such and referenced in the appropriate sections. Any new or updated information describing the affected environment and analysis of impacts on marine birds associated with the Proposed Action is provided in this section. Comments received from the public during scoping related to marine birds are addressed in Section 3.6.6 (Public Comments). Comments received from the public during the Draft Supplemental EIS (SEIS)/OEIS commenting period related to marine birds are addressed in Appendix K (Public Comment Responses).

3.6.1 Affected Environment

As presented in the 2015 MITT Final EIS/OEIS, the habitat found within the MITT Study Area supports a wide diversity of resident and migratory marine birds, with regionally important rookeries for numerous species on FDM. Descriptions of the climate, productivity, and oceanographic conditions were presented in the 2015 MITT Final EIS/OEIS, as well as important rookery locations throughout the Mariana Islands. Because FDM is the only land area within the Study Area that would be impacted by the proposed changes in activities described in Chapter 2 (Description of Proposed Action and Alternatives), the other rookery locations analyzed in the 2015 MITT Final EIS/OEIS are not included in the Study Area for this SEIS/OEIS. The species assemblage in open ocean portions of the Study Area has not changed, nor has the status of rookeries on FDM changed since the publication of the 2015 MITT Final EIS/OEIS. As such, the general description in the 2015 MITT Final EIS/OEIS of the existing conditions within the Study Area remains valid.

Endangered Species Act Listed Marine Bird Species

Three marine birds present in the Study Area are listed under the Endangered Species Act (ESA) as threatened or endangered species. The short-tailed albatross (*Phoebastria albatrus*) and Hawaiian petrel (*Pterodroma sandwichensis*) are listed as endangered, and the Newell's shearwater (*Puffinus auricularis newelli*)[1] is listed as threatened (U.S. Fish and Wildlife Service, 2010, 2015). None of these species have been observed on FDM or within other rookery locations for other species within the Mariana Islands. The short-tailed albatross, Hawaiian petrel, and Newell's shearwater nest outside the Study Area and are thought to occur only rarely within the Study Area (U.S. Fish and Wildlife Service, 2010, 2015), and there would be little to no overlap with at-sea training and testing activities. The 2015 MITT Final EIS/OEIS relied in part on information collected in 2007 from the Navy-funded Mariana Islands Sea Turtle and Cetacean Survey (U.S. Department of the Navy, 2007). Because the short-tailed albatross, Hawaiian petrel, and Newell's shearwater were not expected to be impacted by activities analyzed in the 2015 MITT Final EIS/OEIS, the section 7(a)(2) ESA consultation between the Navy and U.S. Fish and Wildlife Service (USFWS) did not include these species (U.S. Fish and Wildlife Service, 2015). No new

[1] The current taxonomic classification of this species holds that the Newell's shearwater is a subspecies of the Townsend's shearwater. In some instances, this subspecies is also named the Newell's Townsend's shearwater; however, both Newell's shearwater and Newell's Townsend's shearwater refer to the same subspecies (scientific name *Puffinus auricularis newelli*).

survey information is available on at-sea observations of marine birds and shorebirds that would change the analysis from the 2015 MITT Final EIS/OEIS. As such, the description regarding at-sea observations of marine birds presented in the 2015 MITT Final EIS/OEIS remains valid.

3.6.1.1 Group Size

Section 3.6.2.1 of the 2015 MITT Final EIS/OEIS included a description of marine bird group sizes and reasons why some marine birds congregate in groups. Within the Study Area, the largest grouping of marine birds is anticipated during large upwelling events for feeding, and on-land rookery locations (at FDM). There is no new information that changes the basis of the conclusion on the group size analysis from the 2015 MITT Final EIS/OEIS. As such, the additional description regarding group sizes of marine birds presented in the 2015 MITT Final EIS/OEIS remains valid.

3.6.1.2 Diving Behavior

Section 3.6.2.2 (Diving) of the 2015 MITT Final EIS/OEIS describes dive behaviors exhibited by different types of marine birds. Marine birds will dive to various depths in pursuit of prey items, exhibiting plunge diving. Many of the marine bird species found in the Study Area will dive, skim, or grasp prey at the water's surface or within the upper portion (1–2 meters [m]) of the water column (Cook et al., 2011; Jiménez et al., 2012; Sibley, 2014), although some marine birds will dive to depths greater than 30 m in pursuit of prey, with dive durations lasting from a few seconds to several minutes for deep diving marine birds. Dive durations are correlated with depth and range from a few seconds in shallow divers to several minutes in alcids (Ponganis, 2015). No new information is available on dive behavior that would alter the analysis from the 2015 MITT Final EIS/OEIS. As such, the additional description regarding dive behavior presented in the 2015 MITT Final EIS/OEIS remains valid.

3.6.1.3 Flight Altitudes

While foraging birds will be present near the water surface, migrating birds may fly at various altitudes. Flight altitudes for birds have traditionally been estimated from on the ground (or boat) observations, or from planes; however, flight altitude information increasingly relies on radar studies and telemetry techniques, where the bird's measured altitude is subtracted from the ground elevation (Poessel et al., 2018). Jongbloed (2016) completed a literature review to determine flight height of marine birds to assess potential risks from wind turbine collisions. This review found that most seabird species fly beneath the rotor blade altitudes of offshore wind turbines, which reduces the risk for collision. Some species such as sea ducks and loons may be commonly seen flying just above the water's surface, but the same species can also be spotted flying high enough (5,800 feet [ft.]) that they are barely visible through binoculars (Lincoln et al., 1998). While there is considerable variation, the favored altitude for most small birds appears to be between 500 ft. (152 m) and 1,000 ft. (305 m). Radar studies have demonstrated that 95 percent of the migratory movements occur at less than 10,000 ft. (3,050 m), with the bulk of the movements occurring under 3,000 ft. (914 m) (Lincoln et al., 1998). Weather factors may also influence flight heights. Tarroux et al. (2016) examined the flying tactics of Antarctic petrels, (*Thalassoica antarctica)*, in Antarctica revealing the flexibility of flight strategies. Birds tend to fly higher with favorable wind conditions, and fly at 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). This was also found by Stumpf et al. (2011) for marbled murrelets using radar to quantify flight heights off of the Olympic Peninsula and by Sanzenbacher et al. (2014) off of Northern California. 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. In general, the flight altitude of low migrating birds is likely distinctly lower offshore than along the coast or inland of islands within the Mariana Archipelago.

3.6.1.4 Distance from Shore

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. Spiegel et al. (2017) tracked the movements of over 400 individuals of three species (northern gannets, red-footed loon, and surf-scooter) over the course of five years off of the mid-Atlantic coast. In winter, all three species exhibited a largely near-shore, coastal, or in-shore distribution. Habitat use was concentrated in or around large bays, with the most extensive use at bay mouths. Northern gannets ranged much farther offshore than the other two species, and covered a much larger area (including instances of individuals using both the Gulf of Mexico and the mid-Atlantic within a single season). Spiegel et al. (2017) determined that the differences among species distributions were likely due to differences in motility and distribution of their preferred prey. In summary, marine bird distance from shore can depend on a variety of factors, such as physiological abilities of a particular species to tolerate long distance and duration flights, mobility of prey, and seasonal variations in ranges.

Pelagic marine birds are widely distributed throughout the Marianas, but they tend to congregate in areas of high productivity and prey availability. The 2015 MITT Final EIS/OEIS relied on information collected in 2007 from the Navy-funded Mariana Islands Sea Turtle and Cetacean Survey (U.S. Department of the Navy, 2007). No new information is available on at-sea observations of marine birds and shorebirds that would change the analysis from the 2015 MITT Final EIS/OEIS. As such, the description regarding at-sea observations of marine birds presented in the 2015 MITT Final EIS/OEIS remains valid.

3.6.1.5 Hearing and Vocalization

Section 3.6.2.3 of the 2015 MITT Final EIS/OEIS includes a description of marine bird hearing in air, as well as under water. The Navy's literature review of updated information since the publication of the 2015 MITT Final EIS/OEIS has found new information regarding in-air and underwater hearing sensitivities of marine birds.

The Navy conducted a literature search for new information since the publication of the 2015 MITT Final EIS/OEIS on bird hearing and vocalizations that may change the analysis of potential impacts on birds. 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.

Although hearing range and sensitivity has been measured for many land birds, little is known of seabird hearing. The majority of the 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; Dooling, 2002). Very few 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, 2002; Dooling & Popper, 2000). Hearing capabilities have been studied for only a few seabirds (Beason, 2004; Beuter et al., 1986; Crowell et al., 2015; Johansen et al., 2016; 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.

Auditory abilities have been measured in 10 diving bird species in-air using electrophysiological techniques (Crowell et al., 2015; Maxwell et al., 2017). All species tested had the best hearing sensitivity from 1 to 3 kHz. The red-throated loon (*Gavia stellata*) and northern gannet (*Morus bassanus*) (both non-duck species) had the highest thresholds while the lesser scaup (*Aythya affinis*) and ruddy duck (*Oxyura jamaicensis*) (both duck species) had the lowest thresholds (Crowell et al., 2015). Auditory sensitivity varied amongst the species tested, spanning over 30 decibels (dB) in the frequency range of best hearing. While electrophysiological techniques provide insight into hearing abilities, auditory sensitivity is more accurately obtained using behavioral techniques. Crowell et al. (2016) used behavioral methods to obtain an in-air audiogram of the lesser scaup. Hearing frequency range in air was similar to other birds, with best sensitivity at 2.86 kHz with a threshold of 14 dB referenced to (re) 20 micropascals (μPa).

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 of the 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, Crowell et al. (2015) 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.

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).

There is little known about the hearing abilities of birds underwater (Dooling & Therrien, 2012). In air, the size of the bird is usually correlated with the sensitivity to sound (Johansen et al., 2016); for example, songbirds tend to be more sensitive to higher frequencies and larger non-songbirds tend to be more sensitive to lower frequencies (Dooling & Popper, 2000). Two studies have tested the ability of a single diving bird, a great cormorant (*Phalacrocorax carbo sinensis*), to respond to underwater sounds (Hansen et al., 2017; Johansen et al., 2016). These studies suggest that the cormorant's hearing in air is less sensitive than birds of similar size; however, the hearing capabilities in water are better than what would be expected for a purely in-air adapted ear (Johansen et al., 2016). The frequency range of best hearing underwater was observed to be narrower than the frequency range of best hearing in air, with greatest sensitivity underwater observed around 2 kHz (about 71 dB re 1 μPa based on behavioral responses). Although results were not sufficient to be used to generate an audiogram, Therrien (2014) also examined underwater hearing sensitivity of long-tailed ducks (*Clangula hyemalis*) by examining 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.

Diving birds may not hear as well underwater, compared to other (non-avian) species, based on adaptations to protect their ears from pressure changes (Dooling & Therrien, 2012). Because reproduction and communication with conspecifics occurs in air, adaptations for diving may have evolved to protect in-air hearing ability and may contribute to reduced sensitivity underwater (Hetherington, 2008). There are many anatomical adaptations in diving birds that may reduce sensitivity both in air and underwater. Anatomical ear adaptations are not well investigated, but include cavernous tissue in the meatus and middle ear that may fill with blood during dives to compensate for increased pressure on the tympanum, active muscular control of the meatus to prevent water entering the ear, and interlocking feathers to create a waterproof outer covering (Crowell et al., 2015; Rijke, 1970; Sade et al., 2008). The northern gannet, a plunge diver, has unique adaptations to hitting the water at high speeds, including additional air spaces in the head and neck to cushion the impact and a thicker tympanic membrane than similar-sized birds (Crowell et al., 2015). All of these adaptions could explain why best hearing frequencies are narrower under water than on the surface or in flight.

This new information increases the understanding of bird auditory abilities; however, no new information is available on bird hearing that would alter the analysis from the 2015 MITT Final EIS/OEIS. As such, the additional description regarding dive behavior presented in the 2015 MITT Final EIS/OEIS remains valid.

3.6.1.6 General Threats

Section 3.6.2.4 (General Threats) of the 2015 MITT Final EIS/OEIS described the general threats facing marine birds within the Study Area. No new information is available that would change the characterization of threats described in the 2015 document; therefore, the description regarding general threats presented in the 2015 MITT Final EIS/OEIS remains valid. Since the publication of the 2015 MITT Final EIS/OEIS, more complete information regarding potential climate change-related impacts on water quality, which in turn may impact prey base and rookery resiliency to storm events, has become available and been included in this SEIS/OEIS. Section 3.1 (Sediments and Water Quality) describes the updated information included in this SEIS/OEIS in regards to potential impacts on water quality from climate change. These changes (e.g., air and sea temperatures, precipitation, frequency and intensity of storms, pH level of sea water, sea level rise) may potentially impact marine birds by reducing overall marine productivity and biodiversity, which could affect the food resources, distribution, and reproductive success of marine birds (Duffy, 2011; Frost et al., 2017; Lorrain et al., 2017; Ostrom et al., 2017; Ramírez et al., 2017; Trainer, 2017). In the long term, climate change could be the largest threat to marine birds.

On FDM, the primary threats to marine bird rookeries include invasive species currently on the island (e.g., rodents that prey on marine bird eggs and chicks). Extensive biosecurity planning by range operators is in place for land-based training activities on FDM to prevent the accidental introduction of other invasive species, such as the brown treesnake (U.S. Fish and Wildlife Service, 2010, 2015). A more detailed description of stressors on the terrestrial environment of FDM is provided in Section 3.10 (Terrestrial Species and Habitats).

3.6.1.7 Rookery Locations and Breeding Activities on FDM

The 2015 MITT Final EIS/OEIS included a summary of statistical analyses conducted on marine bird counts collected since 1997 and the findings from a non-published technical report produced by the same authors as the published report. Since the publication of the 2015 MITT Final EIS/OEIS, Camp et al. (2016) published this information. During the 159 counts conducted between February 1997 and August 2014, the numbers detected during each count ranged from 0 to 447 for brown booby, 6 to 404 for masked booby, and 42 to 915 for red-footed booby. From 1997 to 2014, there is some evidence that masked and red-footed booby populations on FDM have declined, while brown booby populations have increased. However, the general conclusion is that all three species exhibited population fluctuations over time. Combined with the level of variability observed in the count data, this precluded any definite conclusions about long-term population trends (i.e., the data showed no statistically significant trends) (Camp et al., 2016). Since the publication of the 2015 MITT Final EIS/OEIS, one additional aerial survey was completed in September 2016. Because of a lack of commercial helicopter transit services, surveys have not been conducted since 2016.

3.6.2 Environmental Consequences

In the 2015 MITT Final EIS/OEIS, the Navy considered all potential stressors associated with ongoing training and testing activities in the Mariana Islands and then analyzed their potential impacts on marine birds in the Study Area. In this SEIS/OEIS, the Navy has reviewed the analysis of impacts from these ongoing activities and additionally analyzed new or changing training and testing activities as projected into the reasonably foreseeable future. The Navy has completed a literature review for information on marine birds within the Study Area, which included a search for the best available science since the publication of the 2015 MITT Final EIS/OEIS. Where there has been no substantive or otherwise meaningful change in the action, science, or regulations, the Navy will rely on the previous 2015 MITT Final EIS/OEIS analysis. Where there has been substantive change in the action, science, or regulations, the information and analysis provided in this SEIS/OEIS will supplement the 2015 MITT Final EIS/OEIS to support environmental compliance with applicable environmental statutes for marine birds.

In the alternatives descriptions for this SEIS/OEIS, there have been some modifications to the quantity and type of acoustic stressors under the two action alternatives compared to the 2015 MITT Final EIS/OEIS. In addition, the analysis of potential impacts associated with sonar and other transducers has been improved by incorporating additional information regarding marine bird hearing abilities in water. There have been no updates to the assessment of potential impacts on marine birds from other acoustic sources (e.g., vessel noise, airguns, weapons firing noise, and aircraft noise).

The stressors applicable to birds include the new stressor (high-energy laser) and the same stressors considered in the 2015 MITT Final EIS/OEIS. High-energy laser is detailed in Section 3.0.4.3.2.2 (High-Energy Lasers) and analyzed under the energy stressor category for potential impacts on birds (see Section 3.6.2.3, Energy Stressors).

In general, there have been no substantial changes to the activities analyzed in the 2015 MITT Final EIS/OEIS, which would change the conclusions reached regarding populations of marine birds in the Study Area. Table 2.5.1 and Table 2.5-2 in Chapter 2 (Description of Proposed Action and Alternatives) list the proposed training and testing activities and include the number of times each activity would be conducted annually and the locations within the Study Area where the activity would typically occur under each alternative. The tables also present the same information for activities described in the 2015 MITT Final EIS/OEIS so that the proposed levels of training and testing under this SEIS/OEIS can be compared. The increased use of FDM for training activities proposed in this SEIS/OEIS necessitates FDM-focused analysis for some stressor categories.

Use of acoustic stressors (sonar and other active acoustic sources) and use of explosives have occurred since the 2015 completion of the MITT Final EIS/OEIS Record of Decision. There have been no known adverse effects to marine birds or population impacts that were not otherwise previously analyzed or accounted for in the 2015 MITT Final EIS/OEIS (U.S. Department of the Navy, 2015). The potential stressors associated with the training and testing activities in the Study Area included the following:

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

- Explosives (in-air explosions and in-water explosions)
- Energy (in-water and in-air electromagnetic devices, high-energy lasers)
- Physical disturbance and strike stressors (vessels and in-water devices, military expended materials, seafloor devices)
- Ingestion (military expended materials – munitions, military expended materials other than munitions)
- Secondary stressors (impacts on habitat; impacts on prey availability)

During the preparation of the 2015 MITT Final EIS/OEIS, the Navy assessed the potential for wires and cables, along with decelerators/parachutes, to entangle marine birds. The Navy determined at that time that these materials would not present entanglement risks for marine birds because these items would be expended outside of their range of foraging abilities. During the Navy's literature review, no new information regarding fiber optic cables and guidance wires and decelerators/parachutes was found that would alter this conclusion in the 2015 MITT Final EIS/OEIS; therefore, they are not analyzed further in this SEIS/OEIS.

Analysis of Stressors on Farallon de Medinilla

Analysis of Proposed Increases in Number of Events, Munitions, and Net Explosive Weight on Farallon de Medinilla

Under Alternative 1 and Alternative 2, there would be an overall increase in the number of training events and munitions used on FDM, which would increase the number of exposures to explosives noise, weapons firing noise, and aircraft overflights to deliver munitions to the impact zones on FDM. The types of explosive munitions used on FDM include explosive bombs (less than or equal to 2,000 pounds [lb.]), missiles, rockets, explosive grenades and mortars, medium-caliber projectiles, and large-caliber projectiles (see Table 3.0-20). The calculations for the increases in the number of events proposed on FDM are shown on Table 3.6-1. Table 3.6-2 shows the calculations for the proposed increases in the number of explosive and non-explosive munitions expended on FDM. These increases in events and munitions will result in an increase in net explosive weight (NEW) of explosives over the course of a training year. The calculations for NEW expended on NEW resulting from proposed training activities are shown on Table 3.6-3. The NEW for each ordnance type may vary within each class. Based on these NEW ranges within each explosives bin, the Navy calculated the range of total munitions' NEW under each alternative proposed in the SEIS/OEIS by multiplying the number of munitions used by the low and high NEW ranges for each ordnance type. Based on these calculations, the following assumptions are presented as additional analysis for the SEIS/OEIS:

- In terms of the number of events, there would be an increase of less than 2 percent over what was analyzed previously in the 2015 MITT Final EIS/OEIS. No new activity types are proposed in the SEIS/OEIS from what were previously analyzed in the 2015 MITT Final EIS/OEIS. Some activity types, however, would increase in the number of events per year and/or the number of ordnance items expended. Other activities would not change compared to what was analyzed previously in the 2015 MITT Final EIS/OEIS, and therefore would not contribute to an increase in NEW or the number of munitions expended on FDM. Examples of these training activities include Gunnery Exercise (Air-to-Ground) and Bombing Exercise (Air-to-Ground). Table 3.6-1 shows the number of events that would occur under each alternative compared to what was analyzed in the 2015 MITT Final EIS/OEIS.

- In terms of munitions item numbers, there would be an increase of approximately 9 percent over what was analyzed previously in the 2015 MITT Final EIS/OEIS in the total number of munitions used on FDM. Most of these increases are associated with small-caliber rounds, which do not contribute to increases in NEW. Table 3.6-2 shows the number of munitions proposed under each alternative compared to what was analyzed in the 2015 MITT Final EIS/OEIS.
- In terms of NEW, explosives used on FDM would increase by less than 1 percent compared to what was analyzed in the 2015 MITT Final EIS/OEIS (see calculations in Table 3.6-3).

Taken together, the increase in the number of events per year or the amount of ordnance used during events would result in more ordnance use on FDM and an increase in the amount of NEW expended on FDM each year. Although the amount of increased NEW is negligible (less than 1 percent), the number of events per year and the number of ordnance items (most of which are small and medium projectiles) expended increases the potential exposure to stressors associated with ordnance use. Factors that limit the potential for additional adverse impacts, however, include maintaining the same ordnance type and targeting restrictions included as part of the 2015 MITT Final EIS/OEIS. All ordnance expended on FDM would target existing impact zones, with the same ordnance restrictions imposed on all FDM activities and with the same avoidance and minimization measures in place as with the 2015 MITT Final EIS/OEIS (see Section 5.5, Terrestrial Mitigation Measures to be Implemented).

Table 3.6-1: Number of Events by Activity Type on Farallon de Medinilla

Activity	Number of Events			Percent Increase from 2015 MITT Final EIS/OEIS	
	2015 MITT Final EIS/OEIS	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Marine Air Ground Task Force Exercise (Amphibious) – Battalion	4	4	4	0.0%	0.0%
Naval Surface Fire Support Exercise – Land-based target	10	10	15	0.0%	40.0%
Bombing Exercise (Air-to-Ground)	2,300	2,300	2,300	0.0%	0.0%
Gunnery Exercise (Air-to-Ground)	96	96	96	0.0%	0.0%
Missile Exercise	85	115	115	35.3%	35.3%
Direct Action (Tactical Control Party)	18	18	18	0.0%	0.0%
Total	***2,513***	***2,543***	***2,548***	***1.2%***	***1.4%***

Notes: EIS = Environmental Impact Statement, MITT = Mariana Islands Training and Testing, NEPM = Non-explosive practice munition, OEIS = Overseas EIS

Table 3.6-2: Number of Munitions by Activity Type on Farallon de Medinilla

Activity	Munitions Type	Number of Munitions			Percent Increase from 2015 MITT Final EIS/OEIS	
		2015 MITT Final EIS/OEIS	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Naval Surface Fire Support Exercise – Land-based target	NEPM Rounds	1,800	–	–	NA	NA
	Explosive large-cal rounds	1,000	2,800	4,200	180.0%	320.0%
Bombing Exercise (Air-to-Ground)	NEPM Rounds	2,670	2,670	2,670	0.0%	0.0%
	Explosive Rounds	6,242	6,242	6,242	0.0%	0.0%
Gunnery Exercise (Air-to-Ground)	Small-cal rounds	24,000	24,000	24,000	0.0%	0.0%
	Med-cal rounds	94,150	94,650	94,650	0.5%	0.5%
	Explosive med-cal rounds	17,350	17,500	17,500	0.9%	0.9%
	Explosive large-cal rounds	200	200	200	0.0%	0.0%
Missile Exercise	Explosive rockets	2,000	2,000	2,000	0.0%	0.0%
	Explosive missiles	85	115	115	35.3%	35.3%
Direct Action (Tactical Control Party)	Small-cal rounds	18,000	30,000	30,000	66.7%	66.7%
	Medium-cal explosives	–	1,000	1,000	NA	NA
	Explosives (grenades/mortars)	600	1,000	1,000	66.7%	66.7%
Total		***168,097***	***182,177***	***183,577***	***8.4%***	***9.2%***

Notes: EIS = Environmental Impact Statement, MITT = Mariana Islands Training and Testing, NEPM = Non-explosive practice munition, OEIS = Overseas EIS

Table 3.6-3: Munitions Use on Farallon de Medinilla, Net Explosive Weight Comparisons

Explosive Munitions used at FDM	NEW Range[1]	NEW			Percent Increase from 2015 MITT Final EIS/OEIS	
		2015 MITT Final EIS/OEIS	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Explosive Bombs ≤ 2,000 lb.	250–1,740	3,121,000–10,861,080	3,121,000–10,861,080	3,121,000–10,861,080	0.0%	0.0%
Missiles	10–20	850–1,700	1,150–2,300	1,150–2,300	35.3%	35.3%
Large-caliber Projectiles	5–10	6,000–12,000	15,000–30,000	22,000–44,000	150.0%	266.7%
Medium-caliber Projectiles	2.5–5	43,375–86,750	46,250–92,500	46,250–92,500	6.6%	6.6%
Rockets	2.5–5	1,000–2,000	1,000–2,000	1,000–2,000	0.0%	0.0%
Explosive Grenades and Mortars	0.25–0.5	150–300	250–500	250–500	50.0%	50.0%
Total		***3,172,375–10,981,830***	***3,184,650–11,006,380***	***3,191,650–11,020,380***	***0.22–0.39%***	***0.35–0.61%***

[1] NEW (Net Explosive Weight) measured in lb. (pounds)

Notes: EIS = Environmental Impact Statement, FDM = Farallon de Medinilla, lb. = pounds, MITT = Mariana Islands Training and Testing, NEW = Net Explosive Weight (lb.), OEIS = Overseas EIS

Population-Level Impact Analysis

Under the Migratory Bird Treaty Act (MBTA) regulations applicable to military readiness activities (50 Code of Federal Regulation [CFR] part 21), the stressors introduced during training and testing activities would not result in a significant adverse effect on marine birds protected under the MBTA. While this determination is applicable to all marine birds that occur in the Study Area, the Navy carried out a focused analysis for marine birds known to breed within the Study Area, particularly for breeding marine birds on FDM. The Navy identified two birds in particular that have a heightened concern with regards to 50 CFR Part 21—the great frigatebird and the masked booby.

In the 2015 MITT Final EIS/OEIS, the Navy assessed the significance of injury and mortality of individual masked boobies and great frigatebirds relative to the viability of these species' populations. The populations of the masked booby and great frigatebird were defined based on (1) the distribution of subspecies *S. d. personata* and *F. m. palmerstoni*, (2) the colony locations within these distributions, and (3) the number of individual birds associated with these colonies. The Navy then compared the number of masked boobies and great frigatebirds that are found within the colonies within the Marianas (particularly FDM) to that of the regional population within the western and central Pacific.

Because the numbers of activities described in this SEIS/OEIS potentially affecting these birds and the amount of NEW used on FDM do not appreciably differ from what was analyzed previously, the conclusions within the 2015 MITT Final EIS/OEIS remain valid. These conclusions are summarized below:

- The great frigatebird may occasionally nest on FDM, which is one of only two small breeding colonies known to exist within the Mariana Islands (the other is located on Maug in the northern portion of the archipelago). FDM does not appear to be a temporally or spatially stable rookery location. Compared to the numbers of great frigatebirds estimated throughout central and western Pacific (10,000 pairs in the Hawaiian Islands, with other colonies on Howland, Baker, Jarvis, Johnston Atoll, and Christmas Island), and the apparent low numbers of great frigatebirds from historic times through the present within the Mariana archipelago, the direct and indirect effects on effects of military activities on FDM would not represent a significant adverse impact on the population of the great frigatebird.

- For the masked booby, FDM is the largest breeding colony in Mariana Islands. The colony numbers recorded by the Navy appear to be stable, and the data do not suggest any significant declines of masked booby numbers. Although the masked booby may be subject to short- and long-term impacts of military use of FDM and individuals likely suffer injury and mortality from some activities, FDM continues to support a relatively stable rookery. In the central and western Pacific, 2,500 pairs are estimated within the Northwestern Hawaiian Islands, Jarvis (up to 1,200 pairs), Barker Island (over 1,500 pairs), and smaller colonies in American Samoa, Palmyra, Johnson Atoll, and northern islands in the Mariana archipelago (Maug, Uracas, Guguan, and FDM). Based on the long-term use and stability of the masked booby breeding population on FDM and the wide geographic range and abundance of the masked booby throughout the Pacific, the effects of military use of FDM would not represent a significant adverse impact on the population of the masked booby.

- Pursuant with the Department of Defense's obligations under 50 CFR Part 21, the Department of Defense will continue to implement training restrictions on FDM (see Section 5.5, Terrestrial Mitigation Measures to be Implemented) and monitoring of bird populations on FDM.

3.6.2.1 Acoustic Stressors

Section 3.6.3.1 (Acoustic Stressors) in the 2015 MITT Final EIS/OEIS provided an overview of marine bird hearing, including an explanation of how birds can suffer injury, hearing loss, and physiological stress, as well as various behavioral reactions exhibited by birds when a noise event induces a response. In addition, long-term consequences associated with noise-induced impacts are discussed in the 2015 MITT Final EIS/OEIS in Section 3.6.3.1 (Acoustic Stressors).

3.6.2.1.1 Impacts from Sonar and Other Transducer Stressors Under Alternative 1

Under Alternative 1, the number of sonar hours used in the Study Area during training and testing activities compared to the number analyzed in the 2015 MITT Final EIS/OEIS (see Table 3.0-2 and Table 3.0-3 in this SEIS/OEIS) would decrease overall. Therefore, the analysis in the 2015 MITT Final EIS/OEIS remains valid. Decreases in sonar hours shown for activities proposed under Alternative 1 would have no appreciable change on the impact analysis or conclusions for acoustic stressors presented in the 2015 MITT Final EIS/OEIS, based on the analysis below.

Sonar and other transducers emit sound waves into the water to detect objects, safely navigate, and communicate. Use of sonar and other transducers would typically be transient and temporary. General categories of sonar systems are described in Section 3.0.4.1 (Acoustic Stressors).

Information regarding the impacts of sonar on birds is unavailable, and little is known about the ability for birds to hear underwater. The limited information and data from other species suggest the range of best hearing may shift to lower frequencies in water (Dooling & Therrien, 2012; Johansen et al., 2016; Therrien, 2014). 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. Other than pursuit diving species, the exposure to birds by these sounds is likely to be negligible because they spend only a very short time underwater (plunge-diving or surface-dipping) or forage only at the water surface. Pursuit divers may remain underwater for minutes, increasing the chance of underwater sound exposure.

In addition to diving behavior, the likelihood of a bird being exposed to underwater sound depends on factors such as 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. When used, continuously active sonars transmit more frequently (greater than 80 percent duty cycle) than traditional sonars, but at a substantially lower source level. However, it should be noted that active sonar is rarely used continuously throughout the listed activities, and many sources are mobile. For moving sources such as hull-mounted sonar, the likelihood of an individual bird being repeatedly exposed to a sound source over a short period of time is low because the training and testing activities are transient, and 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 training and testing 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.

Injury due to acoustic resonance of air space in the lungs due to 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.

A physiological impact, such as hearing loss, would likely only occur if a marine bird were close to an intense sound source. Hearing loss is typically quantified in terms of threshold shift—the amount (in dB) that hearing thresholds at one or more specified frequencies are elevated, compared to their pre-exposure values, at some specific time after the noise exposure. The amount of threshold shift measured usually decreases with increasing recovery time—the amount of time that has elapsed since a noise exposure. If the threshold shift eventually returns to zero (i.e., the hearing threshold returns to the pre-exposure value), the threshold shift is called a temporary threshold shift (TTS). If the threshold shift does not completely recover (the threshold remains elevated compared to the pre-exposure value), the remaining threshold shift is called a permanent threshold shift (PTS). 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.

In general, birds are less susceptible to both TTS and PTS than mammals (Saunders & Dooling, 1974). Diving birds have adaptations to protect the middle ear and tympanum from pressure changes during diving that may affect hearing (Dooling & Therrien, 2012). While some adaptions may exist to aid in underwater hearing, other adaptations to protect in-air hearing may limit aspects of underwater hearing (Hetherington, 2008). Because of these reasons, the likelihood of a diving bird experiencing an underwater exposure to sonar or other transducer that could result in an impact on hearing is considered low.

Because there is no new information since the 2015 MITT Final EIS/OEIS that would change the previous analysis for potential impacts on ESA-listed marine bird species, the conclusions in the 2015 MITT Final EIS/OEIS remain valid. The described training and testing activities would present no measurable chance for interaction with ESA-listed marine bird species (e.g., short-tailed albatross, Hawaiian petrel, Newell's shearwater). In the 2015 MITT Final EIS/OEIS and during consultation between the Navy and USFWS, the Navy determined that the use of sonar and other transducers would have no effect on ESA-listed marine birds.

Because of the small numbers of birds potentially exposed to stressors associated with sonar and other transducers, and the low potential of any injurious exposure to sonar and other transducers while birds are under water, marine bird population impacts would not occur.

Pursuant to the ESA, acoustic stressors from the use of sonar and other transducers during training and testing activities, as described under Alternative 1, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, and Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from sonar and other transducers during training and testing activities described under Alternative 1 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.1.2 Impacts from Sonar and Other Transducer Stressors under Alternative 2 (Preferred Alternative)

As with Alternative 1, the number of sonar hours used under Alternative 2 in the Study Area during training and testing activities compared to the number analyzed in the 2015 MITT Final EIS/OEIS (Table 3.0-2 and Table 3.0-3) would decrease overall. Therefore, the analysis in the 2015 MITT Final EIS/OEIS remains valid. Decreases in the number of training and testing activities would potentially decrease the level of acoustic stressors in the Study Area. The conclusions for ESA-listed species presented in the 2015 MITT Final EIS/OEIS is the same as for Alternative 1 in this SEIS/OEIS.

As with Alternative 1, taken together, the small numbers of birds potentially exposed to stressors associated with sonar and other transducers under Alternative 2, and the low potential of any injurious exposure to sonar and other transducers while birds are under water, there would be no impacts on marine bird populations.

Pursuant to the ESA, acoustic stressors from the use of sonar and other transducers during training and testing activities, as described under Alternative 2, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, and Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from sonar and other transducers during training and testing activities described under Alternative 2 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.1.2.1 Impacts from Sonar and Other Transducer Stressors under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer acoustic stressors within the marine environment where Navy activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for impacts on marine birds from sonar and other transducers, but would not measurably improve the overall distribution or abundance of marine birds.

3.6.2.1.3 Impacts from Aircraft Noise

Section 3.6.3.1.3.1 (Fixed-Wing Aircraft) and Section 3.6.1.3.2 (Helicopters) of the 2015 MITT Final EIS/OEIS discuss the different types of aircraft and the noise they generate, along with a summary of potential responses marine birds may exhibit. Since the publication of the 2015 MITT Final EIS/OEIS, no new information was identified during the Navy's literature review that would substantially alter the assessment of potential impacts on marine birds from aircraft noise. Therefore, the information contained in Section 3.6.3.1.3.3 (Vessels) of the 2015 MITT Final EIS/OEIS remains valid.

Birds in areas that may experience repeated exposure often habituate and do not respond behaviorally (Larkin et al., 1996; National Park Service, 1994; Plumpton, 2006). Throughout the Study Area, repeated exposure of individual birds or groups of birds is unlikely based on the dispersed nature of the overflights and the capability of birds to avoid or rapidly vacate an area of disturbance. Therefore, the general health of individual birds would not be compromised. Occasional startle or alert reactions to aircraft noise are not likely to disrupt major behavior patterns (such as migrating, breeding, feeding, and sheltering) or to result in serious injury to any birds.

Training and testing activities where aircraft are used typically occur further offshore; however, increased use of FDM may increase the potential for aircraft strike of birds. Therefore, for the purposes of this SEIS/OEIS, only the use of aircraft related to FDM training activities are discussed below under the alternatives analysis for birds for this stressor category.

3.6.2.1.3.1 Impacts from Aircraft Noise Stressors Under Alternative 1

Under Alternative 1, the number of proposed activities including aircraft would decrease overall throughout the study area (see Table 3.0-11). In the open ocean, marine birds would be exposed to additional aircraft noise sources, but these activities are spread out throughout the Study Area. Because of the increase in munitions use at FDM, however, aircraft overflights over FDM would increase, depending on the delivery platform. For example, some of the increases are associated with ship to surface, while others may involve helicopters and fixed-wing aircraft. Therefore, the analysis in this section focuses on FDM, where actual aircraft overflights would likely increase.

Increased training activities under Alternative 1 would increase the potential for noise exposures for birds on FDM because the increase in the number of training activities would require more aircraft to fly over the island (potentially at low altitude) and land on the island to deliver and pick up personnel. As shown in Table 2.5-1, activities that would increase aircraft overflights include Missile Exercise and Direct Action (Tactical Air Control Party) activities.

Aircraft overflights are expected to elicit short-term behavioral responses in nesting birds at FDM. Based on studies from other nesting bird areas (Barnas et al., 2018; Bowles, 1995; Larkin et al., 1996), any period away from the nest would last a few seconds to a few minutes, which is likely not long enough for opportunistic predation of a nest (e.g., by rats on FDM). The 2015 MITT Final EIS/OEIS analyzed other adverse effects, such as damage to eggs and startling of juveniles and adults.

Anecdotally, some birds typically take flight while roosting or nesting during quarterly helicopter-based marine bird surveys over FDM; birds that are stationary and not on the wing are counted (U.S. Department of the Navy, 2013a). Although no studies are available specific to marine bird responses to low-level overflights over FDM, other studies of shorebird responses to military aircraft overflights are helpful. Black (2005), studied the effects of low-altitude (less than 500 ft. [152 m] above ground level) military training flights with sound levels from 55 to 100 A-weighted decibels on wading bird colonies (i.e., great egret, snowy egret, tricolored heron, and little blue heron). The training flights involved three or four aircraft and occurred once or twice per day. This study concluded that the reproductive activity—including nest success, nestling survival, and nestling chronology—was independent of F-16 overflights. Dependent variables were more strongly related to ecological factors, including location and physical characteristics of the colony and climatology. Another study on the effects of circling fixed-wing aircraft and helicopter overflights on wading bird colonies found that at altitudes of 195 ft. (59 m) to 390 ft. (119 m), there was no reaction in nearly 75 percent of the 220 observations. Ninety percent displayed no reaction or merely looked toward the direction of the noise source. Another 6 percent stood up, 3 percent walked from the nest, and 2 percent flushed (but were without active nests) and returned within five minutes (Kushlan, 1978).

These studies, coupled with anecdotal observations on FDM during quarterly marine bird monitoring surveys, suggest that aircraft overflights do not have harmful effects on nesting and roosting marine birds on FDM, and that the behavioral responses are short term (Camp et al., 2016).

Although some degree of disturbance is expected from the increase in aircraft noise over FDM, the island will likely continue to serve as an important rookery for regional species without long-term significant impacts on marine bird populations. As discussed in Section 3.6.1.7 (Rookery Locations and Breeding Activities on FDM), Camp et al. (2016) published results of multi-year population monitoring of three species of boobies on FDM, showing that there is some evidence that masked and red-footed booby populations on FDM have declined, while brown booby populations have increased. However, the general conclusion is that all three species exhibited population fluctuations over time. Combined with the level of variability observed in the count data, this precluded any definite conclusions about long-term population trends (i.e., the data were non-significant) (Camp et al., 2016).

Because of the dispersed nature of overflights in open ocean training areas, birds or groups of birds in pelagic environments would not likely be exposed to repeated overflights. Because any exposures would be infrequent, and these exposures would not cause injury, population impacts would not occur for bird species in the open ocean.

Aircraft activity described in this SEIS/OEIS would present no measurable chance for interaction with ESA-listed marine bird species (e.g., short-tailed albatross, Hawaiian petrel, Newell's shearwater). In the 2015 MITT Final EIS/OEIS and during consultation between the Navy and USFWS, the Navy determined that aircraft activity would have no effect on ESA-listed marine birds. Although the amount of training and testing activities using aircraft would increase compared to the 2015 MITT Final EIS/OEIS, the potential for geographic and temporal overlap would remain negligible; therefore, the conclusions for ESA-listed species presented in the 2015 MITT Final EIS/OEIS is the same as for Alternative 1 in this SEIS/OEIS.

Pursuant to the ESA, aircraft noise during training activities, as described under Alternative 1, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, and Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from aircraft noise during training activities described under Alternative 1 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.1.3.2 Impacts from Aircraft Noise Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of activities including aircraft would decrease compared to levels analyzed under the 2015 MITT Final EIS/OEIS, but would be more than proposed under Alternative 1 (see Table 3.0-11).

As with Alternative 1, the dispersed nature of overflights in open ocean training areas under Alternative 2 would not likely expose birds or groups of birds in pelagic environments to repeated overflights. Because any exposures would be infrequent, and these exposures would not cause injury, population impacts would not occur for bird species in the open ocean.

No additional targets would be used, and this activity would be constrained by confining targeting to specific sites within designated impact zones. Because the same locations would be used for targeting activities, the impacts of Alternative 2 are the same as Alternative 1. In the open ocean, marine birds would be exposed to additional aircraft noise sources, but these activities are spread out throughout the Study Area, and the potential impacts of at-sea training and testing activities would not be discernable from Alternative 1. Therefore, impacts on marine birds under Alternative 2 from aircraft noise would be negligible.

Pursuant to the ESA, aircraft noise during training activities, as described under Alternative 2, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, and Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from aircraft noise during training activities described under Alternative 2 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.1.3.3 Impacts from Aircraft Noise Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer acoustic stressors within the marine environment where Navy activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for impacts on marine birds from aircraft noise, but would not measurably improve the overall distribution or abundance of marine birds.

3.6.2.1.4 Impacts from Weapons Noise

Sounds produced by weapons firing (muzzle blast), launch boosters, and projectile travel are potential stressors to birds and are discussed as impulsive noise under Section 3.6.3.1.2.2 (Explosions on Land and In-Air) in the 2015 MITT Final EIS/OEIS. Since the publication of the 2015 MITT Final EIS/OEIS, no new information was identified during the Navy's literature review that would substantially alter the assessment of potential impacts on marine birds from weapons noise.

3.6.2.1.4.1 Impacts from Weapons Noise Stressors Under Alternative 1

Under Alternative 1, the number of training and testing activities that would expose marine birds to weapons noise would decrease throughout the Study Area, compared to levels analyzed in the 2015 MITT Final EIS/OEIS (Table 3.0-14 and Table 3.0-16). A bird in the open ocean could be exposed to weapons noise if not already displaced by the visual or noise disturbance of a vessel supporting weapons-firing exercises. 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.

Supersonic projectiles, which would be similar in size to shells fired from 5-inch/54 guns, would travel at approximately 2,600 ft./second, creating a bow shock wave. Pater and Shea (1981) measured the characteristics of a bow shock wave from a 5-inch projectile and found that the shock wave ranged from 40 to 147 dB re 20 µPa sound pressure level peak taken at the ground surface at 1,100 m from the firing location and 190 m perpendicular from the trajectory (for safety reasons). Shells fired from a kinetic energy weapon are considered hypersonic, and would travel at about 6,500 ft./second, and peak pressures would be expected to be several dB higher than for shell velocities described by (Pater & Shea, 1981). By definition, bow shock waves, regardless of shell velocity, would travel at the speed of sound in air. Marine birds would be exposed to this type of noise for a very brief period of time (a few seconds), and would likely cause brief and temporary behavioral reactions described previously for other in-air noise disturbances.

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. Birds foraging or migrating through a training area in the open ocean may respond by avoiding areas where weapons-firing exercises occur. Exposures of most marine birds would be infrequent, based on the brief duration and dispersed nature of the vessels, and the brief duration of the weapons-firing noise. If a bird responds to weapons noise, only short-term behavioral responses such as startle responses, head turning, or avoidance responses would be expected. Weapons noise near rookery locations (only at FDM) may induce startle responses, inducing birds to temporarily leave nests. Because impacts on individual birds, if any, are expected to be minor and limited, no long-term consequences to individuals are expected. Accordingly, there would be no consequences to any bird populations, and weapons noise would not have a significant adverse effect on populations of migratory bird species.

On FDM, however, marine birds would likely be exposed to increased weapons noise because of the increase in the number of explosive and non-explosive munitions (see Table 3.6-1, Table 3.6-2, and Table 3.6-3). Sources of weapons generating noise at the time of weapons firing on or near FDM include small-caliber rounds, rockets, medium-caliber projectiles, and large-caliber projectiles. Other munitions types used on FDM (e.g., non-explosive practice munition and explosive bombs and missiles) are launched far from the target (impact areas on FDM) or released from aircraft.

The potential impacts of explosives noise and weapons firing noise on FDM's wildlife are discussed in Section 3.10.3.1.1 (Impacts from Explosives and Weapons Firing Noise) in Section 3.10 (Terrestrial Species and Habitats) of this SEIS/OEIS, which provides a summary of the different types of sounds, frequency ranges, and intensity of sounds generated from munitions use on FDM. Sources of noise from weapons firing that may be heard by marine birds on FDM include close-in weapons firing from vessels, helicopters, close-combat surface firing from fixed-wing aircraft, and surface firing, with the largest increase in munitions use resulting from small arms, medium-caliber explosives, and mortar and grenade use during Direct Action training activities. As shown in Table 3.6-1, the number of training events for this activity type would stay the same compared to what was previously analyzed in the 2015 MITT Final EIS/OEIS; however, the number of munitions used would increase during each training event (see Table 3.6-2). These training events would occur within the Northern Special Use Area and fire into the impact areas towards the south; therefore, more birds would be exposed to more weapons firing noise under Alternative 1 because of the increased number of small-caliber rounds, medium-caliber explosives, and grenades and mortars fired into impact areas from the Northern Special Use Area. The weapons-firing noise would likely be masked somewhat by natural sounds on FDM, such as waves and winds. The impulsive sound caused by weapon firings would have limited potential to mask any important biological sound simply because the duration of the impulse is brief, even when multiple shots are fired in series.

Although some degree of disturbance is expected from the increase in weapons noise on FDM, the island will likely continue to serve as an important rookery for regional species without long-term significant impacts on marine bird populations. As discussed in Section 3.6.1.7 (Rookery Locations and Breeding Activities on FDM), Camp et al. (2016) published results of multi-year population monitoring of three species of boobies on FDM, showing that there is some evidence that masked and red-footed booby populations on FDM have declined, while brown booby populations have increased. However, the general conclusion is that all three species exhibited population fluctuations over time. Combined with the level of variability observed in the count data, this precluded any definite conclusions about long-term population trends (i.e., the data were non-significant) (Camp et al., 2016).

Weapons noise would present no measurable chance for interaction with ESA-listed marine bird species (short-tailed albatross, Hawaiian petrel, Newell's shearwater). As discussed previously, ESA-listed marine bird species do not occur on FDM (or any other island within the Marianas) and have little to no overlap with the Study Area. In the 2015 MITT Final EIS/OEIS and during consultation between the Navy and USFWS, the Navy determined that weapons noise would have no effect on ESA-listed marine birds. Although the amount of training and testing activities would increase compared to the 2015 MITT Final EIS/OEIS, the potential for geographic and temporal overlap would remain negligible; therefore, the conclusions for ESA-listed species presented in the 2015 MITT Final EIS/OEIS is the same as for Alternative 1 in this SEIS/OEIS.

Pursuant to the ESA, weapons noise during training and testing activities, as described under Alternative 1, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, and Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from weapons noise during training and testing activities described under Alternative 2 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.1.4.2 Impacts from Weapons Noise Stressors Under Alternative 2 (Preferred Alternative)

As with Alternative 1, under Alternative 2 the number of training and testing activities that would expose marine birds to weapons noise would decrease throughout the Study Area, compared to levels analyzed in the 2015 MITT Final EIS/OEIS (see Table 3.0-14 and Table 3.0-16). Compared to Alternative 1, there would be small increases in the number of activities using large-caliber and medium-caliber projectiles and missiles under Alternative 2 for at-sea training and testing activities. Therefore, Alternative 2 would introduce fewer weapons firing events than activities analyzed in the 2015 MITT Final EIS/OEIS for at-sea activities. Because activities would occur within the same locations as with Alternative 1, at-sea weapons firing activities would be widely dispersed, and marine birds would also be widely dispersed, the impacts of Alternative 2 are the same as for Alternative 1.

On FDM, the only training activity that would introduce weapons firing noise is Direct Action (tactical control party). As shown in Table 3.6-1, the number of training events for this activity type would stay the same compared to what was previously analyzed in the 2015 MITT Final EIS/OEIS and compared to Alternative 1; however, the number of munitions used would increase (see Table 3.6-2). These training events would occur within the Northern Special Use Area and fire into the impact areas towards the south; therefore, more birds would be exposed to more weapons firing noise under Alternative 2 because of the increased number of small-caliber rounds, medium-caliber explosives, and grenades and mortars fired into impact areas from the Northern Special Use Area. The weapons-firing noise would likely be masked somewhat by natural sounds on FDM, such as waves and winds. The impulsive sound caused by weapon firings would have limited potential to mask any important biological sound simply because the duration of the impulse is brief, even when multiple shots are fired in series.

As with Alternative 1, some degree of disturbance is expected from the increase in weapons noise on FDM; however, the island will likely continue to serve as an important rookery for regional species without long-term significant impacts on marine bird populations. As discussed in Section 3.6.1.7 (Rookery Locations and Breeding Activities on FDM), Camp et al. (2016) published results of multi-year population monitoring of three species of boobies on FDM, showing that is some evidence that masked and red-footed booby populations on FDM have declined, while brown booby populations have increased. However, the general conclusion is that all three species exhibited population fluctuations over time. Combined with the level of variability observed in the count data, this precluded any definite conclusions about long-term population trends (i.e., the data were non-significant) (Camp et al., 2016). The same conclusions for Alternative 1 for MBTA-protected marine bird species at sea and on FDM, and ESA-listed marine bird species at sea, are applicable to Alternative 2.

Pursuant to the ESA, weapons noise during training and testing activities, as described under Alternative 1, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, and Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from weapons noise during training and testing activities described under Alternative 2 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.1.4.3 Impacts from Weapons Noise Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Acoustic stressors would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer acoustic stressors within the marine environment where Navy activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for impacts on marine birds from weapons noise, but would not measurably improve the overall distribution or abundance of marine birds.

3.6.2.2 Explosives Stressors (explosive shock wave and sound, explosive fragments)

Section 3.6.3.1.2 (Impacts from Explosives and Swimmer Defense Airguns) in the 2015 MITT Final EIS/OEIS discusses the sources and potential impacts of explosives noise on marine birds (e.g., injury, hearing loss, physiological stress, masking, and long-term consequences of exposures). Explosions in the water, near the water surface, on land (FDM), and in the air 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. The information regarding training and testing activities in open ocean training environments that generate explosives noise has not changed since the publication of the 2015 MITT Final EIS/OEIS. Therefore, this section focuses on the potential for increased training activities to impact birds on FDM proposed under the alternatives described in this SEIS/OEIS.

Noise can result from direct munitions impacts (one object striking another), blasts (explosions that result in shock waves), bow shock waves (pressure waves from projectiles flying through the air), and substrate vibrations (combinations of explosion, recoil, or vehicle motion with the ground). Noise may be continuous (i.e., lasting for a long time without interruption) or impulse (i.e., short duration). Continuous impulses (e.g., helicopter rotor noise, bursts from rapid-fire weapons) represent an intermediate type of sound and, when repeated rapidly, may resemble continuous noise. These types of sound are distinguished here as they differ in their effects. Continuous sounds can result in hearing damage, while impulses typically elicit physiological or behavioral responses. Some birds may be killed or injured during these activities, or expend energy stores needed for migration to avoid perturbations generated by explosions.

Because the military will continue to implement mitigation measures designed to avoid or reduce impacts on terrestrial biological resources, all additional ordnance use would still be targeted at existing impact areas.

FDM has three impact areas, a special use area on the northern portion of the island, and a special use area on the land bridge. Since the release of the 2015 Final EIS/OEIS, the Navy has moved gunnery targets into the impact areas from their previous locations near the west-facing cliffs. Targets were relocated in order to minimize impacts on the cliff face. Targeting of areas inside of the special use areas and other areas outside of impact areas are prohibited. In other words, all areas outside of the impact areas are considered "no-fire areas." Any ordnance that inadvertently lands outside of impact areas, including special use areas and in water, must be reported to Mariana Islands Range Complex Operations, in accordance with Commander, U.S. Naval Forces Marianas Instruction 3500.4A (U.S. Department of the Navy, 2011). The impact areas and special use areas are described below:

- **Northern Special Use Area**. Reserved for direct action (tactical air control party) type exercises and personnel recovery. This area is about 41 acres (ac.) (17 hectares [ha]) and includes a landing zone. Weapons may be fired from the special use area into impact areas, such as small-caliber rounds, grenades, and mortars.
- **Impact Area 1**. This area contains high-fidelity target structures and is comprised of vehicle shells and cargo containers. This area is authorized for inert ordnance only, and operators are required to report any live ordnance inadvertently dropped into Impact Area 1 to Mariana Islands Range Complex Operations. Impact Area 1 contains 10 targets of varying shapes and sizes, including four vehicles and six targets comprised of shipping containers.
- **Impact Area 2**. Impact Area 2 may be used for both live and inert ordnance. Strafing is permitted in this area. Impact Area 2 is about 22 ac. (9 ha).
- **Land Bridge**. The land bridge is designated as a "no target zone." Operators are required to report ordnance observed impacting the land bridge.

- **Impact Area 3**. This area is south of the land bridge and authorized for inert ordnance, although live ordnance may be used only with prior approval from Joint Region Marianas. Strafing is permitted in this area. Impact Area 3 is about 11 ac. (4.5 ha).

3.6.2.2.1 Impacts from Explosive Stressors Under Alternative 1

Under Alternative 1, there would be an overall decrease throughout the Study Area in the number of explosive munitions used during training and testing activities compared to the number analyzed in the 2015 MITT Final EIS/OEIS (Table 3.0-16).

As shown in Table 3.6-1, there would be an increase in the number of events using FDM as a training location or target, with an increase in the number of munitions items expended on FDM (see Table 3.6-2).

Taken together, the increase in the number of training events per year or the amount of ordnance used during training events would result in an increase in the amount of NEW expended on FDM each year (see Table 3.6-1, Table 3.6-2, and Table 3.6-3). Although the amount of increased NEW is negligible, the potential exposure to stressors associated with ordnance use would increase under Alternative 1 compared to what was analyzed previously in the MITT Final EIS/OEIS. Factors that limit the potential for additional adverse impacts, however, include maintaining the same ordnance type and targeting restrictions included as part of the 2015 MITT Final EIS/OEIS. All ordnance expended on FDM would target existing impact zones, with the same ordnance restrictions imposed on all FDM activities and with the same avoidance and minimization measures in place (see Section 5.5, Terrestrial Mitigation Measures to be Implemented; and Table 5.5-1). Therefore, the increases in ordnance use on FDM do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS. The conclusions for ESA-listed marine bird species and other marine bird species protected by the MBTA included in the 2015 MITT Final EIS/OEIS remain valid.

Explosives would present no measurable chance for interaction with ESA-listed marine bird species (short-tailed albatross, Hawaiian petrel, Newell's shearwater). In the 2015 MITT Final EIS/OEIS and during consultation between the Navy and USFWS, the Navy determined that training and testing activities using explosives would have no effect on ESA-listed marine birds. Despite the continued at-sea use of explosives compared to the 2015 MITT Final EIS/OEIS, the potential for geographic and temporal overlap would remain negligible; therefore, the conclusions for ESA-listed species presented in the 2015 MITT Final EIS/OEIS is the same as for Alternative 1 in this SEIS/OEIS.

Pursuant to the ESA, explosives used during training and testing activities, as described under Alternative 1, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from explosives stressors during training and testing activities using explosives described under Alternative 1 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.2.2 Impacts from Explosive Stressors Under Alternative 2 (Preferred Alternative)

As with Alternative 1, there would be an overall decrease throughout the Study Area in the number of explosive munitions used during at-sea training and testing activities compared to the number analyzed in the 2015 MITT Final EIS/OEIS. The number of explosive stressors under Alternative 2 would increase as compared to Alternative 1 (see Table 3.0-16), but the conclusions for at-sea activities remains the same. Under Alternative 2, there would be an increase in the number of training events using FDM as a training location or target (see Table 3.6-1), with an increase in the number of munitions items expended on FDM (see Table 3.6-2) compared to what was analyzed previously in the MITT Final EIS/OEIS and under Alternative 1.

Taken together, the increase in the number of training events per year or the amount of ordnance used during events would result in an increase in the amount of NEW expended on FDM each year (see Table 3.6-3). Although the amount of increased NEW is negligible, the potential exposure to stressors associated with ordnance use would increase under Alternative 2 compared to what was analyzed previously in the MITT Final EIS/OEIS. Under Alternative 2, Naval Surface Firing Exercise events would expend more large-caliber projectiles, thereby increasing the NEW expended under Alternative 2 compared to Alternative 1. Factors that limit the potential for additional adverse impacts, however, include maintaining the same ordnance type and targeting restrictions included as part of the 2015 MITT Final EIS/OEIS. All ordnance expended on FDM would target existing impact zones, with the same ordnance restrictions imposed on all FDM activities and with the same avoidance and minimization measures in place (see Section 5.5, Terrestrial Mitigation Measures to be Implemented; and Table 5.5-1). Therefore, the increases in ordnance use on FDM shown in Tables 2.5-1 and 2.5-2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS. The conclusions for ESA-listed marine bird species and other marine bird species protected by the MBTA included in the 2015 MITT Final EIS/OEIS remain valid.

Explosives would present no measurable chance for interaction with ESA-listed marine bird species (short-tailed albatross, Hawaiian petrel, Newell's shearwater). In the 2015 MITT Final EIS/OEIS and during consultation between the Navy and USFWS, the Navy determined that training and testing activities using explosives would have no effect on ESA-listed marine birds. Although the amount of training and testing activities using explosives would increase compared to the 2015 MITT Final EIS/OEIS, the potential for geographic and temporal overlap would remain negligible; therefore, the conclusions for ESA-listed species presented in the 2015 MITT Final EIS/OEIS is the same as for Alternative 1 in this SEIS/OEIS.

Pursuant to the ESA, explosives used during training and testing activities, as described under Alternative 2, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from explosives stressors during training and testing activities using explosives described under Alternative 2 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.2.3 Impacts from Explosive Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Explosive stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer explosive stressors within the marine environment where Navy activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for impacts on marine birds from explosive stressors, but would not measurably improve the overall distribution or abundance of marine birds.

3.6.2.3 Energy Stressors

The energy stressors that may impact marine birds include (1) in-air electromagnetic devices and (2) high-energy lasers. However, as discussed in Section 3.0.4.3 (Energy Stressors), in-air electromagnetic energy would be widely dispersed throughout the Study Area, but more concentrated in portions of the Study Area near ports, naval installations, and range complexes. Because these stressors are operated at power levels, altitudes, and distances from people and animals to ensure that energy received is well below levels that could disrupt behavior or cause injury and because most in-air electromagnetic energy is reflected by water, in-air electromagnetic energy would not impact birds and is not analyzed further in this section.

Since the publication of the 2015 MITT Final EIS/OEIS, additional information has become available that improves understanding of how in-air electromagnetic devices (such as radar) may impact marine birds. This new information is included in this SEIS/OEIS. Studies conducted on in-air electromagnetic sensitivity in birds have typically been associated with land, and little information exists specifically on seabird response to in-air electromagnetic changes at sea. Based on these studies, in-air electromagnetic effects can be categorized as thermal (i.e., capable of causing damage by heating tissue) or non-thermal. Thermal effects are most likely to occur when near high-power systems. Should such effects occur, they would likely cause birds to temporarily avoid the area receiving the electromagnetic radiation until the stressor ceases (Manville, 2016). Currently, questions exist about far-field, non-thermal effects from low-power, in-air electromagnetic devices. Manville (2016) performed a literature review of this topic. Although findings are not always consistent, Manville (2016) reported that several peer-reviewed studies have shown non-thermal effects can include (1) affecting behavior by preventing birds from using their magnetic compass, which may in turn affect migration; (2) fragmenting the DNA of reproductive cells, decreasing the reproductive capacity of living organisms; (3) increasing the permeability of the blood-brain barrier; (4) other behavioral effects; (5) other molecular, cellular, and metabolic changes; and (6) increasing cancer risk.

Many bird species return to the same stopover, wintering, and breeding areas every year and often follow the exact same or very similar migration routes (Akesson & Hedenstrom, 2007). However, ample evidence exists that displaced birds can successfully reorient and find their way when one or more cues are removed. For example, Haftorn et al. (1988) found that after removal from their nests and release into a different area, snow petrels (*Pagodrama nivea*) were able to successfully navigate back to their nests even when their ability to smell was removed. Furthermore, Wiltschko et al. (2011) and Wiltschko and Wiltschko (2005) report that electromagnetic pulses administered to birds during an experimental study on orientation do not deactivate the magnetite-based receptor mechanism in the upper beak altogether but instead cause the receptors to provide altered information, which in turn causes birds to orient in different directions. However, these impacts were temporary, and the ability of the birds to correctly orient themselves eventually returned.

Given (1) the information provided above; (2) the dispersed nature of Navy training and testing activities at sea; (3) the relatively small area around an emitting source that experiences high power electromagnetic pulses; and (4) the relatively low-level and dispersed use of these systems at sea, the following conclusions are reached:

- The chance that in-air electromagnetic devices would cause thermal damage to an individual marine bird is extremely low.
- It is possible, although unlikely, that some marine bird individuals would be exposed to levels of electromagnetic radiation that would cause discomfort, in which case they would likely avoid the immediate vicinity of testing and training activities.
- The strength of any avoidance response would decrease with increasing distance from the in-air electromagnetic device.
- No long-term or population-level impacts would occur.

There is only one new activity involving an energy stressor (i.e., high-energy lasers) that differs from activities with energy stressors that were previously analyzed in the 2015 MITT Final EIS/OEIS. Use of low-energy lasers was covered in the 2015 MITT Final EIS/OEIS in Section 3.0.5.2.2.3 (Lasers), but high-energy laser weapons were not part of the proposed action in the 2015 MITT Final EIS/OEIS. The use of high-energy lasers represents a new substressor used in an existing activity in this SEIS/OEIS. As discussed in this SEIS/OEIS, Section 3.0.4.3.2.2 (High-Energy Lasers), high-energy lasers are designed to disable surface targets, rendering them immobile. The primary concern is the potential for a marine bird to be struck with the laser beam at or near the water's surface, where extended exposure could result in injury or death due to traumatic burns from the beam.

Marine birds could be exposed to a laser only if they flew between the source and the target, or if the beam missed the target and a bird happened to be in the line of fire. Should the laser strike the sea surface, individual sea birds at or near the surface could be exposed. Because laser platforms are typically helicopters and ships, marine birds at sea would likely transit away or submerge in response to other stressors, such as ship or aircraft noise, although some marine birds may not exhibit a response to an oncoming vessel or aircraft, increasing the risk of contact with the laser beam. High-energy laser activities would only occur in open ocean locations (not close to land areas).

3.6.2.3.1 Impacts from High-Energy Lasers Under Alternative 1

Under Alternative 1, the number of proposed activities involving the use of high-energy lasers is shown in Table 3.0-10. High-energy lasers is a new substressor that was not analyzed in the 2015 MITT Final EIS/OEIS. As discussed above, impacts on marine birds from energy stressors should not be expected to occur.

A direct strike of a marine bird at the water's surface or within the beam path is extremely unlikely, and potential impacts on ESA-listed marine bird species are negligible. Therefore, the conclusions for ESA-listed marine bird species and other marine bird species protected by the MBTA included in the 2015 MITT Final EIS/OEIS remain valid.

During section 7 ESA consultation between the Navy and USFWS, the Navy determined that the activities described in the 2015 MITT Final EIS/OEIS would have no effect on the ESA-listed Hawaiian petrel, short-tailed albatross, or Newell's shearwaters.

Pursuant to the ESA, the use of high-energy lasers during training and testing activities, as described under Alternative 1, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, Newell's Townsend's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from energy stressors during training and testing activities using high-energy lasers described under Alternative 1 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.3.2 Impacts from High-Energy Lasers Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the use of high-energy lasers would increase as compared to Alternative 1 (Table 3.0-10), but there would be no change regarding the impact conclusions for energy stressors as summarized above under Alternative 1 and as presented in the 2015 MITT Final EIS/OEIS. Therefore, impacts on marine birds under Alternative 2 from energy stressors, including high-energy lasers, should not be expected to occur.

Pursuant to the ESA, the use of high energy lasers during training and testing activities, as described under Alternative 2, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from energy stressors during training and testing activities using high-energy lasers described under Alternative 2 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.3.3 Impacts from High-Energy Lasers Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Energy stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities. Discontinuing the training and testing activities would result in fewer energy stressors within the marine environment where Navy activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for impacts on marine birds from energy stressors, but would not measurably improve the overall distribution or abundance of marine birds.

3.6.2.4 Physical Disturbance and Strike Stressors

The physical disturbance and strike stressors that may impact marine birds include (1) aircraft and aerial targets, (2) vessels and in-water devices, (3) military expended materials, and (4) wildfires on FDM. For activities occurring at sea, the use of aircraft and aerial targets, vessels and in-water devices, and military expended materials would decrease under this SEIS/OEIS (Tables 3.0-11 through 3.0-17, and Table 3.0-20), with the exception of increased small caliber munitions use. Small-caliber munitions are inert, are meant to be aimed at targets, and are not long-range weapons. As a result, marine birds are extremely unlikely to be struck by expended small caliber munitions. Military expended materials would increase for training activities occurring on FDM. For the purposes of this SEIS/OEIS, only activities that occur on or over FDM and activities that would occur in the open ocean environment that have changed since the publication of the 2015 MITT Final EIS/OEIS are discussed in this section.

Physical disturbances may elicit short-term behavioral or physiological responses such as alert response, startle response, cessation of feeding, fleeing the immediate area, and a temporary increase in heart rate. These disturbances can also result in abnormal behavioral, growth, or reproductive impacts in nesting birds and can cause foraging and nesting birds to flush from or abandon their habitats or nests. Aircraft strikes often result in bird mortalities or injuries.

Physical disturbance on land may induce erosion, either from loosening of rock and soil from direct impacts (which facilitates transport of material by wind and rain) or from wildfires ignited by explosions (see Section 3.6.3.3.5, Impacts from Wildfires, in the 2015 MITT Final EIS/OEIS). Military use of FDM may contribute to ongoing soil disturbance and erosion from natural causes. FDM is comprised of highly weathered limestone overlain by a thin layer of clay soil (U.S. Department of the Navy, 2013b). Ordnance use, particularly within Impact Areas 2 and 3 (where explosive munitions use is permitted), would dislodge sediments that may potentially wash into nearshore waters of FDM. In addition to natural wind and water erosion (including high-energy typhoon events), erosion caused by ordnance use would contribute to increased turbidity and siltation of habitats used by marine bird prey species.

Section 3.6.3.3.1 (Impacts from Aircraft and Aerial Targets) in the 2015 MITT Final EIS/OEIS discusses the potential impacts on birds from collisions with fixed-wing aircraft, helicopters, and aerial targets. Aircraft and aerial target strikes could occur during training and testing activities that use aircraft, particularly in nearshore areas, where birds are more concentrated in the Study Area. Training and testing activities where aircraft are used typically occur further offshore; however, increased use of FDM may increase the potential for aircraft strike of birds. Therefore, for the purposes of this SEIS/OEIS, only the use of aircraft related to FDM training activities are discussed below under the alternatives analysis for birds for this stressor category.

3.6.2.4.1 Impacts from Physical Disturbance and Strike Stressors Under Alternative 1

Under Alternative 1, physical disturbance and strike stressors associated with training and testing activities would decrease in comparison to the 2015 MITT Final EIS/OEIS (Tables 3.0-12 through 3.0-17, 3.0-19), assuming the dismissal of small-caliber munitions use for the reasons noted above. Under Alternative 1, there would be increases in the numbers of large-caliber non-explosive practice munitions (Table 3.0-14) and the number of targets expended at sea (Table 3.0-17), but overall there would be a decrease in the number of combined physical disturbance and strike stressors on marine birds. Consistent with the conclusions provided in the 2015 MITT EIS/OEIS, impacts on marine birds from physical disturbance and strike stressors are not expected to occur.

On FDM, marine birds that nest and roost on the island would be exposed to military expended materials resulting from explosive munitions and non-explosive practice munitions. Explosive munitions increase the potential for a marine bird (or nest) to be struck because of fragments dispersed throughout the blast zone.

As shown in Table 3.6-1, there would be an increase in the number of training events using FDM as a training location or target, with an increase in the number of munitions items expended on FDM (see Table 3.6-2).

Taken together, the increase in the number of training events per year or the amount of ordnance used during events would result in an increase in the amount of NEW expended on FDM each year (see Table

3.6-3). Although the amount of increased NEW is negligible (0.22–0.39 percent, depending on the NEW range of various munition types), the potential exposure to physical disturbance and strike stressors associated with ordnance use would increase under Alternative 1 compared to what was analyzed previously in the MITT Final EIS/OEIS. Factors that limit the potential for additional adverse impacts from physical disturbance and strike, however, include maintaining the same ordnance type and targeting restrictions included as part of the 2015 MITT Final EIS/OEIS. All ordnance expended on FDM would target existing impact zones, with the same ordnance restrictions imposed on all FDM activities and with the same avoidance and minimization measures in place (see Section 5.5, Terrestrial Mitigation Measures to be Implemented; and Table 5.5-1). Therefore, the increases in ordnance use on FDM shown in Tables 2.5-1 and 2.5-2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS. The conclusions for ESA-listed marine bird species and other marine bird species protected by the MBTA included in the 2015 MITT Final EIS/OEIS remain valid.

During section 7 ESA consultation between the Navy and USFWS, the Navy determined that the activities described in the 2015 MITT Final EIS/OEIS would have no effect on the ESA-listed Hawaiian petrel, short-tailed albatross, or Newell's shearwater.

Pursuant to the ESA, training and testing activities that use aircraft and aerial targets, as described under Alternative 1, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from physical disturbance and strike stressors during training and testing activities described under Alternative 1 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.4.2 Impacts from Physical Disturbance and Strike Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, physical disturbance and strike stressors associated with training and testing activities would decrease in comparison to the 2015 MITT Final EIS/OEIS (Tables 3.0-12 through 3.0-17, 3.0-19) assuming the dismissal of small-caliber munitions use for the reasons noted above. Under Alternative 2, there would be increases in the numbers of large-caliber non-explosive practice munitions (Table 3.0-14) and the number of targets expended at sea (Table 3.0-17), but overall there would be a decrease in the number of combined physical disturbance and strike stressors on marine birds. Consistent with the conclusions provided in the 2015 MITT EIS/OEIS, impacts on marine birds from physical disturbance and strike stressors are not expected to occur.

On FDM under Alternative 2, there would be an increase in the number of training events using FDM as a training location or target (see Table 3.6-1), with an increase in the number of munitions items expended on FDM (see Table 3.6-2) compared to what was analyzed previously in the MITT Final EIS/OEIS and under Alternative 1.

Taken together, the increase in the number of training events per year or the amount of ordnance used during events would result in an increase in the amount of NEW expended on FDM each year (see Table 3.6-3). Although the amount of increased NEW is negligible (0.35–0.6 percent, depending on the NEW range of various munition types), the potential exposure to stressors associated with ordnance use would increase under Alternative 2 compared to what was analyzed previously in the MITT Final EIS/OEIS. Under Alternative 2, Naval Surface Firing Exercise events would expend more large-caliber projectiles, thereby increasing the NEW expended under Alternative 2 compared to Alternative 1. Factors that limit the potential for additional adverse impacts, however, include maintaining the same ordnance type and targeting restrictions included as part of the 2015 MITT Final EIS/OEIS. All ordnance expended on FDM would target existing impact zones, with the same ordnance restrictions imposed on all FDM activities and with the same avoidance and minimization measures in place (see Section 5.5, Terrestrial Mitigation Measures to be Implemented; and Table 5.5-1). Therefore, the increases in ordnance use on FDM shown in Tables 2.5-1 and 2.5-2 do not appreciably change the impact conclusions presented in the 2015 MITT Final EIS/OEIS. The conclusions for ESA-listed marine bird species and other marine bird species protected by the MBTA included in the 2015 MITT Final EIS/OEIS remain valid.

Pursuant to the ESA, training and testing activities that use aircraft and aerial targets, as described under Alternative 2, would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), the impacts from physical disturbance and strike stressors during training and testing activities described under Alternative 2 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.4.3 Impacts from Physical Disturbance and Strike Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Physical disturbance and strike stressors would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer physical disturbance and strike stressors within the marine environment where Navy activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for physical disturbance and strike impacts on marine birds, but would not measurably improve the overall distribution or abundance of marine birds.

3.6.2.5 Ingestion Stressors

As discussed in Section 3.6.3.4 (Ingestion Stressors) of the 2015 MITT Final EIS/OEIS, a variety of ingestible materials may be released into the marine environment by training and testing activities. Types of materials that could become ingestion stressors (military expended materials – munitions and military expended materials other than munitions) for marine birds during training and testing activities in the Study Area include non-explosive practice munitions (small and medium caliber), fragments from high-explosive munitions, fragments from targets, chaff, plastic end caps from chaff cartridges, the plastic compression pads, end caps from pistons and flares, and small decelerators/parachutes. Ingestion stressors would decrease with the exception of increased small-caliber munitions use (Table 3.0-14, Table 3.0-15, Tables 3.0-25 through 3.0-26). However, small-caliber munitions are inert, small in size, do not resemble prey items, and end up as part of the seafloor where they are unlikely to be encountered by marine birds. The number of munitions and explosive munitions fragments that an individual marine bird could encounter would generally be low, based on the patchy distribution of both the munitions and open water feeding habitats of marine birds. In addition, it is assumed an animal would not ingest every munition or munition fragment it encountered, and if a munition or munition fragment were ingested, an animal may attempt to reject it when it realizes the item is not food.

3.6.2.5.1 Impacts from Ingestion Stressors Under the Alternative 1

Under Alternative 1, ingestion stressors would decrease, with the exception of increased small-caliber munitions use (Table 3.0-14, Table 3.0-15, Tables 3.0-25 through 3.0-26). For the reasons noted above, the Navy has determined that potential impacts from ingestion stressors would not be substantially different from the 2015 MITT Final EIS/OEIS. Military expended materials would be only a minute portion of the floating debris that marine birds could encounter and accidently ingest. While military expended materials may be a contributing factor to the harmful effects of manmade debris on some marine birds, an individual military expended material would not negatively impact a marine bird. The overall likelihood that individual birds would be negatively impacted by ingestion of military expended materials in the Study Area under Alternative 1 is considered low, but not discountable. Population-level effects would be very unlikely given the relatively small quantities and limited persistence of military expended materials in habitats where birds are most likely to forage. Because of the extreme low likelihood of geographic or temporal overlap with training and testing activities with ESA-listed marine birds, potential ingestion of expended materials by ESA-listed marine birds is considered negligible. Therefore, the analysis from the 2015 MITT Final EIS/OEIS remains valid.

Pursuant to the ESA, potential ingestion stressors introduced by training and testing activities under Alternative 1 would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), potential ingestion stressors introduced by training and testing activities under Alternative 1 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.5.2 Impacts from Ingestion Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, ingestion stressors (military expended materials – munitions and military expended materials other than munitions) would decrease under this SEIS/OEIS in comparison to the ongoing activities, with the exception of increased small-caliber munitions use (Table 3.0-14, Table 3.0-15, and Tables 3.0-25 through 3.0-26). Under Alternative 2, increases as compared to Alternative 1 do not change the impact conclusions for ingestion stressors as summarized above under Alternative 1 and as presented in the 2015 MITT Final EIS/OEIS. Therefore, impacts on marine birds from ingestion of military expended materials under Alternative 2 would be negligible.

Pursuant to the ESA, potential ingestion stressors introduced by training and testing activities under Alternative 2 would have no effect on ESA-listed Hawaiian petrels, short-tailed albatrosses, Newell's shearwaters. This determination is consistent with the previous consultation between the Navy and USFWS for activities described in the 2015 MITT Final EIS/OEIS.

Under the MBTA regulations applicable to military readiness activities (50 CFR Part 21), potential ingestion stressors introduced by training and testing activities under Alternative 2 would not result in a significant adverse effect on populations of the great frigatebird, masked booby, or other marine bird populations.

3.6.2.5.3 Impacts from Ingestion Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Ingestion stressors would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer ingestion stressors within the marine environment where Navy activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for ingestion impacts on marine birds, but would not measurably improve the overall distribution or abundance of marine birds.

3.6.2.6 Secondary Stressors (impacts on habitat, impacts on prey availability)

The potential for secondary stressors, defined as potential impacts on habitat and prey availability, to impact marine bird species was analyzed in Section 3.6.3.5 (Secondary Stressors) of the 2015 MITT Final EIS/OEIS. Training and testing activities analyzed in this SEIS/OEIS would not introduce additional secondary stressors or change the impacts of secondary stressors on marine bird species from what was analyzed previously in the 2015 MITT Final EIS/OEIS.

3.6.2.7 Endangered Species Act Determinations

Since the publication of the 2015 MITT Final EIS/OEIS, there have been no updates to the regulatory status, life history information, or species-specific threats that would alter the analysis from the 2015 MITT Final EIS/OEIS for the short-tailed albatross, Hawaiian petrel, or Newell's shearwater. As such, the description regarding these marine bird species presented in the 2015 MITT Final EIS/OEIS remains valid. Because of the limited period of time that ESA-listed marine bird species would be within the Study Area and the extreme unlikelihood that these birds would be subject to stressors generated by training and testing activities within the Study Area, the Navy and the USFWS have not included these species in past at-sea training and testing consultations within the Study Area (U.S. Fish and Wildlife Service, 2010, 2015). Similar to these past consultations, the activities proposed in Chapter 2 (Description of Proposed Action and Alternatives) of this SEIS/OEIS would have no effect on ESA-listed marine birds.

3.6.3 Migratory Bird Treaty Act

The Navy has conducted an analysis of the potential impacts of increasing the number of events, munitions, and NEW expended on FDM. Taken together with the statistical analysis of bird trends on FDM described above in Section 3.6.2 (Environmental Consequences) and determinations that no significant population impacts would occur, the small increases in events, munitions numbers, and expended NEW on FDM proposed in this SEIS/OEIS would not significantly impact bird populations, as defined in the MBTA regulations applicable to military readiness activities (50 CFR Part 21). While this determination is applicable to all marine birds that occur in the Study Area, the Navy carried out a focused analysis for marine birds known to breed on FDM (see the discussion for population-level analysis in Section 3.6.2, Environmental Consequences). Pursuant with the Department of Defense's obligations under 50 CFR Part 21, the Department of Defense will continue to implement training restrictions on FDM (see Section 5.5, Terrestrial Mitigation Measures to be Implemented) and monitoring of bird populations on FDM.

3.6.4 Public Comments

The public raised a number of issues during the scoping period in regard to marine birds. The issues are summarized in the list below. Comments received from the public during the Draft SEIS/OEIS commenting period related to marine birds are addressed in Appendix K (Public Comment Responses).

- **Public comments regarding potential impacts of marine bird species on FDM –** This SEIS/OEIS includes an analysis of potential impacts from the additional training activities proposed to occur at FDM. For acoustic stressors, Section 3.6.2.1.3 (Impacts from Aircraft Noise) and Section 3.6.2.1.4 (Impacts from Weapons Noise) include an analysis of how these stressor types may impact marine bird rookeries on FDM. For explosives stressors, Section 3.6.2.2 (Explosives Stressors [explosive shock wave and sound, explosive fragments]) includes an analysis of how the proposed increase in munitions for missile exercises and direct action training activities could impact marine birds on the island. Stressor categories within physical disturbance and strike stressors, such as potential strike impacts from aircraft and impacts from wildfires, also include an FDM-focused analysis. While assessing these potential impacts of activities proposed in this SEIS/OEIS, it is important to note that all of the activities would continue under the same targeting constraints as described in the 2015 MITT Final EIS/OEIS. Mitigation measures designed in cooperation with U.S. Fish and Wildlife Service personnel provide a level of protection for the northern end of the island (where booby colonies have persisted), while ordnance use is only allowed in designated impact zones (see Section 5.5, Terrestrial Mitigation Measures to be Implemented).
- **Public comments regarding the status of nesting birds on FDM –** This SEIS/OEIS has been updated to include recent published work that provides a statistical review of repeated marine bird surveys on FDM. Camp et al. (2016) analyzed marine bird survey data collected from aerial surveys from 1997 to 2014. As discussed in Section 3.6.1.7 (Rookery Locations and Breeding Activities within the Mariana Islands), there is some evidence that masked and red-footed booby populations on FDM have declined, while brown booby populations have increased, though none of these trends were statistically significant. The general conclusion is that all three species exhibited population fluctuations over time. These fluctuations, combined with the level of variability observed in the count data, precluded any definitive conclusions about long-term population trends (i.e., the data were non-significant) (Camp et al., 2016). This SEIS/OEIS also includes historical observations and more recent surveys, such as Lusk et al. (2000), to provide context for the trend data and statistical analyses of FDM marine bird populations. Aerial surveys are conducted more frequently over FDM than on-the-ground surveys, with the primary focus to monitor marine bird rookeries (namely, brown boobies, masked boobies, and red-footed boobies). These surveys are described in more detail, along with quantitative trend analysis of populations in Section 3.6.2.6.3 (Farallon de Medinilla) of the 2015 MITT Final EIS/OEIS. All of these studies are summarized and included the Joint Region Marianas Integrated Natural Resources Management Plan (U.S. Department of the Navy, 2019), which is shared with cooperating agencies (e.g., Guam Department of Agriculture Division of Aquatic and Wildlife Resources, Commonwealth of the Northern Mariana Islands Department of Land and Natural Resources Division of Fish and Wildlife, and USFWS Pacific Islands Fish and Wildlife Office).

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3.7 Marine Vegetation

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3.7 Marine Vegetation

3.7.1 Affected Environment

The purpose of this section is to supplement the analysis of impacts on Marine Vegetation presented in the 2015 Mariana Islands Training and Testing (MITT) Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) with new information relevant to proposed changes in training and testing activities conducted at sea and on Farallon de Medinilla (FDM). New information made available since the publication of the 2015 MITT Final EIS/OEIS is included below to better understand potential stressors and impacts on Marine Vegetation resulting from training and testing activities. Comments received from the public during scoping related to marine vegetation are addressed in Section 3.7.3 (Public Comments). Comments received from the public during the Draft Supplemental EIS (SEIS)/OEIS commenting period related to marine vegetation are addressed in Appendix K (Public Comment Responses).

3.7.1.1 General Threats

There is no new information on threats to marine vegetation in the MITT Study Area that would change the conclusions from the 2015 MITT Final EIS/OEIS.

3.7.1.2 Marine Vegetation Groups

There is no new information on marine vegetation groups (phylum Cyanobacteria [blue-green algae], phylum Dinophyta [dinoflagellates], phylum Chlorophyta [green algae], phylum Heterokontophyta [brown algae], phylum Rhodophyta [red algae], and phylum Spermatophyta [flowering plants]) that would change the basis of the conclusions from the 2015 MITT Final EIS/OEIS.

3.7.1.3 Seagrasses

There is no new information on seagrasses that would change the basis of the conclusions from the 2015 MITT Final EIS/OEIS.

3.7.1.4 Mangroves

There is no new information on mangroves that would change the basis of the conclusions from the 2015 MITT Final EIS/OEIS.

3.7.2 Environmental Consequences

The 2015 MITT Final EIS/OEIS considered training and testing activities that currently occur in the Study Area and considered potential stressors related to marine vegetation. With the exception of explosives, stressors analyzed are the same as those analyzed in the 2015 MITT Final EIS/OEIS. In the 2015 MITT Final EIS/OEIS, explosives were addressed under acoustic stressors; however, for purposes of this analysis, explosives are analyzed as a separate stressor. The following are stressors analyzed for marine vegetation from the 2015 MITT Final EIS/OEIS:

- Explosive (in-air explosions and in-water explosions)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices)
- Secondary stressors (impacts associated with sediments and water quality)

This section evaluates how and to what degree potential impacts on marine vegetation from stressors described in Section 3.0 (General Approach to Analysis) may have changed since the analysis presented in the 2015 MITT Final EIS/OEIS was completed. Proposed training and testing activities, the number of times each activity would be conducted annually, and the locations within the Study Area where the activity would typically occur under each alternative are presented in Tables 2.4-1 and 2.4-2 in Chapter 2 (Description of Proposed Action and Alternatives). The tables also present the same information for activities described in the 2015 MITT Final EIS/OEIS so that the proposed levels of training and testing under this SEIS/OEIS can be easily compared.

The Navy conducted a review of federal and state regulations and standards relevant to marine vegetation and reviewed literature published since 2015 for new information that could inform the analysis presented in the 2015 MITT Final EIS/OEIS. The analysis presented in this section also considers standard operating procedures, which are discussed in Section 2.3.3 (Standard Operating Procedures) of this Final SEIS/OEIS, and mitigation measures that are described in Chapter 5 (Mitigation). The Navy implements these measures to avoid or reduce potential impacts on marine vegetation from stressors associated with training and testing activities.

3.7.2.1 Explosive Stressors

As stated in the 2015 MITT Final EIS/OEIS, the potential for an explosion to injure or destroy marine vegetation would depend on the amount of vegetation present, the number of munitions used, and their net explosive weight. In areas where marine vegetation and locations for explosions overlap, marine vegetation on the surface of the water, in the water column, or rooted in the seafloor may be impacted. Seafloor macroalgae and single-celled algae may overlap with underwater and sea surface explosion locations. If these vegetation types are near an explosion, only a small number of them are likely to be impacted. Much of the attached macroalgae grows on live hard bottom areas that would be mostly protected in accordance with Navy mitigation measures (see Chapter 5, Mitigation). Also, some seafloor macroalgae are resilient to high levels of wave action (Mach et al., 2007), which may aid in their ability to withstand underwater explosions that occur near them. Underwater explosions also may temporarily increase the turbidity (sediment suspended in the water) in nearby waters, incrementally reducing the amount of light available to marine vegetation. Reducing light availability decreases, albeit temporarily, the photosynthetic ability of marine vegetation.

Seagrasses may potentially be uprooted or damaged by sea surface or underwater explosions. Regrowth of seagrasses after uprooting can take up to 10 years (Dawes et al., 1997). Explosions may also temporarily increase the turbidity (sediment suspended in the water) in nearby waters, but the sediment would settle to pre-explosion conditions within a few hours to days. Sustained high levels of turbidity may reduce the amount of light that reaches vegetation, which it needs to survive. Seagrasses typically grow in waters that are sheltered from wave action, such as estuaries, lagoons, and bays (Phillips & Meñez, 1988), where most activities are not conducted. Detonations are unlikely to occur in areas with mangroves or sea grasses and would continue to occur in disturbed areas over the unvegetated seafloor such as the Agat Bay site, Piti, and Outer Apra Harbor sites.

3.7.2.1.1 Impacts from Explosive Stressors Under Alternative 1

Under Alternative 1, there would be an overall decrease in the number of explosives used in the Study Area during training and testing activities events compared to the number analyzed in the 2015 MITT Final EIS/OEIS (Table 3.0-7). Under Alternative 1, underwater detonations would increase for underwater demolition qualification/certification (Table 2.4-1). However, these activities would continue to occur in the same areas and would have no appreciable change in the impact analysis or conclusions for explosive stressors as presented in the 2015 MITT Final EIS/OEIS. Therefore, the analysis in the 2015 MITT Final EIS/OEIS remains valid.

As described in the 2015 MITT Final EIS/OEIS, underwater explosions conducted for training and testing activities may destroy or remove marine vegetation. However, exposure to these detonations would be limited to the vicinity of the explosions. For example, the offshore underwater mine neutralization sites are located in areas with water depths that are unlikely for marine vegetation to occur. Underwater and surface explosions conducted for training and testing activities are not expected to pose a risk to seagrass because (1) the impact area of underwater explosions is very small relative to seagrass distribution and (2) the low number of charges reduces the potential for impacts.

Therefore, the use of explosives is not expected to impact the long-term survival, annual reproductive success, and lifetime reproductive success of marine vegetation.

3.7.2.1.2 Impacts from Explosive Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the number of explosives used during training and testing activities would decrease compared to the numbers analyzed in the 2015 MITT Final EIS/OEIS and increase compared to Alternative 1 (Table 3.0-7). Under Alternative 2, increases in the number of underwater explosives would have no appreciable change on the impact conclusions for explosive stressors as summarized above under Alternative 1 and as presented in the 2015 MITT Final EIS/OEIS. Therefore, explosive impacts on marine vegetation under Alternative 2 would be negligible.

3.7.2.1.3 Impacts from Explosive Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Explosive stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer explosive stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for explosive impacts on marine vegetation, but would not measurably improve the overall distribution or abundance of marine vegetation.

3.7.2.2 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts on marine vegetation of the various types of physical disturbance and strike stressors during training and testing activities within the Study Area. Three types of physical disturbance and strike stressors are evaluated for their impacts on marine vegetation, including (1) vessels and in-water devices, (2) military expended materials, and (3) seafloor devices.

The evaluation of the impacts of physical disturbance stressors on marine vegetation focuses on proposed activities that may cause vegetation to be damaged by an object that is moving through the water (e.g., vessels and in-water devices), or dropped to the seafloor (e.g., military expended materials, anchors). Not all activities are proposed throughout the Study Area. Wherever appropriate, specific geographic areas of potential impact are identified.

As described in the 2015 MITT Final EIS/OEIS, vessel disturbance of marine vegetation would be limited to floating marine algae. Vessel movements may disperse or injure algal mats. Because algal distribution is patchy and mats may re-form following a disturbance, training and testing activities involving vessel movement would not impact the general health of marine algae.

3.7.2.2.1 Impacts from Physical Disturbance and Strike Stressors Under Alternative 1

Under Alternative 1, the number of proposed training and testing events involving vessel movements would increase from those presented in the 2015 MITT Final EIS/OEIS (Table 3.0-12). In contrast, the use of towed in-water devices (Table 3.0-13) would decrease. The decrease in the number of in-water devices is unlikely to change the impact conclusion presented in the 2015 MITT Final EIS/OEIS. As stated in the 2015 MITT Final EIS/OEIS, the impact of vessels and in-water devices on marine vegetation would remain inconsequential because of (1) the quick recovery of most vegetation types; (2) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas; and (3) the deployment of in-water devices at depths where they would not likely come in contact with marine vegetation.

Under Alternative 1, the number of military expended materials used for training and testing activities that has the potential to impact marine vegetation would generally increase (see Tables 3.0-14 through 3.0-17). However, these increases are not expected to pose a risk to marine algae or seagrasses because (1) the relative coverage of marine algae in the Study Area is low, (2) new growth may result from marine algae exposure to military expended materials, (3) the impact area of military expended materials is very small relative to marine algae distribution, and (4) seagrass overlap with areas where the stressor occurs is very limited. In addition, as shown in Table 3.0-18, the total area of the seafloor that could be impacted by the use of military expended materials as proposed in this Supplemental EIS/OEIS would decrease from the amount analyzed in the 2015 MITT Final EIS/OEIS under Alternative 1. Based on these factors, potential impacts on marine algae and seagrass from military expended materials are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts.

Under Alternative 1, the number of seafloor devices used in shallow-water habitats during training and testing activities would decrease slightly from the number presented in the 2015 MITT Final EIS/OEIS (Table 3.0-19). Seafloor devices would pose a negligible risk to marine vegetation for the same reasons described above for military expended materials and no impacts on the long-term survival, reproductive success, and lifetime reproductive success would occur.

Therefore, physical disturbance and strike impacts on marine vegetation under Alternative 1 would be negligible.

3.7.2.2.2 Impacts from Physical Disturbance and Strike Stressors Under Alternative 2 (Preferred Alternative)

Under Alternative 2, the combined number of proposed training and testing events involving vessels and in-water devices (Table 3.0-12 and Table 3.0-13) would decrease slightly from those presented in the 2015 MITT Final EIS/OEIS. Military expended materials (Table 3.0-14, Table 3.0-15, and Table 3.0-16) combined would increase, and seafloor devices (Table 3.0-19) would decrease slightly from the number in the 2015 MITT Final EIS/OEIS. Increases in some physical disturbance and strike stressors such as military expended materials could increase the impact risk on marine vegetation but does not appreciably change the analysis or impact conclusions presented in the 2015 MITT Final EIS/OEIS and those summarized above under Alternative 1.

Therefore, physical disturbance and strike impacts on marine vegetation under Alternative 2 would be negligible.

3.7.2.2.3 Impacts from Physical Disturbance and Strike Stressors Under the No Action Alternative

Under the No Action Alternative, proposed training and testing activities would not occur. Other military activities not associated with this Proposed Action would continue to occur. Physical disturbance and strike stressors as listed above would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

Discontinuing the training and testing activities would result in fewer physical disturbance and strike stressors within the marine environment where training and testing activities have historically been conducted. Therefore, discontinuing training and testing activities under the No Action Alternative would lessen the potential for physical disturbance and strike impacts on marine vegetation, but would not measurably improve the overall distribution or abundance of marine vegetation.

3.7.2.3 Secondary Stressors

Stressors from Navy training and testing activities could pose secondary or indirect impacts on marine vegetation via habitat, sediment, or water quality. Potential impacts on marine vegetation exposed to secondary stressors could occur indirectly through sediments and water quality. Components of these stressors that could pose indirect impacts include (1) explosives and byproducts; (2) metals; (3) chemicals; and (4) other materials such as targets, chaff, and plastics.

Section 3.1 (Sediments and Water Quality) considered the impacts on marine sediments and water quality from explosives and explosive byproducts, metals, chemicals other than explosives, and other materials (marine markers, flares, chaff, targets, and miscellaneous components of other materials). As stated in the 2015 MITT Final EIS/OEIS, one example of a localized impact on marine vegetation associated with water quality impacts could be the increase of cyanobacteria associated with munitions deposits in marine sediments. Cyanobacteria may proliferate when the iron is introduced to the marine environment, and this proliferation can affect surrounding habitats by releasing toxins or stimulating the growth of nuisance species (Schils, 2012). Introducing iron into the marine environment from munitions or infrastructure is not associated with red tide events; rather, these harmful events are more associated with natural causes (e.g., upwellings) and the effects of human activities (e.g., agricultural runoff and other coastal pollution) (Hayes et al., 2007; Whitton & Potts, 2008).

Sediments entering the nearshore environment from FDM as a result of natural processes or explosives associated with strike warfare could cause temporary water quality impacts, some of which may be in foraging areas used by marine organisms. By limiting the location and extent of target areas, along with the types of ordnance allowed within specific impact areas, the military minimizes the potential for soil transport and, thus, water quality impacts. Erosion as a result of training activities at FDM may contribute to deposition of soils into the nearshore areas of FDM, causing increased turbidity. Turbidity can impact vegetation communities by reducing the amount of light that reaches these organisms. The impacts of explosive byproducts on sediment and water quality would be indirect, short term, and local. Explosive ordnance could loosen the soil on FDM and runoff from surface drainage areas containing soil, and explosive byproducts could contaminate sediments and the surrounding ocean water.

3.7.3 Public Comments

The public raised a number of issues during the scoping period in regard to marine vegetation. The issues are summarized in the list below. Comments received from the public during the Draft SEIS/OEIS commenting period related to marine vegetation are addressed in Appendix K (Public Comment Responses).

- **Direct impacts on seagrass from sedimentation around FDM and military expended materials as marine debris –** Direct impacts on seagrass from sedimentation around FDM occur due to explosive stressors. Explosives may temporarily increase the turbidity (sediment suspended in the water) of nearby waters, but the sediment would settle to pre-explosion conditions within a short amount of time (e.g., a few hours to days). Sustained high levels of turbidity may reduce the amount of light that reaches vegetation, which it needs to survive. This scenario is not likely given the low number of explosions planned in areas with seagrass. Potential impacts on seagrass from military expended materials are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts. See Section 3.7.2.1 (Explosive Stressors) for further analysis of increased turbidity or sedimentation on marine vegetation including seagrasses in the Study Area including FDM. Military expended materials are discussed in Section 3.7.2.2 (Physical Disturbance and Strike Stressors) as a cause of physical disturbance and strike to marine vegetation.
- **Request survey of all seagrass beds in the Study Area and monitoring of the seagrass beds –** The analysis of impacts on marine vegetation, including seagrasses, concluded that increased turbidity may be caused by items used in training and testing activities; under the standard operating procedures, the Navy avoids the seafloor to the greatest extent practicable. Additionally, activities that have a greater potential to impact the seafloor, such as amphibious assaults, are conducted at high tide to limit such interactions. Anchorages are also scheduled to occur in specific locations, mainly areas that lack vegetation and that have been previously disturbed. Therefore, serious damage is not anticipated, and survey or mitigation measures are not warranted. In addition, the 2015 MITT Final EIS/OEIS includes maps showing areas of marine vegetation in Section 3.7 (Marine Vegetation).
- **Impact of unexploded ordnance on marine species –** Potential impacts on marine vegetation from unexploded ordnance are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts. The impact of unexploded ordnance to marine species, specifically to marine vegetation, is discussed in Section 3.7.2.2 (Physical Disturbance and Strike Stressors) as a cause of physical disturbance and strike to marine vegetation.
- **Impacts on marine species from chemical pollution and destruction of habitat –** The analysis concluded that neither state nor federal standards or guidelines for sediments or water quality would be violated as a result of the implementation of the proposed training and testing activities. Therefore, because these standards and guidelines are structured to protect human health and the environment, and the proposed activities do not violate them, no indirect impacts are anticipated on marine vegetation from the training and testing activities proposed in this SEIS/OEIS. Destruction of habitat is not anticipated to result from the implementation of training and testing activities proposed in this SEIS/OEIS. Impacts on marine species, specifically to marine vegetation from chemical pollution, is discussed in Section 3.7.2.5 (Secondary Stressors).
- **Impacts on marine species from the metals in the water (copper and lead) –** The analysis concluded that neither state nor federal standards or guidelines for sediments or water quality

would be violated as a result of the implementation of the proposed training and testing activities. Therefore, because these standards and guidelines are structured to protect human health and the environment, and the proposed activities do not violate them, no indirect impacts are anticipated on marine vegetation from the training and testing activities proposed in this SEIS/OEIS. Impacts on marine species, specifically on marine vegetation, from metals in the water (such as copper and lead) are discussed in Section 3.7.2.3 (Secondary Stressors).

- **Deposition and resuspension of sediments to Essential Fish Habitat (EFH) from training activities –** Both the 2015 MITT Essential Fish Habitat Assessment (EFHA) and the 2019 MITT Supplemental EFHA concluded that any impacts from explosives or physical disturbance and strike stressors that could cause deposition or resuspension of sediments would be short term and minimal.
- **Erosion and sedimentation impacting EFH –** The 2015 MITT EFHA concluded that any impacts from explosives or physical disturbance and strike stressors that could cause erosion and sedimentation would be short term and minimal.
- **Unexploded ordnance being triggered after use and directly impacting EFH –** Unexploded ordnance that explodes due to being triggered post training and testing would be considered an explosive stressor and the 2015 MITT EFHA concluded that the impacts on attached macroalgae from explosives used during training and testing would be minimal and temporary to short term throughout the Study Area. This analysis remains valid. Given the available information, the impact of explosives used during training and testing on submerged rooted vegetation beds would be minimal.

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