The Mariana Islands Training and Testing

Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS)

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

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FINAL ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT
for
MARIANA ISLANDS TRAINING AND TESTING ACTIVITIES

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

Abstract

The United States Department of the Navy (Navy) prepared this Final Environmental Impact Statement (EIS)/Overseas EIS (OEIS) in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code §4321 et seq.); the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations [C.F.R.] §§1500 et seq.); Navy Procedures for Implementing NEPA (32 C.F.R. §775); and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*. The Navy identified its need to support and conduct current, emerging, and future training and testing activities in the Mariana Islands Training and Testing (MITT) Study Area (Study Area), which is made up of the Mariana Islands Range Complex, additional areas on the high seas, and a transit corridor where training and testing activities may occur. Three alternatives were analyzed in this EIS/OEIS:

- The No Action Alternative represents those training and testing activities as set forth in previously completed environmental planning documentation.
- Alternative 1 (Preferred Alternative) consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.
- Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities.

In this EIS/OEIS, the Navy analyzed potential environmental impacts that result or could result from activities under the No Action Alternative, Alternative 1, and Alternative 2. The resources evaluated include ocean and biological resources (including marine mammals and threatened and endangered species), terrestrial resources, air quality, cultural resources, socioeconomic resources, and public health and safety.

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Executive Summary

EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The United States (U.S.) Department of the Navy (Navy) prepared this Environmental Impact Statement (EIS)/Overseas EIS (OEIS) to assess the potential environmental impacts associated with two categories of military readiness activities: training and testing. The Mariana Islands Training and Testing (MITT) Study Area is composed of the established ranges (at-sea ranges and land based training areas on Guam and the Commonwealth of the Northern Mariana Islands), operating areas, and special use airspace in the region of the Mariana Islands that are part of the Mariana Islands Range Complex (MIRC) and its surrounding seas, and includes a transit corridor[1] (Figure ES.2-1). The transit corridor is outside the geographic boundaries of the MIRC and is a direct route across the high seas for Navy assets in transit between the MIRC and the Hawaii Range Complex (HRC). The Proposed Action also includes pierside sonar maintenance and testing alongside Navy piers located in Inner Apra Harbor. The Navy prepared this EIS/OEIS to comply with the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114.

Major conflicts, terrorism, lawlessness, and natural disasters all have the potential to threaten national security of the United States. National security, prosperity, and vital interests are increasingly tied to other nations because of the close relationships between the United States and other national economies. The Navy carries out training and testing activities to be able to protect the United States against its enemies, as well as to protect and defend the rights of the United States and its allies to move freely on the oceans. Training and testing activities that prepare the Navy and the other services[2] to fulfill their mission to protect and defend the United States and its allies potentially impact the environment. These activities may trigger legal requirements identified in many U.S. federal environmental laws, regulations, and executive orders.

After thoroughly reviewing its environmental compliance requirements for training and exercises at sea, the Navy instituted a policy in the year 2000 designed to comprehensively address these requirements. That policy—the Navy's At-Sea Policy—resulted, in part, in a series of comprehensive analyses of training and testing activities on U.S. at-sea range complexes and operating areas. These analyses served as the basis for the National Marine Fisheries Service (NMFS) to issue Marine Mammal Protection Act (MMPA) incidental take authorizations because of the potential effects of some training and testing activities on species protected by federal law. These analyses also served as the basis for NMFS and the U.S. Fish and Wildlife Service (USFWS) to issue Biological Opinions (BOs) and incidental take statements pursuant to the ESA. The initial analyses for the Study Area considered in this document resulted in incidental take authorizations and incidental take statements, which begin to expire in 2015. The present EIS/OEIS updates these analyses and supports incidental take authorizations. This EIS/OEIS also furthers compliance with the Navy's policy for comprehensive analysis by analyzing the potential

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[1] Vessel transit corridors are the routes typically used by Navy assets to traverse from one area to another. The route depicted in Figure ES.2-1 is a direct route between the MIRC and the HRC. The depicted transit corridor is notional and may not represent actual routes used. Actual routes navigated are based on a number of factors including, but not limited to, weather, training, and operational requirements; however, the corridor represents the environment potentially impacted by the Proposed Action.

[2] Training and testing activities may include foreign allies and partners. Foreign allies and partners may train along U.S. military forces to ensure seamless interoperability.

environmental impacts of training and testing activities in additional areas (areas not analyzed in previous documents) where training and testing activities have historically occurred.

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

The purpose of the Proposed Action is to conduct training and testing activities to ensure that the Navy and other Services meet their mission, which is to maintain, train, and equip combat-ready military forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is achieved in part by conducting training and testing within the Study Area.

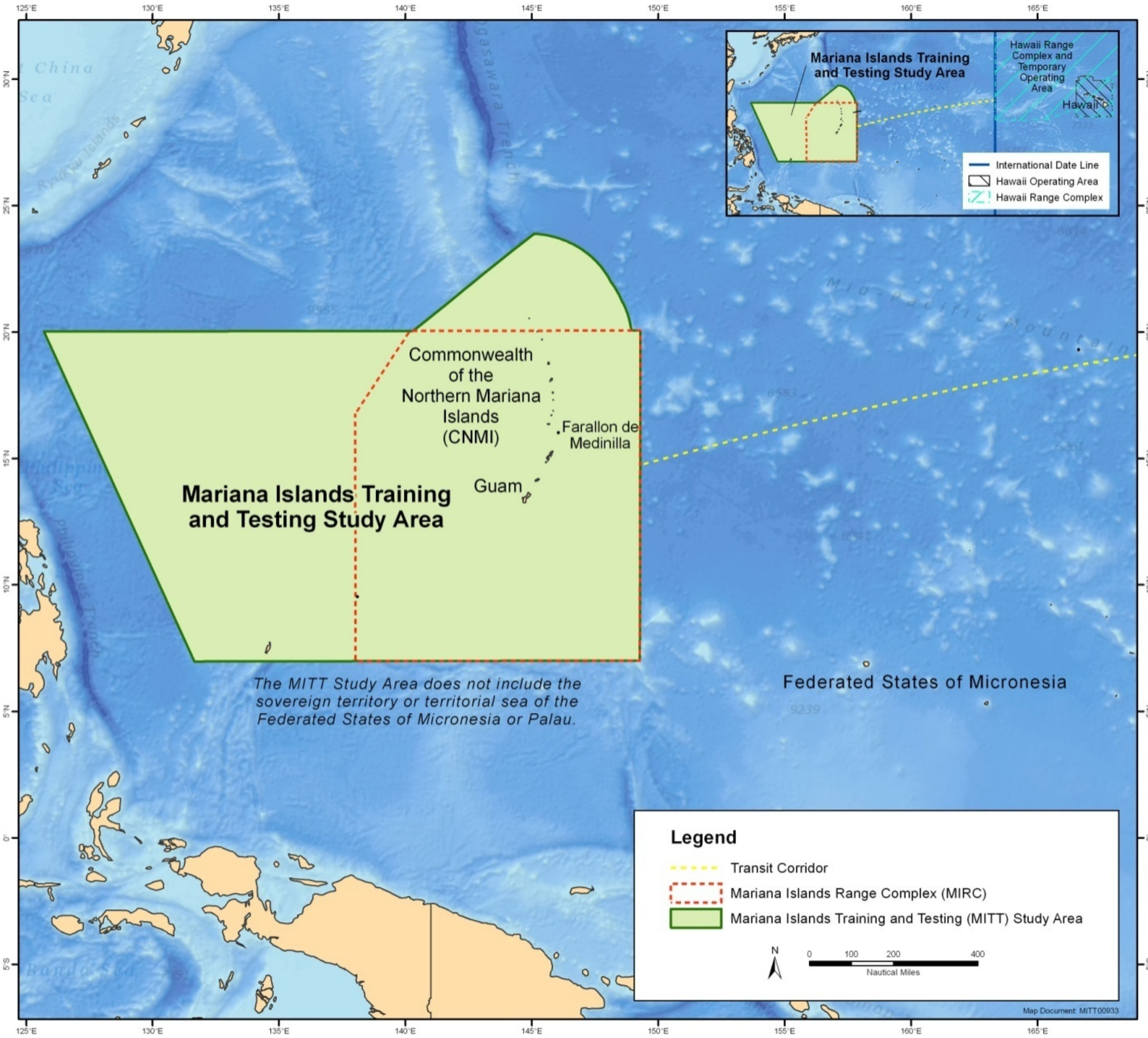

Figure ES.2-1: Mariana Islands Training and Testing Study Area

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

In this EIS/OEIS, the Navy assessed military readiness training and testing activities that could potentially impact human and natural resources, especially marine mammals, sea turtles, and other marine resources in the MITT Study Area. The range of alternatives includes a No Action Alternative and other reasonable courses of action. In this EIS/OEIS, the Navy analyzed direct, indirect, cumulative, short-term, long-term, irreversible, and irretrievable impacts. The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this EIS/OEIS. The NMFS is a cooperating agency because of its expertise and regulatory authority over marine resources. The U.S. Air Force is a cooperating agency because of their expertise and scheduling authority over portions of the Study Area airspace. The U.S. Coast Guard is a cooperating agency because of its expertise, its federal regulatory authority, and its maritime law enforcement mission in the Study Area. Additionally, this document will serve as NMFS' NEPA documentation for the rule-making process under the MMPA.

In accordance with the Council on Environmental Quality (CEQ) Regulations, 40 Code of Federal Regulations (C.F.R.) §1505.2, the Navy will issue a Record of Decision (ROD). The ROD will be based on factors analyzed in this EIS/OEIS, including military training and testing objectives, best available science and modeling data, potential environmental impacts, and public interest.

ES.3.1 National Environmental Policy Act

Federal agencies are required under NEPA to examine the environmental impacts of their proposed actions within the United States and its territories. An EIS is a detailed public document that provides an unbiased assessment of the potential effects, and potentially significant effects, that a major federal action might have on the natural and human environment. The Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with applicable laws, regulations, and executive orders. Presidential Proclamation 5928, issued 27 December 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 nautical miles (nm); however, the proclamation expressly provides that it does not extend or otherwise alter existing federal law or any associated jurisdiction, rights, legal interests, or obligations. Thus, as a matter of policy, the Navy analyzes environmental effects and actions within 12 nm under NEPA (an EIS).

ES.3.2 Executive Order 12114

This OEIS has been prepared in accordance with EO 12114 (44 Federal Register 1957) and Navy implementing regulations in 32 C.F.R. Part 187, *Environmental Effects Abroad of Major Department of Defense Actions*. An OEIS is required when a proposed action and alternatives have the potential to significantly harm the environment of the global commons. The global commons are defined as geographical areas outside the jurisdiction of any nation and include the oceans outside of the territorial limits (more than 12 nm from the coast) and Antarctica but do not include contiguous zones and fisheries zones of foreign nations (32 C.F.R. §187.3). The EIS and OEIS have been combined into one document, as permitted under NEPA and EO 12114, to reduce duplication.

ES.3.3 Marine Mammal Protection Act

The MMPA of 1972 (16 United States Code [U.S.C.] §1361 et seq.) established, with limited exceptions, a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates "takes" of marine mammals in the global commons (that is, the high seas) by vessels or persons under U.S. jurisdiction. The term "take," as defined in Section 3 (16 U.S.C. §1362 [13]) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of harassment: Level A (potential injury) and Level B (potential behavioral disturbance).

The MMPA directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if NMFS finds that the taking will have a negligible impact on the species or stock(s), and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking, other means of attaining the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the mitigation, monitoring, and reporting of such taking.

The National Defense Authorization Act of Fiscal Year 2004 (Public Law 108-136) amended the definition of harassment and removed the "small numbers" provision as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government, consistent with Section 104(c)(3) (16 U.S.C. §1374 [c][3]). The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the FY 2003 National Defense Authorization Act (Public Law 107-314). A "military readiness activity" is defined as "all training and operations of the Armed Forces that relate to combat" and "the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use." As the Proposed Action involves conducting military readiness activities, the relevant definition of harassment is 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
- 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") [16 U.S.C. §1362(18)(B)(i) and (ii)].

ES.3.4 Endangered Species Act

The ESA of 1973 (16 U.S.C. §1531 et seq.) established protection over and conservation of threatened and endangered species and the ecosystems upon which they depend. An "endangered" species is a species in danger of extinction throughout all or a significant portion of its range. A "threatened" species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The USFWS and NMFS jointly administer the ESA and are also responsible for the listing of species (designating a species as either threatened or endangered). The ESA allows the designation of geographic areas as critical habitat for threatened or endangered species. Section 7(a)(2) requires each federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a listed species, that agency is required to consult with NMFS or USFWS, depending on the jurisdiction (50 C.F.R. 402.14[a]). Under the terms of Section 7(b)(4) and Section 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the act provided that such taking complies with the terms and conditions of an Incidental Take Statement. The ESA applies to marine mammals, sea turtles, marine birds, marine invertebrates, fish, and plants evaluated in this EIS/OEIS.

ES.3.5 Migratory Bird Treaty Act

Bird species in the Study Area include those listed under the Migratory Bird Treaty Act (MBTA) of 1918 (16 U.S.C. 703-712; Ch. 128; July 13, 1918; 40 Stat. 755 as amended). A migratory bird is any species or family of birds that live or reproduce in or migrate across international borders at some point during their annual life cycle. The MBTA established federal responsibilities for the protection of nearly all species of birds, eggs, and nests. In 2006, the USFWS and Department of Defense signed a Memorandum of Understanding to promote conservation of migratory birds (U.S. Department of Defense and U.S. Fish and Wildlife Service 2006). There are over 1,000 species of birds protected under the MBTA, with over 100 species known or believed to occur in the Study Area. These bird species include seabirds, shorebirds, and various species of birds that inhabit terrestrial habitats.

Congress determined that allowing incidental take of migratory birds as a result of military readiness activities is consistent with MBTA. The Final Rule was published in the *Federal Register* on 28 February 2007 (Federal Register Volume 72, No. 29, 28 February 2007) and may be found at 50 C.F.R. Part 21.15. Congress defined military readiness activities as all training and operations of the Armed Forces that relate to combat and the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for the proper operation and suitability for combat use. Specifically, 50 C.F.R. Part 21.15 specifies a requirement to confer with the USFWS when the military readiness activities in question will have a significant adverse effect on a population of migratory bird species. An activity has a significant adverse effect if, over a reasonable period of time, it diminishes the capacity of a population of migratory bird species to maintain genetic diversity, to reproduce, and to function effectively in its native ecosystem.

ES.3.6 Other Environmental Requirements Considered

The Navy must comply with all applicable federal environmental laws, regulations, and EOs, including, but not limited to, those listed below. Further information on Navy compliance with these and other environmental laws, regulations, and EOs can be found in Chapters 3 (Affected Environment and Environmental Consequences) and 6 (Additional Regulatory Considerations).

- Abandoned Shipwreck Act
- Antiquities Act
- Clean Air Act
- Clean Water Act
- Coastal Zone Management Act
- Magnuson-Stevens Fishery Conservation and Management Act
- National Historic Preservation Act
- National Marine Sanctuaries Act
- Rivers and Harbors Act
- EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*
- EO 12962, *Recreational Fisheries*
- EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*
- EO 13089, *Coral Reef Protection*
- EO 13112, *Invasive Species*
- EO 13158, *Marine Protected Areas*
- EO 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*

ES.4 PUBLIC INVOLVEMENT

NEPA of 1969 requires federal agencies to examine the environmental effects of their proposed actions within U.S. territories. An EIS is a detailed public document that provides an assessment of the potential effects that a major federal action might have on the human environment. The Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with applicable laws, regulations, and executive orders.

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 in the *Federal Register* on 8 September 2011 and several newspapers beginning on 16 September 2011. In addition, Notice of Intent/Notice of Scoping Meeting letters were distributed on 17 September 2011 to 129 federal, state, and local elected officials and government agencies. Postcards announcing the Notice of Intent and providing the scoping meeting dates, locations, and times were mailed to 475 organizations and individuals. The Notice of Intent provided an overview of the Proposed Action and the scope of the EIS, and initiated the scoping process.

ES.4.1 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. During scoping, the public helps define and prioritize issues through public meetings and written comments.

Five scoping meetings were held on 22, 23, 26, 27, and 29 September 2011, in the villages of Mangilao, Guam; Santa Rita, Guam; Susupe, Saipan; San Jose Village, Tinian; and Sinapalo Village, Rota, respectively. At each scoping meeting, staffers at the welcome station greeted guests and encouraged them to sign in to be added to the project mailing list to receive future notifications. In total, 229 people signed in at the welcome table. The meetings were held in an open house format, presenting informational posters and written information, with Navy staff and project experts available to answer participants’ questions. Additionally, a digital voice recorder was available to record participants’ oral comments. The interaction during the information sessions was productive and helpful to the Navy.

ES.4.2 SCOPING COMMENTS

Scoping participants submitted comments in five ways:

- Oral statements at the public meetings (as recorded by the digital voice recorder)
- Written comments at the public meetings
- Written letters (received any time during the public comment period)
- Electronic mail (received any time during the public comment period)
- Comments submitted directly on the project website (received any time during the public comment period)

In total, the Navy received comments from 34 individuals and groups. Because many of the comments addressed more than one issue, 134 total comments resulted. The summary in Table ES.4-1 provides an overview of comments and is organized by area of concern.

Table ES.4-1: Public Scoping Comment Summary

Area of Concern	Count	Percent of Total
Other	21	16
Proposed Action/Alternatives	9	7
Terrestrial/Birds	10	7
Regional Economy	9	7
Fish/Marine Habitat	8	6
Mitigation	8	6
Cumulative	8	6
Study Area	7	5
Marine Mammals/Sea Turtles	7	5
Marine Mammal Monitoring	5	4
Water Quality	5	4
Cultural Resources	5	4
Commercial/Recreational Fishing	6	4
Public Health and Safety	6	4
SONAR/Underwater Explosions	6	4
Land Use	5	4
Reefs	3	2
Marianas Trench National Monument/Piti Marine Preserve Area	3	2
Air Quality	1	1
Noise	2	1
TOTAL	**134**	**99**

ES.4.3 DRAFT ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

The Draft EIS/OEIS was prepared to assess potential impacts of the Proposed Action and alternatives on the environment. A Notice of Availability was published in the *Federal Register* (13 September 2013) and notices were placed in local and regional newspapers announcing the availability of the Draft EIS/OEIS. The Draft EIS/OEIS was circulated for review and comment, and public meetings were held.

ES.4.4 FINAL ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT/RECORD OF DECISION

This Final EIS/OEIS addresses all public comments received on the Draft EIS. Responses to public comments may include correction of data, clarifications of and modifications to analytical approaches, and inclusion of new or additional data or analyses. In addition, conservation measures resulting from the Navy's Section 7 ESA consultation with the USFWS and Essential Fish Habitat consultation with NMFS have been added.

The Navy will issue a ROD no earlier than 30 days after this Final EIS/OEIS is made available to the public. The ROD will include any changes to mitigation or reporting requirements as a result of consultations.

ES.5 Proposed Action and Alternatives

The Navy proposes to conduct military readiness training and testing activities throughout the MITT Study Area, primarily in established operating and military warning areas of the Study Area. In order to achieve and maintain Fleet readiness, the Navy proposes to:

- Reassess the environmental analyses of military training and testing activities contained in the *2010 Mariana Islands Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy 2010). This reassessment supports reauthorization of incidental takes of marine mammals under the MMPA and incidental takes of threatened and endangered marine and terrestrial species under the ESA.
- Adjust baseline training and testing activities from current levels to the level needed to support military training and testing requirements beginning in 2015. As part of the adjustment, the Navy proposes to account for other activities and sound sources not addressed in the previous analyses.
- Analyze the potential environmental impacts of training and testing activities in additional at-sea areas (areas not covered in previous documents) where training and testing historically occurs, including Navy ports and the transit corridor serving these areas.
- Update the environmental impact analyses in the previous documents to account for force structure changes, including those resulting from the development, testing, and use of weapons, platforms, and systems that will be operational by 2020.
- Implement enhanced range capabilities.
- Update environmental analyses with the best available science and most current acoustic analysis methods to evaluate the potential effects of training and testing activities on the marine environment.

ES.5.1 No Action Alternative

The No Action Alternative is required by regulations of the CEQ as a baseline against which the impacts of the Proposed Action are compared. The No Action Alternative continues baseline training and testing activities and force structure requirements as defined by existing Navy environmental planning documents.

The No Action Alternative represents the activities and events analyzed in previously completed documents. However, it would fail to meet the current purpose and need for the Navy's Proposed Action because it would not allow the Navy to conduct the training and testing activities necessary to achieve and maintain Fleet readiness. For example, the baseline activities do not account for changes in force structure requirements, the introduction of weapons and platforms, and the training and testing required for proficiency with these systems.

ES.5.2 Alternative 1 (Preferred Alternative)

This Alternative consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to location, type, and tempo of training activities, which includes the addition of platforms and systems.

- **Adjustment of the Study Area.** This EIS/OEIS contains an analysis of areas where training and testing would continue as in the past, but were not considered in previous environmental analyses. Alternative 1 would expand the area that is to be analyzed as depicted in Figure ES-1 and described below.

  - **Expansion of the Northern and Western Boundary of the Study Area:** The area to the north of the MIRC that is within the Exclusive Economic Zone of the Northern Mariana Islands and the areas to the west of the MIRC.
  - **Transit Corridor:** An area not previously analyzed in the open ocean between the MIRC and the HRC. During transit within this area, U.S. Navy ships conduct limited training and testing. These activities would be included in this EIS/OEIS.
- **Adjustments to Locations and Tempo of Training and Testing Activities.** This alternative also includes changes to training and testing requirements necessary to accommodate (a) the relocation of ships, aircraft, and personnel; (b) planned aircraft, vessels, and weapons systems; and (c) ongoing activities not addressed in previous documentation.
  - **Force Structure Changes:** Force structure changes involve the relocation of ships, aircraft, and personnel. As forces are moved within the existing Navy structure, training needs will necessarily change as the location of forces change.
  - **Planned Aircraft, Vessels, and Weapons Systems:** This EIS/OEIS examines the training and testing requirements of planned vessels, aircraft, and weapons systems.
  - **Ongoing Activities:** Current training and testing activities not addressed in previous documentation are analyzed in this EIS/OEIS.
  - **Danger Zones:** This EIS/OEIS examines establishment of Title 33 C.F.R. Part 334 Danger Zones for existing shore-based small arms and explosive ordnance disposal ranges and a nearshore small arms training area.
  - **Net Explosive Weight Increases:** An increase in net explosive weight for underwater detonations from 10 pounds (lb.) to 20 lb. at Agat Bay Mine Neutralization Site. This is a change from the Draft EIS/OEIS based on comments received. No increases in the NEW at the Outer Apra Harbor Underwater Detonation Site would occur under Alternative 1.

Alternative 1 reflects adjustments to the baseline activities, which are necessary to support all current and proposed training and testing activities through 2020.

ES.5.3 Alternative 2

Alternative 2 consists of all activities that would occur under Alternative 1 and adjustments to the type and tempo of training and testing. This alternative is contingent upon potential budget increases, strategic necessity, and future training and testing requirements.

Alternative 2 includes the following:

- The addition of three major at-sea training activities (Fleet Strike Group Exercise, Integrated Anti-Submarine Warfare Exercise, and Ship Squadron Anti-Submarine Warfare Exercise) conducted in the Study Area.
- Adjustments to Alternative 1 for Naval Air Systems Command and Naval Sea Systems Command testing activities are proposed.

ES.6 Summary of Environmental Effects

Environmental effects which might result from the implementation of the Navy's Proposed Action or alternatives have been analyzed in this EIS/OEIS. Resource areas analyzed include sediment and water quality, air quality, marine habitats, marine mammals, sea turtles, marine birds, marine vegetation, marine invertebrates, fish, terrestrial species and habitats, cultural resources, socioeconomic resources, and public health and safety. Since the publication of the Draft EIS/OEIS, five coral species and the scalloped hammerhead shark (Indo-West Pacific Distinct Population Segment) have been listed under the ESA. These species are addressed in the Final EIS/OEIS. In addition, since the publication of the Draft EIS/OEIS, the Navy has reviewed numerous publications relevant to the environmental resources analyzed in the Final EIS/OEIS and has identified over 50 additional references, many of them published within the last year, for inclusion in the Final EIS/OEIS. Table ES.6-1 provides a comparison of the environmental impacts of the No Action Alternative, Alternative 1 (Preferred Alternative), and Alternative 2.

Table ES.6-1: 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	**Stressors**: Stressors analyzed include explosives and explosive byproducts, metals, chemicals other than explosives, and other materials. **No Action Alternative:** Explosives and Explosive Byproducts: Impacts of explosive byproducts could be short-term and local, while impacts of unconsumed explosives and metals would be long-term and local. Chemical, physical, or biological changes in sediment or water quality would be measurable but below applicable standards, regulations, and guidelines, and within existing conditions or designated uses. Metals: Impacts of metals would be long-term and local. Corrosion and biological processes would reduce exposure of military expended materials to seawater, decreasing the rate of leaching, and most leached metals would bind to sediments and other organic matter. Sediments near military expended materials would contain some metals, but concentrations would be below applicable standards, regulations, and guidelines. Chemicals Other than Explosives: Impacts of chemicals other than explosives and impacts of other materials could be both short- and long-term and local. Chemical, physical, or biological changes in sediment or water quality would not be detectable, and would be within existing conditions or designated uses. Other Materials: Impacts of other materials would be short-term and local. Most other materials from military expended materials would not be harmful to marine organisms, and would be consumed during use. Chemical, physical, or biological changes in sediment or water quality would not be detectable. **Alternative 1 (Preferred Alternative):** The number of individual impacts may increase under Alternative 1, but the types of impacts would be the same as the No Action Alternative. Despite the increase, changes to sediments and water quality under Alternative 1 would be considered localized, short- and long-term. Impacts under Alternative 1 would be below applicable standards, regulations, and guidelines and would be within existing conditions or designated uses. **Alternative 2:** The number of individual impacts may increase under Alternative 2, but the types of impacts would be the same as the No Action Alternative. Despite the increase, changes to sediments and water quality under Alternative 2 would be considered localized, short- and long-term. Impacts under Alternative 2 would be below applicable standards, regulations, and guidelines and would be within existing conditions or designated uses.

Table ES.6-1: 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	**Stressors**: Stressors analyzed include criteria pollutants and hazardous air pollutants. **No Action Alternative:** All reasonably foreseeable direct and indirect emissions of criteria pollutants in nonattainment and maintenance areas do not equal or exceed applicable *de minimis* levels. The Navy's Proposed Action conforms to the applicable State Implementation Plan, and formal conformity determination procedures are not required. A Record of Non-Applicability has been prepared. The public would not be exposed to substantial concentrations of hazardous air pollutants. **Alternative 1 (Preferred Alternative):** The number of individual impacts may increase under Alternative 1, but the types of impacts would be the same as the No Action Alternative. Despite the increase in criteria air pollutants, changes to air quality under Alternative 1 would be considered minor and localized; changes to air quality from hazardous air pollutants are not expected to be detectable. **Alternative 2:** The number of individual impacts may increase under Alternative 2, but the types of impacts would be the same as the No Action Alternative. Despite the increase in criteria air pollutants, changes to air quality under Alternative 2 would be considered minor and localized; changes to air quality from hazardous air pollutants are not expected to be detectable.

Table ES.6-1: 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	**Stressors:** Stressors analyzed include acoustic (underwater explosives), and physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices). **No Action Alternative:** Acoustic: Most of the high-explosive military expended materials would detonate at or near the water surface. Only bottom-laid explosives could affect bottom substrate and, therefore, marine habitats. Habitat utilized for underwater detonations would primarily be soft-bottom sediment. The surface area of bottom substrate affected would be a fraction of the total training and testing area available in the Study Area. Physical Disturbance and Strike: Ocean approaches would not be expected to affect marine habitats because of the nature of high-energy surf and shifting sands. Seafloor devices would be located in areas that would be primarily soft-bottom habitat. Most seafloor devices would be placed in areas that would result in minor bottom substrate impacts. Once on the seafloor, military expended material would be buried by sediment, corroded from exposure to the marine environment, or colonized by benthic organisms. The surface area of bottom substrate affected would be a fraction of the total training and testing area available in the Study Area. Pursuant to the Essential Fish Habitat requirements of the Magnuson Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom, military expended materials, and seafloor devices during training and testing activities may have an adverse effect on Essential Fish Habitat by reducing the quality and quantity of non-living substrates that constitute Essential Fish Habitat and Habitat Areas of Particular Concern. Essential Fish Habitat conclusions for associated marine vegetation and sedentary invertebrates are summarized in corresponding resource sections (e.g., Marine Vegetation, Marine Invertebrates). Impacts to the water column as Essential Fish Habitat are summarized in corresponding resource sections (e.g., Marine Invertebrates, Fish) because they are impacts on the organisms themselves. **Alternative 1 (Preferred Alternative):** The number of individual impacts may increase under Alternative 1, but the types of impacts would be the same as the No Action Alternative. Despite the increases, most detonations would continue to occur at or near the surface, and those that do occur on the seafloor would be located in primarily soft-bottom habitat. Changes to marine substrates could include localized disturbance of the seafloor and cratering of soft-bottom sediments. Impacts on soft-bottom habitats would be short term, and impacts on hard bottom would be long term. Activities under Alternative 1 would not impact the ability of marine substrates to serve their function as habitat. **Alternative 2:** The number of individual impacts may increase under Alternative 2, but the types of impacts would be the same as the No Action Alternative. Despite the increases, most detonations would continue to occur at or near the surface, and those that do occur on the seafloor would be located in primarily soft-bottom habitat. Changes to marine substrates could include localized disturbance of the seafloor and cratering of soft-bottom sediments. Impacts on soft-bottom habitats would be short term, and impacts on hard bottom would be long term. Activities under Alternative 2 would not impact the ability of marine substrates to serve their function as habitat.

Table ES.6-1: 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	**Stressors:** Stressors analyzed include acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise), energy (electromagnetic devices), physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices), entanglement (fiber optic cables and guidance wires, and decelerators/parachutes), ingestion (munitions and military expended materials other than munitions), and secondary (impacts associated with sediments and water quality). There is no marine mammal critical habitat in the MITT Study Area. **No Action Alternative:** <u>Acoustic</u>: Pursuant to the Marine Mammal Protection Act (MMPA), the use of sonar and other active acoustic sources, and underwater explosives may result in mortality, Level A harassment, or Level B harassment of certain marine mammals. The use of; weapons firing, launch, and impact noise; vessel noise; and aircraft noise are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammals. Pursuant to the Endangered Species Act (ESA), the use of sonar and other active acoustic sources may affect, and is likely to adversely affect, certain ESA-listed marine mammals. The use of underwater explosives may affect, but is not likely to adversely affect, marine mammals. Weapons firing, launch, and impact noise; vessel noise; and aircraft noise may affect, but are not likely to adversely affect, certain ESA-listed marine mammals. <u>Energy</u>: Pursuant to the MMPA, the use of electromagnetic devices is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammals. Pursuant to the ESA, the use of electromagnetic devices may affect, but is not likely to adversely affect, certain ESA-listed marine mammals. <u>Physical Disturbance and Strike</u>: Pursuant to the MMPA, the use of vessels may result in mortality or Level A harassment of certain marine mammal species but is not expected to result in Level B harassment. The use of in-water devices, military expended materials, and seafloor devices is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, vessel use may affect, and is likely to adversely affect, certain ESA-listed species. The use of in-water devices and military expended materials may affect, but is not likely to adversely affect, certain marine mammal species. The use of seafloor devices would have no effect on any ESA-listed marine mammal. <u>Entanglement</u>: Pursuant to the MMPA, the use of fiber optic cables, guidance wires, and decelerators/parachutes is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, the use of fiber optic cables and guidance wires, and decelerators/parachutes may affect, but is not likely to adversely affect, certain ESA-listed marine mammals. <u>Ingestion</u>: Pursuant to the MMPA, the potential for ingestion of all types of military expended materials is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, the potential for ingestion of all types of military expended materials may affect, but is not likely to adversely affect, certain ESA-listed marine mammals. <u>Secondary</u>: Pursuant to the MMPA, secondary stressors are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, secondary stressors may affect, but are not likely to adversely affect, certain ESA-listed marine mammals. **Alternative 1 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Under Alternative 1, swimmer defense airguns would be used. Swimmer defense airguns would have no effect on any ESA-listed marine mammal. Despite the increase and use of swimmer defense airguns, impacts on marine mammals under Alternative 1 are not expected to decrease the overall fitness of any marine mammal population. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Under Alternative 2, swimmer defense airguns would be used. Swimmer defense airguns would have no effect on any ESA-listed marine mammal. Despite the increase and use of swimmer defense airguns, impacts on marine mammals under Alternative 2 are not expected to decrease the overall fitness of any marine mammal population.

Table ES.6-1: 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	**Stressors:** Stressors analyzed include acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch, and impact; vessel noise; and aircraft noise), energy (electromagnetic devices), physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices), entanglement (fiber optic cables and guidance wires, and decelerators/parachutes), ingestion (munitions and military expended materials other than munitions), and secondary (impacts associated with sediments and water quality). There is no critical habitat for any of the five listed sea turtles in the Study Area. **No Action Alternative:** Acoustic: Pursuant to the ESA, the use of sonar and other active acoustic sources may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley or leatherback sea turtles. The use of explosives may affect, and is likely to adversely affect, ESA-listed green and hawksbill sea turtles but is not likely to adversely affect ESA-listed loggerhead, olive ridley, or leatherback sea turtles. Weapons firing, launch, and impact noise; vessel noise; and aircraft noise may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles. Energy: Pursuant to the ESA, energy sources used during training and testing activities may affect, but are not likely to adversely affect, the ESA-listed green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles. Physical Disturbance and Strike: Pursuant to the ESA, physical disturbance and strike stressors may affect, but are not likely to adversely affect, the ESA-listed green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles. Entanglement: Pursuant to the ESA, fiber optic cable and guidance wires, and decelerators/parachutes may affect, but are not likely to adversely affect, the ESA-listed green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles. Ingestion: Pursuant to the ESA, the potential for ingestion of munitions and military expended materials other than munitions may affect, but are not likely to adversely affect, the ESA-listed green, hawksbill, loggerhead, olive ridley and leatherback sea turtles. Secondary: Pursuant to the ESA, secondary stressors would not affect sea turtles because changes in sediments and water quality from explosives, explosive byproducts and unexploded ordnance, metals, and chemicals are not likely to be detectable, and no detectable changes in growth, survival, propagation, or population-levels of sea turtles are anticipated. **Alternative 1 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative with the exception of responses to acoustics. Acoustic: Pursuant to the ESA, the use of sonar and other active acoustic sources may affect, and is likely to adversely affect, ESA-listed green, hawksbill, loggerhead, and leatherback sea turtles. The use of acoustic stressors may affect, but is not likely to adversely affect, the ESA-listed olive ridley sea turtle. The use of explosives may affect, and is likely to adversely affect, ESA-listed green and hawksbill sea turtles, but is not likely to adversely affect ESA-listed loggerhead, olive ridley, and leatherback sea turtles. Under Alternative 1, swimmer defense airguns would be used. Swimmer defense airguns noise would not affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles. Despite the increase and use of swimmer defense airguns, impacts on sea turtles under Alternative 1 are not expected to decrease the overall fitness of any sea turtle population. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative with the exception of responses to acoustics. Acoustic: Pursuant to the ESA, the use of sonar and other active acoustic sources may affect, and is likely to adversely affect, ESA-listed green, hawksbill, loggerhead, and leatherback sea turtles. The use of acoustic stressors may affect, but is not likely to adversely affect, the ESA-listed olive ridley sea turtle. The use of explosives may affect, and is likely to adversely affect, ESA-listed green and hawksbill sea turtles, but is not likely to adversely affect ESA-listed loggerhead, olive ridley, and leatherback sea turtles. Under Alternative 2, swimmer defense airguns would be used. Swimmer defense airguns noise would not affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles. Despite the increase and use of swimmer defense airguns, impacts on sea turtles under Alternative 2 are not expected to decrease the overall fitness of any sea turtle population.

Table ES.6-1: 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	**Stressors:** Stressors analyzed include acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise), energy (electromagnetic devices), physical disturbance and strike (aircraft and aerial targets, vessels, in-water devices, military expended materials, ground disturbance, and wildfires), ingestion (munitions and military expended materials other than munitions), and secondary (impacts associated with sediments and water quality, and air quality). There is no critical habitat for ESA-listed marine birds within the MITT Study Area. **No Action Alternative:** Acoustic: Pursuant to the ESA, the use of sonar and other active acoustic sources, underwater explosives, vessel noise, and aircraft noise would have no effect on ESA-listed marine birds. Energy: Pursuant to the ESA, the use of electromagnetic devices would have no effect on ESA-listed marine birds. Physical Disturbance and Strike: Pursuant to the ESA, the use of aircraft, vessels, in-water devices, and military expended materials would have no effect on ESA-listed marine birds. Ingestion: Pursuant to the ESA, the potential for ingestion of military expended materials would have no effect on ESA-listed marine birds. Secondary: Pursuant to the ESA, secondary stressors would have no effect on ESA listed marine birds. Under the MBTA regulations applicable to military readiness activities (50 C.F.R. Part 21), the stressors introduced during training and testing activities would not result in a significant adverse effect on migratory bird populations. **Alternative 1 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Under Alternative 1, swimmer defense airguns would be used. Despite the increase and use of swimmer defense airguns, impacts on marine birds under Alternative 1 are not expected to decrease the overall fitness of any bird population. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Under Alternative 2, swimmer defense airguns would be used. Despite the increase and use of swimmer defense airguns, impacts on marine birds under Alternative 2 are not expected to decrease the overall fitness of any bird population.

Table ES.6-1: 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	**Stressors:** Stressors analyzed include acoustic (underwater explosives), physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices), and secondary (impacts associated with sediments and water quality). No ESA-listed marine vegetation species are found in the MITT Study Area. **No Action Alternative:** Acoustic: Underwater explosives could affect marine vegetation by destroying individual plants or damaging parts of plants. The impacts of these stressors are not expected to result in detectable changes in survival or propagation, and are not expected to result in population-level impacts on marine plant species. Physical Disturbance and Strike: Physical disturbance and strikes could affect marine vegetation by destroying individual plants or damaging parts of plants. The impacts of these stressors are not expected to result in population-level impacts on marine plant species. Secondary: Secondary stressors are not expected to result in detectable changes in growth, survival, propagation, or population-level impacts because changes in sediment and water quality are not likely to be detectable. Pursuant to EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives and other impulsive sources, vessel movement, in-water devices, military expended materials, and seafloor devices during training and testing activities may have an adverse effect on EFH by reducing the quality and quantity of marine vegetation that constitutes EFH or Habitat Areas of Particular Concern. **Alternative 1 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts from acoustic stressors and physical disturbance are not expected to result in detectable changes to marine vegetation survival or propagation and are not expected to result in population-level impacts. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts from acoustic stressors and physical disturbance are not expected to result in detectable changes to marine vegetation survival or propagation and are not expected to result in population-level impacts.

Table ES.6-1: 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	**Stressors:** Stressors analyzed include acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch and impact noise; vessel noise; and aircraft noise), energy (electromagnetic devices), physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices), entanglement (fiber optic cables and guidance wires, and decelerators/parachutes), ingestion (military expended materials), and secondary (impacts associated with sediments and water quality). There is no marine invertebrate critical habitat in the Study Area. **No Action Alternative:** Acoustic: Pursuant to the Endangered Species Act (ESA), the use of sonar and other active acoustic sources; underwater explosives; swimmer defense airguns weapons firing, launch and impact noise; aircraft noise; and vessel noise may affect ESA-listed coral species. Energy: Pursuant to the ESA, the use of electromagnetic devices would have no effect on ESA-listed coral species. Physical Disturbance and Strike: Pursuant to the ESA, the use of vessels, in-water devices, and military expended materials may affect ESA-listed coral species. The use of military expended materials on FDM may affect ESA-listed coral species as a result of direct strikes from off island munitions. The use of seafloor devices would have no effect on ESA-listed coral species. Entanglement: Pursuant to the ESA, the use of fiber optic cables and guidance wires as well as parachutes/decelerators would have no effect on ESA-listed coral species. Ingestion: Pursuant to the ESA, the use of military expended materials would have no effect on ESA-listed coral species. Secondary: Pursuant to the ESA, secondary stressors would have no effect on ESA-listed coral species. Pursuant to the Essential Fish Habitat (EFH) requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of sonar and other acoustic sources, vessel noise, weapons firing noise, electromagnetic sources, vessel movement, in-water devices, and metal, chemical, or other material byproducts will have no adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The use of electromagnetic sources will have minimal and temporary adverse impact to invertebrates occupying water column EFH or Habitat Areas of Particular Concern. The use of explosives, military expended materials, seafloor devices, and explosives and explosive byproducts may have an adverse effect on EFH by reducing the quality and quantity of sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern.

Table ES.6-1: 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)	**Alternative 1 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase and use of swimmer defense airguns under Alternative 1, impacts to marine invertebrates are expected to be similar to those described under the No Action Alternative. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Despite the increase and use of swimmer defense airguns under Alternative 2, impacts to marine invertebrates are expected to be similar to those described under the No Action Alternative.
Section 3.9 Fish	**Stressors:** Stressors analyzed include acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise), energy (electromagnetic devices), physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices), entanglement (fiber optic cables and guidance wires, and decelerators/parachutes), ingestion (munitions and military expended materials other than munitions), and secondary (impacts associated with sediments and water quality). **No Action Alternative:** <u>Acoustic</u>: Pursuant to the ESA, the use of sonar and other non-impulse acoustic sources may affect, but is not likely to adversely affect ESA-listed scalloped hammerhead shark. The use of explosives and other impulse sound sources may affect, and is likely to adversely affect ESA-listed scalloped hammerhead sharks. Acoustic stressors have the potential to impact certain non-ESA fish species, which may include injury or mortality. These impacts are not expected to result in population-level impacts on fish species. <u>Energy</u>: Electromagnetic devices could affect certain fish species by eliciting a brief behavioral or physiological response. These impacts are not expected to result in population-level impacts on fish species. Pursuant to the ESA, the use of electromagnetic devices may affect, but is not likely to adversely affect ESA-listed scalloped hammerhead sharks. <u>Physical Disturbance and Strike</u>: Physical disturbance and strikes have the potential to impact fish; however, this potential is low. These impacts are not expected to result in population-level impacts on fish species. The use of vessels and in-water devices, military expended materials, and seafloor devices would have no effect on ESA-listed scalloped hammerhead sharks. <u>Entanglement</u>: The use of fiber optic cables and guidance wires, as well as parachutes/decelerators has the potential to impact certain fish species, which may include injury or mortality; however, this potential is low. These impacts are not expected to result in population-level impacts on fish species. Pursuant to the ESA, the use of fiber optic cables, guidance wires, and parachutes may affect, but is not likely to adversely affect ESA-listed scalloped hammerhead sharks. <u>Ingestion</u>: Munitions and military expended materials other than munitions have the potential to be ingested by fish in the Study Area; however, the likelihood is low. Therefore, these impacts are not expected to result in population-level impacts on fish species. Pursuant to the ESA, the potential for ingestion of military expended materials may affect, but is not likely to adversely affect ESA-listed scalloped hammerhead sharks.

Table ES.6-1: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.9 Fish (continued)	Secondary: Secondary stressors are not expected to result in population-level impacts because changes in sediment and water quality are not likely to be detectable. Pursuant to the ESA, secondary stressors may affect, but are not likely to adversely affect, ESA-listed scalloped hammerhead sharks. Pursuant to the EFH requirements, the use of sonar and other active acoustic sources, underwater explosives, and electromagnetic devices may have a minimal and temporary adverse effect on the fishes that occupy water column EFH. **Alternative 1 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative with one exception: swimmer defense airgun noise has the potential to impact certain fish species, which may include injury or mortality. These impacts are not expected to result in population-level impacts on fish species. Overall, despite the increase and use of swimmer defense airguns, impacts on fish under Alternative 1 are not expected to decrease the overall fitness of any fish population. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative with one exception: swimmer defense airgun noise has the potential to impact certain fish species, which may include injury or mortality. These impacts are not expected to result in population-level impacts on fish species. Overall, despite the increase and use of swimmer defense airguns, impacts on fish under Alternative 2 are not expected to decrease the overall fitness of any fish population.
Section 3.10 Terrestrial Species and Habitats	**Stressors:** Stressors analyzed include acoustic (explosives noise, weapons firing noise, and aircraft noise), physical (disturbance or strikes by aircraft and aerial targets, military expended materials including explosive munitions fragments, ground disturbance, and wildfires), and secondary (introduction of invasive species). **No Action Alternative:** Acoustic: Pursuant to the ESA, acoustic stressors on Guam may affect, but are not likely to adversely affect, the Mariana fruit bat, Mariana common moorhen, and the Mariana swiftlet. Acoustic stressors on Guam would have no effect on the Guam rail, Mariana crow, Micronesian kingfisher, or *Serianthes nelsonii*. Acoustic stressors on Rota may affect, but are not likely to adversely affect, the Mariana fruit bat and Mariana crow. Acoustic stressors on Rota would have no effect on Rota bridled white-eye, *Serianthes nelsonii*, *Nesogenes rotensis*, or *Osmoxylon mariannense.* Acoustic stressors on Tinian may affect, but are not likely to adversely affect, the Mariana fruit bat, Micronesian megapode, or Mariana common moorhen. Acoustic stressors on Saipan may affect, but are not likely to adversely affect, the Mariana swiftlet, Micronesian megapode, and nightingale reed-warbler. Acoustic stressors on FDM may affect, and are likely to adversely affect, the Micronesian megapode and the Mariana fruit bat.

Table ES.6-1: 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)	Physical: Pursuant to the ESA, physical stressors on Guam may affect, but are not likely to adversely affect, the Mariana fruit bat, Mariana common moorhen, and the Mariana swiftlet. Physical stressors on Guam would have no effect on the Guam rail, Mariana crow, Micronesian kingfisher, or *Serianthes nelsonii*. Physical stressors on Rota may affect, but are not likely to adversely affect, the Mariana fruit bat and Mariana crow. Physical stressors on Rota would have no effect on Rota bridled white-eye, *Serianthes nelsonii*, *Nesogenes rotensis*, or *Osmoxylon mariannense.* Physical stressors on Tinian may affect, but are not likely to adversely affect, the Mariana fruit bat, Micronesian megapode, or Mariana common moorhen. Physical stressors on Saipan may affect, but are not likely to adversely affect, the Mariana swiftlet, Micronesian megapode, and Nightingale reed-warbler. Acoustic stressors on FDM may affect, and are likely to adversely affect, the Micronesian megapode and the Mariana fruit bat on FDM. Wildfires on FDM may affect, and are likely to adversely affect, the Micronesian megapode and Mariana fruit bat. The USFWS has designated Critical Habitats on Guam for the Mariana fruit bat, Mariana crow, and Guam Micronesian kingfisher. The USFWS has designated Critical Habitats on Rota for the Rota bridled white-eye and Mariana crow. Proposed training and testing activities would not occur within these designated Critical Habitats; therefore, there would be no effect on Critical Habitat. Secondary: Pursuant to the ESA, secondary stressors would have no effect on ESA-listed species. The Navy, in cooperation with the U.S. Fish and Wildlife Service and other resource agencies, engages in policies and practices that reduce the potential for the transport of invasive species to the Mariana Islands and between military training areas. Acoustic and physical stressors have the potential to injure and kill terrestrial bird species that are not ESA-listed, particularly those that roost and breed on FDM. Pursuant to the MBTA and 50 C.F.R. Part 21.15, these impacts will not cause significant adverse effects to populations of bird species not ESA-listed and otherwise protected under the MBTA. **Alternative 1 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Although potential impacts to certain terrestrial species from the training activities that occur on land within the Study Area may include injury or mortality, impacts are not expected to decrease the overall fitness of any given population. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Although potential impacts to certain terrestrial species from the training activities that occur on land within the Study Area may include injury or mortality, impacts are not expected to decrease the overall fitness of any given population.

Table ES.6-1: 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	**Stressors:** Stressors analyzed include acoustic (underwater explosives) and physical disturbance (ground disturbance, use of towed-in-water devices, deposition of military expended materials, and use of seafloor devices). **No Action Alternative:** Acoustic and Physical Disturbance: Acoustic and physical stressors would not adversely affect submerged historic resources within U.S. territorial waters and National Register of Historic Places-eligible resources on Guam and the Commonwealth of the Northern Mariana Islands in accordance with Section 106 of the National Historic Preservation Act because measures were previously implemented to protect these resources and will continue to be implemented according to the conservation measures and procedures identified and described in the 2009 MIRC Programmatic Agreement. In accordance with Section 402 of National Historic Preservation Act, no World Heritage Sites would be affected. The Programmatic Agreement identifies 13 No Training areas (eight on Guam and five on Tinian) and 35 Limited Training areas (20 on Guam and 15 on Tinian). Limited Training areas are defined as pedestrian traffic areas with vehicular access limited to designated roadways and/or the use of rubber-tired vehicles. No pyrotechnics, demolition, or digging is allowed without prior consultation with the appropriate Historic Preservation Office. In addition to establishing No Training and Limited Training areas, stipulations for additional cultural resources investigations in unsurveyed areas, archaeological monitoring and conditions documentation of military use of ingress and egress paths and training areas, and preparation of field reports were also implemented. **Alternative 1 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Training and testing activities associated with acoustic and physical stressors would not impact cultural resources because measures have been previously implemented to protect these resources and would continue to be implemented according to the conservation measures and procedures identified and described in the 2009 MIRC Programmatic Agreement. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Training and testing activities associated with acoustic and physical stressors would not impact cultural resources because measures have been previously implemented to protect these resources and would continue to be implemented according to the conservation measures and procedures identified and described in the 2009 MIRC Programmatic Agreement.

Table ES.6-1: 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	**Stressors:** Stressors analyzed include accessibility (limiting access to the ocean and the air), physical disturbance and strike (aircraft, vessels, in-water devices, and military expended materials), airborne acoustics (weapons firing, aircraft and vessel noise), and secondary (availability of resources). **No Action Alternative:** Accessibility: Accessibility stressors may result in impacts on commercial and recreational fishing, subsistence use, or tourism when areas of co-use are temporarily inaccessible to ensure public safety during military training and testing activities. No impacts on commercial transportation and shipping are anticipated. The military will continue to collaborate with local communities to enhance existing means of communication with the public that are intended to reduce the potential effects of limiting accessibility to areas designated for use by the military. Physical Disturbance and Strike: Physical disturbance and strike stressors are not expected to result in impacts on commercial and recreational fishing, subsistence use, or tourism because the vast majority of military training and testing activities would occur in areas of the Study Area far from the locations of these socioeconomic activities. Furthermore, the large size of the Study Area over which these types of military activities would be distributed, and adherence to the Navy's standard operating procedures, would further reduce any potential for impacts. Airborne Acoustics: Airborne acoustic stressors are not expected to result in impacts to tourism or recreational activities, because the vast majority of military training and testing activities would occur in areas of the Study Area that are far out to sea and far from tourism and recreation locations. Secondary: Secondary stressors are not expected to result in impacts to commercial or recreational fishing, subsistence use, or tourism, based on the level of impacts described in other resources sections. **Alternative 1 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative.

Table ES.6-1: 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	**Stressors:** Stressors analyzed include underwater energy, in-air energy, physical interactions, and secondary (impacts associated with sediments and water quality). **No Action Alternative:** Because of the Navy's standard operating procedures, impacts on public health and safety would be unlikely. **Alternative 1 (Preferred Alternative):** Despite the increase in activities under Alternative 1, Navy safety procedures would continue to prevent proposed activities being co-located with public activities. Because of the Navy's safety procedures, the potential for activities to impact public health and safety under Alternative 1 would be unlikely. **Alternative 2:** Despite the increase in activities under Alternative 2, Navy safety procedures would continue to prevent proposed activities being co-located with public activities. Because of the Navy's safety procedures, the potential for activities to impact public health and safety under Alternative 2 would be unlikely.

Notes: C.F.R. = Code of Federal Regulations, EIS/OEIS = 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

ES.6.1 Cumulative Impacts

Marine mammals, sea turtles, terrestrial species, and socioeconomics are the primary resources of concern for cumulative impacts analysis:

- Past human activities have impacted these resources to the extent that several marine mammal species, all sea turtles 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.
- Several native forest-dwelling birds have been extirpated or suffered extinction in the Mariana Islands, primarily on Guam because of predation by introduced invasive species. These resources would be impacted by multiple ongoing and future actions.
- The use of sonar and other non-impulsive sound sources under the No Action Alternative, Alternative 1, and Alternative 2 has the potential to disturb or injure marine mammals and sea turtles.
- Explosive detonations, and vessel strikes under the No Action Alternative, Alternative 1, and Alternative 2 have the potential to disturb, injure, or kill marine mammals and sea turtles.
- Explosive detonations and other military training activities on Farallon de Medinilla (FDM) under the No Action Alternative, Alternative 1, and Alternative 2 have the potential to disturb, injure, or kill the Mariana fruit bat, Micronesian megapode, and seabirds that nest or visit FDM.
- Under Alternative 1 and Alternative 2, proposed danger zones could potentially restrict access to fishing and recreational areas when ranges are in use.

The aggregate impacts of past, present, and other reasonably foreseeable future actions are expected to result in significant impacts on some individual marine mammal, all sea turtle species, and terrestrial species in the Study Area. The No Action Alternative, Alternative 1, or Alternative 2 would contribute to cumulative impacts; however, marine mammal and sea turtle mortality and injury from bycatch, commercial vessel ship strikes, entanglement, ocean pollution, and other human causes are estimated to be orders of magnitude greater than the potential mortality, strandings, or injury resulting from Navy training and testing activities (hundreds of thousands of animals versus tens of animals) (Culik 2004; International Council for the Exploration of the Sea 2005; Read et al. 2006). Although the only significant impacts on terrestrial species and marine birds would occur on FDM, other activities within the Mariana Islands may indirectly impact or benefit species on FDM. For example, the main threats to terrestrial species within the Mariana Islands include invasive species introductions, habitat degradation, and poaching of fruit bats. These ecological stressors on species may influence inter-island movements, and either increase or decrease the potential for exposure on FDM. Alternatively, natural resource management activities, such as ungulate removal from some islands within the Mariana archipelago, may contribute to the recovery of declining species that occur on FDM.

The analysis presented in Chapter 4 (Cumulative Impacts) and Chapter 3 (Affected Environment and Environmental Consequences) indicate that the incremental contribution of the No Action Alternative, Alternative 1, or Alternative 2 to cumulative impacts on sediments and water quality, air quality, marine habitats, marine birds, marine vegetation, marine invertebrates, fish, cultural resources, socioeconomic resources, and public health and safety would be negligible. When considered with other actions, the No Action Alternative, Alternative 1, or Alternative 2 might contribute to cumulative impacts on submerged prehistoric and historic resources, if such resources are present in areas where bottom-disturbing training and testing activities take place. The No Action Alternative, Alternative 1, or Alternative 2 would also make an incremental contribution to greenhouse gas emissions, representing approximately 0.003, 0.005, and 0.006 percent of U.S. 2009 greenhouse gas emissions, respectively.

ES.7 Standard Operating Procedures, Mitigation, and Monitoring

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

ES.7.1 Standard Operating Procedures

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

ES.7.2 Mitigation

The Navy recognizes that the Proposed Action has the potential to impact the environment. Unlike standard operating procedures, which are established for reasons other than environmental benefit, mitigation measures are modifications to the Proposed Action that are implemented for the sole purpose of reducing a specific potential environmental impact on a particular resource. These measures have been coordinated with NMFS and USFWS through the consultation and permitting processes. The Record of Decision for this EIS/OEIS will address any additional mitigation measures that may result from ongoing regulatory processes.

The Navy has engaged in consultation processes under the ESA with regard to listed species that may be affected by the Proposed Action described in this EIS/OEIS. For the purposes of the ESA Section 7 consultation, the mitigation measures proposed here may be considered by NMFS and USFWS as beneficial actions taken by the Federal agency or applicant (50 C.F.R. 402.14[g][8]). If necessary to satisfy requirements of the ESA, NMFS and USFWS may develop an additional set of measures contained in reasonable and prudent alternatives, reasonable and prudent measures, or conservation recommendations in any Biological Opinion issued for this Proposed Action.

The Navy's mitigation measures are organized into two categories: (1) procedural measures and (2) mitigation areas. The Navy undertook two assessment steps for each recommended mitigation measure. Step 1 is an effectiveness assessment to ensure that mitigations are effective at reducing potential impacts on the resource. Step 2 is an operational assessment of the impacts on safety, practicability, and readiness from the proposed mitigation measure. In determining effectiveness at avoiding or reducing the impact, information was collected from published and readily available sources, as well as Navy after-action and monitoring reports. Table ES.7-1 summarizes the Navy's recommended mitigation measures with currently implemented mitigation measures for each activity category also summarized in the table.

ES.7.3 Mitigation Measures Considered but Eliminated

A number of possible alternative or additional mitigation measures have been suggested during the public scoping period of this EIS/OEIS and comment periods of previous Navy environmental documents. Through the evaluation process, some measures were deemed to either be ineffective, have an unacceptable impact on the proposed training and testing activities, or both, and will not be carried forward for further consideration (refer to Section 5.4, Mitigation Measures Considered But Eliminated).

ES.7.4 Monitoring

The Navy is committed to demonstrating environmental stewardship while executing its National Defense Mission and complying with the suite of federal environmental laws and regulations. As a complement to the Navy's commitment to avoiding and reducing impacts of the Proposed Action through mitigation, the Navy will undertake monitoring efforts to track compliance with take authorizations, help investigate the effectiveness of implemented mitigation measures, and better understand the impacts of the Proposed Action on marine resources. Taken together, mitigation and monitoring comprise the Navy's integrated approach for reducing environmental impacts from the Proposed Action. The Navy's overall monitoring approach will seek to leverage and build on existing research efforts whenever possible.

Consistent with the cooperating agency agreement with NMFS, mitigation and monitoring measures presented in this EIS/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 Integrated Comprehensive Monitoring Program is intended to coordinate monitoring efforts across all regions where the Navy trains and to allocate the most appropriate level and type of effort for each range complex. The current Navy monitoring program is composed of a collection of "range-specific" monitoring plans, each developed individually as part of MMPA and ESA compliance processes as environmental documentation was completed. These individual plans establish specific monitoring requirements for each range complex and are collectively intended to address the Integrated Comprehensive Monitoring Program top-level goals. A Scientific Advisory Group of leading marine mammal scientists developed recommendations that would serve as the basis for a Strategic Plan for Navy monitoring. The Strategic Plan is intended to be a primary component of the Integrated Comprehensive Monitoring Program and provide a "vision" for Navy monitoring across geographic regions—serving as guidance for determining how to most efficiently and effectively invest the marine species monitoring resources to address Integrated Comprehensive Monitoring Program top-level goals and satisfy MMPA regulatory requirements. The objective of the Strategic Plan is to continue the evolution of Navy marine species monitoring towards a single integrated program, incorporating Scientific Advisory Group recommendations, and establishing a more transparent framework for soliciting, evaluation, and implementing monitoring work across the Navy's range complexes and testing ranges.

ES.7.5 Reporting

The Navy is committed to documenting and reporting relevant aspects of training and testing activities in order reduce environmental impact, and improve future environmental assessments. Initiatives include exercise and monitoring reporting, stranding response planning, and bird strike reporting.

Table ES.7-1: At-Sea Mitigation Identification and Implementation[3]

Mitigation Measure	Benefit	Evaluation Criteria	Implementation	Responsible Command	Date Implemented
Marine Species Awareness Training All personnel standing watch on the bridge and Lookouts will successfully complete the training before standing watch or serving as a Lookout.	To learn the procedures for searching for and recognizing the presence of marine species, including detection cues (e.g., congregating seabirds) so that potentially harmful interactions can be avoided.	Successful completion of training by all personnel standing watch and all personnel serving as Lookouts. Personnel successfully applying skills learned during training.	The multimedia training program has been made available to personnel required to take the training. Personnel have been and will continue to be required to take the training prior to standing watch and serving as Lookouts.	Officer Conducting the Exercise or Test	Ongoing
Lookouts					
Use of Four Lookouts for Underwater Detonations Mine countermeasure and neutralization activities using time-delay will use four Lookouts, depending on the explosives being used. If applicable, aircrew and divers will report sightings of marine mammals or sea turtles.	Lookouts can visually detect marine species so that potentially harmful impacts to marine mammals and sea turtles from explosives use can be avoided. Lookouts can more quickly and effectively relay sighting information so that corrective action can be taken. Support from aircrew and divers, if they are involved in the activity, will increase the probability of sightings, reducing the potential for impacts.	Annual report documenting the number of marine mammals and sea turtles sighted, including trend analysis after 3 years. Annual report documenting the number of incidents when a Navy activity was halted or delayed as a direct result of a marine mammal or sea turtle sighting.	All Lookouts will receive marine species awareness training and will be positioned on vessels, and aircraft as described in Section 5.3.1.2 (Lookouts).	Officer Conducting the Exercise or Test	Ongoing

[3] Mitigation and conservation measures on land are being coordinated through the Section 7 ESA consultation process between the Navy and the USFWS. These measures have been included in this Final EIS (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) with the publication of the USFWS Biological Opinion.

Table ES.7-1: Mitigation Identification and Implementation (continued)

Mitigation Measure	Benefit	Evaluation Criteria	Implementation	Responsible Command	Date Implemented
Use of One or Two Lookouts Vessels using low-frequency active sonar or hull-mounted mid-frequency active sonar associated with ASW activities will have either one or two Lookouts, depending on the activity and size of the vessel. Mine countermeasure and neutralization activities with positive control will use two Lookouts, with one on each support vessel. If applicable, aircrew and divers will also report the presence of marine mammals or sea turtles. One Lookout may be used under certain circumstances specific in Section 5.3.1.2 (Lookouts). Sinking Exercises will use two Lookouts (one in an aircraft and one on a vessel).	Lookouts can visually detect marine species so that potentially harmful impacts to marine mammals and sea turtles from Navy sonar and explosives use can be avoided. Lookouts can more quickly and effectively relay sighting information so that corrective action can be taken. Support from aircrew and divers, if they are involved in the activity, will increase the probability of sightings, reducing the potential for impacts.				

Table ES.7-1: Mitigation Identification and Implementation (continued)

Mitigation Measure	Benefit	Evaluation Criteria	Implementation	Responsible Command	Date Implemented
Use of One Lookout Surface ships and aircraft conducing ASW, ASUW, or MIW activities using high-frequency, non-hull mounted mid-frequency active sonar, helicopter dipping mid-frequency active sonar, anti-swimmer grenades, IEER sonobuoys, surface gunnery activities, surface missile activities, bombing activities, explosive torpedo testing, towed mine neutralization activities, and activities using non-explosive practice munitions, will have one Lookout.	Lookouts can visually detect marine species so that potentially harmful impacts to marine mammals and sea turtles from Navy sonar, explosives, sonobuoys, gunnery rounds, missiles, explosive torpedoes, towed systems, and non-explosive munitions can be avoided. A Lookout can more quickly and effectively relay sighting information so that corrective action can be taken.				
Use of a Mitigation Zone A mitigation zone is an area defined by a radius and centered on the location of a sound source or activity. The size of each mitigation zone is specific to a particular training or testing activity (e.g., sonar use or explosive use).	A mitigation zone defines the area in which Lookouts survey for marine mammals and sea turtles. Mitigation zones reduce the potential for injury to marine species.	For those activities where monitoring is required, record observations of marine mammals and sea turtles located outside of the mitigation zone and note any apparent reactions to ongoing Navy activities. Observation of acute reactions may be used as an indicator that the radius of the mitigation zone needs to be increased.	Mitigation zones have been and will continue to be implemented as described in Section 5.3.2 (Mitigation Zone Procedural Measures). Lookouts are trained to conduct observations within mitigation zones of different sizes.	Officer Conducting the Exercise or Test	Ongoing

Notes: ASUW = Anti-surface Warfare, ASW = Anti-submarine Warfare, IEER = Improved Extended Echo Ranging, MIW = Mine Warfare

ES.7.6 Other Considerations

ES.7.6.1 Consistency with Other Federal, State, and Local Plans, Policies and Regulations

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

ES.7.6.2 Relationship Between Short-Term Use of the Human Environment and Maintenance and Enhancement of Long-Term Productivity

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

ES.7.6.3 Irreversible or Irretrievable Commitment of Resources

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

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

ES.7.6.4 Energy Requirements and Conservation Potential of Alternatives and Mitigation Measures

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

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

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
µg/g	microgram(s) per gram
µg/L	microgram(s) per liter
µPa	micropascal(s)
μPa^2-s	micropascal squared second(s)
A-A	Air-to-Air
AAV	Amphibious Assault Vehicle
AAW	Anti-Air Warfare
ac.	acre(s)
ACM	Air Combat Maneuver
ADEX	Air Defense Exercise
AEP	Auditory Evoked Potentials
AFB	Air Force Base
AFI	Air Force Instruction
AFPMB	Armed Forces Pest Management Board
A-G	Air-to-Ground
AG	Airgun
AGL	above ground level
AIC	Air Intercept Control
ALMDS	Airborne Laser Mine Detection System
AMW	Amphibious Warfare
Army	United States Army
A-S	Air-to-Surface
AS	Submarine Tenders
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
ATCAA	Air Traffic Control Assigned Airspace
AUTEC	Atlantic Undersea Test and Evaluation Center
$BaCrO_4$	barium chromate
BAMS	Broad Area Maritime Surveillance
BIA	Biologically Important Area
BO	Biological Opinion
BOMBEX	Bombing Exercise
BNM	Broadcast Notice to Mariners
BRF	Behavioral Response Function
C	Celsius
C-4	Composition 4
CD	Consistency Determination
CEE	Controlled Exposure Experiments
C.F.R.	Code of Federal Regulations
CG	Cruiser
CH_4	methane
CHAFFEX	Chaff Exercise
CITES	Convention on International Trade in Endangered Species
CJMT	Commonwealth of the Northern Mariana Islands Joint Military Training
CLZ	Craft Landing Zone
cm	centimeter(s)
CMECS	Coastal and Marine Ecological Classification Standard
CNMI	Commonwealth of the Northern Mariana Islands
CO	carbon monoxide
CO_2	carbon dioxide
COMNAVMAR	Commander, U.S. Naval Forces Marianas
COMNAVMARIANASINST	Commander, U.S. Naval Forces Marianas Instruction
CRRC	Combat Rubber Raiding Craft
CSAR	Combat Search and Rescue
CV	coefficient of variation
CVN	Aircraft Carrier
dB	decibel(s)
dBA	A-weighted decibel(s)
dB re 1 µPa	decibels referenced to 1 micropascal
DDG	destroyer
DDT	dichlorodiphenyltrichloroethane
DEIS	Draft Environmental Impact Statement
DNA	deoxyribonucleic acid
DoD	Department of Defense
DPS	Distinct Population Segment
DS	Doppler Sonar
DVLA	Distributed Vertical Line Array
DZ	Danger Zone
E	Explosive
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFHA	Essential Fish Habitat Assessment
EIS	Environmental Impact Statement
EL	Exposure Level
EMATT	Expendable Mobile ASW Training Target
EO	Executive Order
EOD	Explosive Ordnance Disposal
Eq	equivalent
ESA	Endangered Species Act
EW	Electronic Warfare
EXTORP	Exercise Torpedo
F	Fahrenheit
FAA	Federal Aviation Administration
FAD	fish aggregating device
FDM	Farallon de Medinilla
FEIS	Final Environmental Impact Statement
FFG	Frigates
FIREX	Fire Support Exercise
FL	Flight Level

FLAREX	Flare Exercise
FR	Federal Register
ft.	square foot/feet
ft./s	feet per second
$ft.^2$	square foot/feet
FY	Fiscal Year
g	gram(s)
G	gauss
g(0)	detection probability
GCA	Guam Code Annotated
GHz	gigahertz
GI	gastrointestinal
GMDSS	Global Maritime Distress and Safety System
GUNEX	Gunnery Exercise
ha	hectare(s)
HARP	High Frequency Recording Package
HC	hydrocarbons
Helo	helicopter
$Hg (CNO)_2$	Fulminate of Mercury
HMX	High Melting Point Explosive
HRC	Hawaii Range Complex
Hz	Hertz
IEER	Improved Extended Echo Ranging
in.	inch(es)
in^3	cubic inches
INRMP	Integrated Natural Resources Management Plan
IR	infrared
ISR	Intelligence, Surveillance, Reconnaissance
ISTT	Improved Surface Tow Target
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
km^3	cubic kilometer(s)
kPa	kilopascal(s)
kV	kilovolt(s)
lb.	pound(s)
LCAC	Air Cushioned Landing Craft
LCM	Landing Craft Mechanized
LCS	Littoral Combat Ship
LCU	Landing Craft, Utility
LHA/LHD	Amphibious Assault Ships
LNM	Local Notice to Mariners
LPD	Amphibious Transport Dock
LSD	Dock Landing Ship
m	meter(s)
M	Acoustic Modems
m/s	meter(s) per second
m^2	square meter(s)
MBTA	Migratory Bird Treaty Act
MCM	Mine Countermeasure(s)
MFA	Mid-frequency Active
mg/L	milligram(s) per liter
mi.	mile(s)
$mi.^2$	square mile(s)
$mi.^3$	cubic mile(s)
MIRC	Mariana Islands Range Complex
MISSILEX	Missile Exercise
MISTCS	Mariana Islands Sea Turtle and Cetacean Survey
MITT	Mariana Islands Training and Testing
MIW	Mine Warfare
ml/L	milliliter(s) per liter
MLA	Military Lease Area
mm	millimeter(s)
MMPA	Marine Mammal Protection Act
MPA (1)	Marine Preserve Area
MPA (2)	Maritime Patrol Aircraft
msl	mean sea level
MSO	Maritime Security Operations
N_2O	nitrous oxide
NAEMO	Navy Acoustic Effects Model
NAVTEXT	Navigational Telex
Navy	United States Department of the Navy
NEPA	National Environmental Policy Act
NEPM	Non-Explosive Practice Munition
NEW	Net Explosive Weight
ng	nanogram(s)
ng/L	nanograms(s)/liter
nm	nautical mile(s)
nm^2	square nautical mile(s)
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NSW	Naval Special Warfare
NSWC	Naval Surface Warfare Center
NTM	Notice to Mariners
NTU	Nephelometric Turbidity Units
nV	nanovolt(s)
O_3	ozone
OASIS	Organic Airborne and Surface Influence Sweep
OBIS	Ocean Biographic Information System
OEA	Overseas Environmental Assessment
OEIS	Overseas Environmental Impact Statement
OPNAVINST	Chief of Naval Operations Instruction
Ops	Operations
oz.	ounce(s)
P	Pingers
Pa	Pascal(s)
Pa-s	Pascal-seconds
PACOM	Pacific Command

$Pb(N_3)_2$	lead azide
PbO	lead (II) oxide
PC	Patrol Coastal Ships
PCB	polychlorinated biphenyl
PCD	Panama City Division
PM	particulate matter
PMRF	Pacific Missile Range Facility
ppb	parts per billion
ppm	parts per minute
ppt	parts per thousand
psi	pounds per square inch
PTS	Permanent Threshold Shift
R	Restricted Area
RDX	Royal Demolition Explosive
REXTORP	Recoverable Exercise Torpedo
RHIB	Rigid Hull Inflatable Boat
RL	Received Level
rms	root mean square
RMS	Remote Minehunting System
ROD	Record of Decision
ROG	Reactive Organic Gases
ROV	Remotely Operated Vehicle
S-A	Surface-to-Air
SAG	Scientific Advisory Group
SAS	Synthetic Aperture Sonar
SCUBA	Self Contained Underwater Breathing Apparatus
SD	Swimmer Detection Sonar
SDST	Ship Deployable Seaborne Target
SEAL	Sea, Air, Land
SEAMAP	Spatial Ecological Analysis of Megavertebrate Populations
SEL	Sound Exposure Level
SF_6	sulfur hexafluoride
SINKEX	Sinking Exercise
SL	Source Level
SMCMEX	Mine Countermeasure Exercise – Surface
SO_2	sulfur dioxide
SOCAL	Southern California
SOx	sulfur oxides
SPL	Sound Pressure Level
spp.	species (plural)
S-S	Surface-to-Surface
SSBN	Fleet Ballistic Missile Submarines
SSGN	Guided Missile Submarines
SSS	Side Scan Sonar
SSTC	Silver Strand Training Complex
STW	Strike Warfare
SUA	Special Use Airspace
SUS	Signal Underwater Sound
SWATH	Small Waterplane Area Twin Hull
T	Tesla
TACP	Tactical Air Control Party
Tg	teragram(s)
Tg CO_2 Eq	carbon dioxide equivalents
TL	Transmission Loss
TNT	Trinitrotoluene
TORP	Torpedoes
TORPEX	Torpedo Exercise
TPY	tons per year
TRACKEX	Tracking Exercise
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
UAV	Unmanned Aerial Vehicle
UISS	Unmanned Influence Sweep System
UNDET	Underwater Detonation
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VHF	Very High Frequency
VOC	volatile organic compounds
W	Warning Area
WPacFIN	Western Pacific Fisheries Information Network
yd.	yard(s)
$yd.^2$	square yard(s)
YP	Yard Patrol Craft

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1 Purpose and Need

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1 PURPOSE AND NEED

1.1 INTRODUCTION

Major conflicts, terrorism, lawlessness, and natural disasters all have the potential to threaten the national security of the United States. The security, prosperity, and vital interests of the United States are increasingly tied to other nations because of the close relationships between the United States and other national economies. The Department of Defense (DoD), through its military departments (United States [U.S.] Army, U.S. Department of the Navy [Navy] [including U.S. Marine Corps], U.S. Coast Guard,[1] and the U.S. Air Force) carries out training and testing activities to be able to protect the United States against its enemies, as well as to protect and defend the rights of the United States and its allies to move freely on the oceans. 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. Congress, after World War II, established the National Command Authorities to identify defense needs—based on the existing and emergent situations in the United States and overseas that must be dealt with now or may be dealt with in the future. The National Command Authorities, which are comprised of the President, the Secretary of Defense, and their deputized alternates or successors, divide defense responsibilities among services. The heads (secretaries) of each service ensure that military personnel are trained, prepared, and equipped to meet those operational requirements.

Training and testing activities that prepare the Navy and the other services[2] to fulfill their mission to protect and defend the United States and its allies have the potential to impact the environment. These activities may trigger legal requirements identified in a number of U.S. federal environmental laws, regulations, and executive orders.

Training. Navy personnel first undergo entry-level (or schoolhouse) training, which varies according to their assigned warfare community (aviation, surface warfare, submarine warfare, and special warfare) and the community's unique requirements. Personnel then train within their warfare community at sea in preparation for deployment; each warfare community has primary mission areas (areas of specialized expertise that involve multiple warfare communities) that overlap with one another, described in detail in Chapter 2 (Description of Proposed Action and Alternatives). The Marine Corps and other services similarly train to support their core capabilities.

Testing. The Navy researches, develops, tests, and evaluates new platforms, systems, and technologies.[3] Many tests are conducted in realistic conditions at sea, and can range in scale from testing new software to operating manned-portable devices. Testing activities may occur independently of or in conjunction with training activities. The other services similarly research, develop, test, and evaluate new systems and technologies.

[1] The U.S. Coast Guard, a component of the Department of Homeland Security, is an Armed Force of the United States. It is a multi-mission maritime service with regulatory and law enforcement authority, maritime home defense and maritime homeland security responsibility, and environmental response and recovery requirements. The U.S. Coast Guard's overarching mission is to protect the public, environment, and U.S. economic interests in the nation's ports and waterways on the high seas. Mission activities pertain to maritime safety, maritime security, and maritime stewardship including law enforcement, national defense, and natural resources protection.
[2] Training and testing activities may include foreign allies and partners. Foreign allies and partners may train along U.S. military forces to ensure seamless interoperability.
[3] Throughout this EIS/OEIS, ships and aircraft may be referred to as "platforms," and weapons, combat systems, sensors, and related equipment may be referred to as "systems."

The Navy prepared this Environmental Impact Statement (EIS)/Overseas EIS (OEIS) to assess the potential environmental impacts associated with two categories of military readiness activities: training and testing. The Navy also prepared this EIS/OEIS to comply with the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114.

The Study Area in this EIS/OEIS is referred to as the Mariana Islands Training and Testing (MITT) Study Area (Figure 1.1-1). The MITT Study Area (984,601 square nautical miles [nm^2]) includes the existing Mariana Islands Range Complex (MIRC) (497,469 nm^2), additional areas on the high seas (487,132 nm^2), and a transit corridor between MIRC and the Hawaii Range Complex (HRC). The Mariana Islands are composed of two U.S. jurisdictions: the Commonwealth of the Northern Mariana Islands (CNMI) and the territory of Guam.

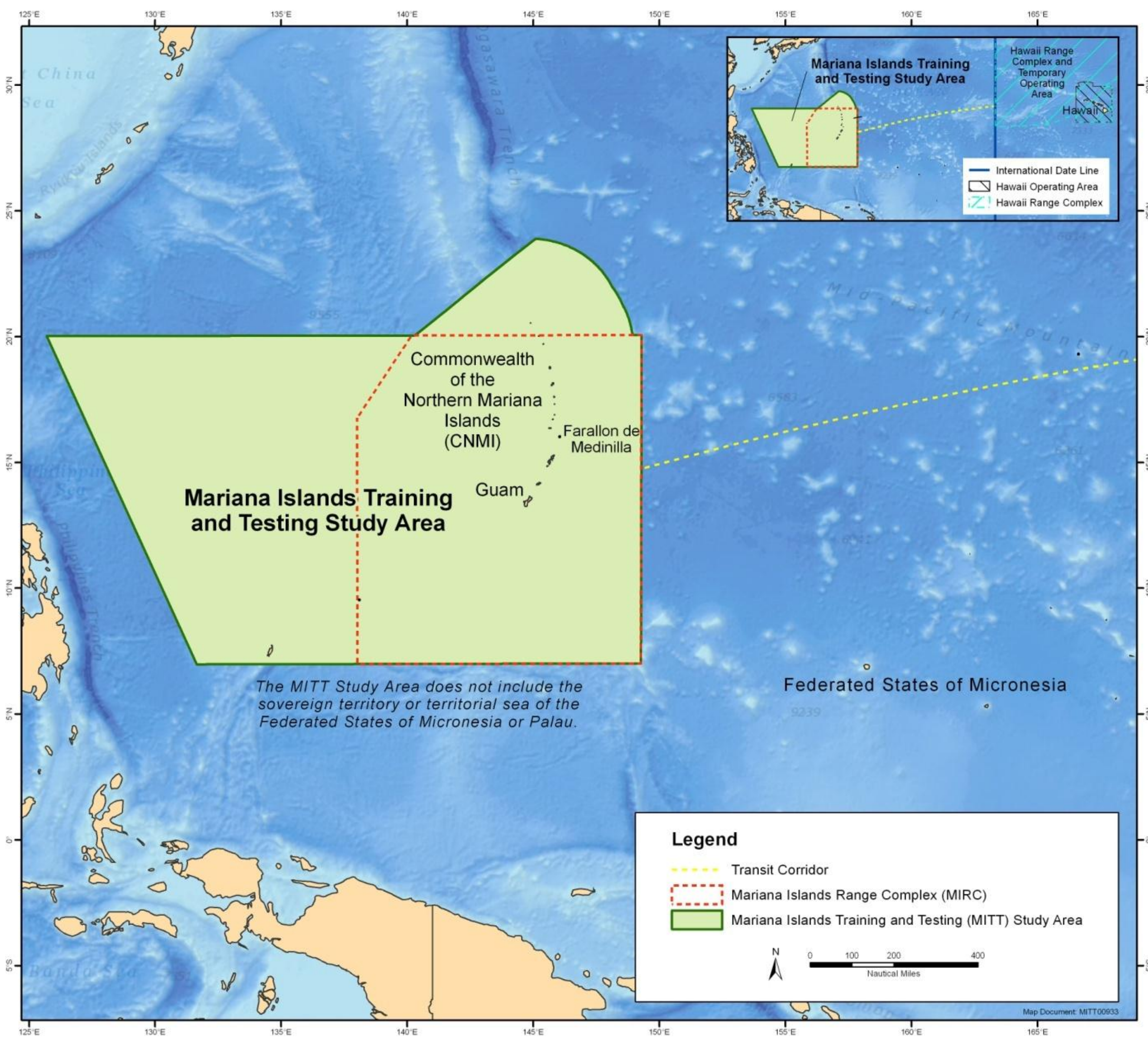

Figure 1.1-1: Mariana Islands Training and Testing Study Area

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

In 2000, the Navy completed a thorough review of its environmental compliance requirements for training at sea and instituted a policy designed to comprehensively address them. The policy, known as the "At-Sea Policy," directed, in part, that the Navy develop a programmatic approach to environmental compliance for ranges and operating areas within its areas of responsibility (U.S. Department of the Navy 2000). Ranges affected by the "At-Sea Policy" are designated water areas that are scheduled to conduct training or testing activities. Operating areas affected by the policy are those ocean areas, defined by specific geographic coordinates, used by the Navy to undertake training and testing activities. To meet the requirements of the policy, the Navy developed an updated Concept of Operations for Phase II Environmental Planning and Compliance for Navy Military Readiness and Scientific Research Activities At Sea in September 2010 (U.S. Department of the Navy 2010d). The concept of operations laid out a plan to achieve comprehensive environmental planning and compliance for Navy training and testing activities at sea.

Phase I of the planning program. The first phase of the programmatic approach was accomplished by the preparation and completion of individual or separate environmental documents for each range complex and at-sea training and testing area. Many of these range complexes and at-sea training and testing areas pre-date World War II and have remained in continuous use by naval forces and other services.

The Navy prepared NEPA/EO 12114 documents for the MIRC. The MIRC EIS/OEIS documented training and testing activities in the MIRC, analyzed potential environmental impacts, and supported permit and other requirements under applicable environmental laws, regulations, and EOs. For example, Marine Mammal Protection Act (MMPA) incidental take authorizations (also known as "Letters of Authorization"), issued by the National Marine Fisheries Service (NMFS), were supported by preparation of the MIRC EIS/OEIS. In addition, the MIRC Airspace Environmental Assessment (EA)/Overseas EA was prepared to analyze air space changes to support the training and testing in the MIRC (see Section 1.10, Ongoing Environmental Documents in the Study Area).

Phase II of the planning program. The second phase of the planning program will cover activities previously analyzed in Phase I NEPA/EO 12114 documents, and also analyze additional geographic areas including, but not limited to, pierside locations and transit corridors. This EIS/OEIS is part of the second phase of environmental planning documents needed to support the Navy's request to obtain an incidental take authorization from NMFS. The Navy re-evaluated impacts from historically conducted activities and updated the training and testing activities based on changing operational requirements, including those associated with new platforms and systems. The Navy will use this new analysis to comply with and consider all federal and state regulations (e.g., MMPA, Endangered Species Act [ESA], Magnuson Stevens Fisheries Conservation and Management Act, and the Coastal Zone Management Act, as applicable, in all appropriate states and territories).

The MITT EIS/OEIS (Figure 1.1-1) combines the geographic scope of the MIRC EIS/OEIS (both land and at sea) and analyzes ongoing, routine at-sea activities that occur during transit between the MIRC and other operating areas. The MIRC is the only Navy range complex in the MITT Study Area. The Navy expanded the geographic scope of the Study Area to analyze the potential environmental impacts of training and testing activities in areas (not covered in previous NEPA documents) where training and testing activities historically occur. The scope of the MITT EIS/OEIS also includes new platforms and weapon systems that were not addressed in previous NEPA/EO 12114 documents.

1.3 PROPOSED ACTION

The Navy's Proposed Action, described in detail in Chapter 2 (Description of Proposed Action and Alternatives), is to conduct training and testing activities, including the use of active sonar and explosives[4] in the MIRC, throughout the in-water areas around the MIRC, and the transit corridor between the MIRC and the HRC. The Proposed Action includes activities such as sonar maintenance and gunnery exercises that are conducted concurrently with ship transits and may occur outside the geographic boundaries of Navy range complexes. The Proposed Action also includes pierside sonar activity that is conducted as part of overhaul, modernization, maintenance, and repair activities, as well as land-based training activities on Guam and the CNMI.

1.4 PURPOSE OF AND NEED FOR PROPOSED MILITARY READINESS TRAINING AND TESTING ACTIVITIES

The purpose of the Proposed Action is to conduct training and testing activities to ensure that the Navy and other Services meet their mission, which is to maintain, train, and equip combat-ready military forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is achieved in part by conducting training and testing within the Study Area.

The following sections are an overview of the need for military readiness training and testing activities.

1.4.1 WHY THE NAVY TRAINS

> Title 10 of the U.S. Code provides for each of the Services to be organized, trained, and equipped to be capable, in conjunction with the other armed forces, of (1) preserving the peace and security, and providing for the defense of the United States, the Commonwealths and possessions, and any areas occupied by the United States; (2) supporting the national policies; (3) implementing the national objectives; and (4) overcoming any nations responsible for aggressive acts that imperil the peace and security of the United States.

Naval forces must be ready for a variety of military operations—from large-scale conflict to maritime security and humanitarian assistance/disaster relief—to deal with the dynamic social, political, economic, and environmental issues that occur in today's world. The Navy supports these military operations through its continuous presence on the world's oceans: the Navy can respond to a wide range of issues because, on any given day, over one-third of its ships, submarines, and aircraft are deployed overseas. Naval forces must be prepared for a broad range of capabilities—from full-scale armed conflict in a variety of different geographic areas[5] to disaster relief efforts[6]—prior to deployment on the world's oceans. To learn these capabilities, personnel must train with the equipment and systems that will achieve military objectives. 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.

Modern weapons bring both unprecedented opportunity and innumerable challenges to the Navy. For example, modern (or smart) weapons are very accurate and help the Navy accomplish its mission with greater precision and far less collateral damage than in past conflicts; however, modern weapons are very complex to use. Military personnel must train regularly with these weapons to understand the capabilities, limitations, and operations of the platform or system. Modern military actions require

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[4] The terms "explosive" and "high explosive" will be used interchangeably throughout the document.
[5] Operation Iraqi Freedom in Iraq and Operation Enduring Freedom in Afghanistan; maritime security operations, including anti-piracy efforts like those in Southeast Asia and the Horn of Africa.
[6] Evacuation of noncombatants from American embassies under hostile conditions, as well as humanitarian assistance/disaster relief like the tsunami responses in 2005 and 2011, and Haiti's earthquake in 2009.

teamwork—teamwork that includes the use of various equipment, vehicles, ships, and aircraft—between hundreds or thousands of people to achieve success.

Military readiness training and preparation for deployment include everything from teaching basic and specialized individual military skills to intermediate skills or small unit training. As personnel increase in skill level and complete the basic training, they advance to intermediate and larger exercise training activities, which culminate in advanced, integrated training activities composed of large groups of personnel and, in some instances, joint service exercises.[7]

Military readiness training must be as realistic as possible to provide the experiences so important to success and survival. While simulators and synthetic training are critical elements of training—to provide early skill repetition and enhance teamwork—there is no substitute for live training in a realistic environment. The range complexes and at-sea training and testing areas have these realistic environments, with sufficient land, sea and airspace vital for safety and mission success. Just as a pilot would not be ready to fly solo after simulator training, a Navy commander cannot allow military personnel to engage in real combat activities based merely on simulator training.

1.4.2 Fleet Readiness Training Plan

The Navy developed the Fleet Response Plan to ensure the constant readiness of naval forces. This plan maintains, staffs, and trains naval forces to deploy for missions. The Fleet Response Plan increases the number of personnel and vessels that can be deployed on short notice. For example, the Navy was able to complete an unscheduled deployment of an additional aircraft carrier to the Middle East in January 2007 because of adherence to the Fleet Response Plan. Observance of the Fleet Response Plan allows the Navy to respond to global events more robustly, while maintaining a structured process that ensures continuous availability of trained, ready Navy forces.

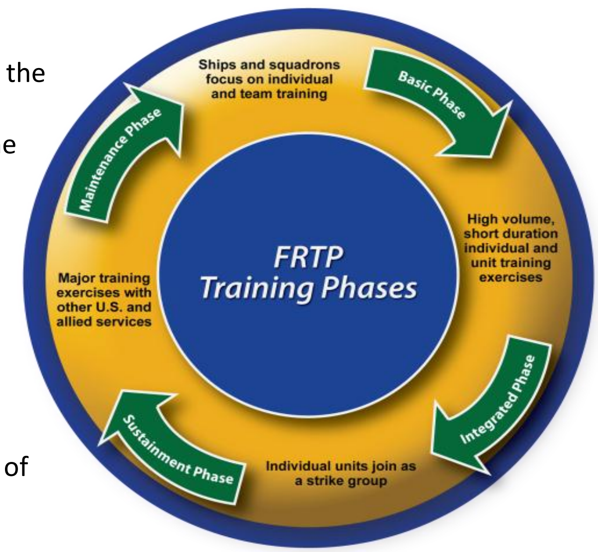

Figure 1.4-1: Fleet Readiness Training Plan

The Fleet Readiness Training Plan implements the requirements in the Fleet Response Plan. The Fleet Readiness Training Plan outlines the training activities required for military readiness that prepares Navy personnel for any conflict or operation. The Navy's building-block approach to training is cyclical and qualifies its personnel to perform their assigned missions. Training activities proceed in four phases: basic, integrated, sustainment, and maintenance, as depicted in Figure 1.4-1.

1.4.2.1 Basic Phase

The basic phase consists of training exercises performed by individual ships and aircraft; it is characterized mostly as unit level training. Fundamental combat skills are learned and practiced during this phase. Operating area and range support requirements for unit level training are relatively modest in size compared to large-scale, major exercises. Training exercises with two or more units (ships, aircraft, or both), known as coordinated unit level training exercises, are also included in the basic

[7] Large group exercises may include carrier strike groups and expeditionary strike groups. Joint exercises may be with other U.S. services and other nations.

phase. These training exercises further refine the basic, fundamental skills while increasing difficulty through coordination with other units.

Access to local range complexes and at-sea training and testing areas in proximity to the locations where Sailors and Marines are stationed reduces the amount of travel time and training costs.

1.4.2.2 Integrated Phase

The integrated phase combines the units involved in the basic, coordinated unit level training into strike groups. Strike groups are composed of multiple ships and aircraft. Strike group skills and proficiencies are developed and evaluated through major exercises. The integrated phase concludes when the strike group is certified for deployment, meaning that the strike group demonstrated the skills and proficiencies across the entire spectrum of warfare that may be needed during deployment.

Major exercises in this phase require access to large, relatively unrestricted ocean at-sea training and testing areas, multiple targets, and unique range attributes (oceanographic features, proximity to naval bases, and land-based targets).

1.4.2.3 Sustainment Phase

The strike group needs continued training activities to maintain its skills after certification for deployment in the integrated phase; these continued training activities fall within the sustainment phase. Sustainment phase activities provide strike groups additional training, as well as the ability to evaluate new and developing technologies and new tactics.

Similar to the integrated phase, sustainment exercises require access to large, relatively unrestricted ocean training and testing areas, and unique range attributes to support the scenarios.

1.4.2.4 Maintenance Phase

Naval forces enter the maintenance phase after forces return from deployment. Maintenance may involve relatively minor repair or major overhaul depending on the system and its age. The maintenance phase also includes testing of a ship's systems; these tests may take place pierside or at sea. Naval forces re-enter the basic phase upon completion of the maintenance phase.

1.4.3 Why the Navy Tests

The Navy's research and acquisition community conducts military readiness activities that involve testing. The Navy tests ships, aircraft, weapons, combat systems, sensors and related equipment, and conducts scientific research activities to achieve and maintain military readiness. The fleet identifies military readiness requirements to support its mission; the Navy's research and acquisition community, including the Navy's systems commands and associated scientific research organizations, provide Navy personnel with ships, aircraft, weapons, combat systems, sensors, and related equipment. The Navy's research and acquisition community is responsible for researching, developing, testing, evaluating, acquiring, and delivering modern platforms and systems to the fleet—and supporting the systems throughout their life. The Navy's research and acquisition community is responsible for furnishing high-quality platforms, systems, and support matched to the requirements and priorities of the fleet, while providing the necessary high return on investment by the American taxpayer.

The Navy's research and acquisition community includes the following:

- The Naval Air Systems Command, which develops, acquires, delivers, and sustains aircraft and systems with proven capability and reliability to ensure Sailors achieve mission success
- The Naval Sea Systems Command, which develops, acquires, delivers, and maintains surface ships, submarines, and weapon system platforms that provide the right capability to the Sailor
- The Space and Naval Warfare Systems Command, which provides the Sailor with knowledge superiority by developing, delivering, and maintaining effective, capable, and integrated command, control, communications, computer, intelligence, and surveillance systems
- The Office of Naval Research, which plans, fosters, and encourages scientific research that promotes future naval seapower and enhances national security
- The Naval Research Laboratory, which conducts a broad program of scientific research, technology, and advanced development to meet the complex technological challenges of today's world

The Navy's research and acquisition community, in cooperation with private companies, designs, tests and builds components, systems, and platforms to address requirements identified by the fleet. Private companies are contracted to assist the Navy in acquiring the platform, system, or upgrade. The Navy's research and acquisition community must test and evaluate the platform, system, or upgrade to validate whether it performs as expected and to determine whether it is operationally effective, suitable, survivable, and safe for its intended use by the fleet.

Testing performed by the Navy's research and acquisition community can be categorized as scientific research testing, private contractor testing, developmental testing and operational testing (including lot acceptance testing), fleet training support, follow-on test and evaluation, and maintenance and repair testing. Fleet training activities often offer the most suitable environment for testing a system because training activities are designed to accurately replicate operational conditions. System tests, therefore, are often embedded in training activities such that it would be difficult for an observer to differentiate the two activities.

- **Scientific research testing.** Navy testing organizations conduct scientific research to evaluate emerging threats or technology enhancement before development of a new system. As an example, testing might occur on a current weapon system to determine if a newly developed technology would improve system accuracy or enhance safety to personnel.
- **Private contractor testing.** Contractors are often required to conduct performance and specification tests prior to delivering a system or platform to the Navy. These tests may be conducted on a Navy range, in a Navy at-sea training and testing area, or seaward of ranges and at-sea training and testing areas; these tests are sometimes done in conjunction with fleet training activities.
- **Developmental testing.** A series of tests are conducted by specialized Navy units to evaluate a platform or system's performance characteristics and to ensure that it meets all required specifications.
- **Operational testing.** Operations are conducted with the platform or system as it would be used by the fleet and other services.
- **Fleet training support.** Systems still under development may be integrated on ships or aircraft for testing. If training has not been developed for use of a particular system, the Navy's systems commands may support the fleet by providing training on the operation, maintenance, and repair of the system during developmental testing activities.

- **Follow-on test and evaluation.** A follow-on test and evaluation phase occurs when a platform receives a new system, after a significant upgrade to an existing system, or when the system failed to meet contractual performance specifications during previous testing. Tests similar to those conducted during the developmental testing or operational testing phase are conducted again, as needed, to ensure that the modified or new system meets performance requirements and does not conflict with existing platform systems and subsystems.
- **Maintenance and repair testing.** Following periodic maintenance, overhaul, modernization, or repair of systems, testing of the systems may be required to assess performance. These testing activities may be conducted at shipyards or Navy piers.

Preparatory checks of a platform or system-to-be-tested are often made prior to actual testing to ensure the platform or system is operating properly. This preparatory check is similar to checking the wipers and brakes on a car before taking a trip. These checks are done to ensure everything is operating properly before expending the often-considerable resources involved in conducting a full-scale test. For example, the MH-60 helicopter program often conducts a functional check of its dipping sonar system in a nearshore bay before conducting a more rigorous test of the sonar system farther offshore. Pierside platform and system checks are conducted during Navy repair and construction activities and are essential to ensure safe operation of the platform or system at sea.

The Navy uses a number of different testing methods, including computer simulation and analysis, throughout the development of platforms and systems. Although simulation is a key component in the development of platforms and systems, it cannot provide information on how a platform or system will perform or whether it will be able to meet performance and other specification requirements in the environment in which it is intended to operate without comparison to actual performance data. For this reason, platforms and systems must undergo at-sea testing at some point in the development process. Thus, like the fleet, the research and acquisition community requires access to large, relatively unrestricted ocean training and testing areas, multiple strike targets, and unique range attributes to support its testing requirements. Navy platforms and systems must be tested and evaluated within the broadest range of operating conditions available (e.g., bathymetry, topography, geography) because Navy personnel must be capable of performing missions within the wide-range of conditions that exist worldwide. Furthermore, Navy personnel must be assured that platforms and systems will meet performance specifications in the real-world environment in which they will be operated.

1.5 Overview and Strategic Importance of Existing Range Complex

The Navy historically uses the MITT Study Area (which includes the MIRC) for training and testing. This area has been designated by the Navy as a “range complex.” A range complex is a set of adjacent areas of sea space, undersea space, land ranges, and overlying airspace delineated for military training and testing activities. Range complexes provide controlled and safe environments where military ship, submarine, and aircraft crews can train in realistic conditions. The combination of undersea ranges and operating areas with land training ranges, safety landing fields, and nearshore amphibious landing sites is critical to realistic training, and allows electronics on the range to capture data on the effectiveness of tactics and equipment—data that provide a feedback mechanism for training evaluation.

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, while fleet assets alternately support testing activities on test ranges; however, there are no dedicated test ranges within the MITT Study Area. Thus, the MITT Study Area must provide the flexibility to meet diverse testing requirements, given the wide range of various advanced platforms and systems and proficiencies that the fleets and systems commands must demonstrate before certification for deployment.

The MITT Study Area is characterized by a unique combination of attributes that make it a strategically important range complex for the services. These attributes include the following:

- Location within and adjacent to U.S. territory
- Ranges and operating areas on the islands of Guam, Rota, Saipan, Tinian, and Farallon de Medinilla (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 to homeported service units based at military installations on Guam and the CNMI
- Training support for deployed forces
- Ability to conduct joint and combined force exercises[8]
- Rehearsal area for Western Pacific contingencies

Due to the strategic location of Guam and the CNMI, and DoD's ongoing reassessment of the Western Pacific military alignment, there has been a dramatic increase in the importance of the MIRC as a training and testing venue and its capabilities to support required military training.

1.6 THE ENVIRONMENTAL PLANNING PROCESS

The Navy undertakes environmental planning for major Navy actions in accordance with applicable laws, regulations, and EOs. The two frameworks for environmental planning are the NEPA of 1969 and EO 12114. Congress enacted NEPA to ensure Federal agency planning and decision-making include consideration of environmental issues. Regulations for Federal agency implementation of the act were established by the President's Council on Environmental Quality. NEPA requires that federal agencies prepare an EIS if an agency's proposed action might significantly affect the quality of the human environment. As discussed in greater detail below, the Navy analyzes environmental effects and actions within 12 nautical miles (nm) under NEPA and those effects occurring beyond 12 nm under the provisions of EO 12114.

1.6.1 NATIONAL ENVIRONMENTAL POLICY ACT REQUIREMENTS

The first step in the NEPA process (Figure 1.6-1) for an EIS is to prepare a Notice of Intent to develop an EIS. The Notice of Intent is published in the *Federal Register* and provides an overview of the proposed action and the scope of the EIS. The Notice of Intent is also the first step in engaging the public.

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. The scoping process for an EIS is initiated by publication of the Notice of Intent in the *Federal Register* and local newspapers. During scoping, the public helps define and prioritize issues through public meetings and written comments.

[8] Joint and combined force exercises may include non-U.S. Forces.

Subsequent to the scoping process, a Draft EIS is prepared to assess the 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 EIS. The Draft EIS is circulated for review and comment; public meetings are also held.

The Final EIS addresses all public comments received on the Draft EIS. Responses to public comments may include correction of data, clarifications of and modifications to analytical approaches, and inclusion of additional data or analyses. In addition, the Final EIS/OEIS considers and incorporates any new relevant science that has become available since the Draft EIS/OEIS.

Finally, the decision-maker will issue a Record of Decision (ROD), no earlier than 30 days after a Final EIS is made available to the public.

1.6.2 Executive Order 12114

Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, in parallel with NEPA through a Draft OEIS and a Final OEIS, directs federal agencies to provide for informed environmental decision-making for major federal actions outside the United States and its territories. Presidential Proclamation 5928, issued 27 December 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 nm; however, the proclamation expressly provides that it does not extend or otherwise alter existing federal law or any associated jurisdiction, rights, legal interests, or obligations. Thus, as a matter of policy, the Navy analyzes environmental effects and actions within 12 nm under NEPA (an EIS) and those effects occurring beyond 12 nm under the provisions of EO 12114 (an OEIS). DoD Directive 6050.7, *Environmental Effects Abroad of Major Department of Defense Actions* and 32 Code of Federal Regulations (C.F.R.), Part 187, *Environmental Effects Abroad of Major Department of Defense Actions*, provides policy and procedures to enable DoD officials to be informed and take account of environmental considerations when authorizing or approving certain major federal actions that do significant harm to the environment of places outside the United States.

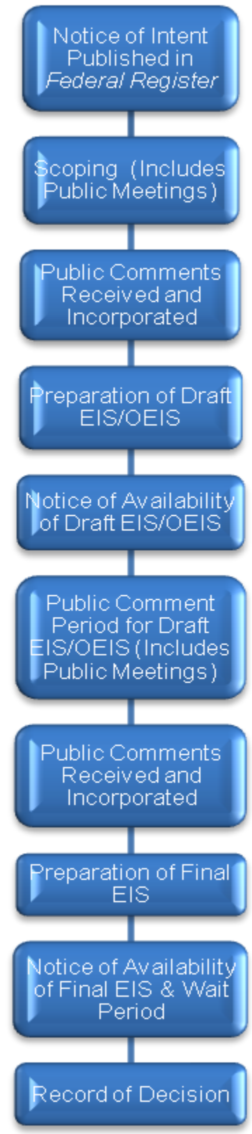

Figure 1.6-1: National Environmental Policy Act Process

1.6.3 Other Environmental Requirements Considered

The Navy must comply with all applicable federal environmental laws, regulations, and EOs, including, but not limited to, those listed below. Further information can be found in Chapter 3 (Affected Environment and Environmental Consequences) and Chapter 6 (Additional Regulatory Considerations).

- Antiquities Act
- Clean Air Act
- Clean Water Act
- Coastal Zone Management Act
- Endangered Species Act
- Magnuson-Stevens Fishery Conservation and Management Act

- Marine Mammal Protection Act
- Migratory Bird Treaty Act
- National Historic Preservation Act
- National Marine Sanctuaries Act
- Rivers and Harbors Act
- EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*
- EO 12962, *Recreational Fisheries*
- EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*
- EO 13089, *Coral Reef Protection*
- EO 13112, *Invasive Species*
- EO 13158, *Marine Protected Areas*
- EO 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*

1.7 Scope and Content

In this EIS/OEIS, the Navy assessed military readiness training and testing activities (activities conducted by all U.S. services: Navy, Marine Corps, Air Force, Army, and the Coast Guard[9]) that could potentially impact human and natural resources, especially marine mammals, sea turtles, and other marine resources, terrestrial resources, and cultural resources. The range of alternatives includes the No Action and other reasonable courses of action. In this EIS/OEIS, the Navy analyzed direct, indirect, cumulative, short-term, long-term, irreversible, and irretrievable impacts. The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this EIS/OEIS. Cooperating agencies include NMFS, the U.S. Air Force, and the U.S. Coast Guard. The NMFS is a cooperating agency because of its expertise and regulatory authority over marine resources. The U.S. Air Force is a cooperating agency as a stakeholder in the Study Area. The U.S. Coast Guard is a cooperating agency because of its expertise, its federal regulator authority, and its maritime law enforcement mission in the Study Area. The Navy will use this new analysis to comply with and consider all federal regulations (e.g., MMPA, ESA, Migratory Bird Treaty Act, Magnuson Stevens Fisheries Conservation and Management Act, and the Coastal Zone Management Act, as applicable, in all appropriate territories).

In accordance with Council on Environmental Quality Regulations, 40 C.F.R. §1505.2, the Navy will issue a ROD that provides the rationale for choosing one of the alternatives. The decision will be based on factors analyzed in this EIS/OEIS, including military training and testing objectives, best available science and modeling data, potential environmental impacts, and public interest.

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

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

- Chapter 1 describes the purpose of and need for the Proposed Action.
- Chapter 2 describes the Proposed Action, alternatives considered but eliminated in the EIS/OEIS, and alternatives to be carried forward for analysis in the EIS/OEIS.
- Chapter 3 describes the existing conditions of the affected environment and analyzes the potential impacts of the training and testing activities in each alternative.

[9] Joint training and testing activities may include foreign allies and partners.

- Chapter 4 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 describes the measures the Navy evaluated that could mitigate impacts to the environment.
- Chapter 6 describes how the Navy complies with other federal, state, and local plans, policies, and regulations.
- Chapter 7 includes a list of the EIS/OEIS preparers.
- Appendices provide technical information that supports the EIS/OEIS analyses and its conclusions.

1.9 Related Environmental Documents

The progression of NEPA/EO 12114 documentation for service activities has developed from planning individual range complex exercises and testing activities to theater assessment planning that spans multiple years and covers multiple range complexes. The following are publicly available documents related to Navy training and testing activities and may be referenced in this EIS/OEIS, as appropriate:

- *Environmental Assessment, Beddown of Training and Support Initiatives at Northwest Field Andersen Air Force Base, Guam*, June 2006 (Department of the Air Force 2006a)
- *Final Environmental Impact Statement, Establishment and Operation of an Intelligence, Surveillance, Reconnaissance, and Strike Capability Andersen Air Force Base, Guam*, November 2006 (Department of the Air Force 2006b)
- *Final Environmental Impact Statement, Guam and CNMI Military Relocation Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Army Air and Missile Defense Task Force*, July 2010 (U.S. Department of the Navy 2010b)
- *Addendum to the Guam and CNMI Military Relocation Final Environmental Impact Statement*, July 2010 (U.S. Department of the Navy 2010a)
- *Final Overseas Environmental Assessment, Notification for Air/Surface International Warning Areas*, June 2002 (Department of Defense 2002)
- *Mariana Islands Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement*, May 2010 (U.S. Department of the Navy 2010c)
- *Final Environmental Impact Statement, Military Training in the Marianas*, June 1999 (Department of Defense 1999a)
- *Record of Decision for Military Training in the Marianas*, July 1999 (Department of Defense 1999b)
- *Acoustic Impact Analysis for the North Pacific Acoustic Laboratory (NPAL) Philippine Sea 2010 Through 2011 Experiment*, February 2011 (U.S. Department of the Navy 2011)
- *Final Environmental Impact Statement for Designation of an Ocean Dredged Material Disposal Site Offshore of Guam*, March 2010 (U.S. Department of the Navy 2010e)
- *Mariana Islands Range Complex Airspace Final Environmental Assessment (EA)/Overseas Environmental Assessment (OEA) and Finding of No Significant Impact/Finding of No Significant Harm*, June 2013 (U.S. Department of the Navy 2013)
- *Final Supplemental Environmental Impact Statement/Overseas Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active Sonar (SURTASS LFA), June 2012* (U.S. Department of the Navy 2012)

1.10 Ongoing Environmental Documents in the Study Area

The following environmental documents relate to projects within the Study Area and are currently in the pre-planning or development of analyses stages. The MITT EIS/OEIS only analyzes the sustainment of current operations in the MITT Study Area on Guam and the CNMI; new programs or actions, as they relate to other uses of land space in the MITT Study Area, will be analyzed in these various documents. A summary of these projects are provided below and analyzed as appropriate in Chapter 4 (Cumulative Impacts).

- *Divert Activities and Exercises, Guam and Commonwealth of Northern Mariana Islands Environmental Impact Statement.* This EIS is being prepared by the U.S. Air Force to assess improvements to existing airports and associated infrastructure in the Mariana Islands in support of expanding mission requirements and to achieve divert capabilities in the western Pacific. The Notice of Intent was published in the Federal Register in September 2011, and the draft EIS was published in June 2012.
- *Guam and CNMI Military Relocation (2012 Roadmap Adjustments) Supplemental Environmental Impact Statement*. The Joint Guam Program Office is preparing a Supplemental EIS to the Guam and CNMI Military Relocation EIS. The proposed action is to construct and operate a Live-Fire Training Range Complex that allows for simultaneous use of all firing ranges to support training and operations on Guam for the relocated Marines (a force of approximately 5,000 Marines and approximately 1,300 dependents) on Guam and a main cantonment area of sufficient size and layout to provide military support functions, including family housing. In addition, the Proposed Action also includes the construction of utilities and infrastructure to support the range complex, main cantonment, and housing. The Notice of Intent to complete an EIS/OEIS was published in the *Federal Register* in February 2012. Three public scoping meetings were held on Guam on 17, 19, and 20 March 2012. The Draft Supplemental EIS was made available to the public on 18 April 2014.
- *CNMI Joint Military Training Environmental Impact Statement.* The U.S. Pacific Command (PACOM) is preparing an EIS to analyze the need to establish ranges and training areas in the Western Pacific to meet the consolidated unfilled training requirements of the Service Components. The additional training capabilities and capacity are needed to ensure that U.S. Forces in the PACOM area of responsibility are capable of meeting their U.S. Code Title 10 responsibilities to maintain, equip, and train combat-ready forces to meet U.S. mission for military readiness in the region. The Notice of Intent to complete an EIS was published in the *Federal Register* on 14 March 2013.

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2 Description of Proposed Action and Alternatives

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2 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

The United States (U.S.) Department of the Navy's (Navy's) Proposed Action is to conduct training and testing activities, including the use of active sonar and explosives in the Mariana Islands Range Complex (MIRC), throughout the in-water areas around the MIRC, and in the transit corridor between the MIRC and the Hawaii Range Complex (HRC). The Proposed Action includes activities such as sonar maintenance and gunnery exercises that are conducted concurrently with ship transits and may occur outside the geographic boundaries of a Navy range complex. The Proposed Action also includes pierside sonar activity that is conducted as part of overhaul, modernization, maintenance, and repair activities, as well as land-based training activities on Guam and the Commonwealth of the Northern Mariana Islands (CNMI).

Through this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), the Navy will:

- Reassess the environmental analyses of military training and testing activities contained in the *2010 Mariana Islands Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement* (U.S. Department of the Navy 2010). This reassessment supports the Navy's application for reauthorization of incidental takes of marine mammals under the Marine Mammal Protection Act (MMPA) and incidental takes of threatened and endangered marine and terrestrial species under the Endangered Species Act (ESA).
- Adjust baseline training and testing activities from current levels to the level needed to support military training and testing requirements proposed to begin in 2015. As part of the adjustment, the Navy proposes to account for other activities and sound sources not addressed in the previous analyses.
- Analyze the potential environmental impacts of training and testing activities in additional at-sea areas (areas not covered in previous documents) where training and testing historically occurs, including Navy ports, and the transit corridor.
- Update the environmental impact analyses in the previous documents to account for force structure changes, including those resulting from the development, testing, and use of weapons, platforms, and systems that will be operational by 2020.
- Implement enhanced range capabilities.
- Update environmental analyses with the best available science and most current acoustic analysis methods to evaluate the potential effects of training and testing activities on the marine environment.

In this chapter, the Navy will build upon the purpose and need to train and test by describing the Study Area and identifying the primary mission areas under which these activities are conducted. Each warfare community conducts activities that uniquely contribute to the success of a primary mission area (described in Section 2.2, Primary Mission Areas). Each primary mission area requires unique skills, sensors, weapons, and technologies to accomplish the mission. For example, in the primary mission area of anti-submarine warfare, surface, submarine, and aviation communities each utilize different skills, sensors, and weapons to locate, track, and eliminate submarine threats. The testing community contributes to the success of each mission area by anticipating and identifying technologies and systems that respond to the needs of the warfare communities. As each warfare community develops its basic skills and integrates them into combined units and strike groups, the intricacies of communication, coordination and planning, movement and positioning of naval forces and targeting/delivery of weapons become increasingly complex. This complexity creates a need for coordinated training and testing between the fleets and systems commands.

In order to address the activities needed to accomplish training and testing in this EIS/OEIS, the Navy has broken down each training and testing activity into basic components that are analyzed for their potential environmental impacts. The training and testing activities are captured in tables and the discussion that follows. Additionally, Chapter 2 provides detailed discussion of how the training and testing activities occur and the platforms, weapons, and systems that are required to complete the activities.

Chapter 2 is organized into eight sections.

- Section 2.1 outlines the area where these activities would occur.
- Section 2.2 outlines the primary mission areas.
- Section 2.3 provides information on sonar, ordnance and munitions, and targets utilized during training and testing activities.
- Section 2.4 outlines the proposed training and testing activities.
- Section 2.5 outlines the process to develop the alternatives to the Proposed Action.
- Sections 2.6, 2.7, and 2.8 outline the No Action Alternative and the Action Alternatives proposed in this EIS/OEIS.

The proposed activities are complex and therefore, the Navy has prepared several appendices that provide a greater level of detail. These appendices will be referenced in the appropriate chapters.

2.1 Description of the Mariana Islands Training and Testing Study Area

The Mariana Islands Training and Testing (MITT) Study Area is composed of the established ranges (at-sea ranges and land based training areas on Guam and CNMI), operating areas, and special use airspace in the region of the Mariana Islands that are part of the MIRC and its surrounding seas, and includes a transit corridor.[1] The transit corridor is outside the geographic boundaries of the MIRC and is a direct route across the high seas for Navy ships in transit between the MIRC and the HRC. The Proposed Action also includes pierside sonar maintenance and testing alongside Navy piers located in Inner Apra Harbor. The MITT Study Area is depicted in Figure 2.1-1.

[1] Vessel transit corridors are the routes typically used by Navy ships to traverse from one area to another. The route depicted in Figure 2.1-1 is a direct route between the MIRC and the HRC, making it a quick and fuel-efficient transit. The depicted transit corridor is notional and may not represent actual routes used. Actual routes navigated are based on a number of factors including, but not limited to, weather and training; however, the corridor represents the environment potentially impacted by the Proposed Action.

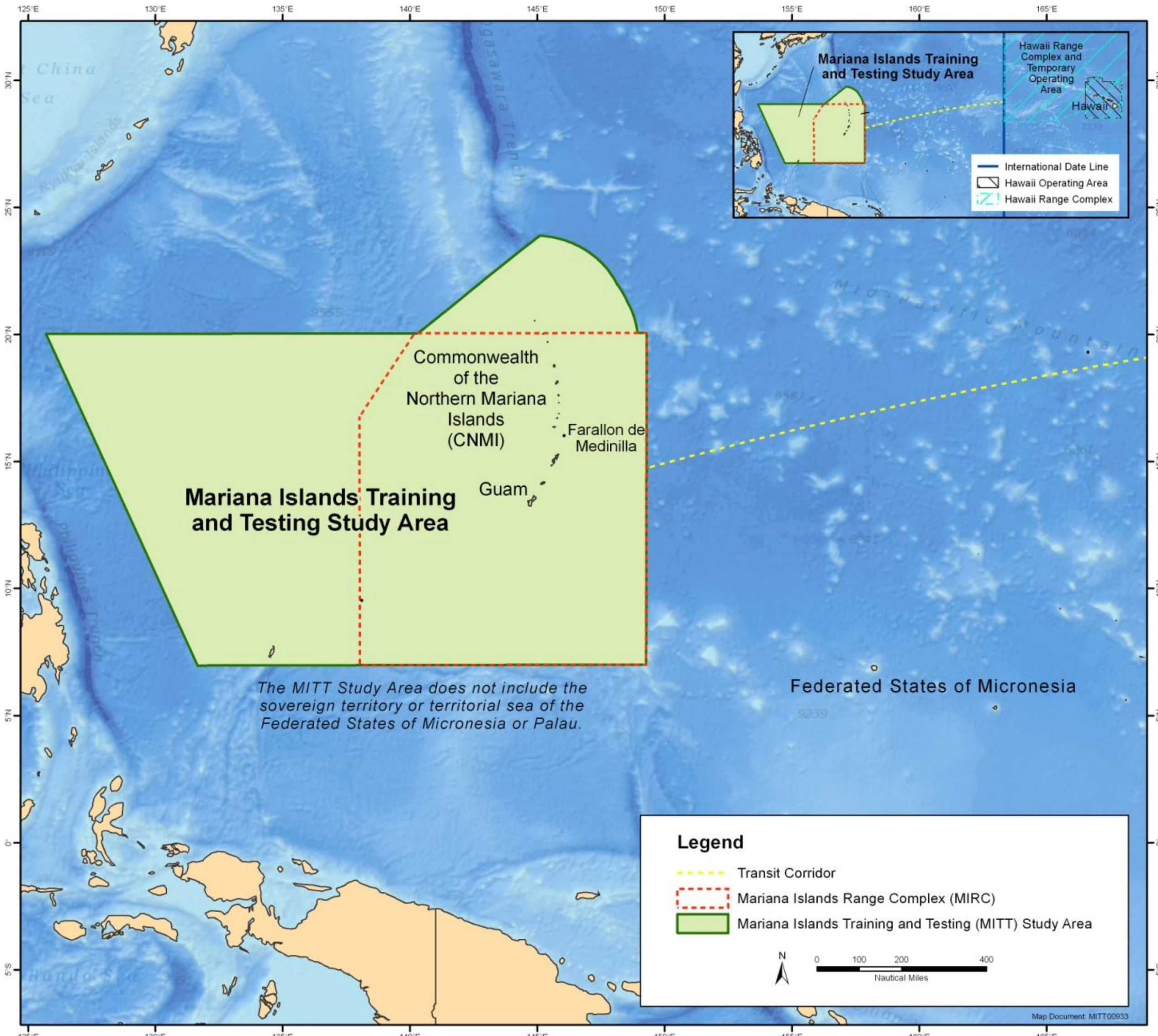

Figure 2.1-1: Mariana Islands Training and Testing Study Area

A range complex is a designated set of specifically bounded geographic areas that encompasses a water component (above and below the surface) and airspace, and may encompass a land component where training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occurs. Range complexes include established ocean operating areas and special use airspace, which may be further divided to provide better control of the area and activities for safety reasons.

- **Operating Area.** An ocean area defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace. Operating areas may include the following:
    - **Danger Zones.** A danger zone is a defined water area used for target practice, bombing, rocket firing, or other especially hazardous military activities. Danger zones are established pursuant to statutory authority of the Secretary of the Army and are administered by the Army Corps of Engineers. Danger zones may be closed to the public

on a full-time or intermittent basis (Title 33 Code of Federal Regulations [C.F.R.] Part 334).

  - **Restricted Areas.** A restricted area is a defined water area for the purpose of prohibiting or limiting public access to the area. Restricted areas generally provide security for Government property and/or protection to the public from the risks of damage or injury arising from the Government's use of that area (33 C.F.R. 334).
  - **Safety Zones.** A Safety Zone is a water area, shore area, or water and shore area to which, for safety or environmental purposes, access is limited to authorized persons, vehicles, or vessels. It may be stationary and described by fixed limits or it may be described as a zone around a vessel in motion. Safety zones are established pursuant to statutory authority of the U.S. Coast Guard. Safety zones may be closed to the public on a full-time or temporary basis (33 C.F.R. 165).
  - **Surface Danger Zones.** A Surface Danger Zone is the surface and airspace designated within the range complex for vertical and lateral containment of projectiles, fragments, debris, and components resulting from the firing, launching, or detonation of weapon systems to include explosives and demolitions. The Surface Danger Zone is a depiction of the mathematically predicted area a projectile will return to earth either by direct fire or ricochet. Surface Danger Zones are calculated by the range operator using safety programs or tables for each unique live fire training event, and location; hence, they are not permanently charted.
  - **Exclusion Zones.** The purpose of the Exclusion Zone is the protection of unauthorized personnel from blast overpressure and fragmentation hazards from ordnance disposal and explosive charges. It is the minimum separation distance between the exploding device or ordnance and unauthorized personnel. The range operator will delay conduct of a live-fire event until the Exclusion Zone has been cleared.
- **Special Use Airspace.** 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). Types of special use airspace most commonly found in range complexes include the following:
  - **Restricted Areas.** Airspace where aircraft are subject to restriction due to the existence of unusual, often invisible hazards (e.g., release of ordnance) to aircraft. Some areas are under strict control of the Department of Defense (DoD), and some are shared with non-military agencies.
  - **Military Operations Areas.** Airspace with defined vertical and lateral limits established for the purpose of separating or segregating certain military training activities from instrument flight rules traffic and to identify visual flight rules traffic where these activities are conducted.
  - **Warning Area.** Areas of defined dimensions, extending from 3 nautical miles (nm) outward from the coast of the United States, which serve to warn nonparticipating aircraft of potential danger.
- **Air Traffic Control Assigned Airspace.** While not designated as special use airspace, Air Traffic Control Assigned Airspace (ATCAA) offers important capability for supporting training and testing activity. It is used to contain specified activities, such as military flight training, that are segregated from other instrument flight rules air traffic.

The MITT Study Area includes the MIRC land training areas and at-sea operating areas that were previously addressed in the MIRC EIS/OEIS (May 2010) with modifications to the special use air space that were addressed in the MIRC Airspace Environmental Assessment (EA)/Overseas EA (OEA) (U.S.

Department of the Navy 2013), and the seaward extensions to the northern and western edges of the MIRC, the transit corridor, and Navy pierside locations in the Apra Harbor Naval Complex.

2.1.1 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 (CNMI), 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.

2.1.1.1 Special Use Airspace and Air Traffic Controlled Assigned Airspace

The MIRC is anticipated to include approximately 70,000 nm^2 of special use airspace and ATCAA (once Federal Aviation Administration [FAA] rule-making and non-rule making airspace changes are complete[2]). As depicted in Figure 2.1-2 and Figure 2.1-3, this airspace is almost entirely over the ocean (except ATCAA 6 and W-13A) and includes warning areas, ATCAAs, and restricted areas.

- Warning Area (W)-517 and W-12 include approximately 11,769 nm^2 of special use airspace (Figure 2.1-2 and Figure 2.1-3); W-11 (A/B) is approximately 10,467 nm^2 of special use airspace, and W-13 (A/B/C) is approximately 13,752 nm^2 of special use airspace.
- The ATCAAs of the MIRC account for more than 28,750 nm^2 of airspace and includes ATCAA 5 and ATCAA 6 (Figure 2.1-2).
- The restricted area airspace over or near land areas within the MIRC makes up 452 nm^2 of special use airspace and includes restricted areas (R)-7201 and R-7201A which extends in a 12 nm radius around Farallon de Medinilla (FDM) (Figure 2.1-2 and Figure 2.1-4).

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 includes designated sea and undersea space training sites to 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 (Figure 2.1-3) is special use airspace where the sea space underneath is also 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 §§431–433), lie within the MIRC. 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).

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[2] The MIRC Airspace EA/OEA tiered off from the MIRC EIS/OEIS; the Navy analyzed the potential impacts of redesignating ATCAAs in the MITT Study Area with Warning Areas and expanding the special use airspace around FDM. In that EA/OEA, no new training or testing events were proposed. The EA/OEA concluded that no significant impacts to the environment would occur as a result of the airspace redesignation and expansion. The FAA has rule-making and non-rule making authority for the airspace redesignation and expansion, and the MIRC Airspace EA/OEA supported the FAA in its rule-making and non-rule making process to establish special use airspace.

The MIRC Airspace EA/OEA proposed and analyzed a Danger Zone around FDM. The Army Corps of Engineers has rule-making authority for Danger Zone establishment. The pending Danger Zone rule for FDM extends out 12 nm from a center point on FDM and over a range hazard area of approximately 452 nm^2 (Figure 2.1-4).

2.1.1.3 Land

Commander Joint Region Marianas provides executive level installation management support to all DoD components and tenants through assigned regional installations on Guam and the Commonwealth of the Northern Mariana Islands in support of training in the Marianas, including coordination with Northern Mariana Islands Commonwealth Port Authority for logistic and operational support of DoD aircraft and vessels; acts as the interface between the Navy and the civilian community; ensures compliance with all environmental laws and regulations, safety procedures, and equal opportunity policy; and performs other functions and tasks as assigned.

Guam. The Navy has control of approximately 28 square miles ($mi.^2$) (72.5 square kilometers [km^2]) of land in noncontiguous properties on Guam. There are five Navy annexes: Main Base (which includes Apra Harbor Naval Complex and Main Base/Polaris Point) (Figure 2.1-5), Naval Base Guam Munitions Site (Figure 2.1-6); Hospital Annex/Nimitz Hill, Naval Base Guam Telecommunications Site (Figure 2.1-7), and Naval Base Guam Barrigada (Figure 2.1-8).

Andersen Air Force Base, one of the largest U.S. Air Force airfields, is located in the northern portion of the island of Guam. Andersen Air Force Base includes the main base and Northwest Field which covers 24.5 $mi.^2$ (63.5 km^2), Andersen South 3.2 $mi.^2$ (8.3 km^2), and Andersen Barrigada Annex 0.7 $mi.^2$ (1.8 km^2) (Figure 2.1-9).

Commonwealth of the Northern Mariana Islands. No DoD personnel are permanently stationed in the CNMI, with the exception of a U.S. Army Reserve unit located on Saipan.

- **FDM.** FDM is a rocky and uninhabited island, approximately 1.7 miles (mi.) (2.7 kilometer [km]) long and 0.3 mi. (0.5 km) wide (Figure 2.1-10). The DoD leases FDM for use as a live and inert gunnery, missile, and bombing range.
- **Tinian.** Tinian has a land area of approximately 39 $mi.^2$ (101 km^2). The DoD leases approximately 15,347 contiguous acres (6,210.7 hectares) of northern Tinian (the Military Lease Area) for field training (Figure 2.1-11). The Military Lease Area is further divided into the Exclusive Military Use Area and the Leaseback Area.
- **Saipan.** Approximately 0.28 $mi.^2$ (0.73 km^2) on Tanapag Harbor is leased by the DoD**.** The Army Reserve center is located in Garapan (Figure 2.1-11).
- **Rota.** Rota is approximately 11 mi. (17.7 km) long and 3 mi. (4.8 km) wide (Figure 2.1-12). Training on Rota is scheduled with Joint Region Marianas and coordinated with Rota officials for proposed training areas and activities. Training activities conducted on Rota typically include special warfare training and combat search and rescue training.

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

In addition to the MIRC, the MITT Study Area is expanded for analysis in Alternative 1 and Alternative 2 and includes the area to the north of the MIRC that is within the Exclusive Economic Zone of the Commonwealth of the Northern Mariana Islands and the areas to the west of the MIRC (Figure 2.1-1). The MITT Study Area also includes a transit corridor, which is a direct route between the MIRC and the HRC.

Although not part of any defined range complex, the transit corridor is important to the Navy in that it provides adequate air, sea, and undersea space in which vessels and aircraft conduct training and some sonar maintenance and testing while in transit.

The transit corridor is defined by a great circle route (e.g., shortest distance) between the MIRC and the HRC. While in transit and along the corridor, vessels and aircraft would, at times, conduct basic and routine unit level training such as gunnery and sonar training as long as the training does not interfere with the primary objective of reaching their intended destination. Ships also conduct sonar maintenance, which includes active sonar transmissions.

2.1.3 Pierside Locations and Apra Harbor

The Study Area includes pierside locations in the Apra Harbor Naval Complex where surface ship and submarine sonar maintenance testing occur. For purposes of this EIS/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 and shipyard (Figure 2.1-5).

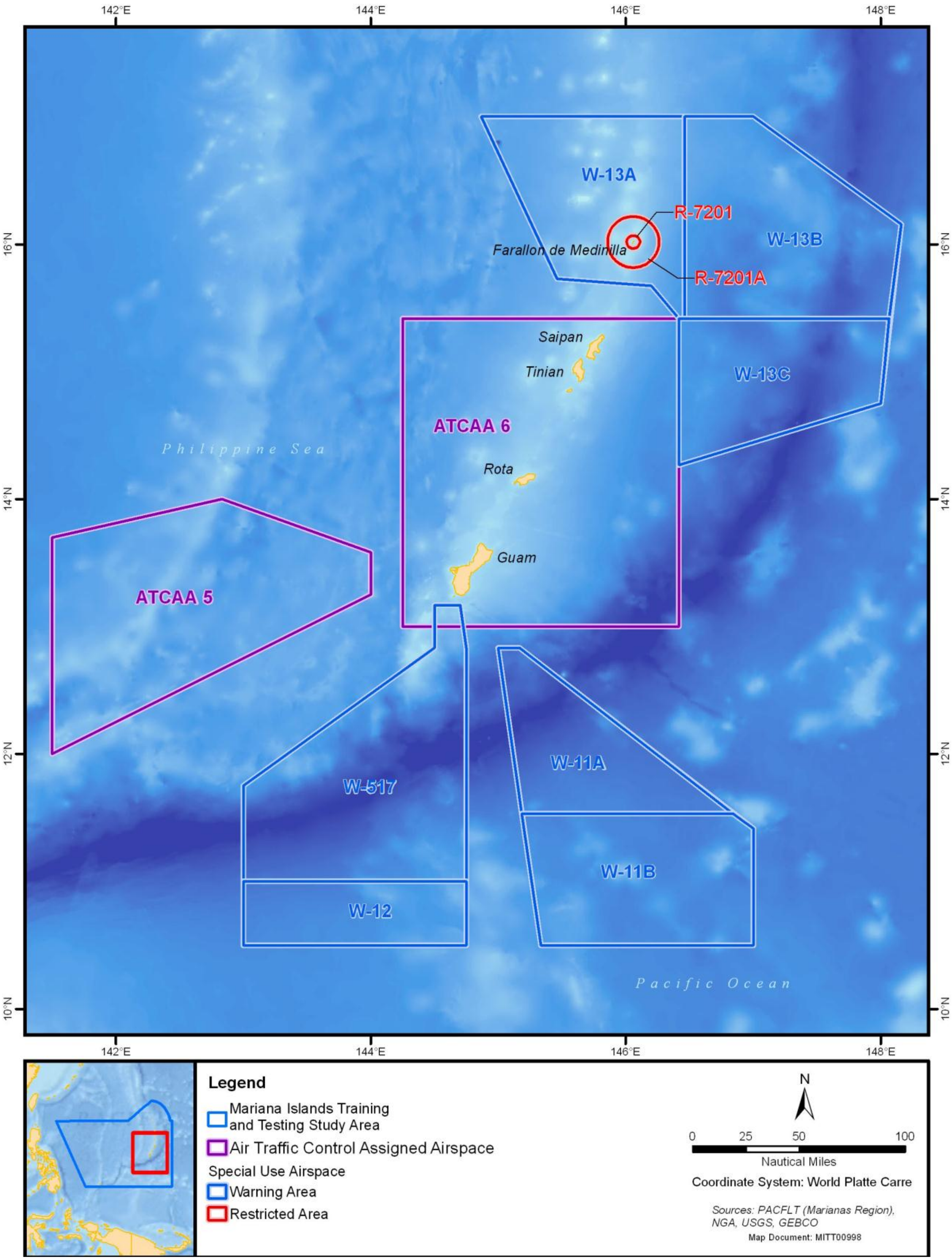

Figure 2.1-2: Mariana Islands Range Complex Airspace

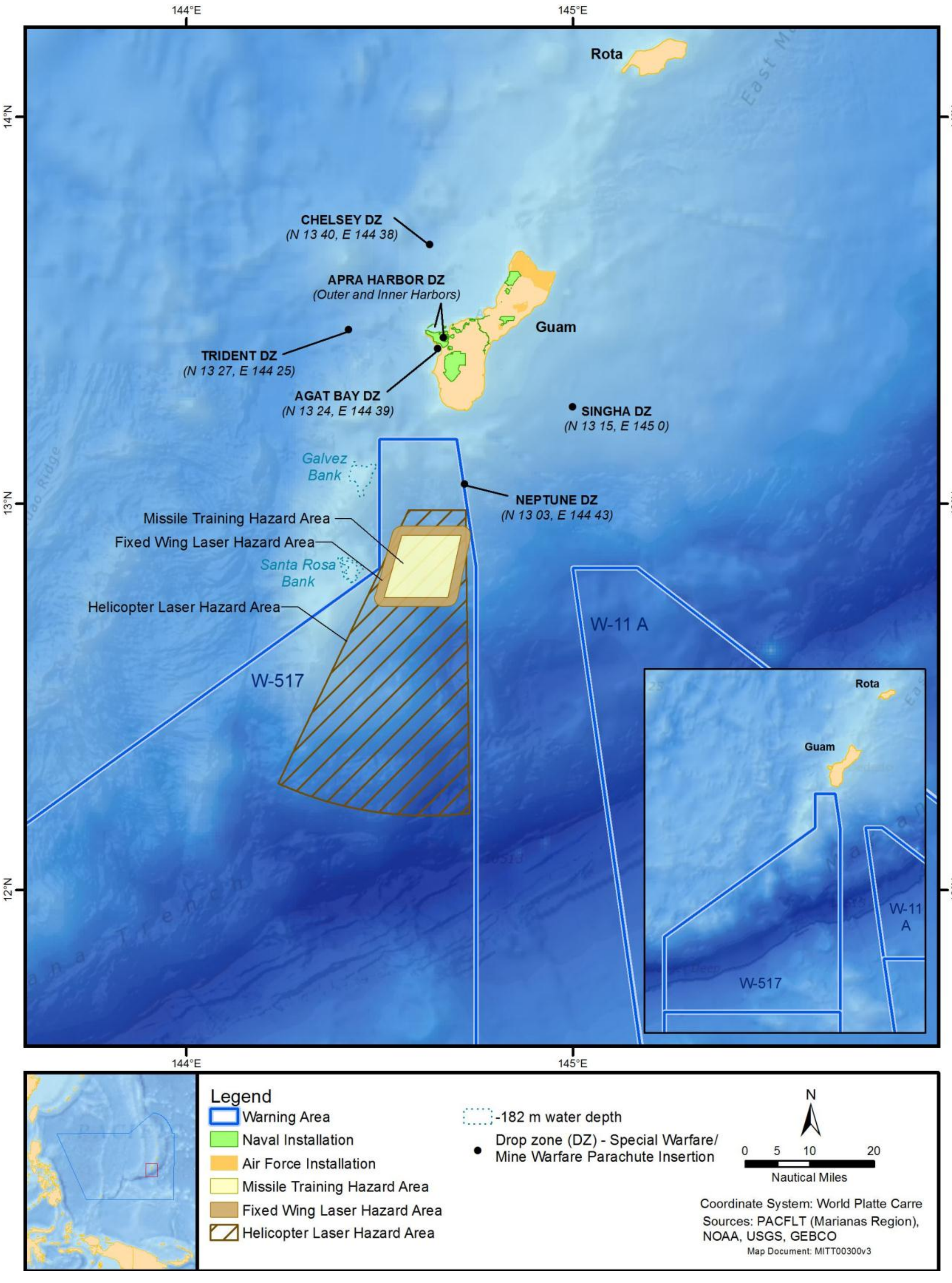

Figure 2.1-3: Warning Area 517

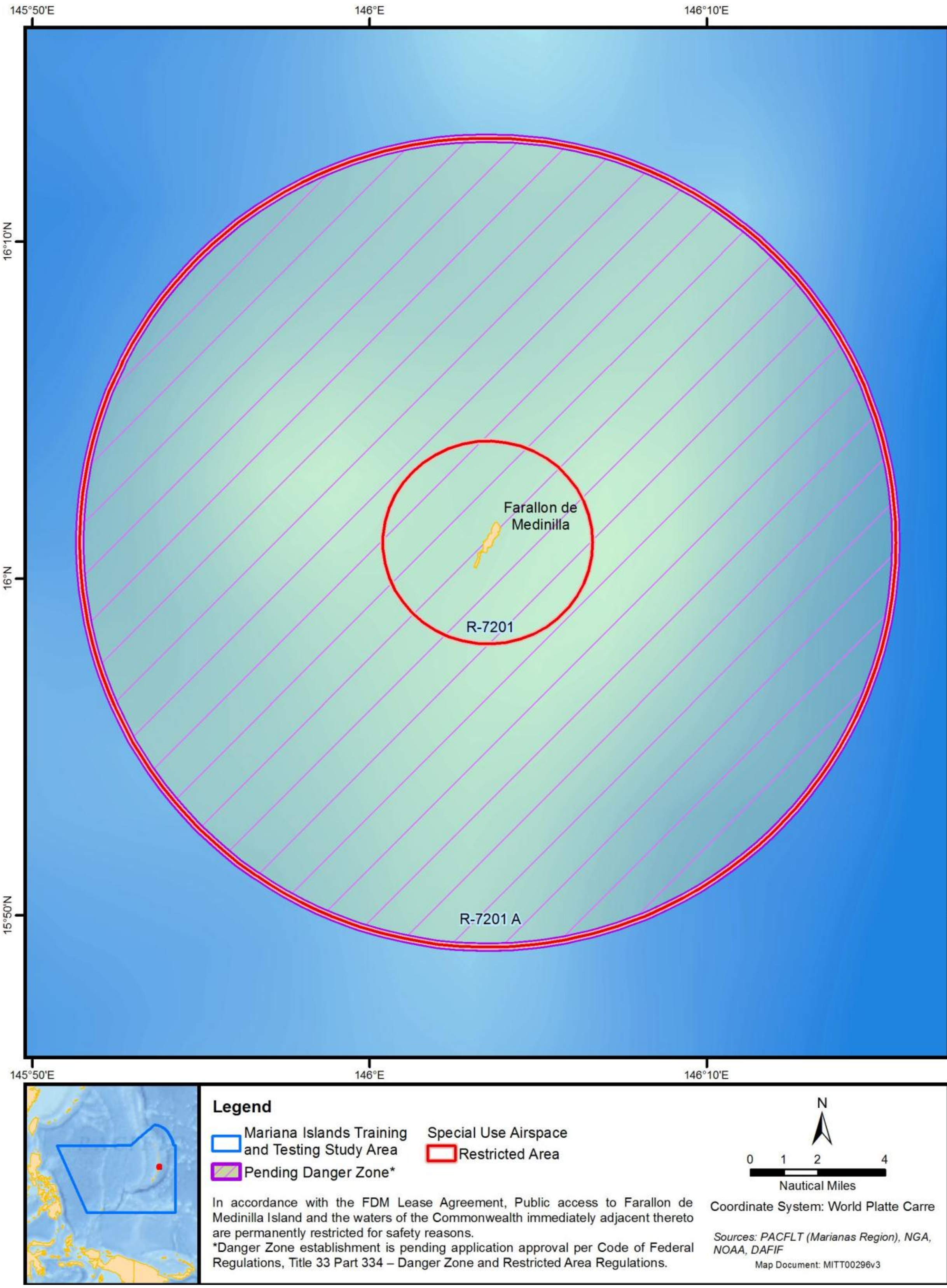

Figure 2.1-4: Farallon de Medinilla Restricted Area 7201, 7201A, and Danger Zone

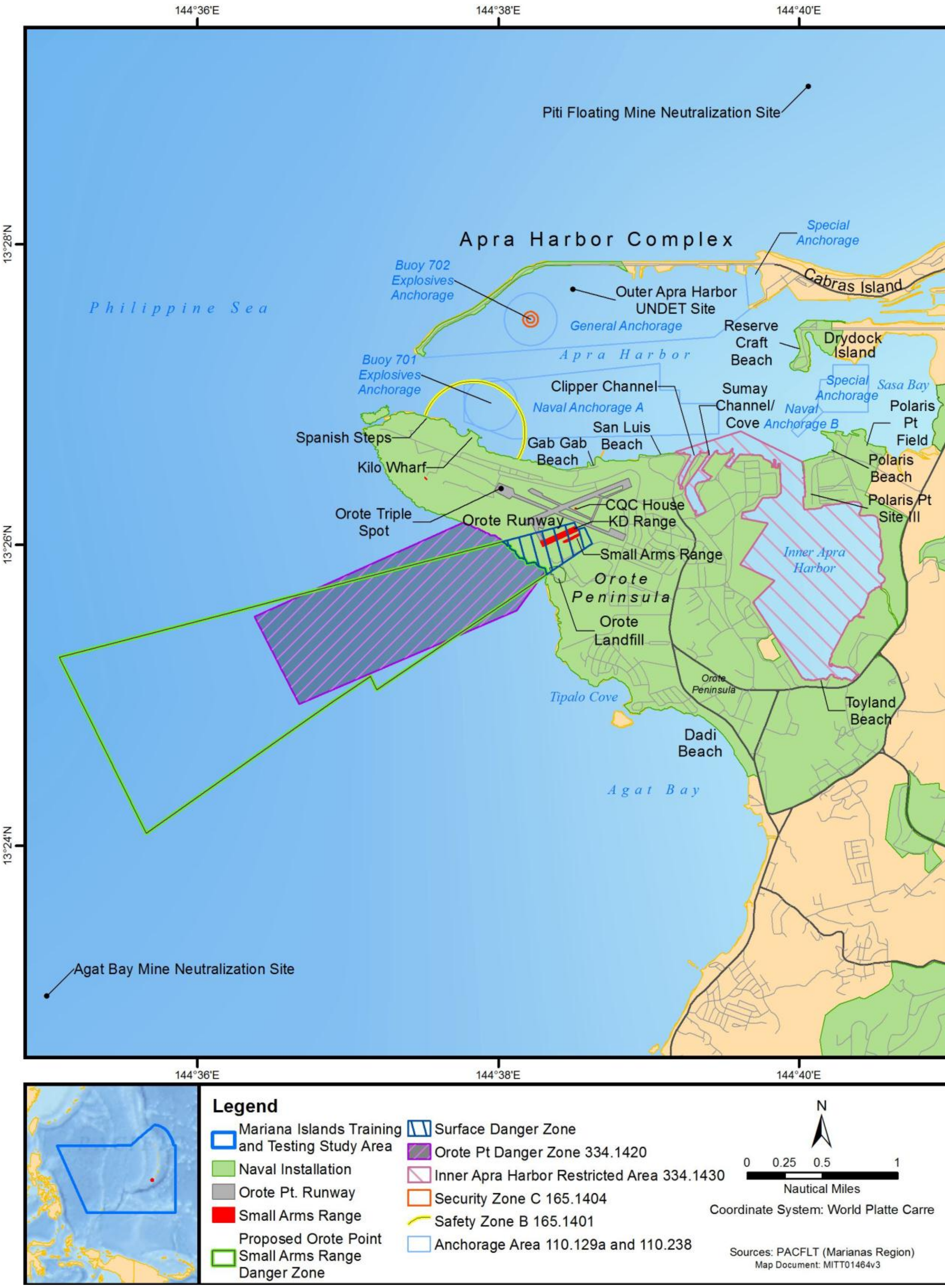

Figure 2.1-5: Apra Harbor Naval Complex (Main Base) and Main Base/Polaris Point

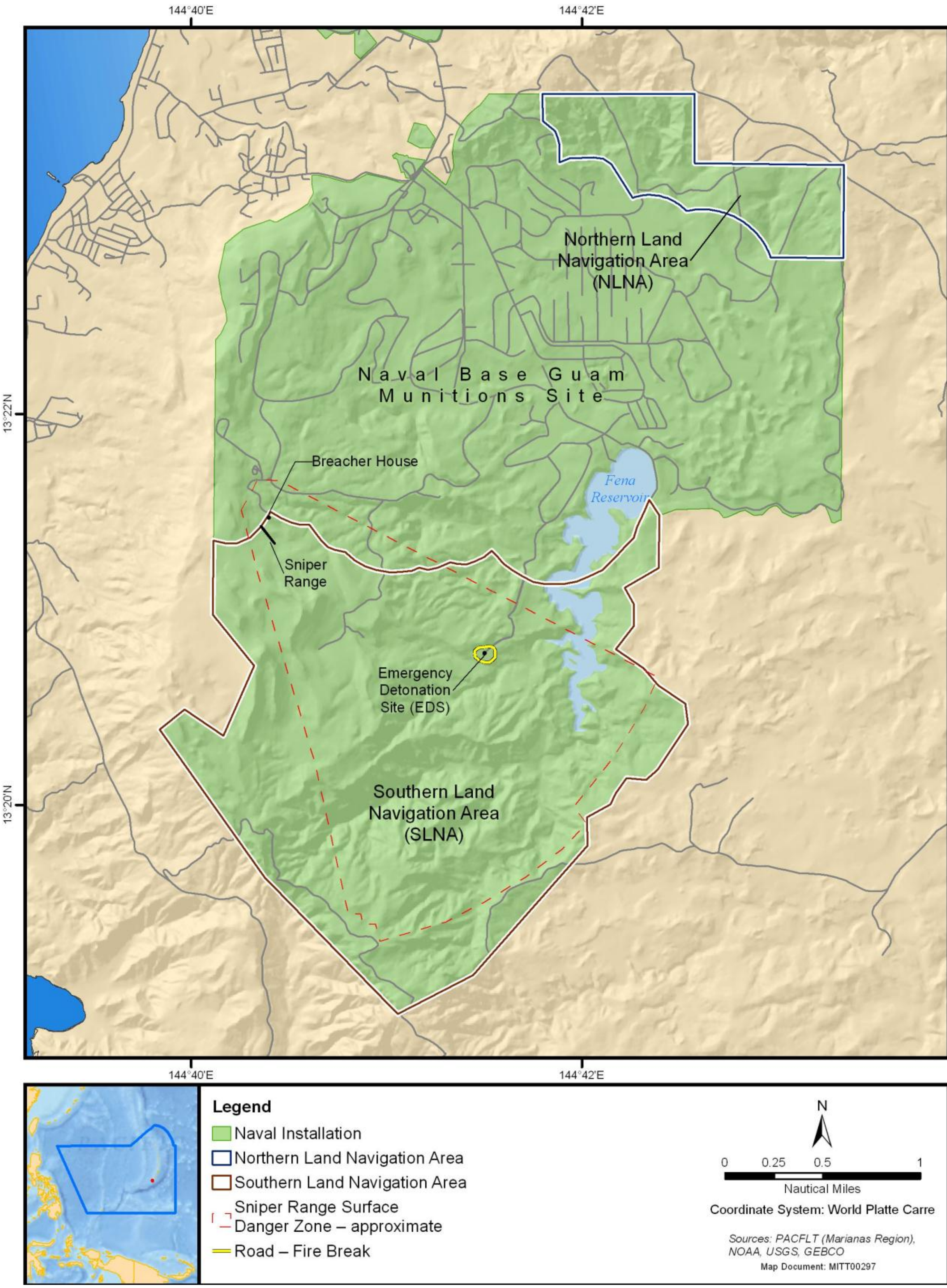

Figure 2.1-6: Naval Base Guam Munitions Site

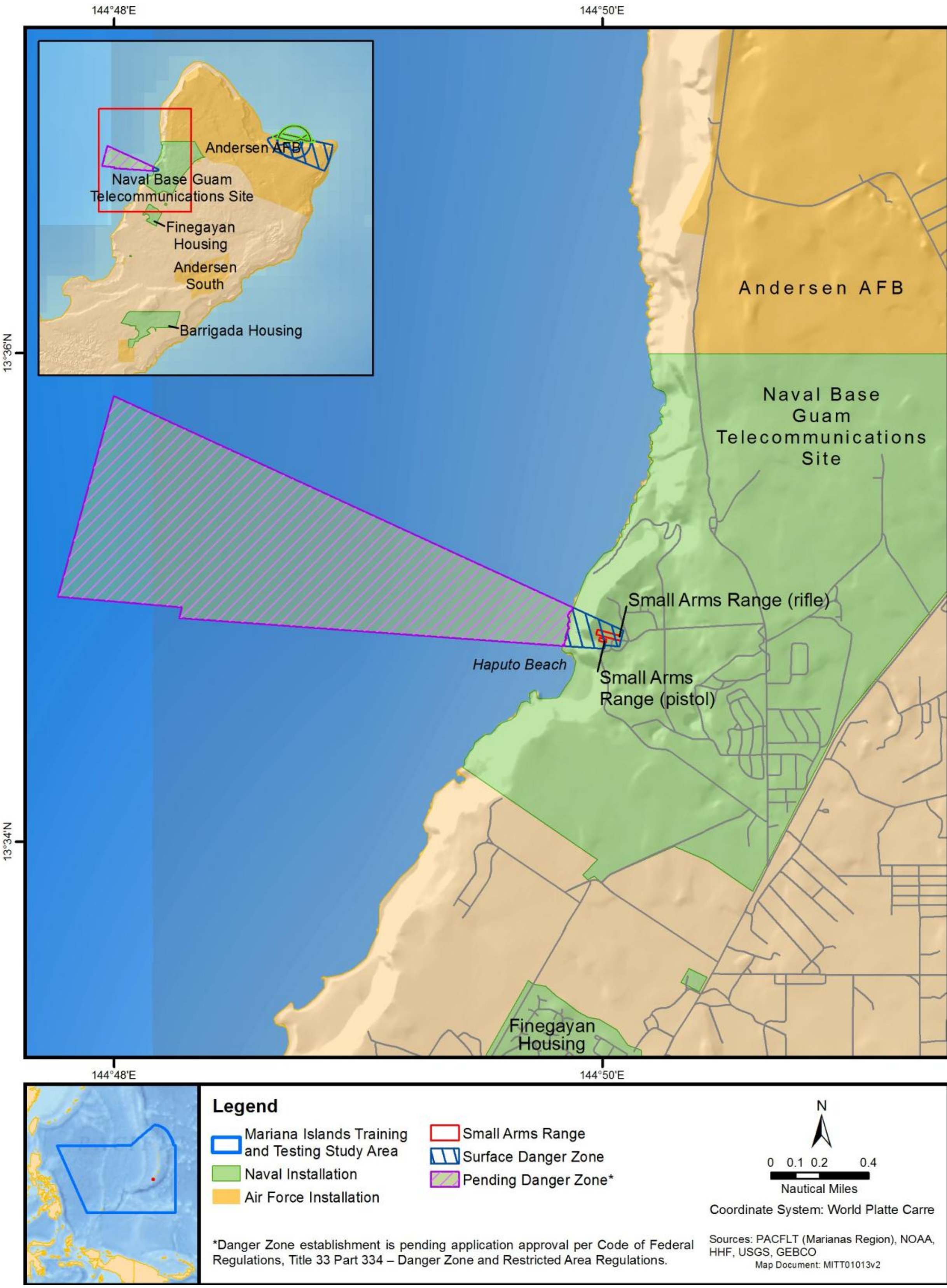

Figure 2.1-7: Naval Base Guam Telecommunications Site (Finegayan)

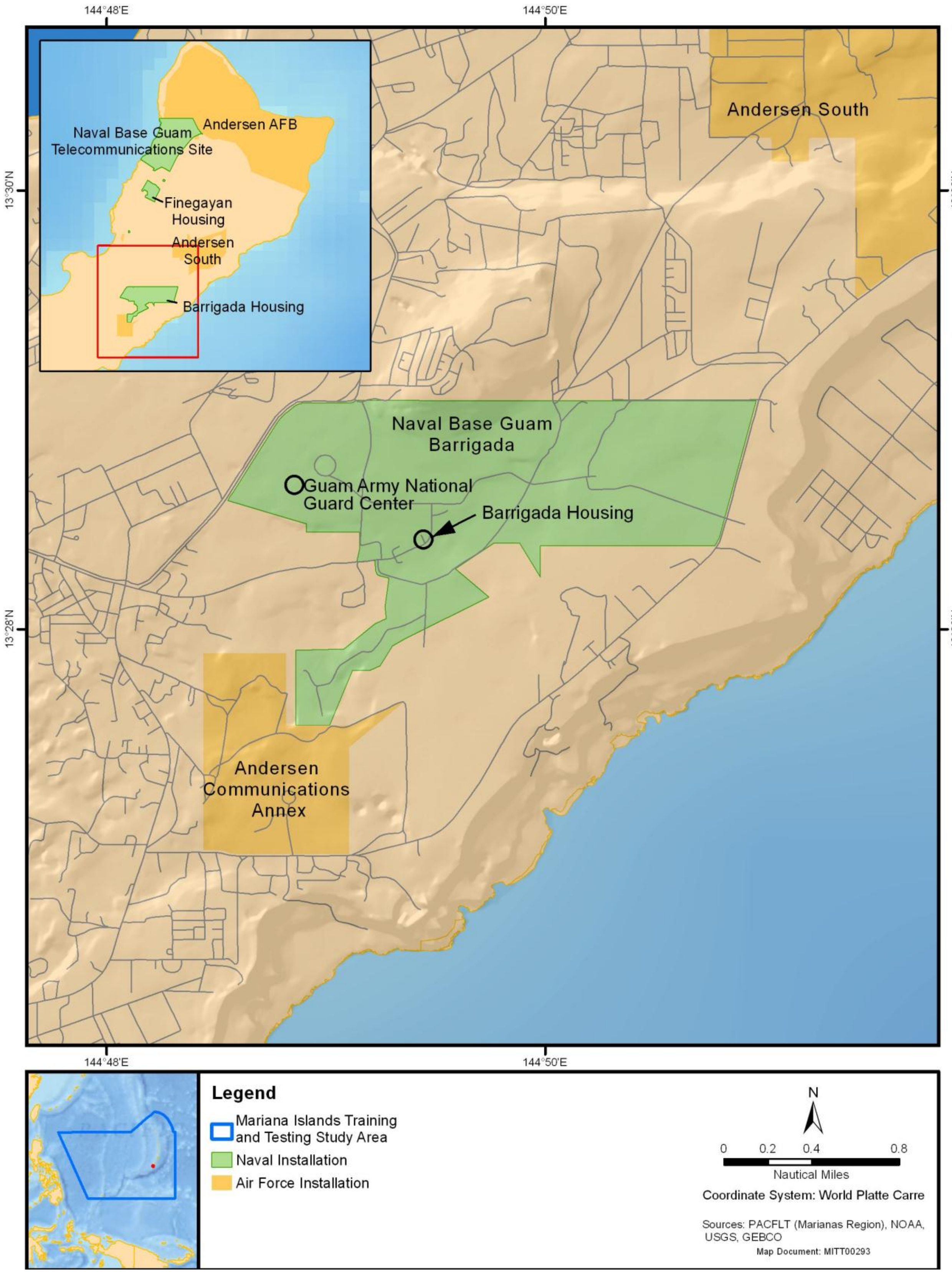

Figure 2.1-8: Naval Base Guam Barrigada

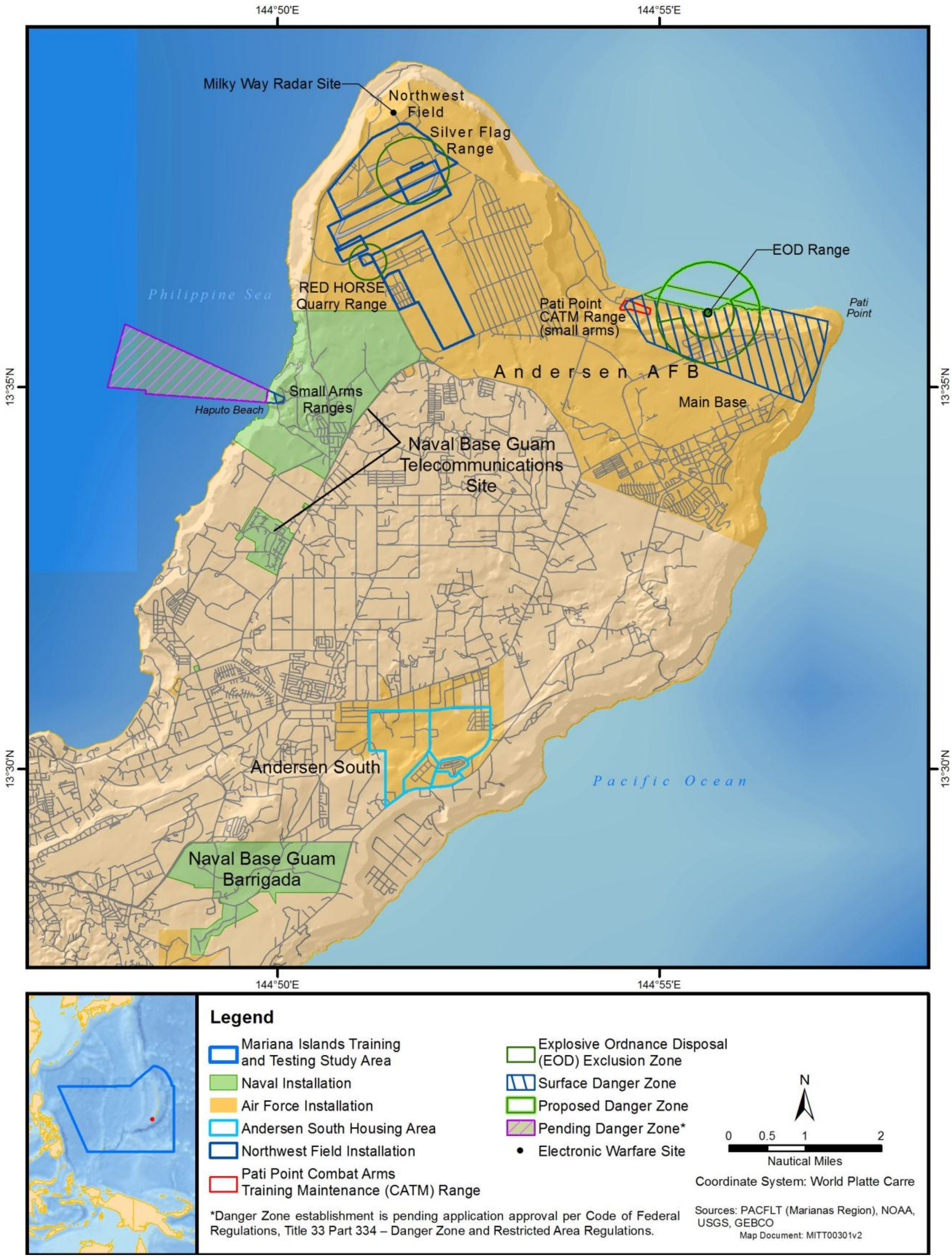

Figure 2.1-9: Andersen Air Force Base

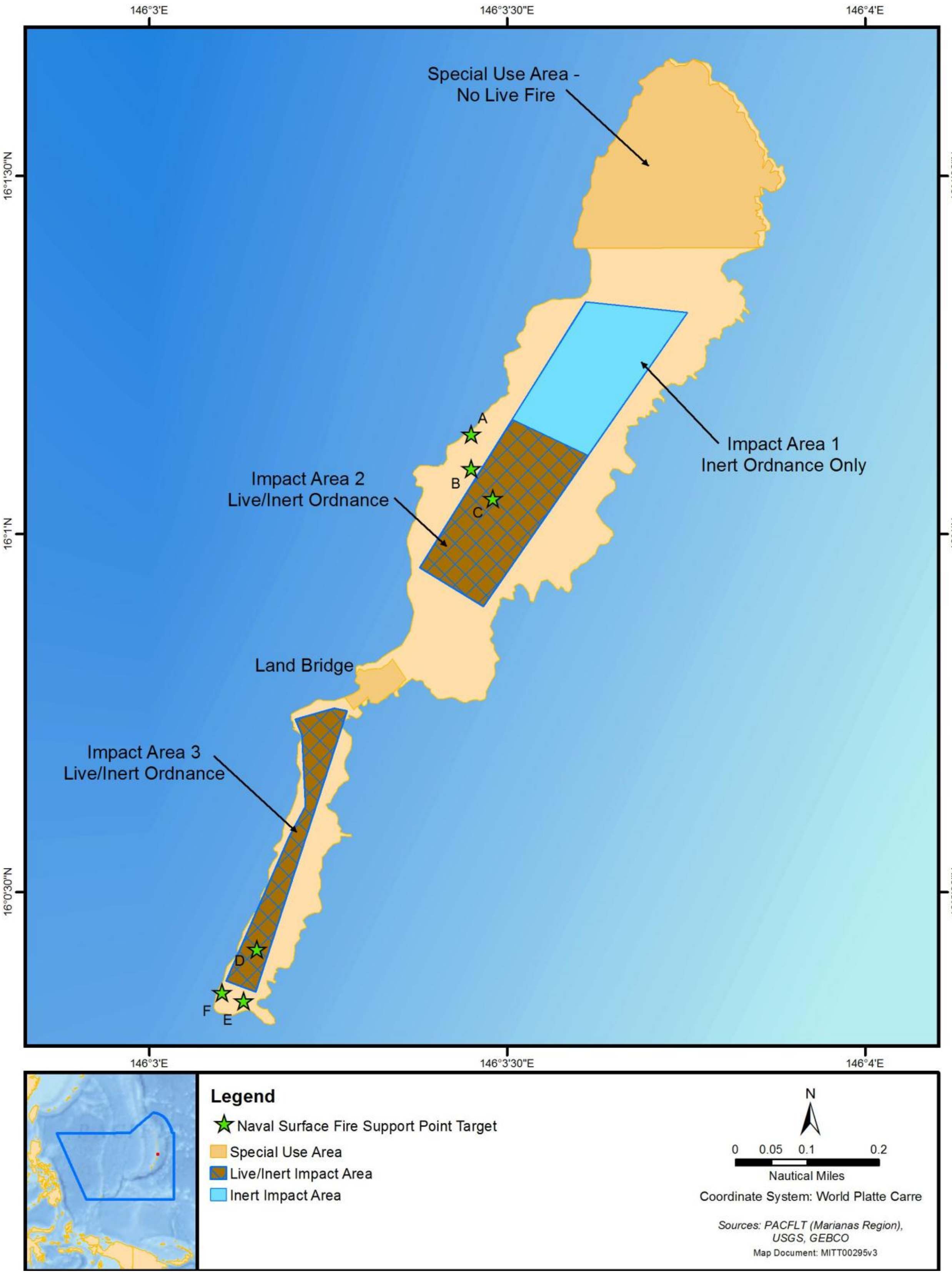

Figure 2.1-10: Farallon de Medinilla

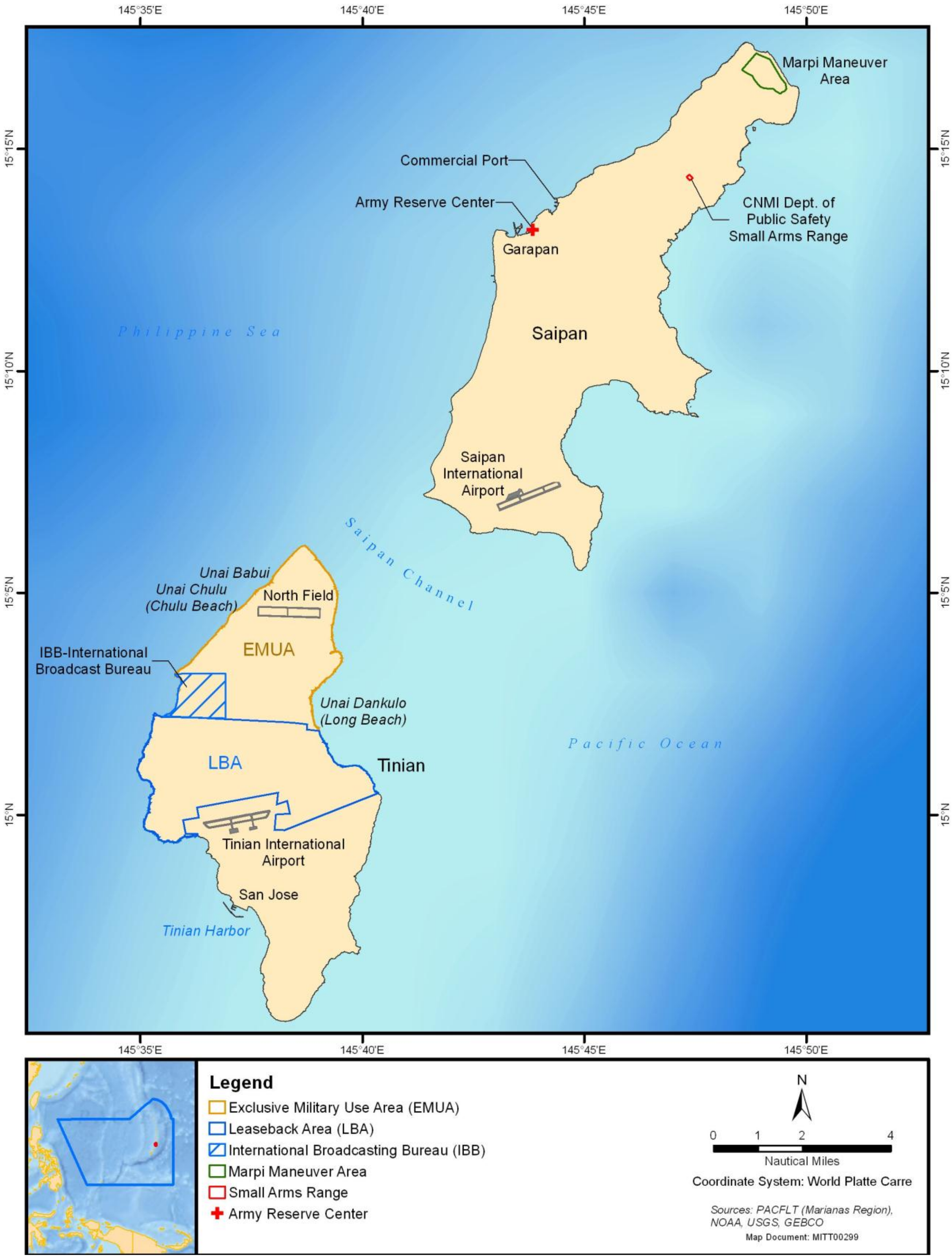

Figure 2.1-11: Tinian and Saipan

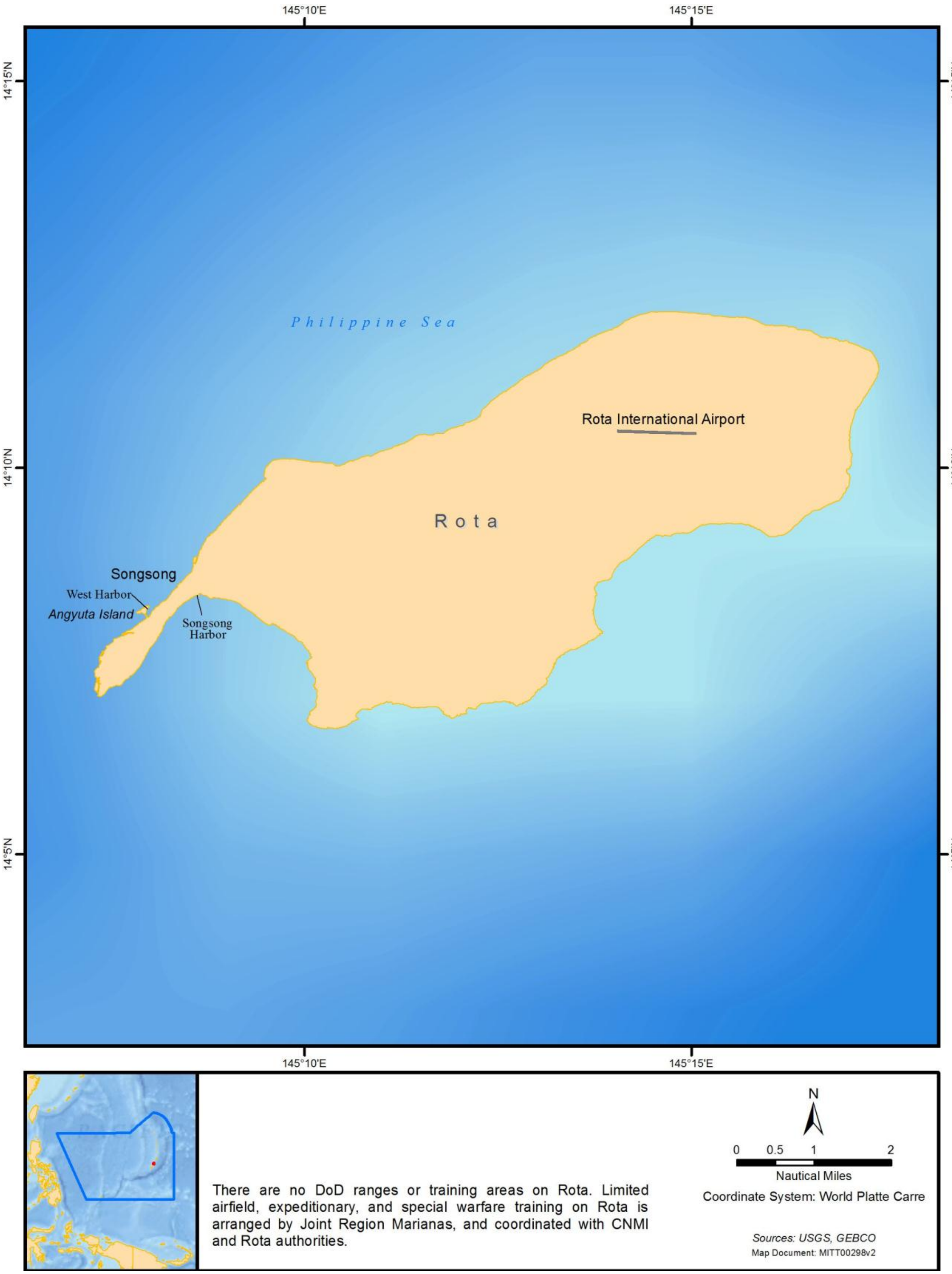

Figure 2.1-12: Rota

2.2 Primary Mission Areas

The Navy categorizes training activities into functional warfare areas called primary mission areas. Training activities fall into the following eight primary mission areas:

- Anti-Air Warfare
- Amphibious Warfare
- Strike Warfare
- Anti-Surface Warfare
- Anti-Submarine Warfare
- Electronic Warfare
- Mine Warfare
- Naval Special Warfare

Most training activities addressed in this EIS/OEIS are categorized under one of these primary mission areas; those activities that do not fall within one of these areas are in a separate category. Each warfare community (surface, subsurface, aviation, and special warfare) may train in some or all of these primary mission areas. The research and acquisition community also categorizes some, but not all, of its testing activities under these primary mission areas.

The sonar, ordnance, munitions, and targets used in the training and testing activities are described in Section 2.3 (Descriptions of Sonar, Ordnance/Munitions, Targets, and Other Systems Employed in Mariana Islands Training and Testing Events). A short description of individual training and testing activities is provided in Tables 2.4-1 through 2.4-4. More detailed descriptions of the training and testing activities are provided in Appendix A (Training and Testing Activities Descriptions).

2.2.1 Anti-Air Warfare

The mission of anti-air warfare is to destroy or reduce enemy air and missile threats (including unmanned airborne threats) and serves two purposes: to protect U.S. forces from attacks from the air and to gain air superiority. Anti-air warfare also includes providing U.S. forces with adequate attack warnings, while denying hostile forces the ability to gather intelligence about U.S. forces.

Aircraft conduct anti-air warfare through radar search, detection, identification, and engagement of airborne threats—generally by firing anti-air missiles or cannon fire. Surface ships conduct anti-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 cannons for close-in point defense. Impacts of overland air activities were analyzed in previous documents and remain valid.

Testing of anti-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. Testing activities are often integrated into training activities and in most cases the systems are used in the same manner in which they are used for fleet training activities.

2.2.2 Amphibious Warfare

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

Amphibious warfare training ranges from individual, crew, and small unit activities 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 close air support training.

2.2.3 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 of 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 event is simulated with video footage obtained by onboard sensors.

2.2.4 Anti-Surface Warfare

The mission of anti-surface warfare is to defend against enemy ships or boats. In the conduct of anti-surface warfare, aircraft use cannons, 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.

Anti-surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile or exercise torpedo launch activities.

Testing of weapons used in anti-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 ordnance 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.

2.2.5 Anti-Submarine Warfare

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine threats to surface forces. Anti-submarine warfare is based on the principle of a layered defense of surveillance and attack aircraft, ships, and submarines all searching for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack hostile submarine threats.

Anti-submarine warfare training addresses basic skills such as detection and classification of submarines, distinguishing between sounds made by enemy submarines and those of friendly submarines, ships and marine life. More advanced, integrated anti-submarine warfare training exercises are conducted in coordinated, at-sea training activities involving submarines, ships, and aircraft. This training integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using either exercise torpedoes or simulated weapons.

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. Torpedo development, testing, and refinement are critical to successful anti-submarine warfare. At-sea sonar testing ensures systems are fully functional in an open-ocean environment prior to delivery to the fleet for operational use. Anti-submarine warfare systems on fixed wing aircraft and helicopters (including dipping sonar) are tested to evaluate the ability to search and track a submarine or similar target. Sonobuoys deployed from surface vessels and aircraft are tested to verify the integrity and performance of a group, or lot, of sonobuoys in advance of delivery to the fleet for operational use. The sensors and systems on board helicopters and maritime patrol aircraft are tested to ensure that tracking systems perform to specifications and meet operational requirements. Testing may be conducted as part of a large-scale fleet training event involving submarines, ships, fixed-wing aircraft, and helicopters. These integrated training activities 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.

2.2.6 Electronic Warfare

The mission of electronic warfare is to degrade the enemy's ability to use their electronic systems, such as communication systems and radar, to confuse or deny them the ability to defend their forces and assets. Electronic warfare is also used to recognize an emerging threat and counter an enemy’s attempt to degrade the electronic capabilities of the U.S. forces and assets.

Typical electronic warfare activities include threat avoidance training, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices to defeat tracking 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. Typical electronic warfare testing activities include the use of airborne and surface electronic jamming devices and chaff and flares to defeat tracking and communications systems. Chaff tests evaluate newly developed or enhanced chaff, chaff dispensing equipment, or modified aircraft systems against chaff deployment. Flare tests evaluate deployment performance and crew competency with newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems against flare deployment.

2.2.7 Mine Warfare

The mission of mine warfare is to detect, 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 (including purpose-built minelayers), submarines, or aircraft.

Mine warfare training includes exercises in which ships, aircraft, submarines, underwater vehicles, or marine mammal detection systems search for mines. Personnel train to destroy or disable mines by attaching and detonating underwater explosives to the mine. Other neutralization techniques involve impacting the mine with a bullet-like projectile or intentionally triggering the mine to detonate.

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 primarily involves the use of unmanned vehicles to support mine detection and classification testing. Mine countermeasure and neutralization testing includes the use of air, surface, and subsurface units and uses tracking devices, countermeasure and neutralization systems, and general purpose bombs to evaluate the effectiveness of neutralizing mine threats. Most neutralization tests use mine shapes, or non-explosive practice mines, to evaluate a new capability. Tests may also be conducted in support of scientific research to support new technologies. The majority of mine warfare systems are currently deployed by ships and helicopters; however, future mine warfare missions will increasingly rely on unmanned vehicles. Tests may also be conducted in support of scientific research to support these new technologies.

2.2.8 Naval Special Warfare

The mission of naval special warfare is to conduct unconventional warfare, direct action, combat terrorism, special reconnaissance, information warfare, security assistance, counter-drug operations, and recovery of personnel from hostile situations. Naval special warfare operations are highly specialized and require continual and intense training.

Naval special warfare units are required to utilize a combination of specialized training, equipment, and tactics, including insertion and extraction operations using parachutes, submerged vehicles, rubber boats, and helicopters; boat-to-shore and boat-to-boat gunnery; underwater demolition training; reconnaissance; and small arms training.

2.3 Descriptions of Sonar, Ordnance/Munitions, Targets, and Other Systems Employed in Mariana Islands Training and Testing Events

The Navy and other services use a variety of sensors, platforms, weapons, and other devices, including ones used to ensure the safety of personnel, to meet its mission. Training and testing with these systems may introduce acoustic (sound) energy and expended materials into the environment. The environmental impact of these activities will be analyzed in Chapter 3 (Affected Environment and Environmental Consequences) of this EIS/OEIS. This section presents and organizes sonar systems, ordnance, munitions, targets, and other systems in a manner intended to facilitate understanding of both the activities that use them and the environmental effects analysis that is later described in Chapter 3 of this EIS/OEIS.

2.3.1 Sonar and Other Acoustic Sources

2.3.1.1 What is Sonar?

Sonar, originally an acronym for "SOund Navigation And Ranging," is a technique that uses underwater sound to navigate, communicate, or detect underwater objects (the term sonar is also used for the equipment used to generate and receive sound). There are two basic types of sonar: active and passive.

Active sonar emits sound waves that travel through the water, reflect off objects, and return to the receiver. Sonar is used to determine the distance to an underwater object by calculating the speed of sound in water and the time for the sound wave to travel to the object and back. For example, active sonar systems are used to track targets or to aid in navigation of the vessel by identifying known ocean floor features. Some whales, dolphins, and bats use echolocation, a similar technique, to identify their surroundings and to locate prey.

Passive sonar uses listening equipment, such as underwater microphones (hydrophones) and receiving sensors on ships, submarines, aircraft and autonomous vehicles, to pick up underwater sounds. The advantage of passive sonar is that it places no sound in the water, and thus does not reveal the location of the listening vessel. Passive sonar can indicate the presence, character, and direction of ships and submarines; however, passive sonar is increasingly ineffective as modern submarines become quieter. Passive sonar has no potential acoustic impact on the environment and, therefore, is not discussed further or analyzed within this EIS/OEIS. For more information on sonar, its uses, and the Navy's analysis of potential sonar impacts in this EIS/OIES, please refer to Section 3.0.4 (Acoustic and Explosives Primer).

2.3.1.2 Sonar Systems

Anti-Submarine Warfare. Systems used in anti-submarine warfare include sonar, torpedoes, and acoustic countermeasure devices. These systems are employed from a variety of platforms (surface ships, submarines, helicopters, and fixed-wing aircraft). Surface ships conducting anti-submarine warfare are typically equipped with hull-mounted sonar (passive and active) for the detection of submarines. Helicopters use dipping sonar or sonobuoys (passive and active) to locate submarines (or submarine targets during training and testing exercises). Fixed-wing aircraft deploy both active and passive expendable sonobuoys to assist in detecting and tracking submarines. Submarines are equipped with hull-mounted sonar to detect, localize, and track other submarines and surface ships. Submarines primarily use passive sonar; active sonar is used mostly for navigation. There are also unmanned vehicles currently under development that will be used to deploy anti-submarine warfare systems.

Anti-submarine warfare activities often use mid-frequency (i.e., 1 kilohertz (kHz) to 10 kHz) active sonar, though low-frequency and high-frequency active sonar systems are also used for specialized purposes (see Section 3.0.4, Acoustic and Explosives Primer, for more information on sonar frequencies). The Navy is currently developing and testing sonar systems that may utilize lower frequencies and longer duty cycles—albeit at lower source levels—than current systems. However, these new systems would be operational only if they significantly increase the Navy's ability to detect and identify quiet submarine threats.

The types of sonar systems and acoustic sensors used during anti-submarine warfare sonar training and testing exercises include the following:

- **Surface Ship Sonar Systems:** A variety of surface ships operate hull-mounted mid-frequency active sonar during training exercises and testing activities (Figure 2.3-1). Typically, only cruisers, destroyers, and frigates have surface ship sonar systems.

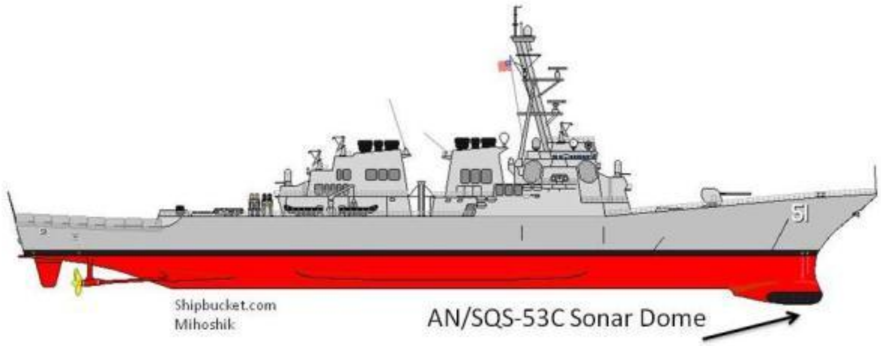

Figure 2.3-1: Guided Missile Destroyer with AN/SQS-53 Sonar

- **Submarine Sonar Systems:** Submarines are equipped with hull-mounted mid-frequency and high-frequency active sonar used to detect and target enemy submarines and surface ships (Figure 2.3-2). A submarine's mission relies on its stealth; therefore, a submarine uses its active sonar sparingly because each sound emission gives away the submarine's location.

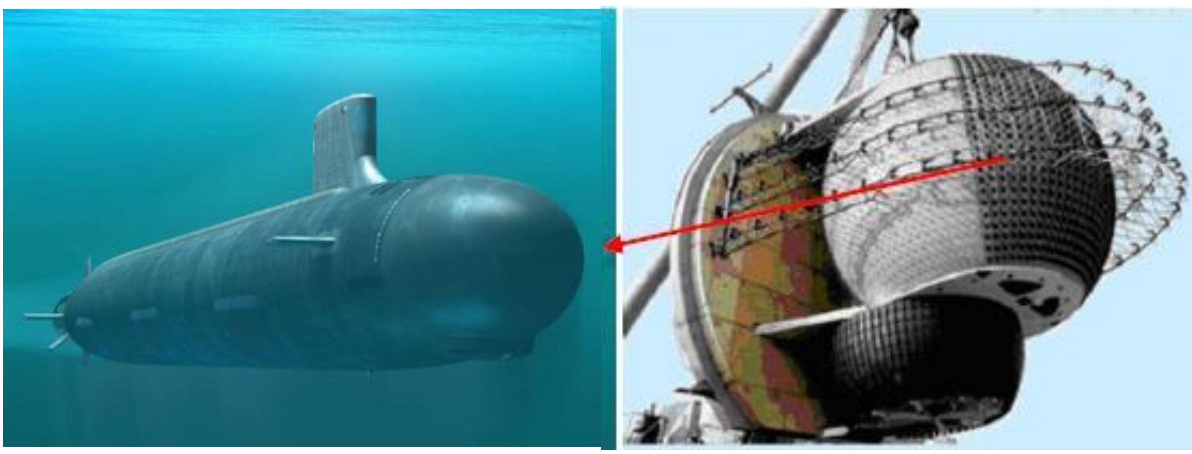

Figure 2.3-2: Submarine with AN/BQQ-10 Sonar Array

- **Aircraft Sonar Systems:** Aircraft sonar systems include sonobuoys and dipping sonar.
  - **Sonobuoys:** Sonobuoys are expendable devices that contain a transmitter and a hydrophone. The sounds collected by the sonobuoy are transmitted back to the aircraft for analysis. Sonobuoys are either active or passive and allow for short- and long-range detection of surface ships and submarines. These systems are deployed by both helicopter and fixed-wing patrol aircraft (Figure 2.3-3).

Figure 2.3-3: Sonobuoys (e.g., AN/SSQ-62)

  - **Dipping Sonar:** Dipping sonar systems are recoverable devices lowered into the water via cable from manned and unmanned helicopters. The sonar detects underwater targets and determines the distance and movement of the target relative to the position of the helicopter (Figure 2.3-4).

Figure 2.3-4: Helicopter Deploys Dipping Sonar

- **Exercise Torpedoes:** Torpedoes are equipped with sonar that helps the torpedoes find their targets. To understand how and when this torpedo sonar is used, the following description is provided. Surface ships, aircraft, and submarines primarily use torpedoes in anti-submarine warfare (Figure 2.3-5). Recoverable, non-explosive torpedoes, categorized as either lightweight or heavyweight, are used during training and testing. Heavyweight torpedoes use a guidance system to operate the torpedo autonomously or remotely through an attached wire (guidance wire). The autonomous guidance systems operate either passively (listening for sounds generated by the target) or actively (pinging to search for the target). Torpedo training in the Study Area is mostly simulated—solid masses that approximate the weight and shape of a torpedo are fired, rather than fully functional torpedoes. Testing in the Study Area mostly uses fully functional exercise torpedoes.

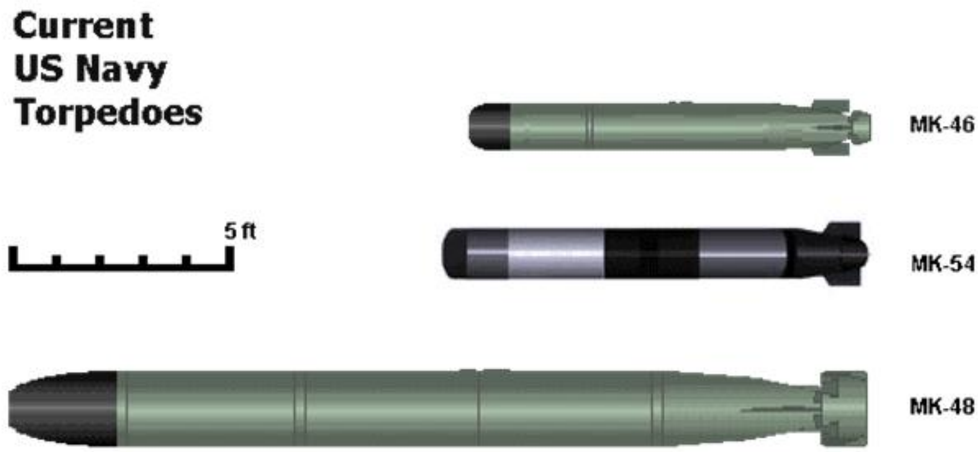

Figure 2.3-5: Navy Torpedoes

- **Acoustic Countermeasures:** Countermeasure devices are towed or free-floating noisemakers that alter the acoustic signature of a Navy ship or submarine, thereby avoiding detection, or act as an alternative target for an incoming threat (e.g., torpedo). Countermeasures are either expendable or recoverable (Figure 2.3-6).

Figure 2.3-6: Acoustic Countermeasures

- **Anti-Submarine Warfare Training Targets:** These targets are equipped with one or more sound producing capabilities that allow the targets to better simulate actual submarines. To understand how and when these sound sources are used, the following description is provided. Anti-submarine warfare training targets (Figure 2.3-7) are autonomous undersea vehicles used to simulate target submarines. The training targets are equipped with one or more of the following devices: (1) acoustic projectors emitting sounds to simulate submarine acoustic signatures, (2) echo repeaters to simulate the characteristics of the echo of a sonar signal reflected from a submarine, and (3) magnetic sources that mimic those of a submarine.

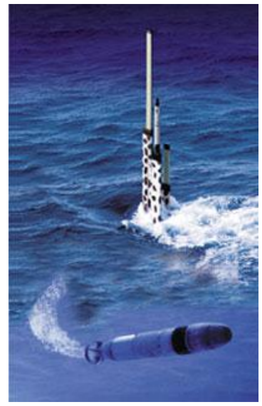

Figure 2.3-7: Anti-Submarine Warfare Training Targets

Portable Underwater Tracking Range. This is a portable instrumented range that allows near real-time tracking and feedback to all participants. The tracking range provides for both a shallow water and deep water operating environment. MK-84 range pingers are used in association with the Portable Underwater Tracking Range. Tracking range transponders are anchored to the seafloor with approximately 200-pound (lb.) concrete blocks or buckets filled with sand bags. The range can track up to four MK-84 range pingers. A typical tracking range configuration consists of ten transponders with three held in reserve, and is deployable from 400 meters (m) to 3,500 m depth. Signals from the transponders are uplinked to a range control for vessel for processing. The transponders can be released from their anchors by acoustic signal to float to the surface for recovery. The anchor blocks are not recovered.

Mine Warfare. Mine warfare training and testing activities use a variety of different sonar systems that are typically high-frequency and very high-frequency. These sonar systems (Figure 2.3-8) are used to detect, locate, and characterize moored and bottom mines. The majority of mine warfare sonar systems can be deployed by more than one platform (i.e., helicopter, unmanned underwater vehicle, submarine, or surface ship) and may be interchangeable among platforms. Surface ships and submarines use sonar to detect mines and objects and minesweeping ships use a specialized variable-depth mine detection and classification high-frequency active sonar system to detect mines.

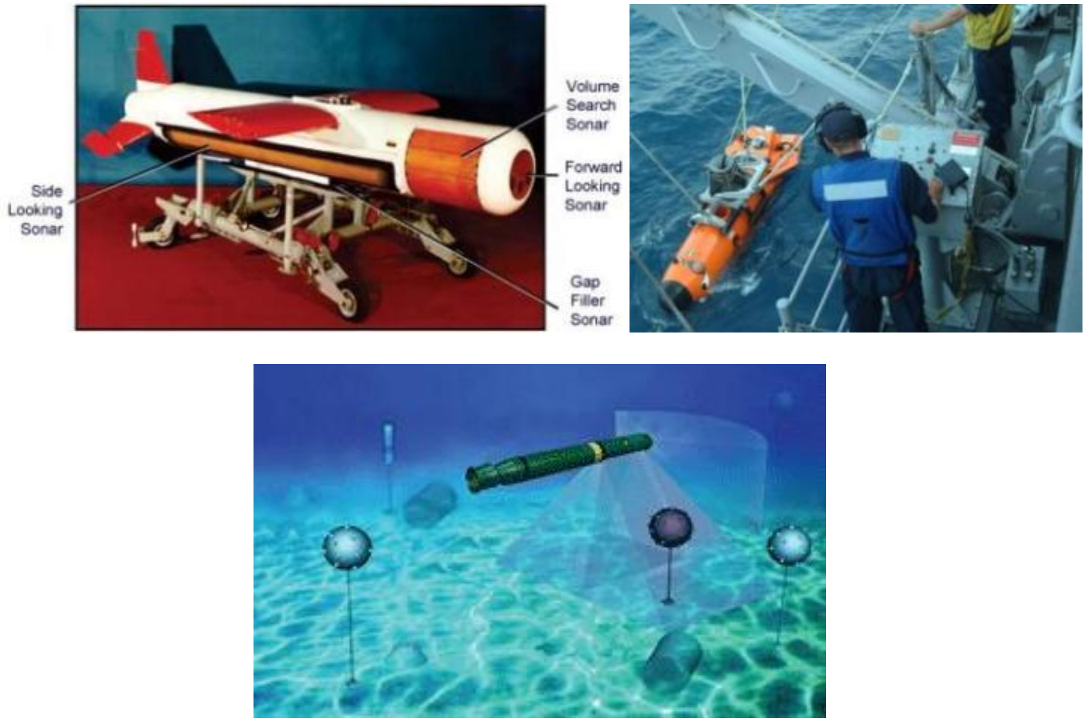

Figure 2.3-8: Mine Warfare Systems

Safety, Navigation, Communications, and Oceanographic Systems. Naval ships, submarines, and unmanned vehicles rely on equipment and instrumentation that uses active sonar during both routine operations and training and testing activities. Sonar systems are used to gauge water depth; detect and map objects, navigational hazards, and the ocean floor; and transmit communication signals.

Other Acoustic Sensors. The Navy uses a variety of other acoustic sensors to protect ships anchored or at the pier, as well as shore facilities. These systems, both active and passive, detect potentially hostile swimmers, broadcast warnings to alert Navy divers of potential hazards, and gather information regarding ocean characteristics (ocean currents, wave measurements). They are generally stationary systems in Navy harbors and piers. In addition, the Navy's research and acquisition community uses various sensors for tracking during testing activities and to collect data for test analysis.

Echolocation Systems. Navy marine mammals (Atlantic bottlenose dolphins [*Tursiops truncatus*] and California sea lions [*Zalophus californianus*]) are also used to detect hostile swimmers around Navy facilities. A trained animal is deployed under behavioral control of a handler to find an intruding swimmer. Upon finding the 'target' of the search, the animal returns to the boat and alerts the animal handlers and the animals are given a localization marker or leg cuff that they attach to the intruder. Swimmers that have been marked with a leg cuff are reeled-in by security support boat personnel via a line attached to the cuff.

2.3.2 ORDNANCE/MUNITIONS

Most ordnance and munitions used during training and testing activities fall into three basic categories: projectiles, missiles, and bombs. Ordnance can be further defined by Net Explosive Weight (NEW). NEW is the trinitrotoluene equivalent of energetic material, which is the standard measure of strength of bombs and other explosives. For example, a 2,000 lb. (907.2-kilogram [kg]) bomb may have a NEW of anywhere from 600 to 1,000 lb. (272.2 to 453.8 kg).

Projectiles. Projectiles are fired during gunnery exercises from a variety of weapons, including pistols and rifles to large-caliber turret mounted guns on the decks of Navy ships. Projectiles can be either explosive munitions (e.g., certain cannon shells) or non-explosive practice munitions (e.g., rifle/pistol bullets). Explosive rounds can be fused to either explode on impact or in the air (i.e., just prior to impact). Projectiles are broken down into three basic categories in this EIS/OEIS:

- **Small-Caliber Projectiles:** Includes projectiles up to .50 caliber (approximately 0.5-inch [in.] diameter). Small-caliber projectiles (e.g., bullets), are primarily fired from pistols, rifles, and machine guns (Figure 2.3-9). Most small-caliber projectiles are fired during training activities for an individual Sailor to become and remain proficient.

Figure 2.3-9: Shipboard Small Arms Training

- **Medium-Caliber Projectiles:** These projectiles are larger than .50 caliber, but smaller than 57 millimeters (mm) (approximately 2.24 in. diameter). The most common size medium-caliber projectiles are 20 mm, 25 mm, and 40 mm. Medium-caliber projectiles are fired from machine guns operated by one to two crewmen and mounted on the deck of a ship, wing-mounted guns on aircraft, and fully automated guns mounted on ships for defense against missile attack (Figure 2.3-10). Medium-caliber projectiles also include 40 mm grenades, which can be fired from hand-held grenade launcher or crew-served deck-mounted guns. Medium-caliber projectiles can be non-explosive practice munitions or explosive projectiles. Explosive projectiles are usually fused to detonate on impact; however, advanced explosive projectiles can detonate based on time, distance, or proximity to a target.

Figure 2.3-10: Shipboard Medium-Caliber Gun Systems

- **Large-Caliber Projectiles:** These include projectiles 57 mm and larger. The largest projectile currently in service has a 5 in. (12.7-centimeter [cm]) diameter (Figure 2.3-11), but larger weapons are under development. The most widely used large-caliber projectiles are 57 mm, 76 mm, 105 mm, and 5 in. The most common 5 in. (12.7 cm) projectile is approximately 26 in. (66 cm) long and weighs 70 lb. (32 kg). Large-caliber projectiles are fired from mounted guns located on ship decks or aircraft (e.g., AC-130 gunship) and can be used to fire on surface ships and boats, in defense against missiles and aircraft, or against land-based targets. Large-caliber projectiles can be non-explosive practice munitions or explosive munitions. Explosive projectiles can detonate on impact or in the air.

Figure 2.3-11: Large-Caliber Projectile Use (5-Inch)

Missiles. Missiles are rocket or jet-propelled munitions used to attack ships, aircraft, and land-based targets, as well as defend ships against other missiles. Guidance systems and advanced fusing technology ensure that missiles reliably impact on or detonate near their intended target. Missiles are categorized according to their intended target, as described below, and can be further classified according to NEW. Rockets are included within the category of missiles.

- **Anti-Air Missiles:** Anti-air missiles are fired from aircraft and ships against enemy aircraft and incoming missiles (Figure 2.3-12). Anti-air missiles are configured to explode near, or on impact with, their intended target. Missiles are the primary ship-based defense against incoming missiles.


Figure 2.3-12: Rolling Airframe Missile (left) and Air-to-Air Missile (right)

- **Anti-Surface Missiles:** Anti-surface missiles are fired from aircraft, ships, and submarines against surface ships (Figure 2.3-13). Anti-surface missiles are typically configured to detonate on impact.

Figure 2.3-13: Anti-Surface Missile Fired from MH-60 Helicopter

- **Strike Missiles:** Strike missiles are fired from aircraft, ships, and submarines against land-based targets. Strike missiles are typically configured to detonate on impact, or near their intended target. The AGM-88 High-speed Anti-Radiation Missile, which is used to destroy enemy radar sites, is an example of a strike missile that is used during at-sea training, and is fired at a sea-borne target that replicates a land-based radar site.

Bombs. Bombs are unpowered munitions dropped from aircraft on land and water targets. Bombs are in two categories: general-purpose bombs and subscale practice bombs. Similar to missiles, bombs are further classified according to the NEW of the bomb.

- **General Purpose Bombs:** General-purpose bombs (Figure 2.3-14) consist of precision-guided and unguided full-scale bombs, ranging in size from 250 to 2,000 lb. (113 to 907 kg). Common bomb nomenclature used includes MK-80 series, which is the Navy's standard model; Guided Bomb Units and Joint Direct Attack Munitions, which are precision-guided (including laser-guided) bombs; and the Joint Standoff weapon, which is a long-range "glider" precision weapon.

Figure 2.3-14: F/A-18 Bomb Release (left) and Loading General Purpose Bombs (right)

- **Subscale Bombs:** Subscale bombs (Figure 2.3-15) are non-explosive practice munitions containing a spotting (smoke) charge to aid in scoring the accuracy of hitting the target during training and testing activities. Common subscale bombs are 25 lb. (11 kg) and less and are steel-constructed. Laser guided training rounds are another variation of a subscale practice bomb. They weigh approximately 100 lb. (45 kg) and are cost-effective non-explosive weapons used in training aircrew in laser-guided weapons employment.

Figure 2.3-15: Subscale Bombs for Training

Other Munitions. There are other munitions and ordnance used in naval at-sea training and testing activities that do not fit into one of the above categories, and are discussed below:

- **Demolition Charges:** Divers place explosive charges in the marine environment during some training and testing activities. These activities may include the use of timed charges, in which the charge is placed, a timer is started, and the charge detonates at the set time. Munitions typically composed of C-4 explosive, with the necessary detonators and cords, are used to support mine neutralization, demolition, and other warfare activities. All demolition charges are further classified according to the NEW of the charge.
- **Anti-Swimmer Grenades:** Maritime security forces use hand grenades to defend against enemy scuba divers.
- **Torpedoes:** Explosive torpedoes are required in some training and testing activities. Torpedoes are described as either lightweight or heavyweight and are further categorized according to the NEW.
- **Extended Echo Ranging Sonobuoys:** Extended Echo Ranging sonobuoys include Improved Extended Echo Ranging sonobuoys and mini sound-source seeker sonobuoys that use explosive charges as the active sound source instead of electrically produced sounds.

2.3.3 TARGETS

Training and testing require an assortment of realistic and challenging targets. Targets vary from items as simple and ordinary as an empty steel drum, used for small-caliber weapons training from the deck of a ship, to sophisticated, unmanned aerial drones used in air defense training. For this EIS/OEIS, targets are organized by warfare area.

- **Anti-Air Warfare Targets:** Anti-air warfare targets, tow target systems, and aerial targets are used in training and testing activities that involve detection, tracking, defending against, and attacking enemy missiles and aircraft. Aerial towed target systems include textile (nylon banner) and rigid (fiberglass shapes) towed targets used for gunnery activities. Aerial targets include expendable rocket-powered missiles and recoverable radio-controlled drones used for gunnery and missile exercises (Figure 2.3-16). Parachute flares are used as air-to-air missile targets. Manned high-performance aircraft may be used as targets—to test ship and aircraft defensive systems and procedures—without the actual firing of munitions.

Figure 2.3-16: Anti-Air Warfare Targets

- **Anti-Surface Warfare Targets:** Stationary and towed targets are used as anti-surface warfare targets during gunnery activities. Targets include floating steel drums, inflatable shapes or target balloons (e.g., Killer Tomato™, see Figure 2.3-17), fiberglass catamarans, and towed sleds. Remote-controlled, high-speed targets, such as jet skis and motorboats, are also used (Figure 2.3-18).

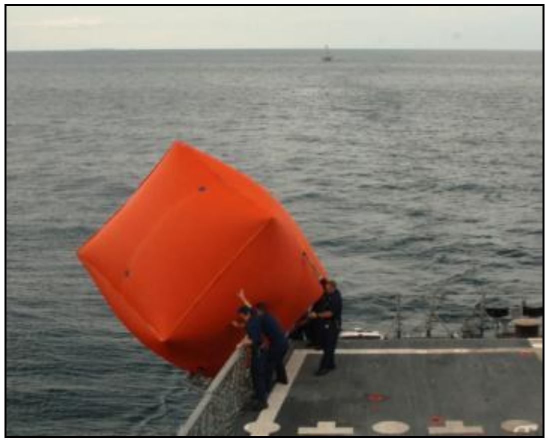

Figure 2.3-17: Deploying a "Killer Tomato™" Floating Target

Figure 2.3-18: Ship Deployable Surface Target (left) and High-Speed Maneuverable Seaborne Target (right)

- **Anti-Submarine Warfare Targets:** Anti-submarine warfare uses multiple types of targets including the following:
    - **Submarines:** Submarines may act as tracking and detection targets during training and testing activities.
    - **Motorized Autonomous Targets:** Motorized autonomous targets simulate the acoustic and magnetic characteristics of a submarine, providing realism for exercises when a submarine is not available. These mobile targets resemble torpedoes, with some models designed for recovery and reuse, while other models are expendable.
    - **Stationary Artificial Targets:** Stationary targets either resemble submarine hulls or are simulated systems with acoustic properties of enemy submarines. These targets either rest on the sea floor or are suspended at varying depths in the water column.

2.3.4 Defensive Countermeasures

Naval forces depend on effective defensive countermeasures to protect against missile and torpedo attack. Defensive countermeasures are devices designed to confuse, distract, and confound precision-guided munitions. While new measures to protect naval ships, aircraft, and personnel from detection and attack are being developed, most generally defensive countermeasures fall within three basic categories:

- **Chaff:** Chaff consists of reflective, aluminum-coated glass fibers used to obscure ships and aircraft from radar-guided systems. Chaff fibers, which are stored in canisters, are either dispensed from aircraft or fired into the air from the decks of surface ships when an attack is imminent. The glass fibers create a radar cloud which acts to mask the position of the ship or aircraft.
- **Flares:** Flares are pyrotechnic devices used to defend against heat seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft's engines. Similar to chaff, flares are also dispensed from aircraft and fired from ships.
- **Acoustic Countermeasures:** Acoustic countermeasures are described above in Section 2.3.1.2 (Sonar Systems). Acoustic countermeasures are either released from ships and submarines or towed at a distance behind the ship.

2.3.5 Mine Warfare Systems

Mine warfare systems are in two broad categories: mine detection and mine neutralization.

Mine Detection Systems. Mine detection systems are used to locate, classify, and map suspected mines. Once located, the mines can either be neutralized or avoided. These systems are specialized to either locate mines on the surface, in the water column, or on the sea floor.

- **Towed or Hull-Mounted Mine Detection Systems:** These detection systems use acoustic and laser or video sensors to locate and classify suspect mines (Figure 2.3-19). Helicopters, ships, and unmanned vehicles are used for towed systems, which can rapidly assess large areas.

Figure 2.3-19: Towed Mine Detection System

- **Unmanned/Remotely Operated Vehicles:** These vehicles use acoustic and video or lasers to locate and classify mines. Unmanned/remotely operated vehicles provide mine warfare capabilities in nearshore littoral areas, surf zones, ports, and channels.
- **Airborne Laser Mine Detection Systems:** Airborne laser detection systems work in concert with neutralization systems (Figure 2.3-20). The detection system initially locates mines and a neutralization system is then used to relocate and neutralize the mine.

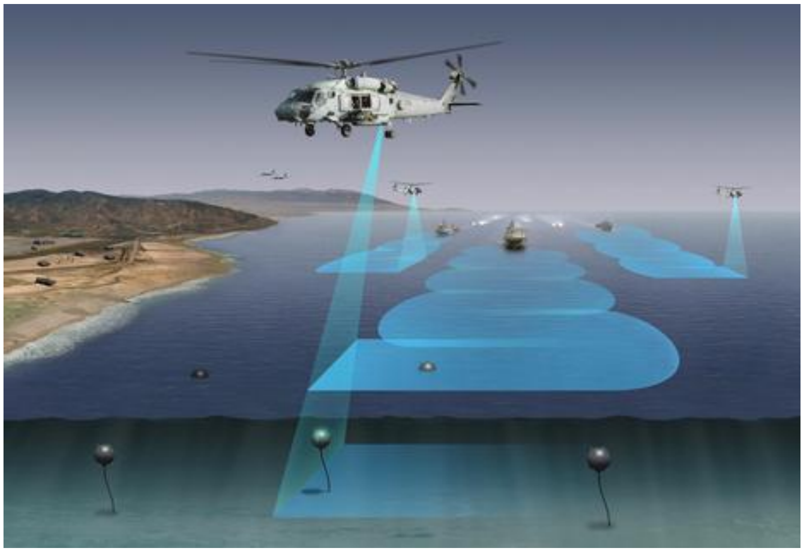

Figure 2.3-20: Airborne Laser Mine Detection System in Operation

- **Marine Mammal System:** Navy personnel and Navy marine mammals work together to detect specified underwater objects. The Navy deploys trained bottlenose dolphins and California sea lions as part of the marine mammal mine-hunting and object-recovery system.

Mine Neutralization Systems. These systems disrupt, disable, or detonate mines to clear ports and shipping lanes, as well as littoral, surf, and beach areas in support of naval amphibious operations. Mine neutralization systems can clear individual mines or a large number of mines quickly.

- **Towed Influence Mine Sweep Systems:** These systems use towed equipment that mimic a particular ship's magnetic and acoustic signature triggering the mine and causing it to explode (Figure 2.3-21).

Figure 2.3-21: Organic and Surface Influence Sweep

- **Towed Mechanical Mine Sweeping Systems:** These systems tow a sweep wire to snag the line that attaches a moored mine to its anchor and then uses a series of cables and cutters to sever those lines. Once these lines are cut, the mines float to the surface where Sailors can neutralize the mines.
- **Unmanned/Remotely Operated Mine Neutralization Systems:** Surface ships and helicopters operate these systems, which place explosive charges near or directly against mines to destroy the mine (Figure 2.3-22).
- **Projectiles:** Small- and medium-caliber projectiles, fired from surface ships or hovering helicopters, are used to neutralize floating and near-surface mine.
- **Diver Emplaced Explosive Charges:** Operating from small craft and aircraft, divers emplace explosive charges near or on mines to destroy the mine or disrupt its ability to function.

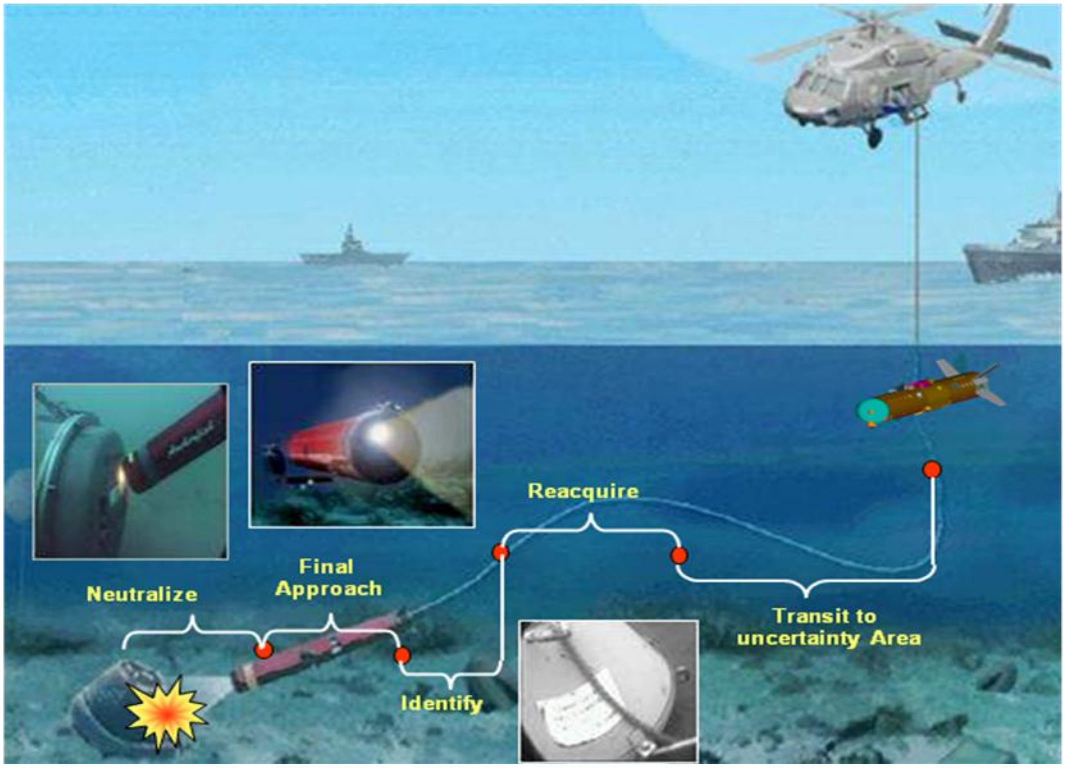

Figure 2.3-22: Airborne Mine Neutralization System

2.3.6 MILITARY EXPENDED MATERIALS

Navy training and testing activities introduce or expend various items, such as non-explosive munitions and targets, into the marine environment as a direct result of using these items for their intended purpose. In addition to the items described below, some accessory materials—related to the carriage or release of these items—are released. These materials, referred to as military expended materials, are not recovered, and potentially result in environmental impacts that are analyzed in detail in Chapter 3 (Affected Environment and Environmental Consequences) of this EIS/OEIS.

Military expended materials analyzed in this document include, but are not limited to, the following:

- **Sonobuoys:** Sonobuoys consist of parachutes and the sonobuoys themselves.
- **Torpedo Launch Accessories:** Torpedoes are usually recovered; however, materials such as parachutes used with air-dropped torpedoes, guidance wire used with submarine-launched torpedoes, and ballast weights are expended. Explosive-filled torpedoes expend torpedo fragments.
- **Decelerators/Parachutes:** Aircraft-launched sonobuoys, lightweight torpedoes (such as the MK-46 and MK-54), illumination flares, and targets use nylon decelerators/parachutes ranging in size from 18 to 48 in. (46 to 122 cm) in diameter.
- **Projectiles and Bombs:** Projectiles, bombs, or fragments from explosive projectiles and bombs are expended during training and testing exercises. These items are primarily constructed of lead (most small-caliber projectiles) or steel (medium- and large-caliber projectiles and all bombs).

- **Missiles:** Non-explosive missiles and missile fragments from explosive missiles are expended during training and testing events. Propellant, and any explosive material involved, is consumed during firing and detonation.
- **Rockets:** Non-explosive rockets and rocket fragments from explosive rockets are expended during training and testing events. Propellant, and any explosive material involved, is consumed during firing and detonation.
- **Countermeasures:** Countermeasures (acoustic, chaff, flares) are expended as a result of training exercises, with the exception of towed acoustic countermeasures.
- **Targets:** Some targets are designed to be expended; other targets, such as aerial drones and remote-controlled boats, are recovered for re-use when possible. Targets struck with ordnance will result in target fragments.
- **Ballast/Anchors:** Bottom mine shapes and other sea floor devices (e.g., portable underwater tracking range transponders) use ballast to sink to a pre-determined depth or to anchor to the bottom. These ballasts and anchors are generally not recovered.

2.4 Proposed Activities

The Navy and other services have been conducting military readiness 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 force structure (organization of ships, weapons, and personnel) changes. Such developments influenced the frequency, duration, intensity, and location of required training and testing activities. As discussed in Chapter 1 (Purpose and Need), training and testing activities were analyzed in the Tactical Theater Training Assessment Program Phase I documents, specifically in the environmental planning documents for MIRC. This EIS/OEIS (Phase II) accounts for those factors that cause training and testing fluctuations and has refined its proposed activities in two ways. First, at-sea training and testing activities have evolved to meet changes to military readiness requirements. Second, this EIS/OEIS includes additional at-sea geographic areas where training and testing activities historically occur.

2.4.1 Proposed Training Activities in the Mariana Islands Training and Testing Study Area

The training activities proposed by the services are described in Table 2.4-1. The table is organized according to primary mission areas and includes the activity name and a short description. Appendix A (Training and Testing Activities Descriptions) has more detailed descriptions of the activities.

Table 2.4-1: Typical Training Activities in the Mariana Islands Training and Testing Study Area

Activity Name	Activity Description
Anti-Air Warfare (AAW)	
Air Combat Maneuver (ACM)	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.
Air Defense Exercise (ADEX)	Aircrew and ship crews conduct defensive measures against threat aircraft or missiles.
Air Intercept Control (AIC)	Aircrew and air controllers conduct aircraft intercepts of other aircraft.
Gunnery Exercise (Air-to-Air) (GUNEX [A-A])	Aircrews defend against threat aircraft with cannons (machine gun).
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	Aircrews defend against threat aircraft with missiles.
Gunnery Exercise (Surface-to-Air) (GUNEX [S-A]) – Large-caliber	Surface ship crews defend against threat aircraft or missiles with guns.
Gunnery Exercise (Surface-to-Air) (GUNEX [S-A]) – Medium-caliber	Surface ship crews defend against threat aircraft or missiles with guns.
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	Surface ship crews defend against threat missiles and aircraft with missiles.
Strike Warfare (STW)	
Bombing Exercise Air-to-Ground (BOMBEX [A-G])	Fixed-wing aircraft drop non-explosive bombs against a land target.
Gunnery Exercise Air-to-Ground (GUNEX [A-G])	Helicopter crews fire guns at stationary land targets; fixed-winged aircraft also strafe land targets.
Missile Exercise (MISSILEX)	Missiles or rockets launched against a land target.
Combat Search and Rescue (CSAR)	CSAR units use helicopters, night vision and identification systems, and insertion and extraction techniques under hostile conditions to locate, rescue, and extract personnel.

Table 2.4-1: Typical Training Activities in the Mariana Islands Training and Testing Study Area (continued)

Activity Name	Activity Description
Amphibious Warfare (AMW)	
Naval Surface Fire Support Exercise-Land Based Target (FIREX [Land])	Surface ship crews use large-caliber guns to fire on land-based targets in support of forces ashore.
Amphibious Rehearsal, No Landing	Amphibious shipping, landing craft, and elements of the Marine Air Ground Task Force rehearse amphibious landing operations without conducting an actual landing on shore.
Amphibious Assault	Forces move ashore from ships at sea for the immediate execution of inland objectives.
Amphibious Raid	Small unit forces move swiftly from ships at sea for a specific short-term mission. Raids are quick operations with as few Marines as possible.
Urban Warfare Training	Forces sized from squad (approximately 13 Marines) to battalions (approximately 950) conduct training activities in mock urban environments.
Noncombatant Evacuation Operations	Military units evacuate noncombatants from hostile or unsafe areas or provide humanitarian assistance in times of disaster.
Humanitarian Assistance/Disaster Relief Operations	Military units evacuate noncombatants from hostile or unsafe areas or provide humanitarian assistance in times of disaster.
Unmanned Aerial Vehicles Ops (UAV OPS)	Military units employ unmanned aerial vehicles to launch, operate, and gather intelligence for specified amphibious missions.
Anti-Surface Warfare (ASUW)	
Gunnery Exercise (Air-to-Surface) – Small-caliber	Fixed-wing and helicopter aircrews, including embarked personnel, use small-caliber guns to engage surface targets.
Gunnery Exercise (Air-to-Surface) – Medium-caliber	Fixed-wing and helicopter aircrews, including embarked personnel, use medium-caliber guns to engage surface targets.
Missile Exercise (Air-to-Surface) – Rocket (MISSILEX [A-S] – Rocket)	Fixed-wing and helicopter aircrews fire precision-guided and unguided rockets against surface targets.
Missile Exercise (Air-to-Surface) – Missile (MISSILEX [A-S] – Missile)	Fixed-wing and helicopter aircrews fire precision-guided missiles against surface targets.
Laser Targeting (at sea)	Fixed-winged, helicopter, and ship crews illuminate enemy targets with lasers.
Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircrews deliver bombs against surface targets.
Torpedo Exercise (Submarine-to-Surface)	Submarine attacks a surface target using exercise or live-fire torpedoes.
Missile Exercise (Surface-to-Surface) (MISSILEX [S-S])	Surface ship crews defend against threat missiles and other surface ships with missiles.

Table 2.4-1: Typical Training Activities in the Mariana Islands Training and Testing Study Area (continued)

Activity Name	Activity Description
Gunnery Exercise Surface-to-Surface (Ship) – Large-caliber (GUNEX-S-S [Ship])	Ship crews engage surface targets with ship's large-caliber guns.
Gunnery Exercise Surface-to-Surface (Ship) – Small- and Medium-caliber (GUNEX-S-S [Ship])	Ship crews engage surface targets with ship's small- and medium-caliber guns.
Sinking Exercise (SINKEX)	Aircraft, ship, and submarine crews deliver ordnance on a seaborne target, usually a deactivated ship, which is deliberately sunk using multiple weapon systems.
Gunnery Exercise Surface-to-Surface (Boat) (GUNEX-S-S [Boat])	Small boat crews engage surface targets with small- and medium-caliber weapons.
Maritime Security Operations (MSO)	Helicopter and surface ship crews conduct a suite of Maritime Security Operations (e.g., Vessel Search, Board, and Seizure; Maritime Interdiction Operations; Force Protection; and Anti-Piracy Operation).
Anti-Submarine Warfare (ASW)	
Tracking Exercise – Helicopter (TRACKEX/TORPEX – Helo)	Helicopter crews search, track, and detect submarines. Exercise torpedoes may be used during this event.
Tracking Exercise – Maritime Patrol Aircraft Extended Echo Ranging Sonobuoys	Maritime patrol aircraft crews search, detect and track submarines using explosive source sonobuoys or multistatic active coherent system.
Tracking Exercise – Maritime Patrol Aircraft (TRACKEX/TORPEX – MPA)	Maritime patrol aircraft crews search, detect, and track submarines. Recoverable air launched torpedoes may be employed against submarine targets.
Tracking Exercise – Surface (TRACKEX/TORPEX – Surface)	Surface ship crews search, track, and detect submarines. Exercise torpedoes may be used during this event.
Tracking Exercise – Submarine (TRACKEX/TORPEX – Sub)	Submarine crews search, detect, and track submarines and surface ships. Exercise torpedoes may be used during this event.

Table 2.4-1: Typical Training Activities in the Mariana Islands Training and Testing Study Area (continued)

Activity Name	Activity Description
Major Training Activities	
Joint Expeditionary Exercise	A 10-day at-sea and ashore exercise which brings different branches of the United States (U.S.) military together in a joint environment that includes planning and execution efforts as well as military training activities at sea, in the air, and ashore. More than 8,000 personnel may participate and could include the combined assets of a Carrier Strike Group and Expeditionary Strike Group, Marine Expeditionary Units, Army Infantry Units, and Air Force aircraft.
Joint Multi-Strike Group Exercise	A 10-day at-sea and ashore exercise in which up to three Carrier Strike Groups integrated with U.S. Air Force and U.S. Marine Corps forces would conduct at-sea training and strike warfare exercises simultaneously.
Fleet Strike Group Exercise	A 7-day at-sea and ashore exercise focused on sustainment training and strike warfare for the forward deployed Carrier Strike Group which integrates joint training activities with the U.S. Air Force and U.S. Marine Corps. The exercise focuses on integrated joint training among U.S. military forces in the maritime environment with an ASW threat.
Integrated Anti-Submarine Exercise	A 5-day at-sea exercise with multiple ships, aircraft and submarines integrating the use of their sensors, including sonobuoys, to search, detect, and track threat submarines.
Ship Squadron Anti-Submarine Warfare Exercise	A 5-day at-sea exercise where the overall objective is to sustain and assess surface ship Anti-Submarine Warfare readiness and effectiveness. The exercise typically involves multiple ships, submarines, and aircraft in several coordinated events, maximizing opportunities to collect high-quality data.
Marine Air Ground Task Force Exercise (Amphibious) – Battalion	A 10-day at-sea and shore exercise which conducts over the horizon, ship to objective maneuver for the elements of the Expeditionary Strike Group and the Amphibious Marine Air Ground Task Force. The exercise utilizes all elements of the Marine Air Ground Task Force (Amphibious), conducting training activities ashore with logistic support of the Expeditionary Strike Group and conducting amphibious landings.
Special Purpose Marine Air Ground Task Force Exercise	A 10-day at-sea and ashore exercise similar to Marine Air Ground Task Force (Amphibious) – Battalion, but task organized to conduct a specific mission (e.g., Humanitarian Assistance, Disaster Relief, Non-combatant Evacuation Operations).
Urban Warfare Exercise	A 7- to 21-day ashore exercise for Marine Expeditionary Unit level integrated urban warfare training conducted over a period of weeks. Enhances the skills needed for military training activities in an urban environment.

Note: Training activities that will be categorized as Major Training Exercises Reported (MTER) will be determined during the Marine Mammal Protection Act consultation process.

Table 2.4-1: Typical Training Activities in the Mariana Islands Training and Testing Study Area (continued)

Activity Name	Activity Description
Electronic Warfare (EW)	
Electronic Warfare Operations (EW OPS)	Aircraft, surface ship, and submarine crews attempt to control portions of the electromagnetic spectrum used by enemy systems to degrade or deny the enemy's ability to take defensive actions.
Counter Targeting – Flare Exercise (FLAREX) – Aircraft	Fixed-winged aircraft and helicopters crews defend against an attack by deploying flares to disrupt threat infrared (IR) missile guidance systems.
Counter Targeting Chaff Exercise (CHAFFEX) – Ship	Surface ships defend against an attack by deploying chaff, a radar reflective material, which disrupt threat targeting and missile guidance radars.
Counter Targeting Chaff Exercise (CHAFFEX) – Aircraft	Fixed-winged aircraft and helicopter crews defend against an attack by deploying chaff, a radar reflective material, which disrupt threat targeting and missile guidance radars.
Mine Warfare (MIW)	
Civilian Port Defense	Naval mine warfare activities conducted at various ports and harbors, in support of maritime homeland defense/security.
Mine Laying	Fixed-winged aircraft and vessel crews drop/launch non explosive mine shapes.
Mine Neutralization – Explosive Ordnance Disposal (EOD)	Personnel disable threat mines. Explosive charges may be used.
Limpet Mine Neutralization System/Shock Wave Generator	Navy divers place a small charge on a simulated underwater mine.
Submarine Mine Exercise	Submarine crews practice detecting mines in a designated area.
Airborne Mine Countermeasure (MCM) – Mine Detection	Helicopter aircrews detect mines using towed and laser mine detection systems (e.g., AN/AQS-20, Airborne Laser Mine Detection System).
Mine Countermeasure Exercise – Towed Sonar	Surface ship crews detect and avoid mines while navigating restricted areas or channels using towed active sonar.
Mine Countermeasure Exercise – Surface (SMCMEX)	Mine countermeasure ship crews detect, locate, identify, and avoid mines while navigating restricted areas or channels using active sonar.
Mine Neutralization – Remotely Operated Vehicle Sonar	Helicopter aircrews disable mines using remotely operated underwater vehicles.
Mine Countermeasure (MCM) – Towed Mine Neutralization	Ship crews and helicopter aircrews tow systems (e.g., Organic and Surface Influence Sweep, MK 104/105) through the water that are designed to disable and/or trigger mines.

Table 2.4-1: Typical Training Activities in the Mariana Islands Training and Testing Study Area (continued)

Activity Name	Activity Description
Naval Special Warfare (NSW)	
Personnel Insertion/Extraction	Military personnel train for covert insertion and extraction into target areas using helicopters, fixed-wing aircraft (insertion only), small boats, and submersibles.
Parachute Insertion	Military personnel train for covert insertion into target areas using parachutes.
Embassy Reinforcement	Special Warfare units train to provide reinforcement of an Embassy under hostile conditions.
Direct Action (Combat Close Quarters)	Military personnel train for use of force, breaching doors and obstacles, and in close quarters combat.
Direct Action (Breaching)	Military personnel train for use of force, breaching doors and obstacles, and in close quarters combat.
Direct Action (Tactical Air Control Party [TACP]/Joint Tactical Air Control)	Military personnel train for controlling of combat support aircraft; providing target designation, airspace de-confliction, and terminal control for Close Air Support. Teams also train in use of small arms and mortars.
Underwater Demolition Qualification/Certification	Navy divers conduct training and certification in placing underwater demolition charges.
Intelligence, Surveillance, Reconnaissance (ISR)	Special Warfare units train to collect and report battlefield intelligence.
Urban Warfare Training	Special Warfare units train in mock urban environments.
Underwater Survey	Navy divers train in survey of underwater conditions and features in preparation for insertion, extraction, or intelligence, surveillance and reconnaissance activities.
Other Training Activities	
Surface Ship Sonar Maintenance	In-port and at-sea maintenance of sonar systems.
Submarine Sonar Maintenance	In-port and at-sea maintenance of sonar systems.
Small Boat Attack	Small boats or personal watercraft conduct attack activities on units afloat.
Submarine Navigation	Submarine crews locate underwater objects and ships while transiting out of port.
Search and Rescue at Sea	United States Coast Guard and military personnel train with ships, fixed wing and rotary aircraft to locate and rescue missing personnel and vessels at sea.
Precision Anchoring	Releasing of anchors in designated locations.
Maneuver (Convoy, Land Navigation)	Units conduct field maneuver training or convoy training.

Table 2.4-1: Typical Training Activities in the Mariana Islands Training and Testing Study Area (continued)

Activity Name	Activity Description
Water Purification	Units conduct water purification training using water purification equipment in field conditions.
Field Training Exercise	Units train in securing an area, establishing a camp or post, and guarding and patrolling. Event typically lasts a week or a few days.
Force Protection	Units train in providing defensive force protection against a terror threat.
Anti-terrorism	Units train in conducting direct action against a terror threat.
Seize Airfield	Train Naval Special Warfare, Navy Expeditionary Combat Command or Marine Corps personnel to seize control of an airfield or port for use by friendly forces.
Airfield Expeditionary	Units conduct training establishing, securing, maintaining, or operating an expeditionary airfield.
Unmanned Aerial Vehicle Operation	Units conduct training with unmanned aerial vehicles from airfields or in the battlefield.
Land Demolitions (Improvised Explosive Device Discovery/Disposal)	Explosive Ordnance units conduct training detecting, isolating, or securing Improvised Explosive Devices or unexploded ordnance.
Land Demolitions (Unexploded Ordnance) Discovery/Disposal	Explosive Ordnance units conduct disposal of unexploded ordnance. Training is incidental to the emergency disposal of unexploded ordnance.

2.4.2 PROPOSED TESTING ACTIVITIES

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 (e.g., missiles, radar, and sonar), and platforms (e.g., surface ships, submarines, and aircraft); and acquisition of systems and platforms to support Navy missions and give a technological edge over adversaries.

The individual commands within the research and acquisition community included in this EIS/OEIS are Naval Air Systems Command, Naval Sea Systems Command, the Office of Naval Research, and the Naval Research Laboratory.

The Navy operates in an ever-changing strategic, tactical, and funding and time-constrained environment. Testing activities occur in response to emerging science or fleet operational needs. For example, future Navy experiments to develop a better understanding of ocean currents may be designed based on advancements made by non-government researchers not yet published in the scientific literature. Similarly, future but yet unknown Navy operations within a specific geographic area may require development of modified Navy assets to address local conditions. Such modifications must be tested in the field to ensure they meet fleet needs and requirements. Accordingly, generic descriptions of some of these activities are the best that can be articulated in a long-term, comprehensive document, like this EIS/OEIS.

Some testing activities are similar to training activities conducted by the fleet. For example, both the fleet and the research and acquisition community fire torpedoes. While the firing of a torpedo might look identical to an observer, the difference is in the purpose of the firing. The fleet might fire the torpedo to practice the procedures for such a firing, whereas the research and acquisition community might be assessing a new torpedo guidance technology or to ensure that the torpedo meets performance specifications and operational requirements. These differences may result in different analysis and potential mitigations for the activity.

2.4.2.1 Naval Air Systems Command Testing Activities

Naval Air Systems Command testing activities generally fall in the primary mission areas used by the fleets. Naval Air Systems Command activities include, but are not limited to, the testing of new aircraft platforms, weapons, and systems before those platforms, weapons and systems are delivered to the fleet. In addition to the testing of new platforms, weapons, and systems, Naval Air Systems Command also conducts lot acceptance testing of weapons and systems, such as sonobuoys.

The majority of testing and development activities conducted by Naval Air Systems Command are similar to fleet training activities, and many platforms (e.g., Maritime Patrol Aircraft) and systems (e.g., sonobuoys) currently being tested are already being used by the fleet or will ultimately be integrated into fleet training activities. However, some testing and development may be conducted in different locations and in a different manner than the fleet and therefore, though the potential environmental effects may be the same, the analysis for those activities may differ. Training with systems and platforms delivered to the fleet within the timeframe of this document are analyzed in the training sections of this EIS/OEIS. This section addresses Naval Air Systems Command's testing activities, which will occur in conjunction with fleet training, and are further described in Table 2.4-2.

Table 2.4-2: Typical Naval Air Systems Command Testing Activities in the Study Area

Activity Name	Activity Description
Anti-Surface Warfare (ASUW)	
Air-to-Surface Missile Test	This event is similar to the training event missile exercise (air-to-surface). Test may involve fixed wing aircraft launching missiles at surface maritime targets to evaluate the weapon system or as part of another systems integration test.
Anti-Submarine Warfare (ASW)	
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoy)	This event is similar to the training event ASW TRACKEX – Maritime Patrol Aircraft. The test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines and to ensure that aircraft systems used to deploy the tracking systems perform to specifications and meet operational requirements.
Anti-Submarine Warfare Torpedo Test	This event is similar to the training event torpedo exercise. The Test evaluates anti-submarine warfare systems onboard rotary wing and fixed wing aircraft and the ability to search for, detect, classify, localize, track, and attack a submarine or similar target. Some tests from fixed-wing aircraft will involve releasing torpedoes and sonobuoys from high altitudes (approximately 25,000 feet [7,620 meters]).
Broad Area Maritime Surveillance (BAMS) – MQ-4C Triton Testing	The Broad Area Maritime Surveillance system will fill a complementary role to the P-8A aircraft, providing maritime reconnaissance support to the Navy. The current BAMS system in testing and development is called “Triton.” It will be equipped with electro-optical/infrared sensors, can remain on station for 30 hours, and fly at approximately 60,000 feet (18,288 meters).
Electronic Warfare (EW)	
Flare Test	Flare tests evaluate newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems against flare deployment. Tests may also train pilots and aircrew in the use of newly developed or modified flare deployment systems. Flare tests are often conducted with other test events, and are not typically conducted as standalone tests. Chaff and flares are expended for this test event.

2.4.2.2 Naval Sea Systems Command Testing Activities

Naval Sea Systems Command testing activities (Table 2.4-3) are aligned with its mission of new ship construction, life cycle support, and other weapon system development and testing. Each major category of Naval Sea Systems Command activities applicable to the MITT Study Area is described below.

2.4.2.3 New Ship Construction Activities

Ship construction activities include testing of ship systems, and developmental and operational test and evaluation programs for new technologies and systems. At-sea testing of systems aboard a ship may include sonar, acoustic countermeasures, radars, and radio equipment. At-sea test firing of shipboard weapon systems, including guns, torpedoes, and missiles, are also conducted.

2.4.2.4 Life Cycle Activities

Testing activities are conducted throughout the life of a Navy ship to verify performance and mission capabilities. Sonar systems testing occurs pierside during maintenance, repair, and overhaul availabilities, and at sea immediately following most major overhaul periods. Radar cross signature testing of surface ships is conducted on new vessels and periodically throughout a ship’s life to measure how detectable the ship is to radar. Additionally, electromagnetic measurements of off-board electromagnetic signature are conducted for submarines, ships, and surface crafts periodically.

2.4.2.5 Other Naval Sea Systems Command Testing Activities

Numerous test activities and technical evaluations, in support of Naval Sea Systems Command's systems development mission, often occur in conjunction with fleet activities within the MITT Study Area. Tests within this category include, but are not limited to anti-submarine warfare and mine warfare tests using torpedoes, sonobuoys, and mine detection and neutralization systems. Pierside, swimmer detection systems will also be tested.

Unique Naval Sea Systems Command planned testing includes a kinetic energy weapon for Navy ships, which uses electromagnetic energy to propel a projectile at a surface, air, or ground target.

Table 2.4-3: Typical Naval Sea Systems Command Testing Activities in the Study Area

Activity Name	Activity Description
Life Cycle Activities	
Ship Signature Testing	Tests ship and submarine radars, electromagnetic, or acoustic signatures.
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing	
Kinetic Energy Weapon Testing	A kinetic energy weapon uses stored electromagnetic energy released in a burst to accelerate a projectile. Projectiles used for testing are either non-explosive or in-air explosive munitions.
Torpedo Testing	Air, surface, or submarine crews employ live/exercise torpedoes against submarines or surface vessels.
Countermeasure Testing	Various systems (e.g., towed arrays and defense systems) are employed to detect, localize, and track incoming weapons.
At-sea Sonar Testing	At-sea testing to ensure systems are fully functional in an open ocean environment.
Shipboard Protection Systems and Swimmer Defense Testing	
Pierside Integrated Swimmer Defense	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and engage swimmer/diver threats in harbor environments.
New Ship Construction	
Anti-Submarine Warfare (ASW) Mission Package Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines.
Mine Countermeasures (MCM) Mission Package Testing	Ships conduct mine countermeasure operations.
Anti-Surface Warfare (ASUW) Mission Package Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute surface vessels.

2.4.2.6 Office of Naval Research and Naval Research Laboratory Testing Activities

As the Navy's Science and Technology provider, Office of Naval Research and the Naval Research Laboratory provide technology solutions for Navy and Marine Corps needs. The Office of Naval Research's missions, defined by law, are to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security. Further, the Office of Naval Research manages the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test and evaluation. The Ocean Battlespace Sensing Department explores science and technology in the areas of oceanographic and meteorological observations, modeling, and prediction in the battlespace environment; submarine detection and classification (anti-submarine warfare); and mine warfare applications for detecting and neutralizing mines in both the ocean and littoral environment. The Office of Naval Research activities include: research, development, test, and evaluation activities; surface processes acoustic communications experiments; shallow water acoustic communications experiments; sediment acoustics experiments; shallow water acoustic propagation experiments; and long range acoustic propagation experiments. Office of Naval Research testing is shown in Table 2.4-4.

Table 2.4-4: Typical Office of Naval Research Testing Activity in the Study Area

Activity Name	Activity Description
Office of Naval Research	
North Pacific Acoustic Lab Philippine Sea 2018–19 Experiment (Deep Water)	The experiment area encompasses international waters. The initial experiment was completed in May of 2011; an acoustic tomography array, a distributed vertical line array (DVLA), and moorings were deployed in the deep-water environment of the northwestern Philippine Sea. The acoustic tomography array and DVLA have remained in situ at the experiment site since that time, collecting oceanographic and acoustic data used to study deep-water propagation and to characterize the temperature and velocity structure in this oceanographically complex and highly dynamic region. In addition, data will be collected during two periods of intensive experimental at-sea operations in May and July of 2018. During fall 2018, data will be collected passively by remotely sensing seagliders. Research vessels, acoustic test sources, side scan sonar, ocean gliders, the existing moored acoustic tomographic array and distributed vertical line array, and other oceanographic data collection equipment will be used to collect information on the ocean environment. The final phases of the experiment will be completed during March through May 2019. The resulting analyses will aid in developing a more complete understanding of deep water sound propagation and the temperature-velocity profile of the water column in this part of the world.

2.5 Alternatives Development

The identification, consideration, and analysis of alternatives are important aspects of the NEPA process and contribute to the goal of objective decision-making. The Council on Environmental Quality requires and provides guidance on the development of alternatives. The 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 C.F.R. §1502.14). The range of alternatives include reasonable alternatives, which must be rigorously and objectively explored, as well as other alternatives that were considered but eliminated from detailed study. To be reasonable, an alternative must meet the stated purpose of and need for the Proposed Action. An EIS must explore all reasonable mitigation measures for a Proposed Action. Mitigation measures are discussed throughout this EIS/OEIS in connection with affected resources, and are also addressed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). The purpose of including a No Action Alternative in environmental impact analyses is to ensure that agencies compare the potential impacts of the Proposed Action to the potential impacts of maintaining the status quo.

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

2.5.1 ALTERNATIVES ELIMINATED FROM FURTHER CONSIDERATION

Alternatives eliminated from further consideration are described in Sections 2.5.1.1 (Alternative Training and Testing Locations) through 2.5.1.3 (Simulated Training and Testing). The Navy determined that these alternatives did not meet the purpose of and need for the Proposed Action after a thorough consideration of each.

2.5.1.1 Alternative Training and Testing Locations

The Navy's use of training ranges has evolved over the decades because these geographic areas allow the entire spectrum of training and testing to occur. While some unit level training and some testing activities may require only one training element (air space, sea space, or undersea space), more advanced training and testing activities may require a combination of air, surface, and undersea space as well as access to land ranges. The ability to utilize the diverse and multi-dimensional capabilities of each range complex allows the Navy to develop and maintain high levels of readiness. No other locations match the attributes found in the MITT Study Area, which are as follows:

- The MITT Study Area is the only capable and efficient training and testing location within the territory of the United States in the Western Pacific for military services homeported, deployed to, or returning from regions in the Western Pacific and the Indian Ocean.
- The MITT Study Area has the capability to support a large number of forces (multi-national air, land, and sea components), has extensive existing range assets, and accommodates training and testing activity responsibilities both geographically and strategically.
- The Mariana Islands strategic location within the MITT Study Area provides the Pacific Joint Commander an area from which he can launch strategic engagement plans that may include multinational training with allied nations from North America, Australia, and Asia or training U.S. forces for contingency response[3] to a humanitarian or geo-political crisis. Multi-national training not only provides a well-trained force, but also furthers international cooperation.
- The MITT Study Area presents a realistic environment for strike warfare training, contingency operations training including amphibious training activities, and anti-submarine warfare. Training may be conducted in the open ocean, close to land masses, and in unobstructed airspace so that battle situations may be realistically simulated. There is room and space to operate within proximity of land but at safe distances from other simultaneous training. This allows both training of locally based units and the necessary build-up of capability through training that culminates in multi-force training in waters offshore of Guam and CNMI. The premier capability of the MITT Study Area is the combination of large ocean and airspace to support subsurface, surface, and airspace warfare training combined with land-based ranges.

[3] A contingency response is a rapid response to an event that is a possibility that must be prepared for (i.e., a future emergency). The response ensures a smooth transition to subsequent operations.

One of the DoD's highest priorities is maintaining the readiness and sustainability of U.S. forces. Readiness is the overall ability of forces to arrive on time where needed, and be sufficiently trained, equipped, and supported to effectively carry out assigned missions. Forces must be placed and maintained such that they can be utilized in a timely fashion. A timely response is directly related to the amount of time required to reach the destination, and dependent on distance traveled. The distance from the potential threat can vary based on unit type and need, as well as mode of transport. Traditionally, forces were deployed in a slow steady buildup over time. Now, however, crises manifest quickly in a variety of locations. Forces must be placed and maintained such that they can provide a rapid and timely response. Therefore, it is imperative to locate forces so that the amount of time required to reach a crisis location is kept to a minimum. Deployed forces that use the MITT Study Area have reduced response times compared to forces positioned in Alaska, Hawaii, or California.

The greatest flexibility for the U.S. military to train is on ranges located in the United States and its territories. Guam and the CNMI are composed of territory belonging to the United States, and thus afford the greatest flexibility and the fewest restrictions from a government-to-government standpoint.

For the above reasons, it is not reasonable, practicable, nor appropriate to seek alternative locations for training conducted in the MITT Study Area. This alternative, therefore, has been eliminated from further consideration in the EIS/OEIS.

2.5.1.2 Reduced Training and Testing

Title 10 Section 5062 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." Reduction or cessation of training and testing would prevent the Navy from meeting its Title 10 requirements and adequately preparing naval forces for operations at sea ranging from disaster relief to armed conflict; thus, this alternative does not meet the purpose and need of the proposal.

2.5.1.3 Mitigations Including Temporal or Geographic Constraints within the Study Area

Alternatives considered under the NEPA process may include mitigation measures. While alternatives including mitigation measures may be considered under the NEPA process, to do so is predicated on the ability to develop appropriate mitigation measures before conducting a detailed analysis and engaging in necessary consultations with regulators. Analysis of military training and testing activities involves compliance with several federal laws including the MMPA and the ESA. These laws require that the Navy complete complex and lengthy permitting processes, which include applying the best available science to analyze the effects of the actions and develop mitigations as required. The best available science is reviewed and identified during the course of the permitting and NEPA/EO 12114 processes. Consequently, in order to allow for potential mitigation measures to be more fully developed as part of the detailed NEPA/EO 12114 analysis and further refined and informed by applicable permitting processes, the Navy did not identify and carry forward for analysis any separate alternatives with pre-determined geographic or temporal restrictions. Rather, Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of this EIS/OEIS contains a detailed discussion of potential mitigation measures that were evaluated. Based on the analysis in Chapter 5, 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, may be implemented under either action alternative as well as the No Action Alternative.

2.5.1.4 Simulated Training and Testing

The Navy currently uses computer simulation for training and testing whenever possible (e.g., command and control exercises are conducted without operational forces); however, there are significant limitations and its use cannot completely substitute for live training or testing. Therefore, simulation as an alternative that 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.

2.5.1.4.1 Simulated Training

The Navy continues to research new ways to provide realistic training through simulation, but there are limits to the realism that technology can presently provide. Unlike live training, computer-based training does not provide the requisite level of realism necessary to attain combat readiness. Simulation cannot replicate the inherent high-stress environment and complexity of the coordination needed to combine multiple military assets and personnel into a single fighting unit. Most notably, simulation cannot mimic dynamic environments involving numerous forces or accurately model the behavior of sound in complex training media such as the marine environment.

Today's simulation technology does not permit anti-submarine warfare training with the degree of fidelity required to maintain proficiency. 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. Moreover, it is imperative that crews achieve competence and gain confidence in their ability to use their equipment.

Sonar operators must train regularly and frequently to develop and maintain the skills necessary to master the process of identifying underwater threats in the complex subsurface environment. Sole reliance on simulation would deny service members the ability to develop battle-ready proficiency in the employment of active sonar in the following specific areas:

- Bottom bounce and other environmental conditions. Sound hitting the ocean floor (bottom bounce) reacts differently depending on the bottom type and depth. Likewise, sound passing through changing currents, eddies, or across changes in ocean temperature, pressure, or salinity is also affected. Both of these are extremely complex to simulate, and both are common in actual sonar operations.
- Mutual sonar interference. When multiple sonar sources are operating in the vicinity of each other, interference due to similarities in frequency can occur. Again, this is a complex variable that must be recognized by sonar operators, but is difficult to simulate with any degree of fidelity.
- Interplay between ship and submarine target. Ship crews, from the sonar operator to the ship's Captain, must react to the changing tactical situation with a real, thinking adversary (a Navy submarine for training purposes). Training in actual conditions with actual submarine targets provides a challenge that cannot be duplicated through simulation.
- Interplay between anti-submarine warfare teams in the strike group. Similar to the interplay required between ships and submarine targets, a ship's crew must react to all changes in the tactical situation, including changes from cooperating ships, submarines, and aircraft.

Computer simulation can provide familiarity and complement live training; however, it cannot provide the fidelity and level of training necessary to prepare naval forces for deployment. Therefore, the alternative of substituting simulation for live training fails to meet the purpose of and need for the Proposed Action and was eliminated from detailed study.

2.5.1.4.2 Simulated Testing

As described in Section 1.4.3 (Why the Navy Tests), the Navy conducts testing activities to collect scientific data; investigate, develop, and evaluate new technologies; and to support the acquisition and life cycle management of platforms and systems used by the warfighters. Throughout the life cycle of platforms and systems, from performing basic research to procurement of the platform or system, the Navy uses a number of different testing methods, including computer simulation, when appropriate. The Navy cannot use or rely exclusively on simulation when performing a number of specific testing activities, including collection of scientific data; verifying contractual requirements; and assessing performance criteria, specifications, and operational capabilities.

The Navy collects scientific data that can only be obtained from direct measurements of the marine environment to support scientific research associated with the development of new platforms and systems. A full understanding of how waves in the ocean move, for example, can only be fully understood by collecting information on waves. This type of direct scientific observation and measurement of the environment is vital to developing simulation capabilities by faithfully replicating environmental conditions.

As the acquisition authority for the Navy, the Systems Commands are responsible for administering large contracts for the Navy's procurement of platforms and systems. These contracts include performance criteria and specifications that must be verified to assure that the Navy accepts platforms and systems that support the warfighter's needs. Although simulation is a key component in platform and systems development, it does not adequately provide information on how a system will perform or whether it will be able to meet performance and other specification requirements because of the complexity of the technologies in development and the marine environments in which they will operate. For this reason, at some point in the development process, platforms and systems must undergo at-sea or in-flight testing. For example, a new jet airplane design can be tested in a wind tunnel that simulates flight to assess elements like maneuverability, but eventually a prototype must be constructed and flown to confirm the wind tunnel data.

Furthermore, the Navy is required by law to operationally test major platforms, systems, and components of these platforms and systems in realistic combat conditions before full-scale production can occur. Under Title 10 of the U.S. Code, this operational testing cannot be based exclusively on computer modeling or simulation. At-sea testing provides the critical information on operability and support liability needed by the Navy to make decisions on the procurement of platforms and systems, ensuring that what is purchased performs as expected and that tax dollars are not wasted. This testing requirement is also critical to protecting the warfighters who depend on these technologies to execute their mission with minimal risk to themselves.

This alternative—substitution of simulation for live testing—fails to meet the purpose of and need for the Proposed Action and was therefore eliminated from detailed study.

2.5.2 ALTERNATIVES CARRIED FORWARD

Three alternatives are analyzed in this EIS/OEIS.

- **No Action Alternative:** Baseline training and testing activities, as well as airspace and seaspace reconfigurations, as defined by existing environmental planning documents including the 2010 MIRC EIS/OEIS, the 2011 Office of Naval Research *Acoustic Impact Analysis for the North Pacific Acoustic Laboratory Philippine Sea 2010 through 2011 Experiment* (U.S. Department of the Navy 2011), and the 2013 MIRC Airspace EA/OEA. The baseline training and testing activities include those testing events that have historically occurred in the Study Area and have been subject to previous analyses pursuant to NEPA/EO 12114.
- **Alternative 1 (Preferred Alternative):** Overall expansion of the Study Area, adjustment of range capabilities, location, type, and level of activities from the baseline as necessary to support current and planned training and testing requirements. This Alternative considers:
  - Analysis of areas where training and testing would continue as in the past, but were not considered in previous environmental analyses. This Alternative would not expand the area where the Navy trains and tests, but would simply expand the area that is to be analyzed.
  - Mission requirements associated with force structure changes, including those resulting from the development, testing, and ultimate introduction of new platforms (vessels and aircraft) and weapon systems into the fleet.
- **Alternative 2:** Consists of Alternative 1 plus adjustments to the type and levels of training and testing.

Each of the alternatives are discussed in further detail in Sections 2.6 (No Action Alternative), 2.7 (Alternative 1 [Preferred Alternative]), and 2.8 (Alternative 2).

2.6 NO ACTION ALTERNATIVE: CURRENT MILITARY READINESS WITHIN THE MARIANA ISLANDS TRAINING AND TESTING STUDY AREA

The Council on Environmental Quality regulations requires that a range of alternatives to the Proposed Action, including a No Action Alternative, be developed for analysis. The No Action Alternative serves as a baseline description from which to compare the potential impacts of the Proposed Action. The Council on Environmental Quality provides two interpretations of the No Action Alternative, depending on the Proposed Action. One interpretation would mean the proposed activity would not take place, and the resulting environmental effects from taking no action would be compared with the effects of taking the Proposed Action. For example, this interpretation would be used if the Proposed Action was the construction of a facility in a location where no facility has or currently exists. The second interpretation, which applies to this EIS/OEIS, allows the No Action Alternative to be thought of in terms of continuing with the present course of action until that action is changed. The No Action Alternative for this EIS/OEIS would continue currently conducted training and testing activities (baseline activities) and force structure requirements as defined by existing Navy environmental planning documents described in Section 2.5.2 (Alternatives Carried Forward).

The No Action Alternative represents the MITT Study Area training and testing activities and events as set forth in previously completed Navy environmental planning documents and Record of Decisions. However, the No Action Alternative would fail to meet the purpose of and need for the Proposed Action because it would not allow the Navy to meet current and future training and testing requirements necessary to achieve and maintain fleet readiness.

For example, the baseline activities do not account for changes in force structure (personnel, weapons, and assets) requirements, the introduction of new or upgraded weapons and platforms, and the training and testing required for proficiency with these systems.

Tables 2.8-1 to 2.8-4 provide a summary of the training and testing activities to be analyzed under the No Action Alternative, Alternative 1, and Alternative 2. Cells under the "Ordnance" column are shaded gray if that activity includes the use of explosive ordnance.

2.7 Alternative 1 (Preferred Alternative): Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems

Alternative 1 would consist of the No Action Alternative, plus the expansion of Study Area boundaries, and adjustments to range capabilities and the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

- **Expansion of the Overall Study Area Boundaries:** This EIS/OEIS contains analysis of areas where training and testing would continue as in the past, but were not considered in previous environmental analyses. This Alternative would simply expand the area that is to be analyzed, as depicted in Figure 2.1-1 and described in Section 2.1 (Description of the Mariana Islands Training and Testing Study Area), including:
    - **Expansion of the Northern and Western Boundary of the Study Area:** The area to the north of MIRC that is within the Exclusive Economic Zone of the Northern Mariana Islands and the areas to the west of the MIRC.
    - **Transit Corridor:** An area not previously analyzed in the open ocean between the MIRC and the HRC. During transit within this area, U.S. Navy ships conduct limited training and testing. These activities would be included in this EIS/OEIS.
    - **Navy Piers and Shipyards:** The Navy tests sonar systems at Navy piers and shipyards. These maintenance testing activities would be included in this EIS/OEIS.
    - **Apra Harbor Channel:** Vessels berthed at Naval Base Guam transit Apra Harbor to and from the naval base. During these transits, some sonar maintenance testing would occur.
- **Adjustments to Range Capabilities, Locations, and Tempo of Training and Testing Activities.** This alternative also includes changes to training and testing requirements necessary to accommodate (a) the relocation of ships, aircraft, and personnel; (b) planned aircraft, vessels, and weapons systems; and (c) ongoing activities not addressed in previous documentation in the MITT Study Area.
    - **Force Structure Changes:** Force structure changes involve the relocation of ships, aircraft, and personnel. As forces are moved within the existing Navy structure, training needs will necessarily change as the location of forces change.
    - **Planned Aircraft, Vessels, and Weapons Systems:** This EIS/OEIS will examine the training and testing requirements of planned vessels, aircraft, and weapon systems.
    - **Ongoing Activities:** Current training and testing activities not addressed in previous documentation will be analyzed in this EIS/OEIS.
    - **Danger Zones:** This EIS/OEIS will examine establishment of Title 33 C.F.R. Part 334 Danger Zones for existing shore-based small arms and explosive ordnance disposal ranges and a nearshore small arms training area. Figure 2.7-1 shows the current, proposed, and pending nearshore danger zones around Guam and FDM. Table 2.7-1,

Nearshore Training and Testing Danger Zones, describes the current, proposed, and pending nearshore danger zones status.

- **Underwater Detonations:** An increase in NEW for underwater detonations from 10 lb. to 20 lb. at the Agat Bay Mine Neutralization Site.

Alternative 1 reflects adjustments to the baseline activities which are necessary to support all current and proposed training and testing activities in the MITT Study Area. Locations identified within Table 2.8-1 through 2.8-4 represent the areas where events are typically conducted. Generally, the range complex is identified but, for some activities, smaller areas within the range are identified. Events could occur outside of the specifically identified areas if environmental conditions are not favorable on a range, the range is unavailable due to other units training or testing or it poses a risk to civilian or commercial users, or to meet fleet readiness requirements.

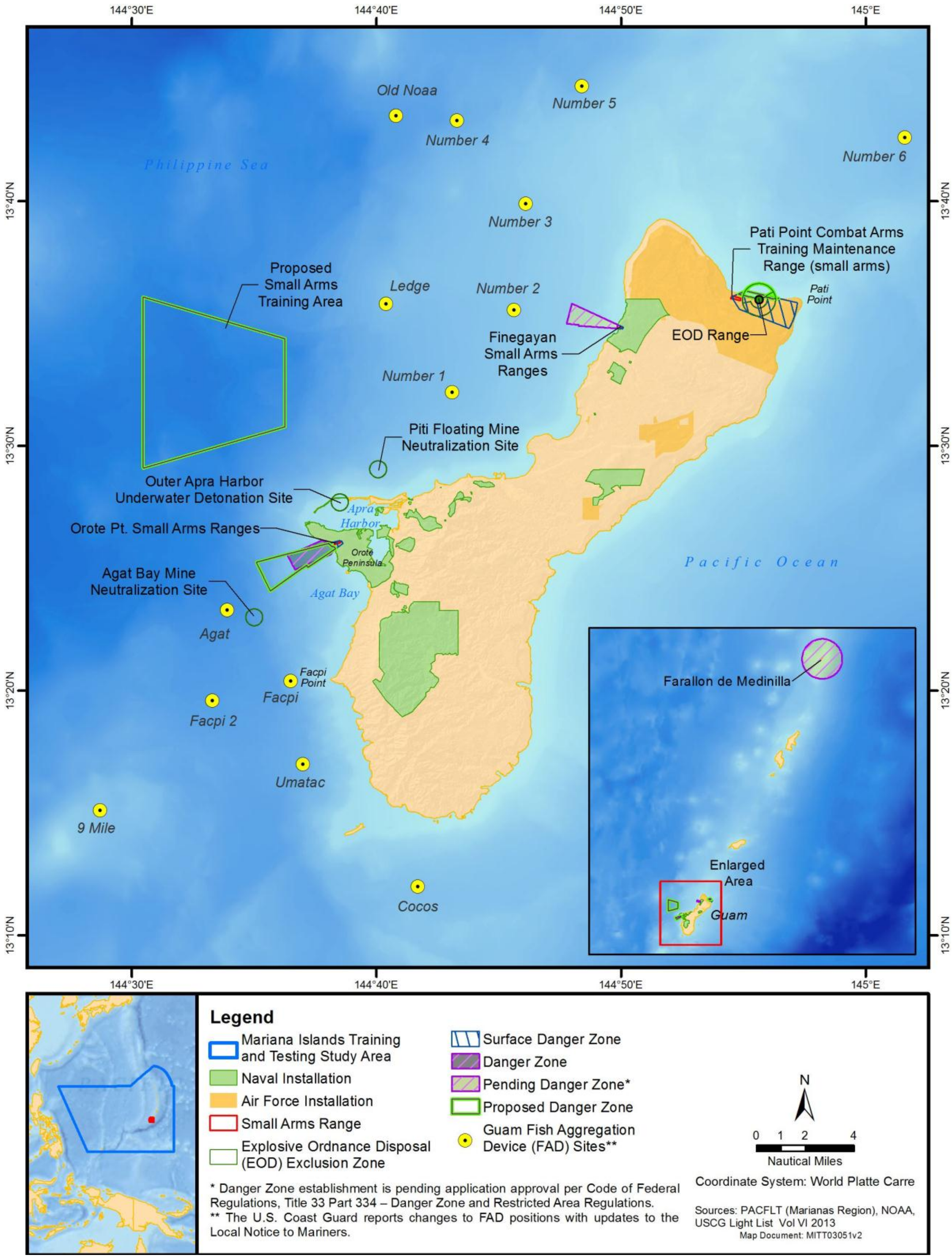

Figure 2.7-1: Nearshore Training and Testing Danger Zones, Surface Danger Zones, and Exclusion Zones

Table 2.7-1: Nearshore Training and Testing Danger Zones

Nearshore Training and Testing Zones (Current, Proposed, and Pending)	Description	Danger Zone Establishment Status (Current, Proposed, or Pending)
Danger Zone – Pacific Ocean around Farallon de Medinilla (FDM) Live Fire and Inert Gunnery, Missile, and Bombing Range	Extends around FDM with a 12-nautical-mile (nm) radius, congruent with the outer edge of Restricted Area 7201A.	Analyzed as part of the 2010 Mariana Islands Range Complex (MIRC) Environmental Impact Statement (EIS)/Overseas EIS (OEIS) and the 2013 MIRC Airspace Environmental Assessment (EA)/Overseas EA. Formal establishment is pending U.S. Army Corps of Engineers (USACOE) rule making.
Danger Zone – Pacific Ocean off Orote Point, Apra Harbor, Island of Guam, Marianas Islands; small arms firing range.	Used for Small Arms Training. Down range Surface Danger Zone extends out over the nearshore waters of Guam off Orote Point. (1) The Danger Zone shall be closed to the public and shipping on specific dates to be designated for actual firing, and no person, vessel, or other craft shall enter or remain in the Danger Zone designated for firing except as may be authorized by the enforcing agency. Notification to maritime interests of specific dates of firing will be disseminated by the enforcing agency. On dates not specified for firing, the Danger Zone shall be open to normal maritime traffic. (2) The regulations in this section shall be enforced by the Commanding Officer, U.S. Naval Station, Guam, Marianas Islands, and such agencies as he may designate.	Rule established in 33 C.F.R Part 334.1420. First established in year 1963, and amended in years 1985 and 1997. Shown on National Oceanic and Atmospheric Administration (NOAA) Chart 81048, Guam. Proposed Danger Zone modification under Mariana Islands Training and Testing (MITT) EIS/OEIS Alternative 1 (Preferred Action) to support the modification of existing Title 33 C.F.R. Part 334 Danger Zone.
Danger Zone – Finegayan Small Arms Range	Used for small arms training. Down range Surface Danger Zone extends out over the nearshore waters of Guam off Haputo Point and overlays part of the "Small Arms Safety Drop Zone" shown on NOAA Chart 81048, Guam.	2010 MIRC EIS/OEIS used to support the establishment of this Title 33 C.F.R. Part 334 Danger Zone. Formal establishment is pending USACOE rule making.
Danger Zone – Pati Point Combat Arms Training Maintenance Small Arms Range	Used for small arms training. Down range Surface Danger Zone extends out over the nearshore waters of Guam off Pati Point.	Proposed under Mariana Islands Training and Testing (MITT) EIS/OEIS Alternative 1 (Preferred Action) to support the establishment of a Title 33 C.F.R. Part 334 Danger Zone.
Danger Zone – Small Arms Training Area	An area used by surface vessel crews to conduct small arms training. This firing area is over water west of Guam.	Proposed under MITT EIS/OEIS Alternative 1 (Preferred Action). MITT analysis will be used to support the establishment of a Title 33 C.F.R. Part 334 Danger Zone.

Table 2.7-1: Nearshore Training and Testing Danger Zones (continued)

Nearshore Training and Testing Zones (Current, Proposed, and Pending)	Description	Danger Zone Establishment Status (Current, Proposed, or Pending)
Exclusion Zone – Agat Bay Mine Neutralization Site	Used by divers training to conduct underwater detonations. The Exclusion Zone has a minimum 640-meter (m) radius and is located beyond 3 nm of Guam and within territorial waters.	No C.F.R. Danger Zone or Safety Zone rule established, pending, or proposed under the MITT EIS/OEIS. Temporary Safety Zones are established by the Coast Guard as required, and announced in Local Notice to Mariners and Broadcast Notice to Mariners.
Exclusion Zone – Piti Point Mine Neutralization Site	Used by divers training to conduct underwater detonations. The Exclusion Zone has a minimum 640 m radius and is located within 3 nm of Guam.	No C.F.R. Danger Zone or Safety Zone rule established, pending, or proposed under the MITT EIS/OEIS. Temporary Safety Zones are established by the Coast Guard as required, and announced in Local Notice to Mariners and Broadcast Notice to Mariners.
Exclusion Zone – Apra Harbor UNDET Site	Used by divers training to conduct underwater detonations. The Exclusion Zone has a minimum 640 m radius over water, and is located within Apra Harbor. The Glass Breakwater forms the northern edge of Exclusion Zone.	No C.F.R. Danger Zone or Safety Zone rule established, pending, or proposed under the MITT EIS/OEIS. Temporary Safety Zones are established by the Coast Guard as required, and announced in Local Notice to Mariners and Broadcast Notice to Mariners.
Exclusion Zone – Pati Point Explosive Ordnance Disposal Range	Land site used by the Air Force to dispose of ordnance. The Exclusion Zone extends partially out over the nearshore waters of Guam off Pati Point.	No C.F.R. Danger Zone or Safety Zone rule currently established. Proposed under MITT EIS/OEIS Alternative 1 (Preferred Action). MITT analysis will be used to support the establishment of a Title 33 C.F.R. Part 334 Danger Zone.

2.7.1 Proposed Adjustments to Baseline Training Activities

The proposed adjustments to baseline levels and types of training, as well the introduction of new activities, are categorized below by primary mission areas. Table 2.8-1 (Baseline and Proposed Training Activities) lists the proposed adjustments.

2.7.1.1 Anti-Air Warfare

- Support requirements by increasing number of events, and the amount of ordnance used for training requirements.

- Utilize new weapons in the conduct of anti-air warfare, such as the 57 mm (2.24 in.) (large-caliber) gun system and rolling airframe missile system installed on the Littoral Combat Ship.
- Proposed new anti-air warfare training activities: Air Defense Exercise, Gunnery Exercise Surface-to-Air – Large-caliber, and Gunnery Exercise Surface-to-Air – Medium-caliber.

2.7.1.2 Strike Warfare

- Support requirements by increasing number of events, and the amount of ordnance used for training requirements.
- Utilize new weapons during strike warfare events, such as the use of precision-guided rockets.

2.7.1.3 Amphibious Warfare

- Support requirements by increasing number of events, and the amount of ordnance used for training requirements.
- Proposed new amphibious warfare training activities: Amphibious Rehearsal (No Landing), and Unmanned Aerial Vehicle (Intelligence, Surveillance, and Reconnaissance).

2.7.1.4 Anti-Surface Warfare

- Support requirements by increasing number of events, and the amount of ordnance used for training requirements.
- Utilize new weapons during anti-surface warfare events, such as the 57 mm (2.24 in.) turret mounted gun on the Littoral Combat Ship, the upgraded 20 mm (0.79 in.) close-in weapon system which allows for its use in defending against surface craft, the 30 mm (1.18 in.) gun, and new precision-guided missiles/rockets currently under development.
- Proposed new anti-surface warfare training activities: Missile Exercise (Air-to-Surface) – Rocket, Torpedo Exercise (Submarine-to-Surface), Missile Exercise (Surface-to-Surface), and Gunnery Exercise – Boat (Medium-Caliber).

2.7.1.5 Anti-Submarine Warfare

- Support anti-submarine warfare requirement by adjusting number of events conducted and the amount of acoustic sensors used during those activities.
- Account for the introduction of planned anti-submarine warfare sensors being made available.

2.7.1.6 Electronic Warfare

- Support requirements by increasing number of events, and the amount of ordnance used for training requirements.
- Account for the introduction and operation of planned threat emitters such as the Joint Threat Emitter.

2.7.1.7 Mine Warfare

- Support requirements by increasing number of events, and the amount of ordnance used for training requirements.
- An increase in net explosive weight for underwater mine neutralization detonations from 10 lb. to 20 lb. at Agat Mine Neutralization Site.
- Employ new mine countermeasure systems in the Marianas in support of all other mine warfare training, such as the AQS-20 and AQS-24 towed sonar systems, the Airborne Laser Mine

Detection System, hull-mounted sonar such as the SQQ-32 and SLQ-48 system, and the ASQ-235 Airborne Mine Neutralization System.
- Propose new training activities: Civilian Port Defense, Limpet Mine Neutralization System/Shock Wave Generator, Submarine Mine Exercise, Airborne Mine Countermeasure – Mine Detection, Mine Countermeasure Exercise – Surface Sonar, Mine Neutralization – Remotely Operated Vehicle Sonar, and Mine Countermeasure – Towed Mine Detection.

2.7.1.8 Naval Special Warfare

- Support requirements by increasing number of events, and the amount of ordnance used for training requirements.
- An increase in net explosive weight for underwater detonations from 10 lb. to 20 lb. at Agat Mine Neutralization Site.

2.7.1.9 Other Training

- Support requirements by increasing number of events, and the amount of ordnance used for training requirements.
- Proposed new training activities: Surface Ship Sonar Maintenance, Submarine Sonar Maintenance, Small Boat Attack, Submarine Navigation, Search and Rescue at Sea, Precision Anchoring, Water Purification, and Unmanned Aerial Vehicle Operation.

2.7.2 Proposed Adjustments to Baseline Testing Activities

The proposed adjustments to baseline levels and types of testing are listed in Table 2.8-2 (Baseline and Proposed Naval Air Systems Command Testing Activities), Table 2.8-3 (Baseline and Proposed Naval Sea Systems Command Testing Activities), Table 2.8-4 (Baseline and Proposed Office of Naval Research Testing Activities), and include the following:

2.7.2.1 Anti-Surface/Anti-Submarine Warfare Testing

Proposed new test events:

- Air-to-Surface Missile Testing.
- Kinetic Energy Weapon Testing, conducted on vessels at-sea (e.g., on Destroyer [DDG] 1000 vessels).
- At-Sea Sonar Testing (ship and submarine sonar testing).
- Tracking Testing (sonobuoys), Maritime Patrol Aircraft.
- Torpedo Testing (ship, air, and submarine launched torpedoes).
- Countermeasure Testing.
- MQ-4C Triton, Broad Area Maritime Surveillance System Testing.

2.7.2.2 Electronic Warfare

Proposed new test event, Flare Test using fixed-wing aircraft.

2.7.2.3 Life Cycle Activities

Proposed new test event, Ship Signature Testing.

2.7.2.4 Shipboard Protection Systems and Swimmer Defense Testing

Proposed new test event, Pierside Integrated Swimmer Defense Testing.

2.7.2.5 New Ship Construction

Proposed new test events:

- Anti-surface warfare mission package testing.
- Anti-submarine warfare mission package testing.
- Mine countermeasure mission package testing.

2.7.2.6 Office of Naval Research

There is no change to the type and level of baseline activity; however, the overall expansion of the Study Area includes ocean area that supports Office of Naval Research acoustic experiments.

2.7.3 PROPOSED PLATFORMS AND SYSTEMS

The following is a representative list of additional platforms, weapons and systems analyzed. The ships and aircraft will not be an addition to the fleet but rather replace older ships and aircraft that are decommissioned and removed from the inventory. Information regarding Navy platforms and systems can be found on the Navy Fact File website: http://www.navy.mil/navydata/fact.asp.

2.7.3.1 Aircraft

F-35 Joint Strike Fighter

The F-35 Joint Strike Fighter Lightning II aircraft will complement the Navy's F/A-18E/F. The F-35 is projected to make up about one-third of the Navy's strike fighter inventory by 2020. The Marine Corps will have a variant of the F-35 with a short takeoff, vertical landing capability that is planned to replace the AV-8B and F/A-18C/D aircraft. The Air Force F-35A is a conventional take-off and landing variant that could be introduced between 2015 and 2020. The Navy variant for aircraft carrier use is scheduled for delivery in 2015; the Marine Corps variant reached initial operating capability in 2012. The F-35 will operate similarly to the aircraft it replaces or complements. It will operate in the same areas and will be used in the same training exercises such as air-to-surface and air-to-air missile exercises, bombing exercises, and any other exercises where fixed-wing aircraft are used in training. No new activities will result from the introduction of the F-35.

EA-18G Airborne Electronic Attack Aircraft

The EA-18G is replacing the aging fleet of EA-6Bs providing a capability to detect, identify, locate, and suppress hostile emitters. It will operate similarly to the EA-6B, and in the same training areas, but will provide greater speed and altitude capabilities. No new activities will result from the introduction of the EA-18G.

E-2D Airborne Early Warning

The E-2D Advanced Hawkeye is the carrier-based Airborne Early Warning aircraft follow on variant of the E-2C Hawkeye. The E-2D will operate similarly to the E-2C, in the same training areas, with an increased on-station time as the new aircraft will include an in-flight refueling capability. Fleet integration is expected in 2015. No new activities will result from the introduction of the E-2D.

2.7.3.2 Ships

CVN-21 Aircraft Carrier (Gerald R. Ford Class)

The CVN-21 Program is designing the replacement for the Nimitz class carriers. The new aircraft carriers' capabilities will be similar to those of the carriers they will replace, and it will train in the same training and testing areas as the predecessor aircraft carriers. The first aircraft carrier (CVN 78) is expected to be delivered in 2015. No new activities will result from the introduction of the CVN 21 class of aircraft carriers.

DDG 1000 Multi-Mission Destroyer (Zumwalt Class)

Developed under the DD(X) destroyer program, Zumwalt (DDG 1000) is the lead ship of a class of next-generation multi-mission destroyers tailored for land attack and littoral dominance. DDG 1000 will operate similarly to the existing Arleigh Burke class of destroyers; however, it will provide greater capability in the nearshore sea space and will train more in that environment. Its onboard weapons and systems will include a 155 mm advanced gun system to replace the 5 in. gun system on current destroyers. This gun system will fire a new projectile at greater distances. See Section 2.7.3.6 (Munitions) for a description of the Long Range Land Attack Projectile.

The DDG 1000 will also be equipped with two new sonar systems; the AN/SQS-60 hull-mounted mid-frequency sonar, and the AN/SQS-61 hull-mounted high-frequency sonar.

The first ship of this class is expected to be delivered in 2016. This class will join the fleets and conduct training alongside existing DDG classes of ships.

Littoral Combat Ship

The Littoral Combat Ship is a fast, agile, mission-focused platform designed for operation in nearshore environments yet capable of open-ocean operation. These ships are capable of speeds in excess of 40 knots. As a focused-mission ship, the Littoral Combat Ship is equipped to perform one primary mission at any given time; however, the mission orientation can be changed by changing out its mission packages. Mission packages are supported by special detachments that will deploy manned and unmanned vehicles and sensors in support of mine, undersea and surface warfare missions. The first Littoral Combat Ships were delivered to the fleet in 2008 and 2010.

Joint High Speed Vessel

The Joint High Speed Vessel is capable of transporting personnel, equipment, and supplies 1,200 nm at an average speed of 35 knots. It is able to transport company-sized units with their vehicles, or reconfigure to become a troop transport for an infantry battalion. The Joint High Speed Vessel, while performing a variety of lift and support missions, is a non-combatant vessel that operates in permissive environments or in higher threat environments under the protection of combatant vessels and other joint forces. The first new vessel of the Spearhead class (JHSV-1) was delivered in 2012.

Amphibious Combat Vehicle

The Marine Corps is developing a vehicle to replace the Amphibious Assault Vehicle. The Amphibious Combat Vehicle will be the expected replacement, which the Marine Corps hopes to introduce to the

Fleet Marine Force by 2020. The Amphibious Combat Vehicle will have the capability of transporting Marines from naval ships located beyond the horizon to shore and further inland.

MK VI Patrol Craft

The MK VI Patrol Craft is 85 ft. (25.9 m) long, propulsion is provided by twin diesels and waterjets, capable of speeds up 30 knots, and a 600 nm range. Its mission is coastal and riverine patrol, and maritime security. It can be mounted with a 25 mm cannon on the bow. Initial craft delivery is expected in 2014 to the Naval Expeditionary Combat Command, followed by an initial four or five craft. Up to 48 craft may eventually be built, and replace the current 68 ft. (20.7 m) MK IV and 34 ft. (10.4 m) Sea Ark patrol craft.

2.7.3.3 Unmanned Vehicles and Systems

2.7.3.3.1 Unmanned Undersea Vehicle

In addition to unmanned undersea vehicles that are currently in service, new ones will be developed and enter fleet service that will support several high-priority missions including: (1) intelligence, surveillance, and reconnaissance; (2) mine countermeasures; (3) anti-submarine warfare; (4) oceanography; (5) communication/navigation network nodes; (6) payload delivery; (7) information operations; and (8) time critical strike.

Sea Maverick Unmanned Undersea Vehicle

Sea Maverick is a fully autonomous underwater vehicle specifically designed to minimize impacts to the environment. It uses no active sonar, and has an advanced propeller system that is encased to prevent damage to sea beds and other marine life.

2.7.3.3.2 Unmanned Surface Vehicle

Unmanned surface vehicles are primarily autonomous systems designed to augment current and future platforms to help deter maritime threats. They will employ a variety of sensors designed to extend the reach of manned ships.

Spartan Unmanned Surface Vehicle

The Spartan is an unmanned surface vehicle with a dipping sonar system. It will train in areas where current sonar training is conducted on Navy ranges.

Sea Horse Unmanned Surface Vehicle

The Sea Horse is an unmanned surface vehicle designed to provide force protection capabilities in harbors and bays.

2.7.3.3.3 Unmanned Aerial Systems

Unmanned aerial systems include aerial vehicles that operate as intelligence, search, and reconnaissance sensors or as armed combat air systems.

MQ-8B Fire Scout

The Fire Scout Vertical Take-Off and Landing Tactical Aerial Vehicle system is designed to operate from air-capable ships with initial deployment on a Guided Missile Frigate, followed by final integration and test on board the Littoral Combat Ship. This unmanned aerial vehicle system is capable of providing radio voice communications relay and has a baseline payload that includes electro-optical/infrared sensors and a laser designator that enables the system to find tactical targets, track and designate targets, accurately provide targeting data to strike platforms, and perform battle damage assessment. There is current testing to place a weapons system on the Fire Scout.

MQ-4C Triton

The MQ-4C Triton is a Broad Area Maritime Surveillance unmanned aerial system in testing and development as a complementary system to the P-8A aircraft, providing maritime reconnaissance support to the Navy. It will be equipped with electro-optical/infrared sensors, can remain on station for 30 hours, and fly at approximately 60,000 ft. (18,288 m).

2.7.3.4 Missiles/Rockets/Bombs

Joint Air-to-Ground Missile

The joint air-to-ground missile is a possible replacement or upgrade to existing air-to-ground weapons currently in use. In addition to having a longer operating range than existing weapons, the joint air-to-ground missile could include a multi-mode seeker, with a combination of semi-active laser, passive infrared, and radar. The MH-60 helicopter and F/A-18 jet are Navy aircraft platforms from which this new missile would be fired.

AGM-154 Joint Standoff Weapon

The Joint Standoff Weapon is a missile able to be launched at increased standoff distances, using global positioning system and inertial navigation for guidance. All Joint Standoff Weapon variants share a common body but can be configured for use against area targets or bunker penetration. This would be integrated into strike warfare exercises as well as exercises where the use of this type of missile is required.

MK-54 Vertical Launch Anti-Submarine Rocket Missile

The Navy has designated the MK-54 torpedo to replace the MK-46 torpedo for rapid employment by surface ships. The missile is a rocket-propelled, three-stage weapon that is deployed on ships equipped with the MK-41 Vertical Launching System. Once entering the water, the MK-54 torpedo will operate similarly to the MK-46 that it replaces.

MK-54 Torpedo, High Altitude Anti-Submarine Warfare Capability

The high-altitude anti-submarine warfare capability is a low-cost, self-contained air launch accessory kit that enables the MK-54 torpedo to be launched from a fixed-wing aircraft operating at high altitude. The torpedo then glides to its normal launch altitude close to the surface, and jettisons the air launch accessory kit prior to water entry at a pre-determined location. Once in the water, the MK-54 torpedo will operate similarly to the MK-46 that it replaces.

Guided Rocket Systems

Guided rocket systems include the low cost guided imaging rocket (a guided infrared 2.75 in. [7 cm] rocket system) and the advanced precision kill weapon system (a laser-guided 2.75 in. [7 cm] rocket). The MH-60 helicopter is one platform expected to be equipped with these rockets.

2.7.3.5 Guns

Kinetic Energy Weapon

An electromagnetic kinetic energy weapon (e.g., rail gun) uses electrical energy to accelerate projectiles to supersonic velocities. This weapon will be operated from ships, firing at floating or in-air targets at sea. Kinetic energy weapons do not require powders or explosives to fire the round and could have ranges as great as 300 mi. (483 km).

2.7.3.6 Munitions

Long Range Land Attack Projectile

The Long Range Land Attack Projectile is part of a family of 155 mm (6.1 in.) projectiles designed to be fired from the Advanced Gun System for the Navy's next-generation DDG 1000 destroyer. The Long Range Land Attack Projectile allows the DDG 1000 class to provide precision fire support to Marine Corps and Army forces from a safe distance offshore. This capability would be integrated into amphibious warfare firing exercises and strike warfare exercises.

2.7.3.7 Other Systems

High Altitude Anti-Submarine Warfare

High altitude anti-submarine warfare integrates new and modifies existing sensors to enhance the sonobuoy capability to conduct anti-submarine warfare at high altitude. Sonobuoy modifications include integrating global positioning system for precise sonobuoy positional information and a digital uplink/downlink for radio frequency interference management. New sensors include a meteorological sensing device (dropsonde) for sensing atmospheric conditions from the aircraft altitude to the surface.

New Sonobuoys

New sonobuoys will operate similarly to existing systems, but will provide greater capabilities through improved processing. The key aspects of these new sonobuoys involve the active sound source.

Littoral Combat Ship Anti-Submarine Warfare Module

The anti-submarine warfare module provides a littoral anti-submarine warfare capability that includes active sonar. An increase to unit level and joint surface ship anti-submarine warfare exercises would be expected upon introduction to the fleets, and training would continue on existing Navy ranges. Note: low-frequency anti-submarine warfare sensors will be analyzed under Alternative 1 and Alternative 2.

Littoral Combat Ship Mine Countermeasure Module

The mine countermeasure module brings together several systems to support bottom mapping, mine detection, mine neutralization, and mine clearance. An increase to surface ship mine warfare training is expected upon introduction to the fleets. This module would include mine detecting sonar and lasers, and neutralization techniques that involve underwater detonations.

Littoral Combat Ship Surface Warfare Module

The surface warfare module is designed to enable the Littoral Combat Ship to combat small, fast boat threats to the fleet. This module would include guns and missiles. Testing of this module would occur in the study area with an increase in training expected upon introduction to the fleets.

High Duty Cycle Sonar

High Duty Cycle Sonar technology provides improved detection performance and improved detection and classification decision time. This technology will be implemented as an alteration to the existing AN/SQQ-89A (V) 15 surface ship combat system.

SQS-60 and SQS-61 Sonar

The AN/SQS-60 and 61 are integrated hull-mounted sonar components of the DDG 1000 Zumwalt class destroyer. The SQS-60 is mid-frequency active sonar and the SQS-61 is high-frequency active sonar, and both would be operated similarly to the current AN/SQS 53 and 56 sonars.

Klein 5000 Sonar

This is a high-frequency side scan sonar system for detecting and classifying bottom objects and moored mine shapes.

Littoral Battlespace Sensing, Fusion and Integration Program

The Littoral Battlespace Sensing, Fusion and Integration program is the Navy’s principal Intelligence Preparation of the Environment enabler. This capability is composed of ocean gliders and autonomous undersea vehicles. Gliders are two-man-portable, long-endurance (weeks to months), buoyancy-driven vehicles that provide a low-cost, semi-autonomous, and highly persistent means to sample and characterize the ocean water column properties at spatial and temporal resolutions not otherwise possible using survey vessels or tactical units alone. Autonomous undersea vehicles s are larger, shorter endurance (hours to days), conventionally powered (typically electric motor) vehicles that will increase the spatial extent and resolution of the bathymetry, imagery data, conductivity, temperature and depth data, and optical data collected by existing ships.

2.8 ALTERNATIVE 2: INCLUDES ALTERNATIVE 1 PLUS ADJUSTMENTS TO THE TYPE AND TEMPO OF TRAINING AND TESTING ACTIVITIES

Alternative 2 consists of all activities that would occur under Alternative 1 and proposed adjustments to type and tempo of training and testing, and new activities.

This alternative allows for potential budget increases, strategic necessity, and future training and testing requirements.

2.8.1 Proposed Adjustments to Alternative 1 Training Activities

The proposed adjustments to Alternative 1 (Preferred Alternative) levels and types of training are as follows:

- The addition of three major at-sea training activities (Fleet Strike Group Exercise, Integrated Anti-Submarine Warfare Exercise, and Ship Squadron Anti-Submarine Warfare Exercise as described in Table 2.4-1) conducted in the Study Area.
- Increases to events/ordnance for the following training activities: Air Combat Maneuver, Area Defense Exercise, Air Intercept Control, Gunnery Exercise (Air-to-Air, medium caliber), Missile Exercise (Air-to-Air), Bombing Exercise (Air-to-Ground), Missile Exercise (Air-to-Surface) – Rocket, Counter Targeting Flare Exercise – Aircraft, and Counter Targeting Chaff Exercise – Aircraft.

2.8.2 Proposed Adjustments to Alternative 1 Testing Activities

Under Alternative 2, the proposed adjustments to Alternative 1 (Preferred Alternative) levels and types of testing includes increases in activities and ordnance required for testing requirements for Naval Air Systems Command and Naval Sea Systems Command and presented in Table 2.8-2 and Table 2.8-3, respectively. No adjustments are proposed for Office of Naval Research testing activities.

Tables 2.8-1 to 2.8-4 provide a summary of the training and testing activities to be analyzed under the No Action Alternative, Alternative 1, and Alternative 2. Cells under the “Ordnance” column are shaded gray if that activity includes the use of explosive ordnance.

Table 2.8-1: Baseline and Proposed Training Activities

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Anti-Air Warfare									
Air Combat Maneuver (ACM)	2,880	None	Study Area > 12 nm from land: SUA/ATCAA	4,800	None	Study Area > 12 nm from land: SUA/ATCAA	5,300	None	Study Area > 12 nm from land: SUA/ATCAA
Air Defense Exercise (ADEX)	n/a	n/a	Study Area > 12 nm from land: SUA/ATCAA	100	None	Study Area > 12 nm from land: SUA/ATCAA	120	None	Study Area > 12 nm from land: SUA/ATCAA
Air Intercept Control (AIC)	320	None	Study Area > 12 nm from land: SUA/ATCAA	4,800	None	Study Area > 12 nm from land: SUA/ATCAA	5,300	None	Study Area > 12 nm from land: SUA/ATCAA
Gunnery Exercise (Air-to-Air) – Medium-caliber (GUNEX [A-A]) Medium-caliber	12	3,000 rounds	Study Area SUA > 12 nm from land	36	9,000 rounds	Study Area SUA > 12 nm from land	45	11,250 rounds	Study Area SUA > 12 nm from land
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	12	12 explosive missiles	Study Area SUA > 12 nm from land	18	36 explosive missiles	Study Area SUA > 12 nm from land	24	48 explosive missiles	Study Area SUA > 12 nm from land
Gunnery Exercise (Surface-to-Air) – Large-caliber (GUNEX [S-A]) – Large-caliber	n/a	n/a	n/a	5	40 rounds	Study Area SUA > 12 nm from land	5	40 rounds	Study Area SUA > 12 nm from land

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	**Ordnance (Number per year)**	**Location**	**No. of activities (per year)**	**Ordnance (Number per year)**	**Location**	**No. of activities (per year)**	**Ordnance (Number per year)**	**Location**
Gunnery Exercise (Surface-to-Air) – Medium-caliber (GUNEX [S-A]) – Medium-caliber	n/a	n/a	n/a	12	24,000 rounds	Study Area SUA/ATCAAs > 12 nm from land	12	24,000 rounds	Study Area SUA/ATCAAs > 12 nm from land
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	2	2 explosive missiles	Study Area SUA > 12 nm from land	15	15 explosive missiles	Study Area SUA > 12 nm from land	15	15 explosive missiles	Study Area SUA > 12 nm from land
Strike Warfare (STW)									
Bombing Exercise (Air-to-Ground) (BOMBEX [A-G])	1,300	2,800 NEPM 2,150 explosive rounds	FDM	2,300	2,670 NEPM 6,242 explosive rounds	FDM	2,520	2,922 NEPM 6,821 explosive rounds	FDM

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Gunnery Exercise (Air-to-Ground) (GUNEX [A-G])	22	n/a	FDM	96	24,000 small-caliber rounds	FDM	96	24,000 small-caliber rounds	FDM
		n/a			94,150 medium-caliber rounds			94,150 medium-caliber rounds	
		21,500 explosive med.-caliber rounds			17,350 explosive med.-caliber rounds			17,350 explosive med.-caliber rounds	
		200 explosive large-caliber rounds			200 explosive large-caliber rounds			200 explosive large-caliber rounds	
Missile Exercise (MISSILEX)	60	60 explosive missiles	FDM	85	2,000 explosive rockets	FDM	85	2,000 explosive rockets	FDM
					85 explosive missiles			85 explosive missiles	

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Combat Search and Rescue	60	None	MIRC; Rota Airport	80	None	MIRC; Rota Airport	80	None	MIRC; Rota Airport
Amphibious Warfare (AMW)									
Naval Surface Fire Support Exercise – Land-based target (FIREX [Land])	8	800 explosive rounds	FDM	10	1,800 NEPM rounds 1,000 explosive rounds	FDM	10	1,800 NEPM rounds 1,000 explosive rounds	FDM
Amphibious Rehearsal, No Landing – Marine Air Ground Task Force	n/a	n/a	n/a	12	None	Study Area and Nearshore	12	None	Study Area and Nearshore
Amphibious Assault	4	Blanks; Simunitions	MIRC; Tinian; Guam	6	Blanks; Simunitions	MIRC; Tinian; Guam	6	Blanks; Simunitions	MIRC: Tinian; Guam
Amphibious Raid	2	Blanks; Simunitions	MIRC; Tinian; Guam	6	Blanks; Simunitions	MIRC; Tinian; Guam; Rota	6	Blanks; Simunitions	MIRC; Tinian; Guam; Rota
Urban Warfare Training	17	Blanks; Simunitions	MIRC; Tinian; Guam	36	Blanks; Simunitions	MIRC; Tinian; Guam	36	Blanks; Simunitions	MIRC: Tinian; Guam
Noncombatant Evacuation Operation	2	Blanks; Simunitions	MIRC; Guam; Tinian; Rota	5	Blanks; Simunitions	MIRC; Guam; Tinian; Rota	5	Blanks; Simunitions	MIRC; Guam; Tinian; Rota

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Humanitarian Assistance/Disaster Relief Operations	2	Blanks; Simunitions	MIRC; Guam; Tinian; Rota	5	Blanks; Simunitions	MIRC; Guam; Tinian; Rota	5	Blanks; Simunitions	MIRC; Guam; Tinian; Rota
Unmanned Aerial Vehicle – Intelligence, Surveillance, and Reconnaissance	n/a	n/a	MIRC; SUA	100	None	MIRC; SUA	100	None	MIRC; SUA
Anti-Surface Warfare (ASUW)									
Gunnery Exercise (Air-to-Surface) – Small-caliber (GUNEX [A-S]) – Small-caliber	220	44,000 non-explosive rounds	Study Area SUA > 12 nm from land	242	48,040 rounds	Study Area SUA > 12 nm from land	242	48,040 rounds	Study Area SUA > 12 nm from land
Gunnery Exercise (Air-to-Surface) – Medium-caliber (GUNEX [A-S]) – Medium-caliber	155	15,500 non-explosive rounds	Study Area SUA > 12 nm from land	295	29,500 non-explosive rounds 7,150 explosive rounds	Study Area SUA > 12 nm from land; Transit Corridor	295	29,500 non-explosive rounds 7,150 explosive rounds	Study Area SUA > 12 nm from land; Transit Corridor
Missile Exercise (Air-to-Surface) – Rocket (MISSILEX [A-S] – Rocket)	n/a	n/a	n/a	3	114 rockets (114 explosive)	Study Area SUA > 12 nm from land	10	380 rockets (380 explosive)	Study Area SUA > 12 nm from land
Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	2	2 explosive missiles	Study Area > 25 nm from land	20	20 explosive missiles	Study Area SUA > 12 nm from land	20	20 explosive missiles	Study Area SUA > 12 nm from land

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Laser Targeting (at sea)	60	None	Study Area > 25 nm from land	600	None	Study Area SUA > 12 nm from land	600	None	Study Area SUA > 12 nm from land
Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	28	72 NEPM 4 explosive rounds	Study Area > 50 nm from land	37	368 NEPM 184 explosive rounds	Study Area > 50 nm from land	37	368 NEPM 184 explosive rounds	Study Area > 50 nm from land
Torpedo Exercise (Submarine-to-Surface)	n/a	n/a	n/a	5	10 EXTORP	Study Area > 3 nm from land	5	10 EXTORP	Study Area > 3 nm from land
Missile Exercise (Surface-to-Surface) (MISSILEX [S-S])	n/a	n/a	n/a	12	12 explosive missiles	Study Area > 50 nm from land	12	12 explosive missiles	Study Area > 50 nm from land
Gunnery Exercise (Surface-to-Surface) Ship – Large-caliber (GUNEX [S-S] – Ship) Large-caliber	12	440 explosive rounds	Study Area SUA > 12 nm from land	140	5,198 non-explosive rounds 500 explosive rounds	Study Area SUA > 12 nm from land; Transit Corridor	140	5,198 non-explosive rounds 500 explosive rounds	Study Area SUA > 12 nm from land; Transit Corridor
Gunnery Exercise (Surface-to-Surface) Ship – Small- and Medium-caliber (GUNEX [S-S] – Ship) Small- and Medium-caliber	5	8,000 non-explosive rounds	Study Area SUA > 12 nm from land	100	21,000 non-explosive rounds 900 explosive rounds	Study Area SUA > 12 nm from land; Transit Corridor	100	21,000 non-explosive rounds 900 explosive rounds	Study Area SUA > 12 nm from land; Transit Corridor

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity		No Action Alternative			Alternative 1			Alternative 2		
		No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Sinking Exercise (SINKEX) Representative ordnance. Actual ordnance used will vary (typically less than shown).		2	28 explosive Bombs 42 explosive Missiles 800 explosive Large-caliber rounds 2 MK-48 explosive 4 explosive Demolitions	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	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	Study Area > 50 nm from land and > 1,000 fathoms depth
Gunnery Exercise (Surface-to-Surface) Boat – Small and Medium-caliber (GUNEX [S-S] – Boat	Medium-caliber	n/a	n/a	n/a	10	2,000 non-explosive rounds 100 explosive rounds	Study Area SUA > 12 nm from land; Transit Corridor	10	2,000 non-explosive rounds 100 explosive rounds	Study Area SUA > 12 nm from land; Transit Corridor
	Small-caliber	32	16,000 rounds	Study Area > 3 nm from land	40	36,000 rounds	Study Area > 3 nm from land; Transit Corridor	40	36,000 rounds	Study Area > 3 nm from land; Transit Corridor
Maritime Security Operations (MSO)		6	None	Study Area; MIRC	40	200 G911 anti-swimmer grenade	Study Area; MIRC	40	200 G911 anti-swimmer grenade	Study Area; MIRC

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Anti-Submarine Warfare (ASW)									
Tracking Exercise – Helicopter (TRACKEX – Helo)	18	None/ REXTORP	Study Area > 3 nm from land	62	None/ REXTORP	Study Area > 3 nm from land; Transit Corridor	62	None/ REXTORP	Study Area > 3 nm from land; Transit Corridor
Torpedo Exercise – Helicopter (TORPEX – Helo)	4	4 EXTORP	Study Area > 3 nm from land	4	4 EXTORP	Study Area > 3 nm from land	4	4 EXTORP	Study Area > 3 nm from land
Tracking Exercise – Maritime Patrol Advanced Extended Echo Ranging Sonobuoys	8	None	Study Area > 3 nm from land	11	None	Study Area > 3 nm from land	11	None	Study Area > 3 nm from land
Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – Maritime Patrol Aircraft)	8	None/ REXTORP	Study Area > 3 nm from land	34	None/ REXTORP	Study Area > 3 nm from land	34	None/ REXTORP	Study Area > 3 nm from land

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Torpedo Exercise – Maritime Patrol Aircraft (TORPEX – Maritime Patrol Aircraft)	4	4 EXTORP	Study Area > 3 nm from land	4	4 EXTORP	Study Area > 3 nm from land	4	4 EXTORP	Study Area > 3 nm from land
Tracking Exercise – Surface (TRACKEX – Surface)	CG/DDG/ FFG 30	None/ REXTORP	Study Area > 3 nm from land	CG/DDG-92 FFG-30 LCS-10	None/ REXTORP	Study Area > 3 nm from land	CG/DDG-92 FFG-30 LCS-10	None/ REXTORP	Study Area > 3 nm from land
Torpedo Exercise – Surface (TORPEX – Surface)	3	3 EXTORP	Study Area > 3 nm from land	3	3 EXTORP	Study Area > 3 nm from land	3	3 EXTORP	Study Area > 3 nm from land
Tracking Exercise – Submarine (TRACKEX – Sub)	10	None	Study Area > 3 nm from land	12	None	Study Area > 3 nm from land; Transit Corridor	12	None	Study Area > 3 nm from land; Transit Corridor
Torpedo Exercise – Submarine (TORPEX – Sub)	10	40 MK-48 EXTORP	Study Area > 3 nm from land	10	40 MK-48 EXTORP	Study Area > 3 nm from land	10	40 MK-48 EXTORP	Study Area > 3 nm from land

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Major Training Events									
Joint Expeditionary Exercise	1	Note 1	Study Area; MIRC	1	Note 1	Study Area; MIRC	1	Note 1	Study Area; MIRC
Joint Multi-Strike Group Exercise	1	Note 1	Study Area > 12 nm from land; FDM	1	Note 1	Study Area; MIRC	1	Note 1	Study Area; MIRC
Fleet Strike Group Exercise	n/a	n/a	n/a	0	Note 1	Study Area > 12 nm from land; FDM	1	Note 1	Study Area > 12 nm from land; FDM
Integrated Anti-Submarine Warfare Exercise	n/a	n/a	n/a	0	Note 1	Study Area > 3 nm from land; FDM	1	Note 1	Study Area > 3 nm from land; FDM
Ship Squadron Anti-Submarine Warfare Exercise	n/a	n/a	n/a	0	Note 1	Study Area > 3 nm from land	1	Note 1	Study Area > 3 nm from land
Marine Air Ground Task Force Exercise (Amphibious) – Battalion	4	Note 1	Study Area to nearshore; MIRC; Tinian; Guam; Rota; Saipan; FDM	4	Note 1	Study Area to nearshore; MIRC; Tinian; Guam; Rota; Saipan; FDM	4	Note 1	Study Area to nearshore; MIRC; Tinian; Guam; Rota; Saipan; FDM
Special Purpose Marine Air Ground Task Force Exercise	2	Note 1	Study Area to nearshore; MIRC; Tinian; Guam; Rota; Saipan	2	Note 1	Study Area to nearshore; MIRC; Tinian; Guam; Rota; Saipan	2	Note 1	Study Area to nearshore; MIRC; Tinian; Guam; Rota; Saipan
Urban Warfare Exercise	5	Blanks/ Simunitions	MIRC; Tinian; Guam; Rota; Saipan	5	Blanks/ Simunitions	MIRC; Tinian; Guam; Rota; Saipan	5	Blanks/ Simunitions	MIRC; Tinian; Guam; Rota; Saipan

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Electronic Warfare (EW)									
Electronic Warfare Operations (EW Ops)	72 (Note 2)	None	Study Area > 12 nm from land	480	None	Study Area	530	None	Study Area
Counter Targeting Flare Exercise (FLAREX) – Aircraft	546	5,740 cartridges	Study Area > 12 nm from land	3,200	25,600 cartridges	Study Area > 12 nm from land	3,534	28,272 cartridges	Study Area > 12 nm from land
Counter Targeting Chaff Exercise (CHAFFEX) – Ship	16	90 cartridges	Study Area > 12 nm from land	40	240 cartridges	Study Area > 12 nm from land	40	240 cartridges	Study Area > 12 nm from land
Counter Targeting Chaff Exercise (CHAFFEX) – Aircraft	546	5740 cartridges	Study Area > 12 nm from land	3,200	25,600 cartridges	Study Area > 12 nm from land	3,534	28,272 cartridges	Study Area > 12 nm from land
Mine Warfare (MIW)									
Civilian Port Defense	n/a	n/a	n/a	1	Note 1	Mariana littorals; MIRC; Inner and Outer Apra Harbor	1	Note 1	Mariana littorals; MIRC, Inner and Outer Apra Harbor
Mine Laying	3	480 mine shapes	W-517	4	480 mine shapes	MIRC Warning Areas	4	480 mine shapes	MIRC Warning Areas

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Mine Warfare (MIW)									
Mine Neutralization – Explosive Ordnance Disposal (EOD)	20	20 explosive charges	MIRC mine neutralization sites, 10 lb. NEW maximum	20	20 explosive charges	Agat Bay site, 20 lb. NEW maximum charge. Piti and Outer Apra Harbor sites, 10 lb. NEW maximum.	20	20 explosive charges	Agat Bay site, 20 lb. NEW maximum charge. Piti and Outer Apra Harbor sites, 10 lb. NEW maximum.
Limpet Mine Neutralization System/Shock Wave Generator	n/a	n/a	n/a	40	40 charges	Mariana littorals; Inner and Outer Apra Harbor	40	40 charges	Mariana littorals; Inner and Outer Apra Harbor
Submarine Mine Exercise	n/a	n/a	n/a	16	n/a	Study Area; nearshore.	16	n/a	Study Area; nearshore
Airborne Mine Countermeasure – Mine Detection	n/a	n/a	n/a	4	n/a	Study Area; nearshore	4	n/a	Study Area; nearshore
Mine Countermeasure Exercise – Towed Sonar (AQS-20, LCS)	n/a	n/a	n/a	4	n/a	Study Area	4	n/a	Study Area
Mine Countermeasure Exercise – Surface (SMCMEX) Sonar (SQQ-32, MCM)	n/a	n/a	n/a	4	n/a	Study Area	4	n/a	Study Area

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Mine Neutralization – Remotely Operated Vehicle Sonar (ASQ-235 [AQS-20], SLQ-48)	n/a	n/a	n/a	4	4 explosive neutralizers	Study Area	4	4 explosive neutralizers	Study Area
Mine Countermeasure – Towed Mine Detection	n/a	n/a	n/a	4	n/a	Study Area	4	n/a	Study Area

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Naval Special Warfare (NSW)									
Personnel Insertion/ Extraction	150	None	MIRC; Guam; Tinian; Rota	240	None	MIRC; Guam; Tinian; Rota	240	None	MIRC; Guam; Tinian; Rota
Parachute Insertion	12	None	MIRC parachute drop zones; Guam; Tinian; Rota	20	None	MIRC parachute drop zones; Guam; Tinian; Rota	20	None	MIRC parachute drop zones; Guam; Tinian; Rota
Embassy Reinforcement	50	Blanks; Simunitions	MIRC; Guam; Tinian; Rota	50	Blanks; Simunitions	MIRC; Guam; Tinian; Rota	50	Blanks; Simunitions	MIRC; Guam; Tinian; Rota
Direct Action (Combat Close Quarters)	40	15,000 rounds	MIRC Combat Close Quarters sites	72	26,250 rounds	MIRC Combat Close Quarters sites	72	26,250 rounds	MIRC Combat Close Quarters sites
Direct Action (Breaching)	40	Total – 15 lb. NEW	MIRC explosive breaching sites	72	Total – 27 lb. NEW	MIRC explosive breaching sites	72	Total – 27 lb. NEW	MIRC explosive breaching sites
Direct Action (Tactical Air Control Party)	3	2,900 small-caliber rounds	FDM	18	18,000 small-caliber rounds	FDM	18	18,000 small-caliber rounds	FDM
		100 explosive (grenade/ mortar)			600 explosive (grenade/ mortar)			600 explosive (grenade/ mortar)	
Underwater Demolition Qualification/ Certification	30	30 explosive charges	MIRC underwater demolition sites (10 lb. NEW maximum/ charge)	30	30 explosive charges	Agat Bay site, 20 lb. NEW maximum charge. Piti and Outer Apra Harbor sites, 10 lb. NEW maximum	30	30 explosive charges	Agat Bay site, 20 lb. NEW maximum charge. Piti and Outer Apra Harbor sites, 10 lb. NEW maximum.

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Intelligence, Surveillance, Reconnaissance (ISR)	16	None	MIRC; Guam; Tinian; Rota; Saipan	16	None	MIRC; Guam; Tinian; Rota; Saipan	16	None	MIRC; Guam; Tinian; Rota; Saipan
Urban Warfare Training	8	Blanks/ Simunitions	MIRC; Tinian; Guam; Rota; Saipan	18	Blanks/ Simunitions	MIRC: Tinian; Guam; Rota; Saipan	18	Blanks/ Simunitions	MIRC; Tinian; Guam; Rota; Saipan
Underwater Survey	6	None	Mariana littorals	16	0	Mariana littorals	16	0	Mariana littorals
Other									
Surface Ship Sonar Maintenance	n/a	None	n/a	42	None	Study Area > 3 nm from land; Inner Apra Harbor; Transit Corridor	42	None	Study Area > 3 nm from land; Inner Apra Harbor; Transit Corridor
Submarine Sonar Maintenance	n/a	None	n/a	48	None	Study Area > 3 nm from land; Inner Apra Harbor; Transit Corridor	48	None	Study Area > 3 nm from land; Inner Apra Harbor; Transit Corridor
Small Boat Attack	n/a	n/a	n/a	6	2,100 small-caliber rounds	Study Area > 3 nm from land	6	2,100 small-caliber rounds	Study Area > 3 nm from land
	n/a	n/a	n/a	12	4000 blank rounds	Study Area	12	4,000 blank rounds	Study Area
Submarine Navigation	n/a	n/a	n/a	8	None	Apra Harbor and Mariana littorals	8	None	Apra Harbor and Mariana littorals
Search and Rescue At Sea	n/a	n/a	n/a	40	None	Study Area	40	None	Study Area

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Precision Anchoring	n/a	n/a	n/a	18	None	Apra Harbor; Mariana Islands anchorages	18	None	Apra Harbor; Mariana Islands anchorages
Maneuver (Convoy, Land Navigation)	16	None	MIRC; Guam; Tinian	16	None	MIRC; Guam; Tinian	16	None	MIRC; Guam; Tinian
Water Purification	n/a	n/a	n/a	16	None	MIRC	16	None	MIRC
Field Training Exercise	100	Blanks/ Simunitions	MIRC; Guam; Tinian; Rota; Saipan	100	Blanks/ Simunitions	MIRC; Guam; Tinian; Rota; Saipan	100	Blanks/ Simunitions	MIRC; Guam; Tinian; Rota; Saipan
Force Protection	75	Blanks/ Simunitions	MIRC; Guam; Tinian; Rota	75	Blanks/ Simunitions	MIRC; Guam; Tinian; Rota	75	Blanks/ Simunitions	MIRC; Guam; Tinian; Rota
Anti-Terrorism	80	Blanks/ Simunitions	MIRC; Guam; Tinian; Rota	80	Blanks/ Simunitions	MIRC; Guam; Tinian; Rota	80	Blanks/ Simunitions	MIRC; Guam; Tinian; Rota
Seize Airfield	12	Blanks/ Simunitions	MIRC airfields[1]	12	Blanks/ Simunitions	MIRC airfields[1]	12	Blanks/ Simunitions	MIRC airfields[1]
Airfield Expeditionary	12	None	MIRC airfields[1]	12	Blanks/ Simunitions	MIRC airfields[1]	12	Blanks/ Simunitions	MIRC airfields[1]
Unmanned Aerial Vehicle Operation	n/a	n/a	n/a	1,000	None	Study Area; MIRC airfields[1]; MIRC SUA	1,000	None	Study Area; MIRC airfields;[1] MIRC SUA

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Land Demolitions (Improvised Explosive Device) Discovery/Disposal	120	None	MIRC; Guam	120	None	MIRC; Guam	120	None	MIRC; Guam
Land Demolitions (Unexploded Ordnance) Discovery/Disposal	200	200 unexploded ordnance and neutralization charge	Navy Emergency Disposal Site	236	236 unexploded ordnance and neutralization charge	200 events, Navy Emergency Disposal Site; 36 events, Air Force Disposal Sites. (Guam)	236	236 unexploded ordnance and neutralization charge	200 events, Navy Emergency Disposal Site; 36 events, Air Force Disposal Sites. (Guam)

[1] Orote Point Airfield, Guam; Northwest Airfield, Guam; North Airfield, Tinian

Notes: (1) Exercise is composed of various activities accounted for elsewhere within Table 2.8-1.

(2) Discussed as an embedded training activity to CHAFFEX/FLAREX in MIRC EIS/OEIS Appendix D (Air Quality Calculations and Record of Non-Applicability).

(3) CHAFF = Chaff Exercise, EIS = Environmental Impact Statement. EOD = Explosive Ordnance Disposal, EXTORP = Exercise Torpedo, FDM = Farallon de Medinilla, FLAREX = Flare Exercise, g = gram, lb. = pound, LCS = Littoral Combat Ship, MIRC = Mariana Islands Range Complex, mm = millimeters, n/a = Not Applicable, NEPM = Non-explosive Practice Munitions, NEW = Net Explosive Weight, nm = nautical miles, OEIS = Overseas Environmental Impact Statement, REXTORP = Recoverable Exercise Torpedo, SUA = Special Use Airspace

Table 2.8-2: Baseline and Proposed Naval Air Systems Command Testing Activities

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Anti-Surface Warfare (ASUW)									
Air-to-Surface Missile Test	n/a	n/a	n/a	8	8 Harpoon Missiles, (up to 4 explosive)	Study Area > 50 nm from land	10	10 Harpoon Missiles, (up to 5 explosive)	Study Area > 50 nm from land
Anti-Submarine Warfare (ASW)									
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoys)	n/a	n/a	n/a	188	240 IEER[1] 553 SUS	Study Area > 3 nm from land	207	260 IEER[1] 624 SUS	Study Area > 3 nm from land
Anti-Submarine Warfare Torpedo Test	n/a	n/a	n/a	40	40 EXTORP	Study Area > 3 nm from land	50	50 EXTORP	Study Area > 3 nm from land
Broad Area Maritime Surveillance (BAMS) Testing – MQ-4C Triton	n/a	n/a	n/a	10	None	Study Area	11	None	Study Area
Electronic Warfare (EW)									
Flare Test	n/a	n/a	n/a	10	300 flares; 600 chaff rounds	Study Area > 3 nm from land	11	330 flares; 660 chaff rounds	Study Area > 3 nm from land

[1] Use of Improved Extended Echo Ranging (IEER) sonobuoys will decrease over time while being replaced by use of Multi-static Active Coherent (MAC) sonobuoys. MAC buoys employ an electronic acoustic source in place of the explosive source used on the IEER buoys.

Notes: EIS = Environmental Impact Statement, EXTORP = Exercise Torpedo, IEER = Improved Extended Echo Ranging, MAC = Multi-static Active Coherent, n/a = Not Applicable, nm = nautical miles, OEIS = Overseas Environmental Impact Statement, SUS = Signal Underwater Sound

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Life Cycle Activities									
Ship Signature Testing	n/a	n/a	n/a	17	None	Study Area	19	None	Study Area
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing									
Kinetic Energy Weapon Testing	n/a	n/a	n/a	50	2,000 projectiles	MIRC > 12 nm from land	55	2,200 projectiles	MIRC > 12 nm from land
				1 event total	5,000 projectiles		1 event total	5,000 projectiles	
Torpedo Testing	n/a	n/a	n/a	2	20 torpedoes, (up to 8 explosive)	MIRC > 3 nm from land	2	20 torpedoes, (up to 8 explosive)	MIRC > 3 nm from land
Countermeasure Testing	n/a	n/a	n/a	2	56 torpedoes	Study Area	3	84 torpedoes	Study Area
At-Sea Sonar Testing	n/a	n/a	n/a	20	None	Study Area	24	None	Study Area
Shipboard Protection Systems and Swimmer Defense Testing									
Pierside Integrated Swimmer Defense	n/a	n/a	n/a	11	None	Inner Apra Harbor	11	None	Inner Apra Harbor

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity		No Action Alternative			Alternative 1			Alternative 2		
		No. of activities (per year)	**Ordnance (Number per year)**	**Location**	**No. of activities (per year)**	**Ordnance (Number per year)**	**Location**	**No. of activities (per year)**	**Ordnance (Number per year)**	**Location**
New Ship Construction										
ASW Mission Package Testing		n/a	n/a	n/a	33	None	Study Area	37	None	Study Area
MCM Mission Package Testing		n/a	n/a	n/a	32	48 neutralizers, (up to 24 explosive)	Study Area	36	56 neutralizers, (up to 28 explosive)	Study Area
ASUW Mission Package Testing	Gun Testing – Small-caliber	n/a	n/a	n/a	4	2,000 rounds	Study Area; Warning Area > 12 nm from land	5	2,500 rounds	Study Area; Warning Area > 12 nm from land
	Gun Testing – Medium-caliber (30 mm)				4	4,080 rounds, (up to 2,040 explosive)		5	4,980 rounds, (up to 2,490 explosive)	
	Gun Testing – Large-caliber (57 mm)				4	5,600 rounds (up to 3,920 in-air explosive)		5	7,000 rounds (up to 4,900 in-air explosive)	
	Missile/ Rocket Testing				4	32 missiles/ rockets, (up to 16 explosive)		5	40 missiles/ rockets, (up to 18 explosive)	

Notes: EE = Explosive, EOD = Explosive Ordnance Disposal, IEER = Improved Extended Echo Ranging, lb. = pound, MCM = Mine Countermeasure, MIRC = Mariana Islands Range Complex, mm = millimeters, n/a = Not Applicable, NEW = Net Explosive Weight, nm = nautical miles, SUS = Signal Underwater Sound

Table 2.8-4: Baseline and Proposed Office of Naval Research Testing Activities

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location	No. of activities (per year)	Ordnance (Number per year)	Location
Office of Naval Research									
North Pacific Acoustic Lab Philippine Sea 2018–19 Experiment (Deep Water)	1	n/a	Study Area	1	n/a	Study Area	1	n/a	Study Area

Note: n/a = Not Applicable

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3 Introduction

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3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.0 INTRODUCTION

This chapter describes existing environmental conditions in the Mariana Islands Training and Testing (MITT) Study Area (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. The resource sections (e.g., Section 3.4, Marine Mammals) refer back to subsections in Section 3.0 for the general information contained here.

Section 3.0.1 (Regulatory Framework) presents the regulatory framework for the analyses of the resources in Chapter 3 (Affected Environment and Environmental Consequences). It briefly describes each law, executive order, and directive used to develop the analyses. Other laws and regulations that may apply to this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), but that were not specifically used in the analysis, are listed in Chapter 6 (Additional Regulatory Considerations). Section 3.0.2 (Data Sources and Best Available Data) lists the sources of data used in the analysis.

One of the major issues addressed in this EIS/OEIS is the effects of sound on biological resources. The topic of acoustics in the water can be very complicated to the general reader, so Section 3.0.4 (Acoustic and Explosives Primer) in this section and a more detailed version, Appendix I (Acoustic and Explosives Primer), present a basic introduction to fundamental concepts on sound propagation in water and in air. The primer explains how sound propagates through air and water; defines terms used in the analysis; and describes the physical properties of sound, metrics used to characterize sound exposure, and frequencies produced during United States (U.S.) Department of the Navy (Navy) training and testing activities.

Section 3.0.5 (Overall Approach to Analysis) describes a general approach to the analysis. It identifies the resources considered for the analysis, as well as those resources eliminated from further consideration. Each Navy training and testing activity was examined to determine which environmental stressors could adversely impact a resource; these stressors were grouped into categories for ease of presentation (Table 3.0-6). The term "stressor" is broadly used in this document to refer to an agent, condition, or other stimulus that causes stress to an organism or alters physical, socioeconomic, or cultural resources. Table 3.0-7 associates the stressor categories with training and testing activities. A detailed description of each stressor category is contained in Section 3.0.5.2 (Identification of Stressors for Analysis). Lastly, the general approach section contains the methods used in the biological resource sections. These methods are also organized by stressor categories.

The sections following Section 3.0 (Introduction) analyze each resource independently. The physical resources (sediment and water quality and air quality) are presented first (Sections 3.1 and 3.2, respectively). Any potential impacts on these resources were considered as potential secondary stressors on the remaining resources to be described: marine habitats, marine mammals, sea turtles, marine birds, marine vegetation, marine invertebrates, fish, and terrestrial species and habitats (Sections 3.3 through 3.10). Following the biological resource sections are human resource sections: cultural, socioeconomics, and public health and safety (Sections 3.11, 3.12, and 3.13).

3.0.1 REGULATORY FRAMEWORK

In accordance with the Council on Environmental Quality regulations for implementing the requirements of the National Environmental Policy Act (NEPA), other planning and environmental review procedures are integrated to the fullest extent possible. This section provides a brief overview of the primary federal statutes (Section 3.0.1.1), executive orders (Section 3.0.1.2), and guidance (Section 3.0.1.3) that form the regulatory framework for the evaluation of resources in this chapter. This section also describes how each applies to the analysis of environmental consequences. Chapter 6 (Additional Regulatory Considerations) provides a summary listing and status of compliance with the applicable environmental laws, regulations, and executive orders that were considered in preparing this EIS/OEIS (including those that may be secondary considerations in the resource evaluations). More detailed information on the regulatory framework, including other statutes not listed here, may be presented as necessary in each resource section. More detailed discussions of selected regulations are included below to provide insight into the criteria used in the analyses.

3.0.1.1 Federal Statutes

3.0.1.1.1 Abandoned Shipwreck Act

The 1987 Abandoned Shipwreck Act (43 U.S. Code [U.S.C.] §§2101–2106) asserts the United States' title to any abandoned shipwreck that meets the following criteria: the shipwreck is embedded in the submerged lands or coralline formations of a State (including Guam and the Commonwealth of the Northern Mariana Islands) or the shipwreck is on submerged State lands and included in (or eligible for inclusion in) the National Register. The Act stipulates that title to these shipwrecks will be transferred to the appropriate State. States have the responsibility to manage the wrecks and to allow access to the sites by the general public for recreational, educational, and other activities, while also preserving the historical and environmental integrity of the site. "Abandoned shipwreck" means any shipwreck to which title has voluntarily been given up by the owner with the intent of never claiming a right or interest in the vessel in the future and without vesting ownership in any other person. Such shipwrecks ordinarily are treated as being abandoned after the expiration of 30 days from the sinking. A shipwreck includes the vessels, its cargo, and any other content.

3.0.1.1.2 Clean Air Act

The purpose of the Clean Air Act (42 U.S.C. §7401 et seq.) is to protect and enhance the quality of the nation's air resources to promote the public health and welfare and the productive capacity of its population. To fulfill the act's purpose, federal agencies classify air basins according to their attainment status under the National Ambient Air Quality Standards (40 Code of Federal Regulations [C.F.R.] Part 50) and regulate emissions of criteria pollutants and air toxins to protect the public health and welfare. Noncriteria air pollutants that can affect human health are categorized as hazardous air pollutants under Section 112 of the Clean Air Act. The U.S. Environmental Protection Agency (USEPA) identified 188 hazardous air pollutants such as benzene, perchloroethylene, and methylene chloride. Section 176(c)(1) of the Clean Air Act, commonly known as the General Conformity Rule, requires federal agencies to ensure that their actions conform to applicable implementation plans for achieving and maintaining the National Ambient Air Quality Standards for criteria pollutants.

3.0.1.1.3 Clean Water Act

The Clean Water Act (33 U.S.C. §1251 et seq.) regulates discharges of pollutants in surface waters of the United States. Section 403 of the Clean Water Act provides for the protection of ocean waters (i.e., waters of the territorial seas, the contiguous zone, and the high seas beyond the contiguous zone) from point-source discharges. Under Section 403(a), the USEPA or an authorized state agency may issue a permit for an ocean discharge only if the discharge complies with Clean Water Act guidelines for protection of marine waters. For the MITT EIS/OEIS, the Proposed Action does not include the analysis of discharges incidental to the normal operation of Navy ships, because certain discharges from Navy ships are excluded under the Clean Water Act.

3.0.1.1.4 Endangered Species Act

The Endangered Species Act (ESA) of 1973 (16 U.S.C. §1531 et seq.) establishes protection over and conservation of threatened and endangered species and the ecosystems upon which they depend. An “endangered” species is a species in danger of extinction throughout all or a significant portion of its range. A “threatened” species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) jointly administer the ESA and are also responsible for the listing of species (designating a species as either threatened or endangered). The ESA allows the designation of geographic areas as critical habitat for threatened or endangered species. Section 7(a)(2) requires each federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action “may affect” a listed species or designated critical habitat, that agency is required to consult with NMFS or USFWS, depending on the jurisdiction (50 C.F.R. §402.14[a]).

3.0.1.1.5 National Invasive Species Act

The National Invasive Species Act became public law in 1966 to address problems associated with nonindigenous species. Executive Order (EO) 13112, Invasive Species, was published in the Federal Register (FR) on 3 February 1999. The EO requires that a Council of Departments dealing with invasive species be created to prevent the introduction of invasive species, provide for their control, and minimize the economic, ecological, and human health impacts that invasive species cause. Under the authority of this EO, federal agencies may not authorize, fund, or carry out actions that they believe are likely to cause or promote the introduction or spread of invasive species.

3.0.1.1.6 Magnuson-Stevens Fishery Conservation and Management Act and Sustainable Fisheries Act

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. §1801 et seq.) enacted in 1976 and amended by the Sustainable Fisheries Act in 1996, mandates identification and conservation of essential fish habitat. Essential fish habitat is defined as those waters and substrates necessary (required to support a sustainable fishery and the federally managed species) to fish for spawning, breeding, feeding, or growth to maturity (i.e., full life cycle). These waters include aquatic areas and their associated physical, chemical, and biological properties used by fish, and may include areas historically used by fish. Substrate types include sediment, hard bottom, structures underlying the waters, and associated biological communities. Federal agencies are required to consult with NMFS and to prepare an essential fish habitat assessment if potential adverse effects on essential fish habitat are anticipated from their activities.

3.0.1.1.7 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §1361 et seq.) establishes, with limited exceptions, a moratorium on the “taking” of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates “takes” of marine mammals in the global commons (that is, the high seas) by vessels or persons under U.S. jurisdiction. The term "take," as defined in Section 3 (16 U.S.C. §1362 [13]) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" is further defined in the 1994 amendments to the MMPA, which provided two levels of harassment: Level A (potential injury) and Level B (potential behavioral disturbance).

The MMPA directs the Secretary of Commerce (Secretary) to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens or agencies who engage in a specified activity (other than commercial fishing) within a specified geographical region if NMFS finds that the taking will have a negligible impact on the species or stock(s), and will not have an immitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking, other means of affecting the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the mitigation, monitoring and reporting of such taking.

The National Defense Authorization Act of Fiscal Year 2004 (Public Law 108-136) amended the definition of harassment and removed the small numbers provision as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government consistent with Section 104(c)(3) (16 U.S.C. §1374 [c][3]). The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the Fiscal Year 2003 National Defense Authorization Act (Public Law 107-314). The Proposed Action constitutes military readiness activities as that term is defined in Public Law 107-314 because activities constitute "training and operations of the armed forces that relate to combat" and constitute "adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use." For military readiness activities, the relevant definition of harassment is 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
- 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") (16 U.S.C. §1362 (18)(B)(i) and (ii)).

3.0.1.1.8 Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 (16 U.S.C. §703 et seq.) and the Migratory Bird Conservation Act (16 U.S.C. §§715–715d, 715e, 715f–715r) of 18 February 1929, are the primary laws in the United States established to conserve migratory birds. The Migratory Bird Treaty Act prohibits the taking, killing, or possessing of migratory birds or the parts, nests, or eggs of such birds, unless permitted by regulation.

The Migratory Bird Treaty Act regulations were amended in 2007 to allow for the incidental taking of migratory birds during military readiness activities (50 C.F.R. §21.15). Readiness activities include (1) all training and operations of the Armed Forces that relate to combat; and (2) the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use (50 C.F.R. §21.3). If the military readiness activities may result in a significant adverse effect on a population of a migratory bird species, the Armed Forces confers and cooperates with the Service to develop and implement appropriate conservation measures to minimize or mitigate such significant adverse effects (50 C.F.R. §21.15).

3.0.1.1.9 National Environmental Policy Act

The Navy prepared this EIS/OEIS in accordance with the President's Council on Environmental Quality regulations implementing the NEPA (40 C.F.R. Parts 1500–1508). NEPA (42 U.S.C. §§4321–4347) requires federal agencies to prepare an EIS for a proposed action with the potential to significantly affect the quality of the human environment, disclose significant environmental impacts, and inform decision makers and the public of the reasonable alternatives to the proposed action. Based on Presidential Proclamation 5928, issued 27 December 1988, impacts on ocean areas that lie within 12 nm of land (U.S. territory) are subject to analysis under NEPA. Therefore, the seas out to 12 nm are subject to analysis under NEPA.

3.0.1.1.10 National Historic Preservation Act

The National Historic Preservation Act of 1966 (16 U.S.C. 470 et seq.) establishes preservation as a national policy, and directs the federal government to provide leadership in preserving, restoring, and maintaining the historic and cultural environment. Section 106 of National Historic Preservation Act requires federal agencies to take into account the effects of their undertakings on historic properties, and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment. The National Historic Preservation Act created the National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices to help protect each state's historical and archaeological (cultural) resources. Section 110 of the National Preservation Act requires federal agencies to assume responsibility for the preservation of historic properties owned or controlled by them, and requires them to locate, inventory, and nominate all properties that qualify for the National Register. Agencies shall exercise caution to assure that significant properties are not inadvertently transferred, sold, demolished, substantially altered, or allowed to deteriorate. The National Preservation Act applies to cultural resources evaluated in this EIS/OEIS.

3.0.1.2 Executive Orders

3.0.1.2.1 Executive Order 12114, Environmental Effects Abroad of Major Federal Actions

This OEIS has been prepared in accordance with Executive Order (EO) 12114 (The President 1979 [44 FR 1957]) and Navy implementing regulations in 32 C.F.R. Part 187, *Environmental Effects Abroad of Major Department of Defense Actions*. An OEIS is required when a proposed action and alternatives have the potential to significantly harm the environment of the global commons. The global commons are defined as geographical areas outside the jurisdiction of any nation and include the oceans outside of the territorial limits (more than 12 nm from the coast) and Antarctica but do not include contiguous zones and fisheries zones of foreign nations (32 C.F.R. §187.3). As used in EO 12114, "environment" means the natural and physical environment and excludes social, economic, and other environments. The EIS and OEIS have been combined into one document, as permitted under NEPA and EO 12114, to reduce duplication.

3.0.1.2.2 Executive Order 13089, Coral Reef Protection

Executive Order 13089 was signed by the President on 11 June 1998 to, "…preserve and protect the biodiversity, health, heritage, and social and economic value of U.S. coral reef ecosystem and the marine environment…" (The President 1998 [63 FR 32701]). Policy defined in the EO requires federal agencies to identify their actions that may affect coral reefs, protect and enhance coral reef ecosystems, and, to the extent permitted by law, ensure that their actions will not degrade coral reef ecosystems. Exceptions to the policy include, among other provisions, reasons of national security, as determined by the President or the Secretary of Defense. The EO also creates and defines the duties of the U.S. Coral Reef Task force to be co-chaired by the Secretary of the Interior and the Secretary of Commerce and includes the Secretary of Defense on the task force. Federal agencies' actions that affect coral reef ecosystems, shall, subject to the availability of funding, support research, monitoring, management, and restoration efforts of the affected coral reef ecosystem in cooperation with the U.S. Coral Reef Task Force as well as other stakeholders.

3.0.1.2.3 Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance

Executive Order 13514 (The President 2009 [74 FR 52117]) was signed in October 2009 to establish an integrated strategy toward sustainability in the federal government and to make reduction of greenhouse gas emissions a priority for federal agencies. The Department of Defense developed the Strategic Sustainability Performance Plan that identifies performance-based goals and subgoals, provides a method to meet the goals (including investment strategies), and outlines a plan for reporting on performance. The Strategic Sustainability Performance Plan is included in the analyses in this EIS/OEIS.

3.0.1.2.4 Executive Order 13547, Stewardship of the Ocean, Our Coasts, and the Great Lakes

Executive Order 13547 (The President 2010 [75 FR 43023]) was issued in 2010. It is a comprehensive national policy for the stewardship of the ocean, our coasts, and the Great Lakes. This order adopts the recommendations of the Interagency Ocean Policy Task Force and directs executive agencies to implement the recommendations under the guidance of a National Ocean Council. This order establishes a national policy to, among other things,

- ensure the protection, maintenance, and restoration of the health of ocean, coastal, and Great Lakes ecosystems and resources;
- enhance the sustainability of ocean and coastal economies, preserve our maritime heritage;
- support sustainable uses and access;
- provide for adaptive management to enhance our understanding of and capacity to respond to climate change and ocean acidification; and
- coordinate with our national security and foreign policy interests.

3.0.1.3 Guidance

3.0.1.3.1 Department of Defense and Navy Directives and Instructions

Several military communications are included in this EIS/OEIS that establish policy or a plan to govern an action, conduct, or procedure. For example, Department of Defense (DoD]) Directive 4540.01, *Use of International Airspace by United States Military Aircraft and for Missile/Projectile Firings*, and Chief of Naval Operations Instruction 3770.4A, *Use of Airspace by U.S. Military Aircraft and Firing over the High Seas*, specify procedures for conducting aircraft maneuvers and for firing missiles and projectiles. Other directives and instructions referred to in the EIS/OEIS are specific for a range complex or test range such as the Commander, Joint Region Marianas Instruction 3500.4A, which is the *Marianas Training Manual* (U.S. Department of the Navy 2011). Each range complex and test range has its own manual; however, many of the components are similar.

3.0.2 DATA SOURCES AND BEST AVAILABLE DATA

The Navy used the best available data and information to compile the environmental baseline and environmental consequences evaluated in Chapter 3 (Affected Environment and Environmental Consequences). In accordance with NEPA, the Administrative Procedure Act of 1946 (5 U.S.C. §§551–

559), and EO 12114, best available data accepted by the appropriate regulatory and scientific communities were used in the analyses of potential impacts on resources.

Literature searches of journals, books, periodicals, bulletins, and other technical reports were conducted in preparation of this EIS/OEIS. Searches included general queries in the resource areas evaluated to document the environmental baseline and specific queries for analysis of environmental consequences. A wide range of primary literature was used in preparing this EIS/OEIS from federal agencies such as the NMFS, the USEPA, international organizations including the United Nations Educational Scientific and Cultural Organization, state agencies, and nonprofit and nongovernment organizations. Internet searches were conducted, and websites were evaluated for credibility of the source, quality of the information, and relevance of the content to ensure use of the best available information in this document.

3.0.2.1 Geographical Information Systems Data

Table 3.0-1 lists sources of non-Navy Geographical Information System data used in Chapter 3 (Affected Environment and Environmental Consequences) figures.

Table 3.0-1: Sources of Non-Navy Geographic Information System Data Used to Generate Figures in Chapter 3 (Affected Environment and Environmental Consequences)

Feature/Layer	Applicable Figures	Data Source References
Benthic Habitat	3.3-1, 3.3-2, 3.3-3, 3.3-4	National Oceanic and Atmospheric Administration
Short-tailed albatross pelagic range and breeding sites	3.6-4	U.S. Fish and Wildlife Service
Newell's shearwater range	3.6-4	Birdlife International
Hawaiian petrel range	3.6-4	Birdlife International
Vegetation Type	3.10-2	Google Earth 5.1
Shipping Lanes	3.12-1	Research and Innovative Technology Administration Bureau of Transportation Statistics
Mariana Islands Special Use Airspace	3.12-2	U.S. Geological Survey, General Bathymetric Chart of the Oceans, National Geospatial-Intelligence Agency
Commercial Airways	3.12-3	National Geospatial-Intelligence Agency Aeronautical Division Flight Data
Farallon de Medinilla Restricted Area and Danger Zone	3.12-4	National Oceanic and Atmospheric Administration, National Geospatial-Intelligence Agency
Guam Public Boat Launch Sites	3.12-5	National Oceanic and Atmospheric Administration, Geographic Names Information System, U.S. Geological Survey
Galvez Bank and Santa Rosa Reefs	3.12-6	U.S. Geological Survey, General Bathymetric Chart of the Oceans, Pacific Islands Benthic Habitat Mapping Center
Guam's Marine Preserves	3.12-7	National Oceanic and Atmospheric Administration, Guam's Coastal management Project, Geographic Names Information System, U.S. Geological Survey

Note: U.S. = United States

3.0.2.2 Navy Integrated Comprehensive Monitoring Program

Since 2006, the Navy, as well as non-Navy marine mammal scientists and research institutions, have conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where the Navy has been training and testing and where it proposes to continue these activities. Data collected from Navy monitoring, scientific research findings, and annual reports provided to NMFS may inform the analysis of impacts on marine mammals for a variety of reasons, including species distribution, habitat use, and evaluation of potential responses to Navy activities. Monitoring is performed using various methods, including visual surveys from surface vessels and aircraft and passive acoustics. Navy monitoring can generally be divided into two types of efforts: (1) collecting long-term data on distribution, abundance, and habitat use patterns within Navy activity areas; and (2) collecting data during individual training or testing activities. Monitoring efforts during anti-submarine warfare and explosive events focus on observing individual animals in the vicinity of the event and documenting behavior and any observable responses. Although these monitoring events are very localized and short-term, over time they will provide valuable information to support the impact analysis.

Most of the training and testing activities the Navy is proposing for the next 5 years are similar if not identical to activities that have been occurring in the same locations for decades. For example, the mid-frequency anti-submarine warfare sonar system on the cruisers, destroyers, and frigates has the same sonar system components in the water as those first deployed in the 1970s. While the signal analysis and computing processes aboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed. Therefore, the history of past marine mammal observations, research, and monitoring reports remain applicable to the analysis of effects from the proposed future training and testing activities.

3.0.2.3 Marine Species Density Database

A quantitative analysis of impacts on a species requires data on the abundance and concentration of the species population 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 significant effort to collect and analyze data to produce a usable estimate. NMFS is the primary agency responsible for estimating marine mammal and sea turtle density within the U.S. Exclusive Economic Zone. Other independent researchers often publish density data for key species in specific areas of interest. For example, manatee abundance data is collected by state agencies. Within most of the world’s oceans, although some survey effort may have been completed, the required amount of surveys has not been conducted to allow density estimation. To approximate distribution and abundance of species for areas or seasons that have not been surveyed, the Habitat Suitability Index or Relative Environmental Suitability model is used to estimate occurrence based on modeled relationships of where the animals are sighted and the associated environmental variables (e.g., depth, sea surface temperature, etc.).

There is no single source of density data for every area of the world, species, and season because of the fiscal costs, resources, and effort involved in providing survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the Study Area, the Navy compiled data from several sources. To compile and structure the most appropriate database of marine species density data, the Navy developed a protocol to select the best available data sources based on species, area, and time (season). Refer to the MITT EIS/OEIS website for a technical report describing in detail the process the Navy used to create the marine species density database. The resulting Geographic Information System database includes seasonal density values for every marine mammal and sea turtle species present within the Study Area (U.S. Department of the Navy 2012).

3.0.3 Ecological Characterization of the Mariana Islands Training and Testing Study Area

Navy activities in the marine environment predominately occur within established operating areas, range complexes, test ranges, ports, and pierside locations, although some occur outside these designated areas. These established locations were defined by training and testing requirements and regulated maritime and airspace boundaries. However, the Navy-defined boundaries are not always consistent with ecological boundaries that may be more appropriate when assessing potential impacts on marine resources within the Study Area. In other Navy training areas, ecological boundaries are able to be described by Large Marine Ecosystems, which were developed by the U.S. National Oceanic and Atmospheric Administration. Large Marine Ecosystems are regions of the world's oceans that encompass coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margins of the major ocean current systems. However, while there are 64 Large Marine Ecosystems around the world, the MITT Study Area is within an established Large Marine Ecosystem. Therefore, as ocean patterns and distribution of organisms in the Study Area are fairly uniform, the MITT Study area is assessed based on environmental characteristics of the near-shore and open-ocean areas where training and testing activities may occur.

The environmental characteristics used to analyze potential impacts of Navy training and testing activities in the Study Area include local bathymetry, currents, circulation patterns, water masses, fronts, and ocean conditions; and are discussed briefly below. All of these environmental characteristics are discussed in greater detail in the various resources sections if they have the potential to change the impacts from Navy training and testing. For example, the bathymetry (or water depth) of the Study Area reflects the features (topography) of the seafloor, which may influence the way sound travels underwater. Thus, if the travel (propagation) of the underwater sound is affected by the topography of the Study Area, it is included in the acoustic exposure modeling analysis for marine mammals and is discussed in detail in Section 3.4 (Marine Mammals).

Bathymetry. The seafloor of the Study Area region is characterized by the Mariana Trench, the Mariana Trough, ridges, numerous seamounts, hydrothermal vents, and volcanic activity. Two volcanic arcs, the West Mariana Ridge (a remnant volcanic arc) and the Mariana Ridge (an active volcanic arc), are separated by the Mariana Trough. The Mariana Trough formed when the oceanic crust in this region began to spread between the ridges 4 million years ago. The Mariana Trough is spreading at a rate of less than 0.4 inch [in.] (1 centimeter [cm]) per year in the northern region and at rates up to 1.2 in. (3 cm) per year in the center of the trough. The Mariana archipelago is located on the Mariana Ridge, 99 to 124 miles (mi.) (159 to 200 kilometers [km]) west of the Mariana Trench subduction zone. The Mariana archipelago comprises 15 volcanic islands: Guam, Rota, Tinian, Saipan, Farallon de Medinilla (FDM), Aguiguan, Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrigan, Asunción, Maug, and Farallon de Pajaros. Approximately 497 mi. (800 km) separate Guam from Farallon de Pajaros (U.S. Department of the Navy 2005a).

Currents. Surface currents consist predominantly of the horizontal movement of water. Surface currents of the Pacific Ocean include equatorial currents, circumpolar currents, eastern boundary, and western boundary currents. Oceanographic currents are either surface currents in the upper portion of the water column or thermohaline currents in the intermediate and bottom layers of the oceans. Upper surface currents in the Study Area are predominantly wind driven (Starmer et al. 2008; U.S. Environmental Protection Agency 2010); the rotation in the Northern Hemisphere and counter clockwise in the Southern Hemisphere combine with the bathymetry, which results in a weak mean current that flows from west to east. A series of eddies create vertical fluxes, upwelling, and downwelling (Takeoka et al. 1997).

Circulation. Overall, the flow of the Pacific Ocean's circulation in the Study Area is northwestward; however, very little is known about the oceanic circulation around the islands in the Study Area and the impact that the eddies that the islands create has upon the circulation of the open ocean (Wolanski et al. 2003).

Water Masses. Water masses throughout the world's oceans are defined by their chemical and physical properties. The temperature and salinity of a water mass determines its density. Density differences cause water masses to move both vertically and horizontally in relation to one another. Deep water masses in the Study Area include Lower and Upper Circumpolar Deep Waters, Antarctic Circumpolar Current, and North Pacific Deep Water. Lower and Upper Circumpolar Deep Waters and Antarctic Intermediate Water are transported from the Antarctic Circumpolar Current to the North Pacific (Kawabe and Fujito 2010). Intermediate water masses (residing above deep water and below surface water) in the Study Area include Pacific Intermediate Water, Pacific Central Water, and Antarctic Intermediate Water (Johnson 2008; Kawabe and Fujito 2010).

Fronts. Within the Study Area, to the north of the Marianas Archipelagoes and south of the American Samoa, there are subtropical frontal zones that consist of several convergent fronts that are called "Transition Zones." Transition zones are found in the Study Area's coastal seas where stratified and tidally mixed areas are adjacent to each other (Takeoka et al. 1997). To the north of American Samoa and south of the Marianas Archipelagoes, an equatorial current system of alternating east and west zonal flows with adjacent fronts (Tomczak and Godfrey 2005).

Ocean Characteristics of the Study Area. The ocean temperature in the Study Area averages 82 degrees (°) Fahrenheit (27.8° Celsius) with little seasonal variation (Pacific Regional Integrated Sciences and Assessment Program 2012). The water column in the Study Area contains a well-mixed surface layer ranging from approximately 300 to 410 feet (ft.) (91.4 to 125 meters [m]). Immediately below the mixed layer is a rapid decline in temperature to the cold deeper waters. Unlike more temperate climates, the thermocline is relatively stable, rarely turning over and mixing the more nutrient waters of the deeper ocean in to the surface layer. This constitutes what has been defined as a "significant" surface duct (a mixed layer of constant water temperature extending from the sea surface to 100 ft. [30.5 m] or more), which influences the transmission of sound in the water. This factor has been included in the acoustic exposure modeling analysis for marine mammals, discussed in detail in Section 3.4 (Marine Mammals).

3.0.4 Acoustic and Explosives Primer

This section introduces basic acoustic principles and terminology that describes how sound travels or "propagates" in air and water. These terms and concepts are used when analyzing potential impacts from acoustic sources and explosives used during naval training and testing. This section briefly explains the transmission of sound and defines acoustical terms, abbreviations, and units of measurement. Finally, it discusses the various sources of underwater sound, including physical, biological, and anthropogenic sounds. A more complete and more technical introduction to acoustics is provided in Appendix I (Acoustic and Explosives Primer).

3.0.4.1 Terminology/Glossary

Sound may be described in terms of both physical and subjective attributes. Physical attributes may be directly measured. Subjective (or sensory) attributes cannot be directly measured and require a listener to make a judgment about the sound. Physical attributes of a sound at a particular point are obtained by measuring pressure changes as sound waves pass. The following material provides a short description of some of the basic parameters of sound.

3.0.4.1.1 Particle Motion and Sound Pressure

Sound can be described as a vibration traveling through a medium (air or water in this analysis) in the form of a wave. Introducing a vibration from a sound source into water causes the water particles to vibrate, or oscillate about their original position, and collide with each other, transferring the vibration through the water in the form of a wave. As the sound wave travels through the water, the particles of water oscillate but do not actually travel with the wave. The result is a mechanical disturbance (i.e., the sound wave) that propagates away from the sound source.

Sound has two components: particle motion and pressure. Particle motion is quantified as the velocity, amount of displacement (i.e., amplitude), and direction of displacement of the particles in the medium. The pressure component of sound is created when vibrations in the medium compress and then decompress the particles in the medium in an oscillating manner, resulting in fluctuations in pressure that propagate through the medium as a sound wave. Animals with an eardrum or similar structure directly detect the pressure component of sound. Some marine fish also have specializations to detect pressure changes. Certain animals (e.g., most invertebrates and many marine fish) do not have anatomical structures that enable them to detect the pressure component of sound and are only sensitive to the particle motion component of sound. The particle motion component of sound that these animals can detect degrades more rapidly with distance from the sound source than the pressure component, such that particle motion is most detectable by these animals near the sound source. This difference in acoustic energy sensing mechanisms limits the range at which these animals can detect most sound sources analyzed in this document. The majority of the analysis presented focuses on animals that can detect sound pressure.

3.0.4.1.2 Frequency

The number of oscillations or waves per second is called the frequency of the sound, and the metric is Hertz (Hz). One Hz is equal to one oscillation per second, and 1 kilohertz (kHz) is equal to 1,000 oscillations per second. The inverse of the frequency is the period or duration of one acoustic wave.

Frequency is the physical attribute most closely associated with the subjective attribute “pitch”; the higher the frequency, the higher the pitch. Human hearing generally spans the frequency range from 20 Hz to 20 kHz.

The pitch based on these frequencies is subjectively “low” (at 20 Hz) or “high” (at 20 kHz). In this document, sounds are generally described as either low- (less than 1 kHz), mid- (1–10 kHz), high- (greater than 10–100 kHz), or very high- (greater than 100 kHz and less than 200 kHz) frequency. Hearing ranges of marine animals (e.g., fish, birds, and marine mammals) are quite varied and are species-dependent. For example, some fish can hear sounds below 100 Hz and some species of marine mammals have hearing capabilities that extend above 100 kHz. Discussions of sound and potential impacts must therefore focus not only on the sound pressure, but the composite frequency of the noise and the species considered.

3.0.4.1.3 Duty Cycle

Duty cycle describes the portion of time that a sound source actually generates sound. It is defined as the percentage of the time during which a sound is generated over a total operational period. For example, if a sound navigation and ranging (sonar) source produces a 10-second ping once every 100 seconds, the duty cycle is 10 percent. Duty cycles vary among different acoustic sources; in general, a low duty cycle is 20 percent or less and a high duty cycle is 80 percent or higher.

3.0.4.1.4 Loudness and Auditory Weighting Functions

Sound levels are normally expressed in decibels (dB), a commonly misunderstood term. Although the term “decibel” always means the same thing, decibels may be calculated in several ways, and the explanations of each can quickly become both highly technical and confusing.

Because mammalian ears can detect large pressure ranges and humans judge the relative loudness of sounds by the ratio of the sound pressures (a logarithmic behavior), sound pressure level is described by taking the logarithm of the ratio of the sound pressure to a reference pressure (American National Standards Institute 1994). Use of a logarithmic scale compresses the wide range of pressure values into a more usable numerical scale. (The softest audible sound has a power of about 0.000000000001 watt/square meter (m^2) and the threshold of pain is around 1 watt/m^2. With the advantage of the logarithmic scale, this ratio is efficiently described as 120 dB.)

On the decibel scale, the smallest audible sound (near total silence) is 0 dB. A sound 10 times more powerful is 10 dB. A sound 100 times more powerful than near total silence is 20 dB. A sound 1,000 times more powerful than near total silence is 30 dB. Table 3.0-2 compares common sounds to their approximate decibel rating. Table 3.0-2 also lists common underwater sounds and their source levels. Because seawater is a very efficient medium for the transmission of sound, there is a significant difference between transmission of sound in water and transmission of sound in air. It is important to note that, because of the difference in the media in which the sound is traveling (water vs. air), the same absolute pressures would result in different dB values for each medium. Different reference units are used for sounds in air and sounds in water, making side-by-side comparisons in decibels meaningless. In water, the reference pressure is 1 micropascal (1 μPa), whereas in air the reference pressure is 20 μPa. Consider the 140 dB gunshot and the 194–219 dB dolphin click from Table 3.0-2.

Animals, including humans, are not equally sensitive to sounds across their entire hearing range. The subjective judgment of a sound level by a receiver such as an animal is known as loudness. Two sounds received at the same sound pressure level (an objective measurement), but at two different frequencies, may be perceived by an animal at two different loudness levels depending on its hearing sensitivity (lowest sound pressure level at which a sound is first audible) at the two different frequencies. Furthermore, two different species may judge the relative loudness of the two sounds differently.

Auditory weighting functions are a method common in human hearing risk analysis to account for differences in hearing sensitivity at various frequencies. This concept can be applied to other species as well. When used in analyzing the impacts of sound on an animal, auditory weighting functions adjust received sound levels to emphasize ranges of best hearing and de-emphasize ranges of less or no sensitivity. A-weighted sound levels, often seen in units of “dBA,” (A-weighted decibels) are frequency-weighted to account for the sensitivity of the human ear to a barely audible sound. Many measurements of sound in air appear as dBA in the literature because the intent of the authors is often to assess noise impacts on humans.

Table 3.0-2: Common In-Air and Underwater Sounds and their Approximate Source Levels

In-Air Source	Source Level (dB re 20 µPa at 1 m)
Near total silence	0
Whisper	15
Normal conversation	60
Lawnmower	90
Car horn	110
Rock concert	120
Gunshot	140 (peak)
In-Water Source	**Source Level** (dB re 1 µPa at 1 m)
Ice breaker ship	1,931
Large tanker	1,861
Seismic airgun array (32 guns)	259 (peak)[1]
Dolphin whistles	125–173[1]
Dolphin clicks	194–219[2]
Humpback whale song	144–174[3]
Snapping shrimp	183–189[4]
Sperm whale click	236[5]
Naval mid-frequency active sonar (SQS-53)	235
Lightning strike	260[6]
Seafloor volcanic eruption	255[7]

[1] Richardson et al. 1995
[2] Rasmussen et al. 2002
[3] Payne and Payne 1985; Thompson et al. 1979
[4] Au and Banks 1998
[5] Levenson 1974; Watkins 1980
[6] Hill 1985
[7] Northrop 1974
Note: dB re 1 µPa at 1 m = decibels referenced to 1 micropascal at 1 meter

3.0.4.1.5 Categories of Sound

3.0.4.1.5.1 Signal Versus Noise

When sound is purposely created to convey information, communicate, or obtain information about the environment, it is often referred to as a signal. Examples of sounds that could be considered signals are sonar pings, marine mammal vocalizations/echolocations, tones used in hearing experiments, and small sonobuoy explosions used for submarine detection.

Noise is undesired sound (American National Standards Institute 1994). Sounds produced by naval aircraft and vessel propulsion are considered noise because they represent possible inefficiencies and increased detectability, which are undesirable. Whether a sound is noise often depends on the receiver (i.e., the animal or system that detects the sound). For example, small explosives and sonar used to generate sounds that can locate an enemy submarine produce *signals* that are useful to sailors engaged in anti-submarine warfare, but are assumed to be *noise* when detected by marine mammals.

Noise also refers to all sound sources that may interfere with detection of a signal (background noise) and the combination of all of the sounds at a particular location (ambient noise) (American National Standards Institute 1994).

3.0.4.1.5.2 Impulse Versus Non-Impulse Sounds

Sounds may be categorized as impulse or non-impulse. Impulse sounds feature a very rapid increase to high pressures, followed by a rapid return to the static pressure. Impulse sounds are often produced by processes involving a rapid release of energy or mechanical impacts (Hamernik and Hsueh 1991). Non-impulse sounds lack the rapid rise time and can have longer durations than impulse sounds. Non-impulse sound can be continuous or intermittent.

3.0.4.1.6 Classification of Acoustic and Explosive Sources

In order to better organize and facilitate the analysis of approximately 300 individual sources of underwater acoustic sound or explosive energy, a series of source classifications, or source bins, were developed. The use of source classification bins provides the following benefits:

- provides the ability for new sensors or munitions to be covered under existing regulatory authorizations, as long as those sources fall within the parameters of a "bin"
- simplifies the source utilization data collection and reporting requirements anticipated under the MMPA
- ensures a conservative approach to all impacts estimates, as all sources within a given class are modeled as the loudest source (lowest frequency, highest source level, longest duty cycle, or largest net explosive weight) within that bin
- allows analysis 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/count) 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 real world events

There are two primary types of acoustic sources: impulsive and non-impulsive. A description of each source classification is provided in Tables 3.0-3 and 3.0-4. Impulsive bins are based on the net explosive weight of the munitions or explosive devices or the source level for air and water guns. Non-impulsive acoustic sources are grouped into bins based on the frequency,[1] source level[2] , and, when warranted, the application in which the source would be used. The following factors further describe the considerations associated with the development of non-impulse source bins:

- Frequency of the non-impulse 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
- Source level of the non-impulse source.
  - Greater than 160 dB, but less than 180 dB
  - Equal to 180 dB and up to 200 dB
  - Greater than 200 dB
- Application in which the source would be used.

[1] Bins are based on the typical center frequency of the source. Although harmonics may be present, those harmonics would be several decibels lower than the primary frequency.

[2] Source decibel levels are expressed in terms of sound pressure level and are values given in dB referenced to 1 micropascal at 1 meter.

- How a sensor is employed supports how the sensor's acoustic emissions are analyzed
- Factors considered include pulse length (time source is on); beam pattern (whether sound is emitted as a narrow, focused beam or, as with most explosives, in all directions); and duty cycle (how often or how many times a transmission occurs in a given time period during an event)

Table 3.0-3: Non-Impulse Acoustic Sources Quantitatively Analyzed

Source Category	Source Bin	Description
Low-Frequency (LF): Sources that produce low-frequency (less than 1 kHz) signals	LF4	Low-frequency sources equal to 180 dB and up to 200 dB
	LF5	Low-frequency sources less than 180 dB
	LF6	Low-frequency sonar currently in development (e.g., anti-submarine warfare sonars associated with the Littoral Combat Ship)
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1 to 10 kHz) signals	MF1	Hull-mounted surface ship sonar (e.g., AN/SQS-53C and AN/SQS-60)
	MF2	Hull-mounted surface ship sonar (e.g., AN/SQS-56)
	MF3	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonar systems (e.g., AN/AQS-22 and AN/AQS-13)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF6	Active underwater sound signal devices (e.g., MK-84)
	MF8	Active sources (greater than 200 dB) not otherwise binned

Table 3.0-3: Non-Impulse Acoustic Sources Quantitatively Analyzed (continued)

Source Category	Source Bin	Description
	MF9	Active sources (equal to 180 dB and up to 200 dB) (e.g., Underwater Communications)
	MF10	Active sources (greater than 200 dB)
	MF11	Hull-mounted surface ship sonar systems with an active duty cycle greater than 80%
	MF12	High duty cycle – variable depth sonar
Source Category	**Source Bin**	**Description**
High-Frequency (HF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 100 kHz) signals	HF1	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF5	Active sources (greater than 200 dB) not otherwise binned
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned
Anti-Submarine Warfare (ASW): Tactical sources such as active sonobuoys and acoustic countermeasures systems used during the conduct of ASW training and testing activities	ASW1	Mid-frequency Deep Water Active Distributed System (DWADS)
	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)
	ASW3	Mid-frequency towed active acoustic countermeasure systems (e.g., AN/SLQ-25)
	ASW4	Mid-frequency active acoustic device countermeasures (e.g., MK-3)
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK-46, MK-54)
	TORP2	Heavyweight torpedo (e.g., MK-48, electric vehicles)
Airguns (AG): Underwater airguns are used during swimmer defense and diver deterrent training and testing activities	AG	Up to 60 cubic inch airguns (e.g., Sercel Mini-G)
Acoustic Modems (M): Systems used to transmit data acoustically through the water	M3	Mid-frequency acoustic modems (up to 210 dB) (e.g., UEWS, ATN)
Swimmer Detection Sonar (SD): Systems used to detect divers and submerged swimmers	SD1	High-frequency sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security.

Notes: (1) Refer to Table 3.0-5 for those sources excluded from quantitative analysis. (2) ATN = aid to navigation, dB = decibel, DICASS = Directional Command Activated Sonobuoy System, kHz = kilohertz, UEWS = underwater emergency warning system, UUV = unmanned underwater vehicle, VDS = variable depth sonar

Table 3.0-4: Training and Testing Explosive Source Classes

Source Class	Representative Munitions	Net Explosive Weight (lb.)
E1	Medium-caliber projectiles (30 mm projectile)	0.1–0.25
E2	Medium-caliber projectiles (40 mm projectile)	> 0.25–0.5
E3	Large-caliber projectiles	> 0.5–2.5
E4	Improved extended echo ranging sonobuoy	> 2.5–5.0
E5	5 in. projectiles	> 5–10
E6	Hellfire Missile	> 10–20
E7	AGM-88 HARM	> 20–60
E8	250 lb. bomb	> 60–100
E9	500 lb. bomb	> 100–250
E10	1,000 lb. bomb	> 250–500
E11	Mine	> 500–650
E12	2,000 lb. bomb	> 650–1,000

Notes: HARM = High Speed Anti-Radiation Missile, IEER = Improved Extended Echo Ranging, in. = inch, lb. = pound, mm = millimeter

3.0.4.1.6.1 *De Minimis* Sources

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 some combination of these factors, that are not anticipated to result in takes of protected species and therefore are not required to be quantitatively analyzed. These sources will be categorized as *de minimis* sources and will be qualitatively analyzed to determine the appropriate determinations under NEPA, MMPA, and ESA. When used during routine training and testing activities, and in a typical environment, *de minimis* sources generally meet one or more of the following criteria:

- Acoustic source classes listed in Table 3.0-5 (actual source parameters are listed in the classified bin list)
- Acoustic sources that transmit primarily above 200 kHz
- Sources operated with source levels of 160 dB referenced to (re) 1 µPa at 1 m, or less

However, the operational use of a source during a training or testing event may require quantitative analysis in accordance with enclosure (2) to determine whether they can be considered de minimis sources.

The types of sources with source levels less than 160 decibels referenced to 1 micropascal at 1 meter (dB re 1 µPa at 1 m) are typically hand held sonars, range pingers, transponders, and acoustic communication devices. Assuming spherical spreading for a 160 dB 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.

Analysis of potential behavioral effects on marine mammals is estimated using a behavioral risk function (see Appendix I, Acoustic and Explosives Primer, for details). The behavioral risk function equation is:

$$R = \frac{1 - \left(\frac{L-B}{K}\right)^{-A}}{1 - \left(\frac{L-B}{K}\right)^{-2A}}$$

where,

R = risk (0–1.0)
L = received level (RL) in dB (140 dB re 1 μPa)
B = basement RL in dB (120 dB re 1 μPa)
K = RL increment above basement with 50 percent risk (45 dB re 1 μPa)
A = risk transition sharpness

For odontocetes, pinnipeds, manatees, sea otters, and polar bears, A = 10; therefore, R = 0.0003, or 0.03 percent risk. For mysticetes, A = 8; therefore, R = 0.0015, or 0.15 percent risk.

Therefore:

- For all marine mammals subject to a behavioral risk function, these sources will not significantly increase the number of potential exposures as determined by the effects criteria.
- For beaked whales, given a sound source level of 160 dB re 1 μPa at 1 m, the range to the behavioral threshold (i.e., a received level of 140 dB re 1 μPa) is only 10 m. The likelihood of any potential behavioral effect is low because of the small affected area defined by the behavioral threshold (a sphere with a radius of 10 m) and the relatively low density of beaked whales.
- For harbor porpoises, the range to the behavioral threshold of 120 dB re 1 μPa is 100 m from the sound source. Based on the above discussion and the extremely short propagation range to 120 dB, the potential for exposures resulting in a behavioral change to a behavior (e.g., feeding) to the extent that the behavior is abandoned or significantly altered is unlikely.
- For sea turtles, the behavioral threshold of 175 dB re 1 μPa is above the 160 dB re 1 μPa at 1 m source level, and, therefore, no behavioral effect would be expected
- Additionally for all of the above calculations, the attenuation of sound in water is not considered, and would increase the actual transmission losses, further reducing the range to a behavioral effect and the potential for exposures.
- Should any impact criteria thresholds be lowered below 120 dB re 1 μPa, or should the behavioral risk function parameters change, the current *de minimis* sources and source classes in the classified bin list will be re-evaluated for *de minimis* consideration.

3.0.4.1.6.2 *De Minimis* Source Classes

An entire source bin, or some sources from a bin, may be excluded from quantitative analysis (Table 3.0-5) if one or more of the following criteria are met:

- The source may result in no response, or responses that would be short term and inconsequential based on the system's acoustic characteristics (e.g., short pulse length, frequency range at the limit of marine species hearing, and low source level) and manner of system operation.
- The sources are determined to meet the criteria specified in the Section 3.0.4.1.6.1 (*De Minimis* Sources) or Table 3.0-5.
- Bins contain sources needed for safe operation and navigation.

In summary, exposures from *de minimis* sources are unlikely, but if exposure does occur the response would be considered inconsequential since it would not likely result in any biological costs to the animal outside the normal variation experienced in an animal's daily life history.

If a source (e.g., new acoustic system) substantially meets the criteria in Section 3.0.4.1.6.1 (*De Minimis* Sources) and Table 3.0-5, that source does not require quantitative analysis. Specific *de minimis* source parameters (e.g., beam width, pulse length, duty cycle, transmit power and others) are often classified, and, therefore, it is not possible to list specific parameters for each system in an unclassified document. These parameters are listed in a classified bin list that is maintained by the Naval Undersea Warfare Center Division Newport, Environmental Division, and should be used to determine if a current system or newly developed system has similar operational parameters and can operate in a manner similar to a current *de minimis* source class listed in Table 3.0-5. Sources that meet these criteria shall be qualitatively analyzed to determine the appropriate determinations under NEPA, MMPA, and ESA (Table 3.0-5).

Table 3.0-5: Source Classes Excluded from Quantitative Analysis

Source Category	Source Bin	Justification
Doppler Sonar/Speed Logs (DS) Navigation equipment, downward focused, narrow beamwidth, HF/VHF spectrum utilizing very short pulse length pulses	DS2, DS3, DS4	Marine species are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler or pinger given their characteristics (e.g., narrow downward-directed beam), which is focused directly beneath the platform. Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for marine species that might be exposed to these sound sources.
Fathometers (FA) High-frequency sources used to determine water depth	FA1, FA2, FA3, FA4	Marine species are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler or pinger given their characteristics (e.g., narrow, downward-directed beam, and short pulse length). Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for marine species that might be exposed to these sound sources. Fathometers use a downward directed, narrowly focused directly below the vessel (typically much less than 30 degrees), using a short pulse length (less than 10 milliseconds [msec]). Use of fathometers is also required for safe operation of Navy vessels.
Hand-held Sonar (HHS) High-frequency sonar devices used by Navy divers for object location	HHS1	Hand-held sonar generates very high frequency sound at low power levels (150–178 dB re 1 micropascal), short pulse lengths, and narrow beam widths. Because output from these sound sources would attenuate to below any current threshold for marine species at a very short range, and they are under positive control of the diver on which direction the sonar is pointed marine species reactions are not likely. No additional quantitative modeling is required for marine species that might be exposed to these sound sources.
Acoustic Releases (R) Systems that transmit active acoustic signals to release a bottom-mounted object from its housing in order to retrieve the device at the surface	R1, R2, R3	Acoustic releases operate at mid and high-frequencies. As these types of devices are only used to retrieve bottom mounted devices they typically transmit only a single ping. Marine species are expected to exhibit no more than short-term and inconsequential responses to these sound sources given that any sound emitted is extremely short in duration. Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for marine species that might be exposed to these sound sources.

Table 3.0-5: Source Classes Excluded from Quantitative Analysis (continued)

Source Category	Source Bin	Justification
Imaging Sonar (IMS) HF or VHF, very short pulse lengths, narrow bandwidths. IMS1 is a side-scan sonar (HF/VHF, narrow beams, downward directed). IMS2 is representative of a downward looking source, narrow beam, and operates above 180 kHz (basically a fathometer).	IMS1, IMS2	These sonar systems typically operate in a very high frequency range relative to marine mammal hearing (Richardson et al. 1995; Southall et al. 2007). The frequency range from these types of sonars is beyond the hearing range of mysticetes (baleen whales), pinnipeds, manatees, and sea turtles and, therefore, not expected to affect these species. The frequency range from these sonars is within the upper end of odontocete hearing (Richardson et al. 1995), which means that they are not perceived as loud acoustic signals. Therefore, marine species may be less likely to react to these types of systems in a biologically significant way. Further, in addition to spreading loss, high frequency sources are also more quickly absorbed than sounds with lower frequencies (Urick 1983). Additionally, these systems are generally operated in the vicinity of the sea floor, thus reducing the potential of sound exposure even more. Marine species are expected to exhibit no more than short-term and inconsequential responses to these types of systems given their characteristics (e.g., narrow downward-directed beam and short pulse length (generally 20 msec). Such reactions are not considered to constitute “taking” and, therefore, no additional quantitative modeling is required for marine species that might be exposed to and affected by these sound sources.
Acoustic Modems and Tracking Pingers	M2, P1, P2, P3, P4	Acoustic modems, and tracking pingers operate at frequencies between 2 and 170 kHz, low duty cycles, (single pings in some cases), short pulse lengths (typically 20 msec), and relatively low source levels. Marine species are expected to exhibit no more than short-term and inconsequential responses to these systems given the characteristics as described above. Such reactions are not considered to constitute “taking” and, therefore, no additional quantitative modeling is required for marine species that might be exposed to and affected by these sound sources.
Side Scan Sonar (SSS) Sonar that use active acoustic signals to produce high-resolution images of the seafloor	SSS1, SSS2, SSS3	Marine species are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics such as a downward-directed beam, and short pulse lengths (less than 20 msec). Such reactions are not considered to constitute “taking” and, therefore, no additional quantitative modeling is required for marine species that might be exposed to and affected by these sound sources.
Small Impulsive Sources	Sources with explosive weights less than 0.1 lb. net explosive weight (less than bin E1)	Quantitative modeling in multiple locations has validated that these low level impulsive sources are expected to cause no more than short-term and inconsequential responses in marine species due to the low explosive weight and corresponding very small zone of influence associated with these types of sources.

Notes: dB = decibel, HF = high frequency, kHz = kilohertz, lb. = pound, m = meter, msec = milliseconds, NWTT = Northwest Training and Testing, VHF = very high frequency

3.0.5 OVERALL APPROACH TO ANALYSIS

The approach to analysis included in this EIS/OEIS follows these steps:

- Identification of resources for analysis
- Resource-specific impacts analysis for individual stressors
- Resource-specific impacts analysis for multiple stressors
- Examination of potential population-level impacts
- Cumulative impacts analysis
- Consideration of mitigations to reduce identified potential impacts

Navy training and testing activities in the Proposed Action are comprised of multiple components that may cause stress on a resource. Appendix F (Training and Testing Activities Matrices) includes tables (Tables F-1 and F-2) that indicate these components by activity. For example, one component of a missile exercise (surface-to-air) is vessel movement. The potential stressors are categorized by the way in which they may affect the environment. In Table 3.0-6, stressors are listed under the resource areas in which they can cause an effect. A single activity may result in multiple stressors (i.e., a torpedo test may involve water quality stressors from torpedo exhaust, physical disturbance and strike stressors from an object moving through the water, and acoustic stressors from the guidance system operation).

Table 3.0-6: List of Stressors Analyzed

Components and Stressors for Physical Resources	
Sediments and Water Quality	
• Explosives and explosive byproducts	• Chemicals other than explosives
• Metals	• Other materials
Air Quality	
• Criteria pollutants	• Hazardous air pollutants
Components and Stressors for Biological Resources	
Acoustic Stressors	• Weapons firing, launch, and impact noise
• Sonar and other active acoustic sources	• Vessel noise
• Underwater Explosives	• Aircraft noise
• Swimmer Defense airguns	
Energy Stressors	
• Electromagnetic devices	• Lasers
Physical Disturbance and Strike Stressors	
• Aircraft and aerial targets	• Seafloor devices
• Vessels	• Ground disturbance
• In-water devices	• Wildfires
• Military expended materials	

Table 3.0-6: List of Stressors Analyzed (continued)

Components and Stressors for Biological Resources
Entanglement Stressors • Fiber optic cables and guidance wires • Decelerators/Parachutes
Ingestion Stressors • Military expended materials from munitions • Military expended materials other than munitions
Secondary Stressors • Habitat (sediments and water quality, air quality) • Prey availability • Invasive species introductions into terrestrial habitats
Components and Stressors for Human Resources
Cultural Resources Stressors
• Acoustic • Physical Disturbance and Strike
Socioeconomic Resources Stressors
• Accessibility • Airborne acoustics • Physical disturbance and strike • Secondary impacts from availability of resources
Public Health and Safety Stressors
• Underwater energy • In-air energy • Physical interactions • Secondary stressors (sediments and water quality)

A summary of which stressors result from the activity types being analyzed in this document is given in Table 3.0-7. Not all stressors affect every resource, nor do all proposed military activities produce all stressors.

First, a preliminary analysis was conducted to determine the environmental resources potentially impacted and associated stressors. Secondly, each resource was analyzed for potential impacts of individual stressors, followed by an analysis of the combined impacts of all stressors related to the Proposed Action. A cumulative impact analysis was conducted to evaluate the incremental impact of the Proposed Action when added to other past, present, and reasonably foreseeable future actions. Mitigation measures are discussed in detail in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring).

In this phased approach, the initial analyses were used to develop each subsequent step so the analysis focuses on relevant issues (defined during scoping) that warranted the most attention. The systematic nature of this approach allowed the Proposed Action with the associated stressors and potential impacts to be effectively tracked throughout the process. This approach provides a comprehensive analysis of applicable stressors and potential impacts. Each step is described in more detail below.

Table 3.0-7: Stressors by Warfare and Testing Area

Warfare Area/Testing Area	Biological Resources						Physical Resources		Human Resources		
	Acoustic Stressors	Energy Stressors	Physical Disturbance and Strike Stressors	Entanglement Stressors	Ingestion Stressors	Secondary Stressors	Air Quality Stressors	Sediment and Water Quality Stressors	Cultural Stressors	Socioeconomic Stressors	Public Health and Safety
Training Activities											
Anti-Air Warfare	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Strike Warfare	✓		✓			✓	✓		✓	✓	
Amphibious Warfare	✓		✓			✓	✓	✓	✓	✓	✓
Anti-Surface Warfare	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Anti-Submarine Warfare	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Major Training Activities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Electronic Warfare	✓		✓		✓	✓	✓	✓	✓	✓	✓
Mine Warfare	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Naval Special Warfare	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Other Training Activities	✓		✓		✓	✓	✓	✓	✓	✓	✓
Testing Activities											
Anti-Surface Warfare	✓		✓		✓	✓	✓	✓	✓	✓	✓
Anti-Submarine Warfare	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Electronic Warfare			✓		✓	✓	✓	✓	✓	✓	✓
Life Cycle Activities	✓		✓			✓	✓			✓	✓
Anti-Surface Warfare/Anti-Submarine Warfare	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Shipboard Protection Systems and Swimmer Defense Testing	✓		✓						✓	✓	✓
New Ship Construction	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Office of Naval Research	✓		✓								

3.0.5.1 Resources and Issues Evaluated

Physical resources and issues evaluated include sediments, water quality, and air quality. Biological resources (including threatened and endangered species) evaluated include marine habitats, marine mammals, sea turtles, marine birds, marine vegetation, marine invertebrates, fish, and terrestrial species and habitats. Human resources evaluated in this EIS/OEIS include cultural resources, socioeconomics, and public health and safety.

3.0.5.1.1 Resources and Issues Not Carried Forward for More Detailed Discussion

Environmental Justice and Protection of Children were evaluated and are discussed below. EO 12898 (11 February 1994), Federal Actions to Address Environmental Justice in Minority Populations, requires each Federal agency to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minorities and low-income populations. EO 13045, Protection of Children from Environmental Health and Safety Risks (1997), requires each Federal agency to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children and ensure that its policies, programs, activities, and standards address disproportionate risks to children. The Proposed Action will not result in disproportionate impacts to minority and low-income populations or children. A detailed analysis of the Environmental Justice and Protection of Children resources is presented in Section 3.18 of the MIRC EIS/OEIS (U.S. Department of the Navy 2010) and is incorporated by reference.

According to the MIRC EIS/OEIS, the action would not result in disproportionate impacts to minority and low-income populations or children (U.S. Department of the Navy 2010). The analysis in the MIRC EIS/OEIS was reviewed as it pertains to the Proposed Action and it was determined to be valid. The Affected Environment for the Proposed Action is essentially the same as in the MIRC EIS/OEIS. For example, implementation of the Proposed Action would not result in a change to demographics and no changes are anticipated to the local population of the counties of the coastal states that abut the Study Area. There would be no change in the pattern of residential or economic use among various ethnic populations, nor would there be a change in the concentrations of children in the immediate vicinity of training or testing activities within the Study Area. Additionally, the analysis of Environmental Effects in the MIRC EIS/OEIS would be essentially the same. There is either minimal or no change to land-based training and testing activities proposed in this EIS/OEIS. Training and testing activities would occur primarily on lands or waters owned, controlled, or leased by the military in the Study Area. No relocation of additional personnel would occur.

Therefore, the following conclusions are made for the MITT EIS/OEIS: No aspects of the proposed actions are likely to act as stressors to minorities, low-income, and children populations; thus, the No Action Alternative, Alternative 1, or Alternative 2 would not result in effects on minority populations or the protection of children. The proposed actions would have no effect on environmental justice components in territorial waters under the No Action Alternative, Alternative 1, or Alternative 2. In non-territorial waters there would be no effect on environmental justice components under the No Action Alternative, Alternative 1, or Alternative 2.

3.0.5.2 Identification of Stressors for Analysis

The proposed training and testing activities were evaluated to identify specific components that could act as stressors (Table 3.0-6) by having direct or indirect impacts on the environment. This evaluation included identification of the spatial variation of the identified stressors. The warfare and testing areas along with their associated environmental stressors are identified previously in Table 3.0-7. Matrices were prepared to identify associations between stressors, resources, training and testing activities, warfare and testing areas, range complexes, and alternatives. The following subsections describe the environmental stressors for biological resources in more detail. Each description contains a list of activities in which the stressor may occur. Refer to Appendix F (Training and Testing Activities Matrices) for more information on stressors associated with each training and testing activity. Resources that may occur or are known to occur within the Study Area and that may be exposed to the identified stressors are also listed in Appendix F. Stressors for physical resources (sediment and water quality, air quality) and human resources (cultural resources, socioeconomic resources, and public health and safety) are described in their respective sections of Chapter 3 (Affected Environment and Environmental Consequences).

A preliminary analysis identified the stressor/resource interactions that warrant further analysis in the EIS/OEIS based on scoping, previous NEPA analyses, and opinions of subject matter experts. Stressor/resource interactions that were determined to have negligible or “no impacts” were not carried forward for analysis in this EIS/OEIS.

3.0.5.2.1 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 provides the basis for analysis of acoustic and explosive impacts to resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). For additional details on the properties of sound and explosives, see Section 3.0.4 in this section and Appendix I (Acoustics and Explosive Primer).

3.0.5.2.1.1 Sonar and Other Active Acoustic Sources

Sonar and other active acoustic sources (Table 3.0-8) emit sound waves into the water to detect objects, safely navigate, and communicate. Most systems operate within specific frequencies (although some harmonic frequencies may be emitted at lower sound pressure levels). Sonar use associated with anti-submarine warfare would emit the most active acoustic sound underwater during training and testing activities. Sonar use associated with mine warfare would also contribute a notable portion of overall acoustic sound. Other sources of acoustic noise include acoustic communications, sonar used in navigation, and other sound sources used in testing.

Table 3.0-8: Training and Testing Acoustic Sources Quantitatively Analyzed in the Mariana Islands Training and Testing Study Area

Source Class Category	Source Class	Annual Source Use for Training Activities (hours except as noted*)			Annual Source Use for Testing Activities (hours except as noted*)		
		No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Low-Frequency (LF) Sources that produce signals less than 1 kHz	LF4	0	0	0	0	123	123
	LF5	0	0	0	0	11	14
	LF6	0	0	0	0	40	44
Mid-Frequency (MF) Tactical and non-tactical sources that produce signals from 1 to 10 kHz	MF1	2,173	1,856	2,490	0	16	19
	MF2	140	596	820	0	29	29
	MF3	12	191	223	0	1	1
	MF4	148	144	206	0	70	77
	MF5*	1,654	1,908	2,580	0	680	758
	MF6*	0	0	0	0	33	36
	MF8	0	0	0	0	123	123
	MF9	0	0	0	0	47	62
	MF10	0	0	0	0	231	461
	MF11	0	308	446	0	16	19
	MF12	0	472	648	0	184	202

Table 3.0-8: Training and Testing Acoustic Sources Quantitatively Analyzed in the Mariana Islands Training and Testing Study Area (continued)

Source Class Category	Source Class	Annual Source Use for Training Activities (hours except as noted)			Annual Source Use for Testing Activities (hours except as noted)		
		No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
High-Frequency (HF) and Very High-Frequency (VHF) Tactical and non-tactical sources that produce signals greater than 10 kHz but less than 180 kHz	HF1	0	100	109	0	13	16
	HF4	0	716	716	0	344	378
	HF5	0	0	0	0	336	504
	HF6	280	1,036	1,036	0	137	164
Anti-Submarine Warfare (ASW) Tactical sources used during anti-submarine warfare training and testing activities	ASW1	0	0	0	0	144	162
	ASW2*	110	160	224	0	500	550
	ASW3	0	3,574	5,046	0	361	532
	ASW4*	0	11	32	0	0	0
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	TORP1*	11	11	11	0	104	142
	TORP2*	28	50	50	0	12	12
Acoustic Modems (M) Transmit data acoustically through the water	M3	0	0	0	0	112	140
Swimmer Detection Sonar (SD) Used to detect divers and submerged swimmers	SD1	0	0	0	0	2,341	2,341
Air Guns (AG) Used during swimmer defense and diver deterrent training and testing activities	AG*	0	0	0	0	308	308

* These sources are modeled in terms of number of items, not by number of hours of use.

Note: kHz = kilohertz

Underwater sound propagation is highly dependent upon 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 (Appendix I, Acoustic and Explosives Primer).

Most use of active acoustic sources involves a single unit or several units (ship, submarine, aircraft, or other platform) employing a single active sonar source in addition to sound sources used for communication, navigation, and measuring oceanographic conditions. Anti-submarine warfare activities may also use an acoustic target or an acoustic decoy.

Anti-Submarine Warfare Sonar

Sonar used in anti-submarine warfare is deployed on many platforms and are operated in various ways. Anti-submarine warfare active sonar is usually mid-frequency (1 to 10 kHz) because mid-frequency sound balances sufficient resolution to identify targets and distance within which threats can be identified.

- Ship tactical hull-mounted sonar contributes the largest portion of overall non-impulse sound. Duty cycle can vary from about a ping per minute to continuously active. Sonar can be wide-ranging in a search mode or highly directional in a track mode.
- A submarine's mission revolves around its stealth; therefore, a submarine's mid-frequency sonar is used infrequently because its use would also reveal a submarine's location.
- Aircraft-deployed, mid-frequency, anti-submarine warfare systems include omni-directional dipping sonar (deployed by helicopters) and omni-directional sonobuoys (deployed from various aircraft), which have a typical duty cycle of several pings per minute.
- Acoustic decoys that continuously emulate broadband vessel sound or other vessel acoustic signatures may be deployed by ships and submarines.
- Torpedoes use directional high-frequency sonar when approaching and locking onto a target. Practice targets emulate the sound signatures of submarines or repeat received signals.

Most anti-submarine warfare events occur more than 3 nm from shore and within areas of the Study Area designated for anti-submarine warfare activities.

Mine Warfare Sonar

Sonar used to locate mines and other small objects is typically high frequency, which provides higher resolution. Mine detection sonar is deployed at variable depths on moving platforms to sweep a suspect mined area (towed by ships, helicopters, or unmanned underwater vehicles). Mine detection sonar use would be concentrated in areas where practice mines are deployed, typically in water depths less than 200 ft. (61 m). Most events usually occur over a limited area and are completed in less than 1 day, often within a few hours.

Other Active Acoustic Sources

Active sound sources used for navigation and obtaining oceanographic information (e.g., depth, bathymetry, and speed) are typically directional, have high duty cycles, and cover a wide range of frequencies, from mid frequency to very high frequency. These sources are similar to the navigation systems on standard large commercial and oceanographic vessels. Sound sources used in communications are typically high frequency or very high frequency. These sound sources could be used by vessels during most activities and while transiting throughout the Study Area.

Use of Sonar During Training and Testing

Non-impulse sound sources are used in offshore waters, in inland waters such as bays, and while pierside. These activities include sonar maintenance, object detection/mine countermeasures, and navigation.

Most non-impulse sound stressors associated with training or testing events involve a single unit (ship, submarine, aircraft, or other platform) employing a single active sonar source in addition to sound sources used for communication, navigation, and measuring oceanographic conditions. Anti-submarine warfare activities may also use an acoustic target or an acoustic decoy. These events usually occur over a limited area and are completed in less than 1 day, often within a few hours.

3.0.5.2.1.2 Explosives

Explosive detonations during training and testing activities are associated with explosive ordnance, including bombs, missiles, and naval gun shells; torpedoes, demolition charges, and explosive sonobuoys. The numbers of explosions in each explosive source class proposed under each alternative are shown in Table 3.0-9.

Table 3.0-9: Explosives for Training and Testing Activities Quantitatively Analyzed in the Mariana Islands Training and Testing Study Area

Explosives	Training Activities (Annual In-Water Detonations)			Testing Activities (Annual In-Water Detonations)		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
E1 (0.1–0.25 lb. NEW)	0	8,100	8,100	0	2,040	2,490
E2 (>0.25–0.5 lb. NEW)	0	106	106	0	0	0
E3 (>0.5–2.5 lb. NEW)	153	380	380	0	552	624
E4 (> 2.5–5 lb. NEW)	110	156	186	0	264	286
E5 (> 5–10 lb. NEW)	562	684	950	0	0	0
E6 (> 10–20 lb. NEW)	1	60	60	0	16	18
E8 (> 60–100 lb. NEW)	8	12	12	0	4	4
E9 (> 100–250 lb. NEW)	4	4	4	0	0	0
E10 (> 250–500 lb. NEW)	0	8	8	0	4	5
E11 (> 500–650 lb. NEW)	2	2	2	0	4	4
E12 (> 650–1,000 lb. NEW)	4	184	184	0	0	0

Notes: lb. = pound, NEW = Net Explosive Weight

These detonations would occur in the air or near the water's surface. Some underwater explosives associated with torpedoes and explosive sonobuoys would occur in the water column; demolition charges could occur near the surface, in the water column, or the ocean bottom. Most detonations would occur in waters greater than 200 ft. (61 m) in depth, and greater than 3 nm from shore, although mine warfare, demolition, and some testing detonations could occur in shallow water close to shore.

Detonations associated with Anti-Submarine Warfare would typically occur in waters greater than 600 ft. (182.9 m) depth.

Explosives in the water introduce loud, impulse, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: (1) the weight of the explosive warhead, (2) the type of explosive material, and (3) the detonation depth. The net explosive weight, the explosive power of a charge expressed as the equivalent weight of TNT, accounts for the first two parameters. The properties of explosive detonations are discussed in Section 3.0.4 (Acoustic and Explosives Primer). Table 3.0-10 shows the depths at which representative explosive source classes are assumed to detonate underwater for purposes of analysis.

Table 3.0-10: Representative Ordnance, Net Explosive Weights, and Detonation Depths

Representative Ordnance	Explosive Source Class (Net Explosive Weight)	Representative Underwater Detonation Depth[1]
Medium-caliber projectiles	E1 (0.1–0.25 lb.)	1 m (3 ft.)
Medium-caliber projectiles	E2, E3 (>0.25–2.5 lb.)	1 m (3 ft.)
Improved extended echo ranging sonobuoy	E4 (> 2.5–5 lb.)	10 m (33 ft.), 20 m (66 ft.)
5 in. projectiles	E5 (> 5–10 lb.)	1 m (3 ft.)
demo block/shaped charge	E6, E7 (> 10–60 lb.)	15 m (50 ft.)
500 lb. bomb	E8, E9 (> 60–250 lb.)	1 m (3 ft.)
650 lb. mine	E10, E11 (> 250–650 lb.)	6 m (20 ft.), 10 m (33 ft.)
2,000 lb. bomb	E12 (> 650–1,000 lb.)	1 m (3 ft.)

[1] Underwater detonation depths listed are those assumed for purposes of acoustic impacts modeling. Detonations assumed to occur at a depth of 3.3 ft. (1 m) include detonations that would actually occur at or just above the water surface.
Notes: ft. = feet, in. = inches, lb. = pound, m = meters

In general, explosive events would consist of a single explosion or multiple explosions over a short period. During training, all large, explosive bombs would be detonated near the surface over deep water. Bombs with explosive ordnance would be fused to detonate on contact with the water. Other detonations would occur near but above the surface upon impact with a target; these detonations are conservatively assumed to occur at a depth of 3.3 ft. (1 m) for purposes of analysis. Detonations of projectiles during anti-air warfare would occur far above the water surface.

Since most explosive sources used in military activities are munitions that detonate essentially upon impact, the effective source depths are quite shallow and, therefore, the surface-image interference effect can be pronounced (see Appendix I, Acoustic and Explosives Primer). This effect would reduce peak pressures and potential impacts near the water surface.

3.0.5.2.1.3 Swimmer Defense Airguns

Swimmer defense airguns would be used for pierside integrated swimmer defense testing at pierside locations. Pierside integrated swimmer defense testing involves a limited number of impulses from a small airgun in Inner Apra Harbor. Airguns would be fired a limited number of times during each activity at an irregular interval as required for the testing objectives.

Underwater impulses would be generated using small (approximately 60 cubic inch) airguns, which are essentially a stainless steel tube charged with high-pressure air via a compressor. An impulse sound is generated when the air is almost instantaneously released into the surrounding water, an effect similar to popping a balloon in air. Generated impulses would have short durations, typically a few hundred milliseconds. The root-mean-squared sound pressure level and sound exposure level at a distance 1 m from the airgun would be approximately 200 to 210 dB re 1 µPa and 185 to 195 dB re 1 micropascal squared second, respectively. Swimmer defense airguns lack the strong shock wave and rapid pressure increase that would be expected from explosive detonations.

3.0.5.2.1.4 Weapons Firing, Launch, and Impact Noise

Noise associated with weapons firing and the impact of non-explosive practice munitions could happen at any location within the Study Area but generally would occur at locations greater than 12 nm from shore for safety reasons. These training and testing events would occur in the Study Area designated for anti-surface warfare and similar activities. Testing activities involving weapons firing noise would be those events involved with testing weapons and launch systems. These activities would also take place throughout the Study Area primarily in the same locations as the training events occur.

The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated by firing the gun (muzzle blast), vibration from the blast propagating through a ship's hull, and sonic booms generated by the projectile flying through the air (Table 3.0-11). Missiles and targets would produce noise during launch. In addition, the impact of non-explosive practice munitions at the water surface can introduce sound into the water. Detonations of explosive projectiles are considered in Section 3.0.4.1.5 (Categories of Sound).

Table 3.0-11: Representative Weapons Noise Characteristics

Noise Source	Sound Level
In-Water	
Naval Gunfire Muzzle Noise (5-inch/54-caliber)	Approximately 200 dB re 1 µPa directly under gun muzzle at 5 ft. (1.5 m) below the water surface[1]
Airborne	
Naval Gunfire Muzzle Noise (5-inch/54-caliber)	178 dB re 20 µPa directly below the gun muzzle above the water surface[1]
Hellfire Missile Launch from Aircraft	149 dB re 20 µPa at 15 ft. (4.5 m)[2]
7.62-millimeter M-60 Machine Gun	90 dBA re 20 µPa at 50 ft. (15 m)[3]
0.50-caliber Machine Gun	98 dBA re 20 µPa at 50 ft. (15 m)[4]

[1] Yagla and Stiegler 2003
[2] U.S Department of the Navy 2005c
[3] Investigative Science and Engineering, Inc. 1997
Notes: µPa = micropascal, dB = decibel; dBA = decibel, A-weighted; ft. = foot, m = meters, re = referenced to

Naval Gunfire Noise

Firing a ship deck gun produces a muzzle blast in air that propagates away from the muzzle in all directions, including toward the water surface. As explained in Appendix I (Acoustic and Explosives Primer), most sound enters the water in a narrow cone beneath the sound source (within 13° of vertical). In-water sound levels were measured during the muzzle blast of a 5 in. deck-mounted gun, the largest caliber gun currently used in proposed Navy activities. The highest sound level in the water (on average 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 (U.S. Department of the Navy 2000; Yagla and Stiegler 2003). The average impulse at that location was 19.6 Pascal-seconds. The corresponding average peak in-air pressure was 178 dB re 20 µPa, measured at the water surface below the firing point.

Gunfire also sends energy through the ship structure, into the water, and away from the ship. This effect was investigated in conjunction with the measurement of 5 in. gun blasts described above. The energy transmitted through the ship to the water for a typical round was about 6 percent of that from the air blast impinging on the water. Therefore, sound transmitted from the gun through the hull into the water is a minimal component of overall weapons firing noise.

The projectile shock wave in air by a shell in flight at supersonic speeds propagates in a cone (generally about 65°) behind the projectile in the direction of fire (Pater 1981). Measurements of a 5 in. projectile shock wave ranged from 140 to 147 dB re 20 µPa taken at the surface at 0.59 nm distance from the firing location and 10° off the line of fire for safety (approximately 623 ft. [190 m] from the shell's trajectory). Sound level intensity decreases with increased distance from the firing location and increased angle from the line of fire (Pater 1981). Like sound from the gun firing blast, sound waves from a projectile in flight would enter the water primarily in a narrow cone beneath the sound source. The region of underwater sound influence from a single traveling shell would be relatively narrow, the duration of sound influence would be brief at any point, and sound level would diminish as the shell gains altitude and loses speed. Multiple, rapid gun firings would occur from a single firing point toward a target area. Vessels participating in gunfire activities would maintain enough forward motion to maintain steerage, normally at speeds of a few knots. Acoustic impacts from weapons firing would often be concentrated in space and duration.

Launch Noise

Missiles can be rocket or jet propelled. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket. It rapidly fades as the missile or target reaches optimal thrust conditions and the missile or target reaches a downrange distance where the booster burns out and the sustainer engine continues. Launch noise level for the Hellfire missile, which is launched from aircraft, is about 149 dB re 20 µPa at 14.8 ft. (4.5 m) (U.S. Department of the Navy 2005c).

Non-Explosive Munitions Impact Noise

Large-caliber non-explosive projectiles, non-explosive bombs, and intact missiles and targets could produce a large impulse upon impact with the water surface (McLennan 1997). Sounds of this type are produced by the kinetic energy transfer of the object with the target surface and are highly localized to the area of disturbance. Sound associated with impact events is typically of low frequency (less than 250 Hz) and of short duration.

3.0.5.2.1.5 Vessel Noise

Vessels (including ships, small craft, and submarines) would produce low-frequency, broadband underwater sound. Overall, military vessel traffic is often a minor component of total vessel traffic (Mintz and Filadelfo 2011; Mintz and Parker 2006). Commercial vessel traffic, which included cargo vessels, bulk carriers, passenger vessels, and oil tankers (all over 65 ft. [20 m] in length), was heaviest near and between the major shipping ports.

Radiated noise from military ships ranges over several orders of magnitude. The quietest warships radiate much less broadband noise than a typical fishing vessel, while the loudest ships are almost on par with large oil tankers (Mintz and Filadelfo 2011). For comparison, a typical commercial cargo vessel radiates broadband noise at a source level around 172 dB re 1 µPa and a typical fishing vessel radiates noise at a source level of about 158 dB re 1 µPa (Richardson et al. 1995; Urick 1983). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below about 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies (approximately the one-third octave band centered at 100 Hz) (Richardson et al. 1995; Urick 1983).

The acoustic signatures of naval vessels are classified information. Anti-submarine warfare platforms (such as Guided Missile Destroyers) and submarines make up a large part of Navy traffic but contribute little noise to the overall sound budget of the oceans as these vessels are designed to be quiet to minimize detection. These platforms are much quieter than Navy oil tankers, for example, which have a smaller presence but contribute substantially more broadband noise than anti-submarine warfare platforms (Mintz and Filadelfo 2011). Sound produced by vessels will typically increase with speed. During training, speeds of most larger naval vessels generally range from 10 to 15 knots; however, ships will, on occasion, operate at higher speeds within their specific operational capabilities.

A variety of smaller craft, such as service vessels for routine operations and opposition forces used during training events, would be operating within the Study Area. These small craft types, sizes, and speeds vary, but in general, they will emit higher-frequency noise than larger ships.

While commercial traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Navy traffic is episodic in the ocean. Vessels engaged in training and testing may consist of a single vessel involved in unit-level activity for a few hours or multiple vessels involved in a major training exercise that could last a few days within a given area. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours to up to 2 weeks. Navy vessels do contribute to the overall increased ambient noise in inland waters near Navy ports, although their contribution to the overall noise in these environments is minimal because these areas typically have large amounts of commercial and recreational vessel traffic.

In an attempt to determine traffic patterns for Navy and non-Navy vessels, the Center for Naval Analysis (Mintz and Parker 2006) conducted a review of historic data for commercial vessels, coastal shipping patterns, and Navy vessels along the east and west coasts. Commercial and non-Navy traffic, which included cargo vessels, bulk carriers, passenger vessels and oil tankers (all over 65 ft. [20 m] in length), was heaviest along the U.S. west coast between San Diego and Seattle (Puget Sound) and between the Hawaiian Islands (Mintz and Parker 2006). Well-defined international shipping lanes are also heavily traveled. Compared to coastal vessel activity, there was relatively little concentration of vessels in the other portions of the Study Area (Mintz and Parker 2006).

3.0.5.2.1.6 Aircraft Overflight Noise

Fixed- 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. Aircraft used in training and testing generally have reciprocating, 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. Takeoffs and landings occur at established airfields as well as on vessels at sea throughout the Study Area. Most aircraft noise would be produced around air stations in the range complexes. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Source levels for some typical aircraft used during training and testing in the Study Area are shown in Table 3.0-12.

<u>Fixed-Wing Aircraft</u>

Noise generated by fixed-wing aircraft is transient in nature and extremely variable in intensity. Most fixed-wing aircraft sorties would occur above 3,000 ft. (900 m). Air combat maneuver altitudes generally range from 5,000 to 30,000 ft. (1.5 to 9.1 km) and typical airspeeds range from very low (less than 100 knots) to high subsonic (less than 600 knots). Sound exposure levels at the sea surface and at FDM from most air combat maneuver overflights are expected to be less than 85 dBA (based on an FA-18 aircraft flying at an altitude of 5,000 ft. [1,500 m] and at a subsonic airspeed [400 knots]) (U.S. Department of the Navy 2009). Exposure to fixed-wing aircraft noise would be brief (seconds) as an aircraft quickly passes overhead.

Helicopters

Noise generated from helicopters is transient in nature and extremely variable in intensity. In general, helicopters produce lower-frequency sounds and vibration at a higher intensity than fixed-wing aircraft (Richardson et al. 1995). Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz. Helicopters often radiate more sound forward than backward. The underwater noise produced is generally brief when compared with the duration of audibility in the air.

Helicopter unit level training typically entails a high volume of single-aircraft sorties over water that start and end at an air station, although flights may occur from ships at sea. Individual flights typically last about 2 to 4 hours. Some events require low-altitude flights over a defined area, such as mine countermeasure activities deploying towed systems. Most helicopter sorties associated with mine countermeasures would occur at altitudes as low as 75 to 100 ft. (23 to 31 m). Likewise, in some anti-submarine warfare events, dipping sonar is deployed from a line suspended from a helicopter hovering at low altitudes over the water.

Underwater Transmission of Aircraft Noise

Sound generated in air is transmitted to water primarily in a narrow area directly below the aircraft. A sound wave propagating from an aircraft must enter the water at an angle of incidence of 13° or less from the vertical for the wave to continue propagating under the water's surface. At greater angles of incidence, the water surface acts as an effective reflector of the sound wave and allows very little penetration of the wave below the water (Urick 1983). Water depth and bottom conditions strongly influence propagation and levels of underwater noise from passing aircraft. For low-altitude flights, sound levels reaching the water surface would be higher, but the transmission area would be smaller. As an aircraft gains altitude, sound reaching the water surface will diminishes, but the possible transmission area increases. Estimates of underwater sound pressure level are provided for representative aircraft in Table 3.0-12.

Underwater sound from aircraft overflights has been modeled for some airframes. Eller and Cavanagh (2000) modeled underwater sound pressure level as a function of time at various depths (2, 10, and 50 m) for F/A-18 Hornet aircraft subsonic overflights (250 knots) at various altitudes (300, 1,000, and 3,000 m). For the worst modeled case of an F/A-18 at the lowest altitude (300 m), the sound level at 2 m below the surface peaked at 152 dB re 1 µPa, and the sound level at 50 m below the surface peaked at 148 dB re 1 µPa. When F/A-18 flight was modeled at 3,000 m altitude, peak sound level at 2 m depth dropped to 128 dB re 1 µPa.

Table 3.0-12: Representative Aircraft Sound Characteristics

Noise Source	Sound Level
In-Water	
F/A-18 Subsonic at 1,000 ft. (300 m) Altitude	148 dB re 1 µPa at 6 ft. (2 m) below water surface
F/A-18 Subsonic at 10,000 ft. (3,000 m) Altitude	128 dB re 1 µPa at 6 ft. (2 m) below water surface
H-60 Helicopter Hovering at 50 ft. (15 m) Altitude	Approximately 125 dB re 1 µPa at 3 ft. (1 m) below water surface
Airborne	
Jet Aircraft under Military Power	144 dBA re 20 µPa at 50 ft. (15 m) from source
Jet Aircraft under Afterburner	148 dBA re 20 µPa at 50 ft. (15 m) from source
H-60 Helicopter Hovering	90 dBA re 20 µPa at 50 ft. (15 m) from source

Notes: µPa = micropascal; dB = decibel; dBA = decibel, A-weighted; ft. = foot; m = meter; re = referenced to

Sonic Booms

An intense but infrequent type of aircraft noise is the sonic boom, produced when an aircraft exceeds the speed of sound. Supersonic aircraft flights are usually limited to altitudes above 30,000 ft. (9,100 m) or locations more than 30 nm from shore. Several factors influence sonic booms: weight, size, 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 and louder than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the stronger the shock waves (U.S. Department of the Navy 2007).

Of all the factors influencing sonic booms, increasing altitude is the most effective method of reducing sonic boom intensity. The width of the boom "carpet" or area exposed to sonic boom beneath an aircraft is about 1 mi. (1.6 km) for each 1,000 ft. (300 m) of altitude. For example, an aircraft flying supersonic straight and level at 50,000 ft. (15,000 m) can produce a sonic boom carpet about 50 mi. (80 km) 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 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 2007).

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 (Laney and Cavanagh 2000). The results show that sound pressure level and energy attenuate rapidly with water depth or distance from the source (Table 3.0-13). Laney and Cavanagh (2000) conclude that even under ideal conditions for the transfer of sound energy from air to water (i.e., a rough surface), the strongest sonic booms would be highly unlikely to generate sound pressure levels that would affect marine mammals.

Table 3.0-13: Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight

Mach Number[1]	Aircraft Altitude (km)	Peak Pressure (dB re 1 μPa)			Energy Flux Density (dB re 1 μPa^2-s)		
		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] Mach number equals aircraft speed divided by the speed of sound
Notes: km = kilometer, m = meter, μPa = micropascal, μPa^2-s = micropascal squared second, re = referenced to

3.0.5.2.2 Energy Stressors

This section describes the characteristics of energy introduced into the water through naval training and testing and the relative magnitude and location of these activities to provide the basis for analysis of potential electromagnetic and laser impacts to resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences).

3.0.5.2.2.1 Electromagnetic Devices

Electromagnetic energy emitted from magnetic influence mine neutralization systems is analyzed in this document. The training and testing activities that involve the use of magnetic influence mine neutralization systems are detailed in Appendix A (Training and Testing Activities Descriptions). There are no in-water electromagnetic energy training or testing events conducted under the No Action Alternative. Under Alternative 1 and 2, there are five in-water electromagnetic energy events.

The majority of devices involved in these activities include towed or unmanned mine warfare systems that simply mimic the electromagnetic signature of a vessel passing through the water. None of the devices include any type of electromagnetic “pulse.” An example of a representative device is the Organic Airborne and Surface Influence Sweep mine neutralization system that is towed behind a MH-60S helicopter (or surface vessel) and works by emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The sound and electromagnetic signature cause nearby mines to detonate.

Generally, voltage used to power these systems is around 30 volts relative to seawater. This amount of voltage is comparable to two automobile batteries. Since saltwater is an excellent conductor, only very moderate voltages of 35 volts (capped at 55 volts) are required to generate the current. These small levels represent no danger of electrocution in the marine environment, because the difference in electric charge is very low in saltwater.

The static magnetic field generated by the electromagnetic devices is of relatively minute strength. Typically, the maximum magnetic field generated would be approximately 0.0023 Tesla (T) at the source and would decrease with distance from the source. The strength of this magnetic field is comparable to magnetic fields generated by many common household items. The magnetic field near a small refrigerator magnet, for example, is approximately 0.01 T; and the magnetic field 1 ft. from a standard household can opener is approximately 0.00015 T (Halliday and Resnick 1988; U.S. Environmental Protection Agency 1992).

The strength of all magnetic fields decreases rapidly as distance from the source increases. At a distance of 13 ft. (4 m), the magnetic field generated by the electromagnetic devices proposed for use are comparable to the earth's magnetic field, which is approximately 0.0001 T at the earth's surface (Halliday and Resnick 1988). The strength of the magnetic field at approximately 26 ft. (8 m) from the device is 40 percent of the strength of earth's magnetic field, and at 79 ft. (24 m) from the device is only 10 percent of the earth's magnetic field. At a distance of 660 ft. (200 m), the magnetic field would be approximately 0.0000002 T (or 2×10^{-7} T), which is 500 times less than the strength of the earth's magnetic field (U.S. Department of the Navy 2005b).

3.0.5.2.2.2 Kinetic Energy Weapon

The kinetic energy weapon (commonly referred to as the rail gun) is under development by the Navy and will be tested and eventually used in training events aboard surface vessels, firing non-explosive projectiles at sea-based targets. The system uses stored electrical energy to accelerate the projectiles, which are fired at supersonic speeds over great distances. The system charges for 2 minutes and fires in less than a second; therefore, any electromagnetic energy released would be done so over a very short period. Also, the system would likely be shielded so as not to affect shipboard controls and systems. The amount of electromagnetic energy released from this system would likely be low and contained on the surface vessel. Therefore, this device is not expected to result in any impacts and will not be further analyzed for biological resources in this document.

3.0.5.2.2.3 Lasers

Laser devices can be organized into two categories: (1) low energy lasers and (2) high energy lasers. Low energy lasers are used to illuminate or designate targets, to guide weapons, and to detect or classify mines. High energy lasers are used as weapons to disable surface targets. No high energy lasers would be used in the Study Area as part of the Proposed Action training and testing activities, and are not discussed further.

Low Energy Lasers

Within the category of low energy lasers, the highest potential level of exposure would be from an airborne laser beam directed at the ocean's surface. An assessment on the use of low energy lasers by the Navy determined that low energy lasers, including those involved in the training and testing activities in this EIS/OEIS, have an extremely low potential to impact marine biological resources (Swope 2010). The assessment determined that the maximum potential for laser exposure is at the ocean's surface, where laser intensity is greatest (Swope 2010). As the laser penetrates the water, 96 percent of a laser beam is absorbed, scattered, or otherwise lost (Ulrich 2004). Based on the parameters of the low energy lasers and the behavior and life history of major biological groups, it was determined the greatest potential for impact would be to the eye of a marine mammal or sea turtle. However, an animal's eye would have to be exposed to a direct laser beam for at least 10 seconds or longer to sustain damage. Swope (2010) assessed the potential for damage based on species specific eye/vision parameters and the anticipated output from low energy lasers and determined that no animals were predicted to incur damage. Therefore, low energy lasers are not analyzed further in this document as a stressor to biological resources.

3.0.5.2.3 Physical Disturbance and Strike Stressors

This section describes the characteristics of physical disturbance and strike stressors from Navy training and testing activities. It also describes the relative magnitude of these activities to provide the basis for analyzing the potential physical disturbance and strike impacts to resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences).

3.0.5.2.3.1 Aircraft and Aerial Targets

Aircraft involved in Navy training and testing activities are separated into three categories: (1) fixed-wing aircraft, (2) rotary-wing aircraft, and (3) unmanned aerial systems. Fixed-wing aircraft include, but are not limited to, aircraft such as F-35, P-8, F/A-18, and E/A-18G. Rotary-wing aircraft are generally helicopters such as the MH-60. Unmanned aerial systems include a variety of platforms, including but not limited to the Small Tactical Unmanned Aircraft System—Tier II, Broad Area Maritime Surveillance unmanned aircraft, Fire Scout Vertical Take-off and Landing Unmanned Aerial Vehicle, and the Unmanned Combat Air System. Aircraft strikes are only applicable to birds.

Appendices A (Training and Testing Activities Description) and F (Training and Testing Activities Matrices) list the training and testing activities that include the use of various types of aircraft.

The number of events including aircraft movement is summarized in Table 3.0-14.

Table 3.0-14: Annual Number of Events Including Aircraft Movement

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Total Study Area	6,860	22,432	24,575	0	320	362

3.0.5.2.3.2 Vessels

Vessels used as part of the Proposed Action include ships (e.g., aircraft carriers, surface combatants), support craft, and submarines, ranging in size from 5 to over 300 m. Table 3.0-15 provides examples of the types of vessels, length, and speeds used in both testing and training activities. The U.S. Navy Fact Files on the World Wide Web provide the latest information on the quantity and specifications of the vessels operated by the Navy.

Table 3.0-15: Representative Vessel Types, Lengths, and Speeds

Type	Example(s)	Length (m)	Typical Operating Speed (knots)	Max Speed (knots)
Aircraft Carrier	Aircraft Carrier	> 300	10–15	30+
Surface Combatant	Cruisers, Cutters, Destroyers, Frigates, Littoral Combat Ships	100–200	10–15	30+
Support Craft/Other	Amphibious Assault Vehicle; Combat Rubber Raiding Craft; Landing Craft, Mechanized; Landing Craft, Utility; Submarine Tenders; Yard Patrol Craft; Barge	545	Variable	20
Support Craft/Other – Specialized High Speed	High Speed Ferry/Catamaran, Patrol Coastal Ships, Rigid Hull Inflatable Boat, Joint High Speed Vessel	20–110	Variable	50+
Submarines	Fleet Ballistic Missile Submarines, Attack Submarines, Guided Missile Submarines	100–200	8–13	20+

Note: m = meters

Large Navy ships generally operate at speeds in the range of 10 to 15 knots, and submarines generally operate at speeds in the range of 8 to 13 knots. Small craft (for purposes of this discussion, less than

40 ft. [12 m] in length), which are all support craft, have much more variable speeds (dependent on the mission). While these speeds are representative of most events, some vessels need to operate outside of these parameters. For example, to produce the required relative wind speed over the flight deck, an aircraft carrier vessel group engaged in flight operations must adjust its speed through the water accordingly. Conversely, there are other instances such as launch and recovery of a small rigid hull inflatable boat, vessel boarding, search, and seizure training events or retrieval of a target when vessels would be dead in the water or moving slowly ahead to maintain steerage. There are a few specific events including high speed tests of newly constructed vessels such as aircraft carriers, amphibious assault ships and the joint high speed vessel (which will operate at an average speed of 35 knots) where vessels would operate at higher speeds.

The number of military vessels in the Study Area at any given time varies and is dependent on local training or testing requirements. Most activities include either one or two vessels and may last from a few hours up to 2 weeks. Vessel movement 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, range complexes and testing ranges.

The locations and number of hours of military vessel usage for training and testing activities are dependent upon the locations of Navy ports, piers, and established at-sea training and testing areas. These areas have not appreciably changed in the last decade and are not expected to change in the foreseeable future.

The distribution of vessels, actual locations, and hours of Navy vessel usage are also dependent upon training and testing requirements, deployment schedules, annual budgets, and other factors with a high degree of unpredictability. Consequently, vessel use can be highly variable. The difference between the No Action Alternative and Alternatives 1 and 2 includes an expansion of the Study Area and an increase in the number of activities. Because multiple activities usually occur from the same vessel, the increased activities would not necessarily result in an increase in vessel use or transit. The concentration of use and the manner in which the military uses vessels to accomplish its testing and training activities is likely to remain consistent with the range of variability observed over the last decade. Consequently, the Navy is not proposing appreciable changes in the levels, frequency, or locations where vessels have been used over the last decade.

3.0.5.2.3.3 In-Water Devices

In-water devices as discussed in this analysis are unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles and unmanned undersea vehicles and towed devices. These devices are self-propelled and unmanned or towed through the water from a variety of platforms including helicopters and surface ships. In-water devices are generally smaller than most Navy vessels ranging from several inches to about 15 m. See Table 3.0-16 for a range of in-water devices used.

These devices can operate anywhere from the water surface to the benthic zone. Certain devices do not have a realistic potential to strike living marine resources because they either move slowly through the water column (e.g., most unmanned undersurface vehicles) or are closely monitored by observers manning the towing platform (e.g., most towed devices). Because of their size and potential operating speed, in-water devices that operate in a manner with the potential to strike living marine resources are the Unmanned Surface Vehicles.

Training and testing activities that employ towed in-water devices are listed in Table 3.0-17. Appendix A (Training and Testing Activities Descriptions) also lists training and testing activities that involve the use of unmanned surface or underwater vehicles.

Table 3.0-16: Representative Types, Sizes, and Speeds of In-Water Devices

Type	Example(s)	Length (m)	Typical Operating Speed (knots)
Towed Device	AQS Systems; Towed SONAR System; OASIS, Orion, Shallow Water Intermediate Search System, Towed Pinger Locator 30	< 10	10–40
Unmanned Surface Vehicle	Seaborne Powered Target, Ship Deployable Seaborne Target (SDST), Small Waterplane Area Twin Hull (SWATH), Unmanned Influence Sweep System (UISS)	< 15	Variable, up to 50+
Unmanned Undersea Vehicle	Light and Heavy Weight Torpedoes, Magnum ROV, Manned Portables, MINIROVs, MK 30 ASW Targets, RMMV, Remote Minehunting System (RMS), Unmanned Influence Sweep	< 15	1–15

Notes: AQS = Air Quality System, ASW = Anti-Submarine Warfare, EMATT = Expendable Mobile ASW Training Target, OASIS = Organic Airborne and Surface Influence Sweep, RMS = Remote Minehunting System, RMMV = Remote Multi-Mission Vehicle, ROV = Remotely Operated Vehicle, SDST = Ship Deployable Seaborne Target, SONAR = Sound Navigation and Ranging, SWATH =Small Waterplane Area Twin Hull, UISS = Unmanned Influence Sweep System

Table 3.0-17: Annual Number of Events Including Towed In-Water Devices

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Total Study Area	174	1,175	1,185	1	66	73

3.0.5.2.3.4 Military Expended Materials

Military expended materials include: (1) all sizes of non-explosive practice munitions; (2) fragments from explosive munitions; and (3) expended materials other than ordnance, such as sonobuoys, ship hulks, and expendable targets.

While disturbance or strike from any material as it falls through the water column is possible, it is not likely because the objects will slow in velocity as it sinks toward the bottom and can be avoided by highly mobile organisms. For living marine resources in the water column, the discussion of military expended material strikes focuses on the potential of a strike at the surface of the water. The effect of materials settling on the bottom will be discussed in the appropriate resource sections as an alteration of the bottom substrate and associated organisms (i.e., invertebrates and vegetation).

Training and testing activities with military expended material that can potentially impact marine resources and involve the use of non-explosive practice munitions (small-, medium-, and large-caliber missiles, rockets, bombs, torpedoes, and neutralizers), fragments from explosives, and materials other than munitions (flares, chaff, sonobuoys, parachutes, aircraft stores and ballast, and targets) are detailed in Tables 3.0-18 through 3.0-20 and Appendices A (Training and Testing Activities Descriptions) and F (Training and Testing Activities Matrices).

Table 3.0-18: Annual Number of Non-Explosive Practice Munitions Expended At Sea in the Study Area

Non-Explosive Ordnance	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Mine Neutralization System Neutralizers	0	0	0	0	24	28
Torpedoes[1]	51	61	61	0	108	146
Bombs	522	848	848	0	0	0
Rockets	0	0	0	0	0	0
Missiles	0	0	0	0	20	27
Large-Caliber Projectiles	0	5,238	5,238	0	1,680	2,100
Medium-Caliber Projectiles	26,500	85,500	87,750	0	2,040	2,490
Small-Caliber Projectiles	60,000	86,140	86,140	0	2,000	2,500
Sonobuoys	8,065	10,980	10,980	0	932	1,025

[1] Exercise torpedoes are recovered for reuse following completion of the training or testing activity.

Table 3.0-19: Annual Number of Explosive Ordnance Used in the Study Area Resulting in Expended Fragments

Explosive Ordnance	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Mine Neutralization System Neutralizers	0	4	4	0	24	28
Torpedoes	2	2	2	0	8	8
Bombs	32	212	212	0	0	0
Rockets	0	114	380	0	0	0
Missiles	58	125	137	0	20	25
Large-Caliber Projectiles	1,240	1,300	1,300	0	10,920	12,100
Medium-Caliber Projectiles	0	8,150	8,150	0	2,040	2,490
Sonobuoys	8	11	11	0	793	884

Table 3.0-20: Annual Number of Targets Expended in the Study Area

Target	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
All Targets	159	426	447	0	360	401

3.0.5.2.3.5 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, bottom placed instruments, and robotic vehicles referred to as "crawlers." 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).

Appendix A (Training and Testing Activities Descriptions) lists the training and testing activities that include the deployment of sea-floor devices. The number of events including seafloor devices is summarized in Table 3.0-21.

Table 3.0-21: Annual Number of Events Including Seafloor Devices

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Total Study Area	44	136	136	1	64	68

3.0.5.2.3.6 Ground Disturbance and Wildfires

The potential for animals on FDM to be exposed to explosions depends on several factors, including the presence of animals near the detonation, location of the detonation, size of the explosive, and distance from the detonation. Detonations create blast waves and acoustic waves in air and are also transmitted through the ground. Some of the sound could be attenuated by surrounding vegetation. 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). Appendix A (Training and Testing Activities Descriptions) lists the training and testing activities that use ordnance on FDM. The number of ordnance use on FDM is summarized in Table 3.0-22.

Table 3.0-22: Annual Number of Ordnance Used on Farallon de Medinilla by Alternative

Ordnance Use	No Action Alternative	Alternative 1	Alternative 2
Small-caliber Rounds	2,900	42,000	42,000
NEPM Bombs ≤ 2,000 lb.	2,800	2,670	2,922
Explosive Bombs ≤ 2,000 lb.	2,150 [500 (≤ 500 lb.) 1,650 (500–2,000 lb.)]	6,242	6,821
Explosive Missiles and Rockets ≤ 5"	60 explosive	85 missiles; 2,000 rockets	85 missiles; 2,000 rockets
Explosive Grenades and Mortars	100	600	600
Medium-caliber Projectiles	21,500 explosive	17,350 explosive; 94,150 NEPM	17,350 explosive; 94,150 NEPM
Large-caliber Projectiles	1,000 explosive	1,200 explosive; 1,800 NEPM	1,200 explosive; 1,800 NEPM

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

Ground disturbance can result from pedestrian activities and vehicles, which may occur in all areas where the military conducts training activities. The most severe ground disturbance activities, however, occur on FDM with the use of explosives (on FDM). Sources of habitat fragmentation, degradation, and loss on FDM include wildland fires and introduction of invasive predators and pests. Habitat fragmentation on FDM is evidenced by changes in habitat configuration with the remaining habitat occurring in patches among areas of non-habitat. Degradation and loss of habitats on FDM has been caused by fires, altering successional state, composition, and structure of vegetation communities on the island. When vegetation is affected by activities, edges (a type of habitat fragmentation) are created. Edges form the boundary of a habitat and have differing properties than the habitat itself. For example, edges often have different microclimate patterns which are more xeric, warmer, and less shaded than forest interiors. In addition, edges may also facilitate further fire encroachment by serving as a “ladder” to spread ground fires into higher canopy levels.

The only location within the Study Area where by training activities associated with the Proposed Action could result in a wildland fire is at FDM. Section 3.10 (Terrestrial Species and Habitats) provides an assessment of wildfire potential associated with training activities at FDM, and how wildfires could impact species and habitats. Fire season should be considered year-round at FDM; however, fuel loading (the amount of flammable vegetation) and ignition potential would increase during the dry season (February through April) and decrease in the wet season (July through October). Wildland fires can set back succession within vegetation communities and facilitate establishment of fire-tolerant species, which may alter the composition and structure of vegetation communities. Fires may cause direct mortality of birds and nests in vegetated areas with fuel loadings sufficient to carry fire, and indirect mortality through exposure to smoke or displacement of nest predators into nesting habitats. Fire can indirectly affect wildlife at FDM by changing the physical and biological characteristics of the area, which subsequently degrades habitats and reduces the forage base.

3.0.5.2.4 Entanglement Stressors

This section describes the entanglement stressors introduced into the water through naval training and testing and the relative magnitude and location of these activities to provide the basis for analysis of potential impacts to resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). To assess the entanglement risk of materials expended during training and testing, the Navy examined the characteristics of these items (such as size and rigidity) for their potential to entangle marine animals. For a constituent of military expended materials to entangle a marine animal, it must be long enough to wrap around the appendages of marine animals. Another critical factor is rigidity; the item must be flexible enough to wrap around appendages or bodies. This analysis includes the potential impacts from two types of military expended materials including: (1) fiber optic cables and guidance wires, and (2) parachutes (or decelerators).

Unlike typical fishing nets and lines, the Navy's equipment is not designed for trapping or entanglement purposes. The Navy deploys equipment designed for military purposes and strives to reduce the risk of accidental entanglement posed by any item it releases into the sea.

3.0.5.2.4.1 Fiber Optic Cables and Guidance Wires

Fiber Optic Cables

The only type of cable expended during military training and testing are fiber optic cables. Fiber optic cables are flexible, durable, and abrasion or chemical-resistant and the physical characteristics of the fiber optic material render the cable brittle and easily broken when kinked, twisted, or bent sharply (i.e., to a radius greater than 360 degrees). The cables are often designed with controlled buoyancy to minimize the cable's effect on vehicle movement. The fiber optic cable would be suspended within the water column during the activity, and then be expended to sink to the sea floor.

Appendix A (Training and Testing Activities Descriptions) lists the training and testing activities that include the use of fiber optic cables. The estimated number of events including expended fiber optic cables is detailed below in Table 3.0-23.

Table 3.0-23: Annual Number of Expended Fiber Optic Cable

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Total Study Area	0	16	16	0	128	144

Guidance Wires

The only types of wires expended during military training and testing activities are guidance wires from heavy-weight torpedoes and tube-launched, optically tracked, wire guided missiles. Guidance wires are used to help the firing platform control and steer the torpedo or missile. They trail behind the torpedo or missile as it moves through the water or air. Finally, the guidance wire is released from both the firing platform and the torpedo or tube-launched, optically tracked, wire guided missile and sinks to the ocean floor.

The torpedo guidance wire is a single-strand, thin gauge, coated copper alloy. The tensile breaking strength of the wire is a maximum of 42 pounds (lb.) (19 kilograms [kg]) and can be broken by hand (Environmental Sciences Group 2005), contrasting with the rope or lines associated with commercial fishing towed gear (trawls), stationary gear (traps), or entanglement gear (gillnets) that utilize lines with substantially higher (up to 500–2,000 lb. [227–907 kg]) breaking strength as their "weak links" to minimize entanglement of marine animals (National Marine Fisheries Service 2008). The physical characteristics of the wire prevent it from tangling, unlike the monofilament fishing lines and polypropylene ropes identified in the literature (U.S. Department of the Navy 1996). Torpedo guidance wire sinks at an estimated rate of 0.7 ft. (0.2 m) per second.

The tube-launched, optically tracked, wire guided missile system has two thin (5.75 millimeters [mm] or 0.146 mm diameter) wires. Two wire dispensers containing several thousand meters each of single-strand wire with a minimum tensile strength of 10 lb. are mounted on the rear of the missile. The length of wire dispensed would generally be equal to the distance the missile travels to impact the target and any undispensed wire would be contained in the dispensers upon impact. While degradation rates for the wire may vary because of changing environmental conditions in seawater, assuming a sequential failure or degradation of the enamel coating (degradation time is about 2 months), the copper plating (degradation time is about 1.5 to 25 months), and the carbon-steel core (degradation time is about 8 to 18 months), degradation of the tube-launched, optically tracked, wire guided missile guide wire would take 12 to 45 months. Appendix A (Training and Testing Activities Descriptions) lists the training and testing activities that include the use of guidance wires.

The overall number of events per year that expend guidance wire is detailed below in Table 3.0-24.

Table 3.0-24: Annual Number of Expended Guidance Wire

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Total Study Area	40	40	40	0	20	20

3.0.5.2.4.2 Decelerators/Parachutes

Aircraft-launched sonobuoys, lightweight torpedoes (such as the MK 46 and MK 54), illumination flares, and targets use nylon parachutes or decelerators ranging in size from 18 to 48 in. (46 to 122 cm) in diameter. Decelerators are made of cloth and nylon, and many have weights attached to the lines for rapid sinking. At water impact, the decelerator assembly is expended, and it sinks away from the unit. The decelerator assembly may remain at the surface for 5 to 15 seconds before the decelerator and its housing sink to the seafloor, where it becomes flattened (Environmental Sciences Group 2005). Some decelerators are weighted with metal clips that facilitate their descent to the seafloor. Once settled on the bottom the canopy may temporarily billow if bottom currents are present. Training and testing activities that expend decelerators or parachutes are listed in Appendix F (Training and Testing Activities Matrices).

The estimated number of decelerators that would be expended is detailed below in Table 3.0-25.

Table 3.0-25: Annual Number of Expended Decelerators/Parachutes

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Total Study Area	8,032	10,845	10,845	0	1,727	1,912

3.0.5.2.5 Ingestion Stressors

This section describes the ingestion stressors introduced into the water through naval training and testing and the relative magnitude and location of these activities to provide the basis for analysis of potential impacts to resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). To assess the ingestion risk of materials expended during training and testing, the Navy examined the characteristics of these items (such as buoyancy and size) for their potential to be ingested by marine animals in the Study Area. The Navy expends the following types of materials that could become ingestion stressors during training and testing in the Study Area: non-explosive practice munitions (small- and medium-caliber), fragments from explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and parachutes. Other military expended materials such as targets, large-caliber projectiles, intact training and testing bombs, guidance wires, 55 gallon drums, sonobuoy tubes, and marine markers are too large for marine organisms to consume and are eliminated from further discussion.

Solid metal materials, such as small-caliber projectiles, or fragments from explosive munitions, sink rapidly to the seafloor. Lighter items may be caught in currents and gyres and could remain in the water column for hours to weeks or indefinitely before sinking (e.g., plastic end caps or pistons).

3.0.5.2.5.1 Non-Explosive Practice Munitions

Only small- or medium-caliber projectiles would be small enough for marine animals to ingest. This would vary depending on the resource and will be discussed in more detail within each resource section. Small- and medium-caliber projectiles include all sizes up to and including those that are 2.25 in. (57 mm) in diameter. These solid metal materials would quickly move through the water column and settle to the sea floor.

The training and testing activities that involve the use of small- and medium-caliber non-explosive practice munitions are listed in Appendix A (Training and Testing Activities Descriptions).

3.0.5.2.5.2 Fragments from Explosive Munitions

Many different types of explosive munitions can result in fragments that are expended at sea during training and testing activities. Types of explosive munitions that can result in fragments include demolition charges, grenades, projectiles, missiles, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the net explosive weight and munition type; however, typical sizes of fragments are unknown. These solid metal materials would quickly sink through the water column and settle to the seafloor.

3.0.5.2.5.3 Military Expended Materials Other Than Munitions

Several different types of materials other than munitions are expended at sea during training and testing activities.

<u>Target-Related Materials</u>

At-sea targets are usually remotely-operated airborne, surface, or subsurface traveling units, most of which, but not all, that are designed to be recovered for re-use. However, if they are used during activities that utilize explosives then they may result in fragments. Expendable targets that may result in fragments would include air-launched decoys, surface targets (such as marine markers, paraflares, cardboard boxes, and 10 ft. (3.05 m) diameter red balloons), and mine shapes. Most target fragments would sink quickly to the seafloor. Floating material, such as Styrofoam, may be lost from target boats and remain at the surface for some time (see Section 2.3.3, Targets, for additional information on targets). Only targets that may result in smaller fragments are included in the analyses of ingestion potential.

The training and testing activities that may expend targets are listed in Appendix F (Training and Testing Activities Matrices). The number and location per year of targets used during training and testing activities with the potential to result in small fragments are also detailed in Appendix F.

Chaff

Chaff consists of reflective, aluminum-coated glass fibers used to obscure ships and aircraft from radar-guided systems. Chaff, which is stored in canisters, is either dispensed from aircraft or fired into the air from the decks of surface ships when an attack is imminent. The glass fibers create a radar cloud that mask the position of the ship or aircraft. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (U.S. Air Force 1997). Chaff is released or dispensed in cartridges or projectiles that contain millions of fibers. When deployed, a diffuse cloud of fibers is formed that is undetectable to the human eye. Chaff is a very light material, similar to fine human hair. It can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (U.S. Air Force 1997; Arfsten 2002). Doppler radar has tracked chaff plumes containing approximately 900 grams of chaff drifting 200 mi. (322 km) from the point of release, with the plume covering greater than 400 cubic miles (1,667 cubic kilometers) (Arfsten 2002).

The chaff concentrations that marine animals could be exposed to following release of multiple cartridges (e.g., following a single day of training) is difficult to accurately estimate because it depends on several variable factors. First, specific release points are not recorded and tend to be random, and chaff dispersion in air depends on prevailing atmospheric conditions. After falling from the air, chaff fibers would be expected to float on the sea surface for some period, depending on wave and wind action. The fibers would be dispersed farther by sea currents as they float and slowly sink toward the bottom. Chaff concentrations in benthic habitats following the release of a single cartridge would be lower than the values noted in this section, based on dispersion by currents and the dilution capacity of the ocean.

Several literature reviews and controlled experiments indicate that chaff poses little risk to organisms, except at concentrations substantially higher than those that could reasonably occur from military training (U.S. Air Force 1997; Hullar et al. 1999; Arfsten 2002). Nonetheless, some marine animal species within the Study Area could be exposed to chaff through direct body contact, inhalation, and ingestion. Chemical alteration of water and sediment from decomposing chaff fibers is not expected to occur. Based on the dispersion characteristics of chaff, it is likely that marine animals would occasionally come in direct contact with chaff fibers while either at the water's surface or while submerged, but such contact would be inconsequential. Because of the flexibility and softness of chaff, external contact would not be expected to impact most wildlife (U.S. Air Force 1997) and the fibers would quickly wash off shortly after contact. Given the properties of chaff, skin irritation is not expected to be a problem (U.S. Air Force 1997). The potential exists for marine animals to inhale chaff fibers if they are at the surface while chaff is airborne. Arfsten (2002), Hullar et al. (1999), and U.S. Air Force (1997) reviewed the potential impacts of chaff inhalation on humans, livestock, and other animals and concluded that the fibers are too large to be inhaled into the lungs. The fibers were predicted to be deposited in the nose, mouth, or trachea and are either swallowed or expelled.

In laboratory studies conducted by the University of Delaware (Hullar et al. 1999), blue crabs and killifish were fed a food-chaff mixture daily for several weeks and no significant mortality was observed at the highest exposure treatment. Similar results were found when chaff was added directly to exposure chambers containing filter-feeding menhaden. Histological examination indicated no damage from chaff exposures. A study on cow calves that were fed chaff found no evidence of digestive disturbance or other clinical symptoms (U.S. Air Force 1997).

Chaff cartridge plastic end caps and pistons would also be released into the marine environment, where they would persist for long periods and could be ingested by marine animals. Chaff end caps and pistons sink in saltwater (Spargo 2007).

The training and testing activities that involve chaff are listed in Appendix A (Training and Testing Activities Descriptions). The estimated number of events per year that would involve expending chaff is detailed below in Table 3.0-26.

Table 3.0-26: Annual Number of Expended Chaff Cartridges

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Total Study Area	5,830	25,840	28,512	0	600	660

Flares

Flares are pyrotechnic devices used to defend against heat-seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft's engines. Similar to chaff, flares are also dispensed from aircraft and fired from ships. The flare device consists of a cylindrical cartridge approximately 1.4 in. (3.6 cm) in diameter and 5.8 in. (14.7 cm) in length. Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic end cap (approximately 1.4 in. [3.6 cm] in diameter).

An extensive literature review and controlled experiments conducted by the U.S. Air Force revealed that self-protection flare use poses little risk to the environment or animals (U.S. Air Force 1997).

The training and testing activities that involve the use of flares are listed in Appendix A (Training and Testing Activities Descriptions). The overall annually expended number of flares is detailed in Table 3.0-27.

Table 3.0-27: Annual Number of Expended Flares

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Total Study Area	5,740	25,600	28,272	0	300	330

3.0.5.3 Resource-Specific Impacts Analysis for Individual Stressors

The direct and indirect impacts of each stressor carried forward for further analysis were analyzed for each resource in their respective section. Quantitative and semi-quantitative methods were used to the extent possible, but inherent scientific limitations required the use of qualitative methods for most stressor/resource interactions. Resource-specific methods are described in sections of Chapter 3 (Affected Environment and Environmental Consequences), where applicable. While specific methods used to analyze the impacts of individual stressors varied by resource, the following generalized approach was used for all stressor/resource interactions:

- The frequency, duration, and spatial extent of exposure to stressors were analyzed for each resource. The frequency of exposure to stressors or frequency of a proposed activity was characterized as intermittent or continuous, and was quantified in terms of number per unit of time when possible. Duration of exposure was expressed as short- or long-term and was quantified in units of time (e.g., seconds, minutes, and hours) when possible. The spatial extent of exposure was generally characterized as widespread or localized, and the stressor footprint or area (e.g., square feet, square nautical miles [nm^2]) was quantified when possible.
- An analysis was conducted to determine whether and how resources are likely to respond to stressor exposure or be altered by stressor exposure based upon available scientific knowledge. This step included reviewing available scientific literature and empirical data. For many stressor/resource interactions, a range of likely responses or endpoints was identified. For example, exposure of an organism to sound produced by an underwater explosion could result in no response, a physiological response such as increased heart rate, a behavioral response such as being startled, injury, or mortality.
- The information obtained was used to analyze the likely impacts of individual stressors on a resource and to characterize the type, duration, and intensity (severity) of impacts. The type of impact was generally defined as beneficial or adverse and was further defined as a specific endpoint (e.g., change in behavior, mortality, change in concentration, loss of habitat, loss of fishing time). When possible, the endpoint was quantified. The duration of an impact was generally characterized as short-term (e.g., minutes, days, weeks, months, depending on the resource), long-term (e.g., months, years, decades, depending on the resource), or permanent. The intensity of an impact was then determined. For biological resources, the analysis started with individual organisms and their habitats, and then addressed populations, species, communities, and representative ecosystem characteristics, as appropriate.

3.0.5.4 Resource-Specific Impacts Analysis for Multiple Stressors

The stressors associated with the proposed training and testing activities could affect the environment individually or in combination. The impacts of multiple stressors may be different when considered collectively rather than individually. Therefore, following the resource-specific impacts analysis for individual stressors, the combined impacts of all stressors were analyzed for that resource. This step determines the overall impacts of the alternatives on each resource, and it considers the potential for impacts that are additive (where the combined impacts on the resource are equal to the sum of the individual impacts), synergistic (where impacts combine in such a way as to amplify the effect on the resource), and antagonistic (where impacts will cancel each other out or reduce a portion of the effect on the resource). In some ways, this analysis is similar to the cumulative impacts analysis described below, but it only considers the activities in the alternatives and not other past, present, and reasonably foreseeable future actions. This step helps focus the next steps of the approach (cumulative impacts analysis) and make overall impact conclusions for each resource.

Evaluating the combined impacts of multiple stressors can be complex, especially when the impacts associated with a stressor are hard to measure. Therefore, some general assumptions were used to help determine the potential for individual stressors to contribute to combined impacts. For this analysis, combined impacts were considered more likely to occur in the following situations:

- Stressors that occur at the same time and location, causing a resource to be simultaneously affected by more than one stressor.
- A resource is repeatedly affected by multiple stressors or is re-exposed before fully recovering from a previous exposure.
- The impacts of individual stressors are permanent or long-term (years or decades) versus short-term (minutes, days, or months).
- The intensity of the impacts from individual stressors is such that mitigation would be necessary to offset adverse impacts.

The resource-specific impacts analysis for multiple stressors included the following steps:

- Information obtained from the analysis of individual stressors was used to develop a conceptual model to predict the combined impacts of all stressors on each resource. This conceptual model incorporated factors such as the co-occurrence of stressors in space and time; the impacts or assessment endpoints of individual stressors (e.g., mortality, injury, changes in animal behavior or physiology, habitat alteration, changes in human use); and the duration and intensity of the impacts of individual stressors.
- To the extent possible, additive impacts on a given resource were considered by summing the impacts of individual stressors. This summation was only possible for stressors with identical and quantifiable assessment endpoints. For example, if one stressor disturbed 0.25 nm^2 of benthic habitat, a second stressor disturbed 0.5 nm^2, and all other stressors did not disturb benthic habitat, then the total benthic habitat disturbed would be 0.75 nm^2. For stressors with identical but not quantifiable assessment endpoints, available scientific knowledge, best professional judgment, and the general assumptions outlined above were used to evaluate potential additive impacts.
- For stressors with differing impacts and assessment endpoints, the potential for additive, synergistic, and antagonistic effects were evaluated based on available scientific knowledge, professional judgment, and the general assumptions outlined above.

3.0.5.5 Cumulative Impacts

A cumulative impact is the impact on the environment that results when the incremental impact of an action is added to other past, present, and reasonably foreseeable future actions. The cumulative impacts analysis (Chapter 4, Cumulative Impacts) considers other actions regardless of what agency (federal or nonfederal) or person undertakes the actions. Cumulative impacts result when individual actions combine with similar actions taking place over a period of time to produce conditions that frequently alter the historical baseline (40 C.F.R. §1508.7). The goal of the analysis is to provide the decision makers with information relevant to reasonably foresee potentially significant impacts. See Chapter 4 (Cumulative Impacts) for the specific approach used for determining cumulative impacts.

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3.1 Sediments and Water Quality

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3.1 SEDIMENTS AND WATER QUALITY

SEDIMENTS AND WATER QUALITY SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following have been analyzed for sediments and water quality:

- Explosives and explosive byproducts
- Metals
- Chemicals other than explosives
- Other materials

Preferred Alternative (Alternative 1)

- Explosives: Impacts of explosive byproducts could be short-term and local; impacts of unconsumed explosives and metals would be long term and local. Chemical, physical, or biological changes to sediments or water quality would be measurable but below applicable standards, regulations, and guidelines, and would be within existing conditions or designated uses.
- Metals: Impacts of metals would be long term and local. Corrosion and biological processes would reduce exposure of military expended materials to seawater, decreasing the rate of leaching, and most leached metals would bind to sediments and other organic matter. Sediments near military expended materials would contain some metals, but concentrations would be below applicable standards, regulations, and guidelines.
- Chemicals: Impacts of chemicals other than explosives and impacts of other materials associated with ordnance could be both short- and long-term and local. Chemical, physical, or biological changes in sediment or water quality would not be detectable and would be within existing conditions or designated uses.
- Other Materials: Impacts of other materials would be short-term and local. Most other materials from military expended materials would not be harmful to marine organisms and would be consumed during use. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

3.1.1 INTRODUCTION AND METHODS

3.1.1.1 Introduction

The following sections provide an overview of the characteristics of sediments and water quality in the Mariana Islands Training and Testing (MITT) Study Area (Study Area), and describe in general terms the methods used to analyze potential impacts on these resources. Open ocean and nearshore environments are considered in this section. Terrestrial environments (including wetlands) are discussed in Section 3.10 (Terrestrial Species and Habitats).

3.1.1.1.1 Sediments

The discussion of sediments begins with an overview of sediment sources and characteristics in the Study Area and considers factors that affect sediment quality.

3.1.1.1.1.1 Characteristics of Sediments

Sediments consist of solid fragments of organic matter from vegetation and animals and inorganic matter from the weathering of rock transported by water, wind, and ice (glaciers) and deposited at the bottom of bodies of water. Components of sediments range in size from boulders, cobble, and gravel to sand (particles 0.05 to 2.0 millimeters [mm] in diameter), silt (0.002 to 0.05 mm), and clay (less than or equal to 0.002 mm). Sediment deposited on the continental shelf is mostly transported by rivers, but also by local and regional currents and wind. Most sediment in nearshore areas and on the continental shelf is aluminum silicate derived from rocks on land deposited at rates of more than 10 centimeters (cm) (3.94 inches [in.]) per 1,000 years. Sediments may also be produced locally by nonliving particulate organic matter ("detritus") that sinks to the bottom (Hollister 1973; Milliman et al. 1972). Some areas of the deep ocean contain an accumulation of the shells of marine microbes composed of silicones and calcium carbonates, termed biogenic ooze (Chester 2003). Through the downward movement of organic and inorganic particles in the water column, substances that are otherwise scarce in the water column (e.g., metals) are concentrated in bottom sediments (Chapman et al. 2003; Kszos et al. 2003).

3.1.1.1.1.2 Factors Affecting Marine Sediment Quality

The quality of sediments is influenced by their physical, chemical, and biological components, where they are deposited, the properties of seawater, and other inputs and sources of contamination. Because these factors interact to some degree, sediments tend to be dynamic and are not easily generalized. For this discussion, "contaminant" refers to biological, chemical, or physical materials normally absent in sediments, but which, when present or when at high concentrations, can impact marine processes.

3.1.1.1.1.3 Sediment Physical Characteristics and Processes

At any given site, the texture and composition of sediments are important physical factors that influence the types of substances retained in sediments and subsequent biological and chemical processes. Clay-sized and smaller sediments and similarly sized organic particles tend to bind potential sediment contaminants such as metals, hydrocarbons, and persistent organic pollutants. Through this attraction, these particles efficiently scavenge contaminants from the water column and the water between grains of sediment ("porewater") and may bind them so strongly that their movement in the environment is limited (U.S. Environmental Protection Agency 2008a). Fine-grained sediments are easily disturbed by currents and bottom-dwelling organisms (Hedges and Oades 1997), dredging (Eggleton and Thomas 2004), storms (Chang et al. 2001), and bottom trawling (Churchill 1989). Disturbance is also possible in deeper areas where currents are minimal, such as from mass wasting events (e.g., underwater slides, debris flows). If resuspended, fine-grained sediments (and any substances bound to them) can be transported long distances.

3.1.1.1.1.4 Sediment Chemical Characteristics and Processes

The concentration of oxygen in sediments is a major influence on sediment quality by its effect on the binding of materials to sediment particles. At the sediment surface, the level of oxygen is usually the same as that of the overlying water. Deeper sediment layers, however, are often low in oxygen ("hypoxic") or have no oxygen ("anoxic") and have a low oxidation-reduction ("redox") potential. Redox potential predicts the stability of various compounds that regulate nutrient and metal availability in sediments. Certain substances combine in oxygen-rich environments and become less available for other chemical or biological reactions. If these combined substances settle into the low or no-oxygen sediment zone, the change may release them into pore water, making them available for other chemical or biological reactions. Conversely, substances that remain in solution in oxygenated environments may combine with organic or inorganic substances under hypoxic or anoxic conditions and may be removed from further chemical or biological reactions (Spencer and MacLeod 2002; Wang et al. 2002).

3.1.1.1.1.5 Sediment Biological Characteristics and Processes

Organic matter in sediments provides food for resident microbes. Their metabolism can change the chemical environment in sediments, thereby increasing or decreasing the mobility of various substances and influencing the ability of sediments to retain and transform those substances (Mitsch and Gosselink 2007; U.S. Environmental Protection Agency 2008b). Bottom-dwelling animals often rework sediments in the process of feeding and burrowing, also known as "bioturbation." In this way, marine organisms can influence the structure, texture, and composition of sediments as well as the horizontal and vertical distribution of substances in the sediment (Boudreau 1998). Moving substances out of or into low- or no-oxygen zones in sediments may alter the form and availability of various substances. The metabolic processes of bacteria also influence sediment components directly. For example, sediment microbes may alter mercury to methyl mercury, increasing its toxicity (Mitchell and Gilmour 2008).

3.1.1.1.1.6 Location

The quality of coastal and marine sediments is influenced substantially by inputs from adjacent watersheds (Turner and Rabalais 2003). Proximity to watersheds with large cities and intensively farmed lands often increases the amount of both inorganic and organic contaminants that find their way into coastal and marine sediments. Metals enter estuaries through weathering of natural rocks and mineralized deposits carried by rivers and through man-made inputs that often contribute amounts substantially above natural levels. Metals of greatest concern include cadmium, chromium, mercury, lead, selenium, arsenic, and antimony because they bioaccumulate, are toxic in low concentrations to biota, and have few natural functions in biological systems (Summers et al. 1996). In addition to metals, a wide variety of organic substances, such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs), and pesticides—often referred to collectively as "persistent organic pollutants"—are discharged into coastal waters by urban, agricultural, and industrial point and non-point sources in the watershed (Keller et al. 2010).

Estuaries provide ecological functions such as sediment retention and nutrient cycling. Examples of these processes include the binding of materials to small particles in the water column and the settling of those particles on the bottom in calm areas (Li et al. 2008). Thus, the concentrations of various substances decrease with distance from shore. Once in the ocean, the locations of various substances may also be influenced by longshore currents that travel parallel to the shore (Duursma and Gross 1971). Location on the ocean floor also influences the distribution and concentration of various elements through local geology and volcanic activity (Demina and Galkin 2009), as well as through mass wasting events (Coleman and Prior 1988).

3.1.1.1.1.7 Other Contributions to Sediments

While the greatest mass of sediments are carried into marine systems by rivers (U.S. Environmental Protection Agency 2008c), wind and rain also deposit materials in coastal waters and contribute to the mass and quality of sediments. For instance, approximately 80 percent of the mercury released by human activities comes from coal combustion, mining and smelting, and solid waste incineration (Agency for Toxic Substances and Disease Registry 1995). These activities are generally considered the major sources of mercury in marine systems (Fitzgerald et al. 2007). Atmospheric deposition of lead is similar in that human activity is a major source of lead in sediments (Wu and Boyle 1997).

Hydrocarbons are common in marine sediments. In addition to washing in from land and shipping sources, they are generated by the combustion of fuels (both wood and petroleum), are produced directly by marine and terrestrial biological sources, and arise from processes in marine sediments, including microbial activity and natural hydrocarbon seeps (Boehm and Requejo 1986; Geiselbrecht et al. 1998). Means (1995) noted that, because of the large binding capacities of organic-rich, fine-grained sediments found at many coastal and estuarine sites, “hydrocarbons may concentrate to levels far exceeding those observed in the water column of the receiving water body.”

Morrison et al. (2013) summarized studies conducted along the western coast of Saipan and identified the commercial port (Saipan Harbor) and bulk fuel facility, a sewer outfall, a municipal waste dump, and two small-boat marinas as the primary sources of impacts on the sediments and biota within Tanapag Lagoon. For example, mercury levels were seen to decline in certain species of fish 18 months after a medical waste incinerator was shut down in 2006 (Denton et al. 2006).

3.1.1.1.2 Water Quality

The discussion of water quality begins with an overview of the characteristics of marine waters, including pH, temperature, oxygen, nutrients, and salinity and other dissolved elements. The discussion then considers how those characteristics of marine waters are influenced by physical, chemical, and biological processes.

Inshore and nearshore waters in the Study Area include bays and harbors. A bay is a body of water mostly surrounded by land and, as such, has calmer waters than the surrounding sea because the land blocks waves and reduces winds. A harbor is a landform where the adjacent body of water is deep enough to provide anchorage. Natural harbors, such as Apra Harbor in Guam, are surrounded on several sides by prominent land masses, while artificial harbors have breakwaters, sea walls, or jetties that are deliberately constructed, such as by dredging. See Figure 2.1-5, which shows the location of Naval Base Guam Apra Harbor.

3.1.1.1.2.1 Characteristics of Marine Waters

The composition of water in the marine environment is determined by complex interactions among physical, chemical, and biological processes. Physical processes include region-wide currents and tidal flows, seasonal weather patterns and temperature, sediment characteristics, and unique local conditions, such as the volume of freshwater delivered by large rivers. Chemical processes involve chemical properties, such as salinity, pH, dissolved minerals and gases, particulates, nutrients, and pollutants. Biological processes involve the influence of living things on the physical and chemical environment. The two dominant biological processes in the ocean are photosynthesis and respiration, particularly by microorganisms. These processes involve the uptake, conversion, and excretion of waste products during growth, reproduction, and decomposition (Mann and Lazier 1996).

3.1.1.1.2.2 pH

pH is a measure of the degree to which a solution is either acidic (pH less than 7.0) or basic (pH greater than 7.0). Seawater has a relatively stable pH between 7.5 and 8.5 due to the presence of dissolved elements, particularly carbon and hydrogen. Most of the carbon in the sea is present as dissolved inorganic carbon generated through the complex interactions of dissolved carbon dioxide in seawater. This carbon dioxide-carbonate equilibrium is the major pH buffering system in seawater. The maintenance of shells by specialized marine animals (e.g., mollusks) is made difficult by changes in pH outside of the normal range (Fabry et al. 2008; Veron 2009).

3.1.1.1.2.3 Temperature

Temperature influences the speed at which chemical reactions take place in solution: higher temperatures increase reaction rates and lower temperatures decrease reaction rates. Seasonal changes in weather influence water temperatures that, in turn, influence the degree to which marine waters mix.

The increases in surface water temperatures during summer create three distinct layers in deeper water, a process known as stratification. The warmer surface layer is separated from colder water toward the bottom by an intervening layer ("thermocline") within which the temperature changes rapidly. Stratification can limit the exchange of gases and nutrients as well as the onset and decline of phytoplankton blooms (Howarth et al. 2002). In fall and winter, lower air temperatures and cool surface waters break down the vertical stratification and promote mixing within the water column.

3.1.1.1.2.4 Oxygen

Surface waters in the ocean are usually saturated or supersaturated with dissolved oxygen by photosynthetic activity and wave mixing (with oxygen saturation levels ranging from 89 to 106 percent; 4.49 to 5.82 milliliters per liter [ml/L]). As water depth below the surface increases, the oxygen concentration decreases from more than 60 percent (4.4 ml/L) to a minimum (27 percent [1.7 ml/L]) at intermediate depths between 1,000 and 3,000 feet (ft.) (300 and 900 meters [m]). Thereafter, the oxygen level increases with depth to about 6,500 ft. (2,000 m) (5.4 to 6.7 ml/L) and remains relatively constant at greater depths (Seiwell 1934).

A dissolved oxygen concentration of less than 2 milligrams per liter (mg/L) is considered to be poor, a condition referred to as hypoxia (Rabalais et al. 2002; U.S. Environmental Protection Agency 2008c). Such low oxygen levels are natural in marine systems under certain conditions, such as oxygen minimum zones at intermediate depths, upwelling areas, deep ocean basins, and fjords (Helly and Levin 2004). Upwelling refers to the movement of colder, nutrient-rich waters from deeper areas of the ocean to the surface. However, the occurrence of hypoxia and anoxia in shallow coastal and estuarine areas can adversely affect fish, bottom-dwelling ("benthic") creatures, and submerged aquatic vegetation. Hypoxia appears to be increasing (Diaz and Rosenberg 1995), and affects more than half of the estuaries in the United States (Bricker et al. 1999).

3.1.1.1.2.5 Nutrients

Nutrients are elements and compounds necessary for the growth and metabolism of organisms. In marine systems, basic nutrients include dissolved nitrogen, phosphates, silicates, and metals such as iron and copper. Dissolved inorganic nitrogen occurs in ocean water as nitrates, nitrites, and ammonia (Zehr and Ward 2002). Depending on local conditions, the productivity of marine ecosystems may be limited by the amount of phosphorus available or, more often, by the amount of nitrogen available (Anderson et al. 2002; Cloern 2001). Too much of either nutrient can lead to deleterious conditions referred to as eutrophication. Too many nutrients can stimulate algal blooms, the rapid expansion of microscopic algae (phytoplankton). Once the excess nutrients are consumed, the algae population dies off, and the remains are consumed by bacteria. Bacterial consumption causes dissolved oxygen in the water to decline to the point where organisms can no longer survive (Boesch et al. 1997). Sources of excess nutrients include fertilizers applied on land, wastewater, and atmospheric deposition of combustion products from burning fossil fuels (Turner and Rabalais 2003). Biogeochemical processes in estuaries and on the continental shelf influence the extent to which nitrogen and phosphorus reach the open ocean. Many of these nutrients eventually reside in coastal sediments (Nixon et al. 1996).

3.1.1.1.2.6 Salinity, Ions, and Other Dissolved Substances

The concentrations of major ions in seawater determine its salinity. These ions include sodium, chloride, potassium, calcium, magnesium, and sulfate. Salinity varies seasonally and geographically, especially in areas influenced by large rivers (Milliman et al. 1972). Table 3.1-1 provides estimated concentration of elements in open ocean waters. The presence of extremely small organic particles (less than 0.63

micrometers), carbonates, sulfides, phosphates, and other metals, will influence the dominant form of some substances, and determine whether they remain dissolved or form solids.

Table 3.1-1: Concentrations of Selected Elements in Seawater

Element	Estimated Mean Oceanic Concentration (ng/kg [ppt])
Magnesium	1,280,000,000
Silicon	2,800,000
Lithium	180,000
Phosphorus	62,000
Molybdenum	10,000
Uranium	3,200
Nickel	480
Zinc	350
Chromium (VI)	210
Copper	150
Cadmium	70
Aluminum	30
Iron	30
Manganese	20
Tungsten	10
Titanium	6.5
Lead	2.7
Chromium (III)	2
Silver	2
Cobalt	1.2
Tin	0.5
Mercury	0.14
Platinum	0.05
Gold	0.02

Notes: ng = nanograms, kg = kilograms, ppt = parts per trillion
Source: Nozaki 1997

Salts in ocean waters may come from land, rivers, undersea volcanoes, hydrothermal vents, or other sources. When water evaporates from the surface of the ocean, the salts are left behind, and salinity will depend on the ratio of evaporation to precipitation. For example, regions closer to the equator are generally higher in salinity because of their higher evaporation rates. The 1994 World Ocean Atlas (National Oceanic and Atmospheric Administration 1994) shows mean sea surface salinity in the Study Area to be in the range of 34 to 36 practical salinity units or parts per thousand (ppt). Observed salinity values in the vicinity of Cabras Island (the northern shore of Outer Apra Harbor in Guam) and the glass breakwater in a 1978 study were 34.43 ppt at the surface and 35.13 ppt at 150 m (492 ft.) depth (Lassuy 1979).

3.1.1.1.2.7 Influence of Marine Properties and Processes on Seawater Characteristics

Ocean currents and tides mix and redistribute seawater. In doing so, they alter surface water temperatures, transport and deposit sediment, and concentrate and dilute substances that are dissolved and suspended in the water. These processes operate to varying degrees from nearshore areas to the abyssal plain. Salinity affects the density of seawater and, therefore, its movement relative to the sea surface (Libes 2009). Upwellings bring cold, nutrient-rich waters from deeper areas, increasing the productivity of local surface waters (Mann and Lazier 1996). Storms and hurricanes also result in strong mixing of marine waters (Li et al. 2006).

Temperature and pH influence the behavior of trace metals in seawater, such as the extent to which they dissolve in water ("solubility") or their tendency to adsorb to organic and inorganic particles. However, the degree of influence differs widely among metals (Byrne et al. 1988). The concentration of a given element may change with position in the water column. For example, some metals (e.g., cadmium) are present at low concentrations in surface waters and at higher concentrations at depth (Bruland 1992), while others decline quickly with increasing depth below the surface (e.g., zinc and iron) (Morel and Price 2003). On the other hand, dissolved aluminum concentrations are highest at the surface, lowest at mid-depths, and increase again at depths below about 3,300 ft. (1,000 m) (Li et al. 2008).

Substances like nitrogen, carbon, silicon, and trace metals are extracted from the water by biological processes; others, like oxygen and carbon dioxide, are produced. Metabolic waste products add organic compounds to the water and may also absorb trace metals, removing those metals from the water column. Those organic compounds may then be consumed by organisms, or they may aggregate with other particles and sink (Mann and Lazier 1996; Wallace et al. 1977).

Runoff from coastal watersheds influences local and regional coastal water conditions, especially near large rivers. Influences include increased sediments and pollutants, and decreased salinity (Turner and Rabalais 2003). Coastal bays and large estuaries serve to filter river outflows and reduce total discharge of water to the ocean (Edwards et al. 2006). Depending on their structure and components, estuaries can directly or indirectly affect coastal water quality by recycling various compounds (e.g., excess nutrients), sequestering elements in more inert forms (e.g., trace metals), or altering them, such as the conversion of mercury to methylmercury (Mitchell and Gilmour 2008; Mitsch and Gosselink 2007).

3.1.1.1.2.8 Coastal Water Quality

A recent coastal condition report by the United States (U.S.) Environmental Protection Agency (EPA) (U.S. Environmental Protection Agency 2008b) evaluated the condition of U.S. coastal water quality. According to the report, most water quality problems in coastal waters of the United States are from degraded water clarity or increased concentrations of phosphates or chlorophyll *a*. Water quality indicators measured included dissolved inorganic nitrogen, dissolved inorganic phosphorus, water clarity or turbidity, dissolved oxygen, and chlorophyll *a*. Chlorophyll *a* is an indicator of microscopic algae (phytoplankton) abundance used to judge nutrient availability (i.e., phosphates and nitrates). Excess phytoplankton blooms can decrease water clarity and, when phytoplankton die off following blooms, lower concentrations of dissolved oxygen. Most sources of these negative impacts arise from on-shore point and non-point sources of pollution. Point sources are direct water discharges from a single source, such as industrial or sewage treatment plants, while non-point sources are the result of many diffuse sources, such as runoff caused by rainfall.

3.1.1.1.2.9 Hydrocarbons, Trace Metals, and Persistent Organic Pollutants

In addition to the characteristics discussed above, other substances influence seawater quality, including hydrocarbons, metals, and persistent organic pollutants (e.g., pesticides, PCBs, organotins, polycyclic aromatic hydrocarbons, and similar synthetic organic compounds). The sources of these contaminants include commercial and recreational vessels; oil and gas exploration, processing, and spills; industrial and municipal discharges (point source pollution); runoff from urban and agricultural areas (non-point source pollution); legal and illegal ocean dumping; poorly or untreated sewage; and atmospheric deposition of combustion residues (U.S. Environmental Protection Agency 2008c). Various physical, chemical, and biological processes work to remove many of these substances from seawater; thereafter, they become part of nearshore and continental shelf sediments. Additional discussion of contaminants in sediments is provided in Section 3.1.1.1.1 (Sediments).

Hydrocarbons

Hydrocarbons are common in marine ecosystems. They arise from man-made sources, from natural hydrocarbon seeps, and from microbial activity (Boehm and Requejo 1986; Geiselbrecht et al. 1998). According to Kvenvolden and Cooper (2003), during the 1980s, about 10 percent of crude oil entering the marine environment came from natural sources; 27 percent came from oil production, transportation, and refining; and the remaining 63 percent came from atmospheric emissions, municipal and industrial sources, and urban and river runoff. These sources produce many thousands of chemically different hydrocarbon compounds. When hydrocarbons enter the ocean, the lighter-weight components evaporate, degrade by sunlight ("photolysis"), or undergo chemical and biological degradation. A wider range of constituents are consumed by microbes ("biodegradation"). Higher-weight molecular compounds such as asphaltenes are more resistant to degradation, and tend to persist after these processes have occurred (Blumer et al. 1973; Mackay and McAuliffe 1988).

Trace Metals

Trace metals commonly present in seawater are listed in Table 3.1-1. Levels of dissolved metals in seawater are normally quite low because some are extracted by organisms (e.g., iron), many tend to precipitate with various ions already present in the water, and others bind to various metal oxides and small organic and inorganic particles in the water (Turekian 1977). These processes transform the metals from a dissolved state to a solid (particulate) state, and substantially decrease the concentrations of dissolved metals in seawater (Wallace et al. 1977). Concentrations of heavy metals normally decrease with increasing distance from shore (Wurl and Obbard 2004) and vary with depth (Li et al. 2008). Certain amounts of trace metals are naturally present in marine waters because of the dissolution of geological formations on land by rain and runoff. However, the additional amounts produced by human activity often have adverse consequences for marine ecosystems (Summers et al. 1996), such as the atmospheric deposition of lead in marine systems (Wu and Boyle 1997).

Persistent Organic Pollutants

Persistent organic pollutants, such as herbicides, pesticides, PCBs, organotins, polycyclic aromatic hydrocarbons, and similar synthetic organic compounds, are chemical substances that persist in the environment and bioaccumulate through the food web. Persistent organic pollutants have long half-lives in the environment. They are resistant to degradation, do not readily dissolve in water, and tend to adhere to organic solids and lipids (fats) (Jones and de Voogt 1999) and plastics. Although they are present in the open ocean and deep ocean waters, they are more common and in higher concentrations in nearshore areas and estuaries (Means 1995; Wurl and Obbard 2004). The surface of the ocean represents an important micro-habitat for a variety of microbes, larvae, and fish eggs. Because of the tendency of hydrocarbons and persistent organic pollutants to float in this surface micro-layer, they can be significantly more toxic to those organisms than the adjacent sub-surface water (Wurl and Obbard 2004).

Persistent organic pollutants that adhere to particulates may sink to the seafloor. Sauer et al. (1989) noted that concentrations of PCBs and dichlorodiphenyltrichloroethane (DDT) have been declining in the open ocean for several decades. PCBs are mixtures of up to 209 individual chlorinated compounds that are related chemicals of similar molecular structure, also known as congeners. They were used widely as coolants and lubricants in transformers, capacitors, and other electrical equipment. Manufacture of PCBs stopped in the United States in 1977 (Agency for Toxic Substances and Disease Registry 2000). Marine sources include runoff from agricultural and urban areas and atmospheric deposition from industrial areas (Kalmaz and Kalmaz 1979). PCBs do not readily degrade in the environment, and they tend to persist for many years. They can easily move between air, water, and soil, although in aquatic systems, they tend to adhere to fine-grained sediments, organic matter, and marine debris. PCBs have a variety of effects on aquatic organisms, including disrupting endocrine systems. PCBs persist in the tissues of animals at the bottom of the food chain. Consumers of those species accumulate PCBs to levels that may be many times higher than their concentrations in water. Microbial breakdown of PCBs (dechlorination) has been documented in estuarine and marine sediments (Agency for Toxic Substances and Disease Registry 2000).

3.1.1.2 Methods

Four stressors may impact sediment or water quality: (1) explosives and explosive byproducts, (2) metals, (3) chemicals other than explosives, and (4) a miscellaneous category of other materials. The term “stressor” is used because the military expended materials in these four categories may negatively affect sediment or water quality by altering their physical or chemical characteristics. The potential impacts of these stressors are evaluated based on the extent to which the release of these materials would directly or indirectly impact sediments or water quality such that existing laws or standards would be violated or recommended guidelines would be exceeded. The differences between standards and guidelines are described below.

- **Standards** are established by law or through government regulations that have the force of law. Standards may be numerical or narrative. Numerical standards set allowable concentrations of specific pollutants (e.g., micrograms per liter [µg/L] or levels of other parameters (e.g., pH) to protect the water’s designated uses. Narrative standards describe water conditions that are not acceptable.
- **Guidelines** are non-regulatory and generally do not have the force of law. They reflect an agency’s preference or suggest conditions that should prevail. Guidelines are often used to assess the condition of a resource to guide subsequent steps, such as the disposal of dredged materials. Terms such as screening criteria, effect levels, and recommendations are also used.

3.1.1.2.1 Territory and Commonwealth Standards and Guidelines

Territorial (Guam) and commonwealth jurisdiction over sediments and water quality extends from the low tide line out to 3 nautical miles (nm). Creating state-level sediment and water quality standards and guidelines begins with each state establishing a use for the water, which is referred to as its “beneficial” or “designated” use.[1] Examples of such uses of marine waters include fishing, shellfish harvest, and

[1] Although Guam and the CNMI are not states, the Clean Water Act includes Guam and CNMI in the definition of “state” in accordance with 33 U.S. Code 1362(3). Therefore, the EPA follows procedures for establishing sediment and water quality

swimming. For this section, a water body is considered "impaired" if any one of its designated uses is not met. Once this use is designated, standards or guidelines are established to protect the water at the desired level of quality. Yap and Palau are also within the Study Area, but no training or testing activities occur within the territorial waters of these islands. Therefore, standards and guidelines specific to Yap and Palau are not analyzed in this section.

3.1.1.2.2 Federal Standards and Guidelines

Chief of Naval Operations Instruction 5090.1 is the Navy's controlling authority for all at-sea compliance with federal regulations. Federal jurisdiction over ocean waters extends from 3 to 12 nm (Outer Continental Shelf Lands Act of 1953 [43 U.S. Code {U.S.C.} §1331 et seq.]). Sediments and water quality standards and guidelines are mainly the responsibility of the EPA, specifically ocean discharge provisions of the Clean Water Act (33 U.S.C. §1251, et seq.). Ocean discharge may not result in "unreasonable degradation of the marine environment." Specifically, the disposal may not result in (1) unacceptable negative effects on human health, (2) unacceptable negative effects on the marine ecosystem, (3) unacceptable negative persistent or permanent effects because of the particular volumes or concentrations of the dumped materials, or (4) unacceptable negative effects on the ocean for other uses as a result of direct environmental impact (40 Code of Federal Regulations [C.F.R.] §125.122). Federal standards and guidelines applicable to each stressor are detailed in Section 3.1.3 (Environmental Consequences). Where U.S. legal and regulatory authority do not apply (e.g., beyond 200 nm from shore), federal standards and guidelines may be used as reference points for evaluating effects of proposed training and testing activities on sediment and water quality.

The International Convention for the Prevention of Pollution from Ships (Convention) addresses pollution generated by normal vessel operations. The Convention is incorporated into U.S. law as 33 U.S.C. §§1901–1915. The Convention includes six annexes: Annex I, oil discharge; Annex II, hazardous liquid control; Annex III, hazardous material transport; Annex IV, sewage discharge; Annex V, plastic and garbage disposal; and Annex VI, air pollution. The U.S. Department of the Navy (Navy) is required to comply with the Convention; however, the United States is not a party to Annex IV. The Convention contains handling requirements and specifies where materials can be discharged at sea, but it does not contain standards and guidelines related to sediment and water quality.

Water and sediment quality effects associated with training and testing activities are analyzed for potential impacts to resources addressed in other sections of this Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS). These potential impacts are included in the resource-specific sections. For example, Section 3.9 (Fish) includes an analysis of potential impacts on water and sediment quality in relation to Essential Fish Habitat. Section 3.4 (Marine Mammals), Section 3.5 (Sea Turtles), Section 3.6 (Marine Birds), Section 3.7 (Marine Vegetation), and Section 3.8 (Marine Invertebrates) consider potential water and sediment quality effects and potential impacts to the various resources analyzed, including species protected under the Endangered Species Act.

3.1.1.2.3 Intensity and Duration of Impact

The intensity or severity of impact is defined as follows (increasing order of negative impacts):

- Chemical, physical, or biological changes in sediment or water quality would not be detectable, and total concentrations would be below or within existing conditions or designated uses.

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standards by first designating beneficial use of a water body. In Guam, the lead agency is the Guam Environmental Protection Agency. In the CNMI, the lead agency is the CNMI Department of Environmental Quality.

- Chemical, physical, or biological changes in sediment or water quality would be measurable, but total concentrations would be below applicable standards, regulations, and guidelines, and would be within existing conditions or designated uses.
- Chemical, physical, or biological changes in sediment or water quality would be measurable and readily apparent, but total concentrations would be within applicable standards, regulations, and guidelines. Sediment or water quality would be altered compared to historical baseline, desired conditions, or designated uses. Mitigation would be necessary and would likely be successful.
- Chemical, physical, or biological changes in sediment or water quality would be readily measurable, and some standards, regulations, and guidelines would be periodically approached, equaled, or exceeded by total concentrations. Sediment or water quality would be frequently altered from the historical baseline or desired conditions or designated uses. Mitigation would be necessary, but success would not be assured.

Duration is characterized as either short-term or long-term. Short-term is defined as days or months. Long-term is defined as months or years, depending on the type of activity or the materials involved.

3.1.1.2.4 Measurement and Prediction

Many of the conditions discussed above often influence each other, so measuring and characterizing various substances in the marine environment is often difficult (Byrne 1996; Ho et al. 2007). For instance, sediment contaminants may also change over time. Valette-Silver (1993) reviewed several studies that demonstrated the gradual increase in a variety of contaminants in coastal sediments that began as early as the 1800s, continued into the 1900s, peaked between the 1940s and 1970s, and declined thereafter (e.g., lead, dioxin, PCBs). After their initial deposition, normal physical, chemical, and biological processes can resuspend, transport, and redeposit sediments and associated substances in areas far removed from the source (Hameedi et al. 2002; U.S. Environmental Protection Agency 2008c). The conditions noted above further complicate predictions of the impact of various substances on the marine environment.

3.1.1.2.5 Sources of Information

Relevant literature was systematically reviewed to complete this analysis of sediment and water quality. The review included journals, technical reports published by government agencies, work conducted by private businesses and consulting firms, U.S. Department of Defense (DoD) reports, operational manuals, natural resource management plans, and current and prior environmental documents for facilities and activities in the Study Area.

Because of its importance and proximity to humans, information is readily available regarding the condition of inshore and nearshore sediment and water quality. However, much less is known about deep ocean sediments and open ocean water quality. Because inshore and nearshore sediments and water quality are negatively affected mostly by various human social and economic activities, two general assumptions are used in this discussion: (1) the greater the distance from shore, the higher the quality of sediments and waters; and (2) deeper waters are generally of higher quality than surface waters.

3.1.1.2.6 Areas of Analysis

The locations where specific military expended materials would be used are discussed under each stressor in Section 3.1.3 (Environmental Consequences).

3.1.2 Affected Environment

The affected environment includes sediments and water quality within the Study Area, from nearshore areas to the open ocean and deep sea bottom. Existing sediment conditions are discussed first, and water quality is discussed thereafter.

3.1.2.1 Sediments

The following subsections discuss sediments in the Study Area.

3.1.2.1.1 Marine Sediments

In support of the *EIS for the Designation of an Ocean Dredged Material Disposal Site Offshore of Guam* (U.S. Environmental Protection Agency 2010a), extensive sediment studies were conducted at two alternative disposal sites that begin approximately 12.4 nm north and 8.9 nm northwest of the entrance to Naval Base Guam Apra Harbor, and at a proposed reference site (required for Tier III testing in accordance with the Marine Protection, Research, and Sanctuaries Act) located inshore of the two alternative sites. Alternative sites and the inshore reference site are located in the MITT Study Area, and were selected to avoid navigation lanes, military use areas, marine protected areas, important fishing areas (including fish aggregating devices), and other environmental constraints. Information presented in the following paragraphs provides a summary of these studies as some indication of sediment characteristics and good sediment quality in the Study Area.

Sediments in all three locations were found to consist of sand, silt, and clay (no gravel) in that order of dominance and with slightly varying distribution. Sediment samples from the northwest alternative site were finer than those from the north alternative site, which is attributed to the contrast in seafloor location of these sites. The northwest site is located on the southeastern slope of a seamount, whereas the north site is located in a depression between seamounts.

Concentrations of total organic carbon, nitrogen, sulfides and solids in the sediments at all three locations were low, although total organic carbon concentrations at the reference location were more than twice as high at the alternative sites most likely because the reference location is closer to shore. Nitrogen concentrations were found to be approximately two orders of magnitude lower than the biologically toxic concentration of 30 parts per million (ppm) in sediment samples from all three locations. Sulfides ranged from 175 to 200 ppm and percent solids averaged about 55 percent in sediment samples from all three locations.

Analyses for 23 metals were conducted on sediment samples from all three locations. Cadmium, zinc, mercury, arsenic, chromium, lead, and silver concentrations at all three locations were below the Effects Range Low value when compared to central Pacific Ocean sediment data collected at comparable depths with similar bathymetric features.[2] Sediment metal analyses resulted in average copper concentrations slightly exceeding the Effects Range Low but at concentrations well below the Effects Range Median, and average nickel concentrations were approximately two times the Effects Range Low, but slightly less than the Effects Range Median for sediment samples from all three locations.

[2] Sediment quality criteria, as defined by the National Oceanic and Atmospheric Administration, are based on extensive sediment toxicity test data. The lower 10th percentile of these concentrations that were labeled as toxic is the Effects Range Low. Concentrations below the Effects Range Low are within the defined "no effects range." The Effects Range Median is the median concentration of the sediment test results labeled as toxic. Concentrations between the Effects Range Low and Effects Range Median are within the defined "possible effects range," and concentrations above the Effects Range Median are defined as the "probable effects range."

Sediment metal concentrations for barium, cobalt, copper, lead, manganese, nickel, titanium, vanadium and zinc were below the average concentrations in oceanic crustal material. Average aluminum concentrations were an order of magnitude greater, while average chromium concentrations were more than double the oceanic crustal concentrations measured in the central Pacific Ocean.

Polycyclic aromatic hydrocarbons, organochlorine pesticides, and polychlorinated biphenyls were also analyzed in the sediment samples. Because of its chemical affinity for lipids, polycyclic aromatic hydrocarbons in the marine environment are found primarily in carbon rich sediments. Unlike polycyclic aromatic hydrocarbons, organochlorine pesticides and polychlorinated biphenyls are solely human-related in origin. Organochlorine pesticides and polychlorinated biphenyls were not detected in sediment samples from all locations. In the north site and inshore reference study areas, polycyclic aromatic hydrocarbons were detected in very low concentrations.

Organotins, which have no known natural sources and are assumed to have only human-related origins, were analyzed in the sediment samples. None were detected in sediment samples from all three locations.

Dioxins and furans, which are byproducts of combustion and chemical processes involving chlorine and that can also result from natural processes such as volcanic eruptions and forest fires, were analyzed in the sediment samples. It should be noted that the Study Area contains a number of active volcanoes, including the submerged volcanic areas of the Mariana Trench Marine National Monument. Dioxins and furans were detected in low concentrations in sediment samples from all three locations.

Apra Harbor is a natural harbor, protected by Orote Peninsula on the south and Cabras Island on the north. Development of Naval Base Guam Apra Harbor following World War II required sediment dredging. Historical construction dredging occurred in Inner Apra Harbor in the late 1940s and between 1962 and 1964. Initial deepening of Inner Apra Harbor and development of the Naval Base was conducted between 1946 and 1950 with design depths of -32 ft. (-10 m) mean lower low water. Between 1962 and 1964, a construction dredging project increased water depths of the northern half of Inner Apra Harbor to -35 ft. (-11 m) mean lower low water. Approximately 64,000 cubic yards (49,390 cubic meters) of sediment was likely dredged and placed upland between 1962 and 1964. Historical maintenance dredging occurred in Inner Apra Harbor in 1978 and 2003 and one maintenance dredging project was conducted in Outer Apra Harbor between 1997 and 1998. Between 1997 and 1998, sediment was dredged along Delta and Echo Fuel Piers in Outer Apra Harbor. In 2003, maintenance dredging of Inner Apra Harbor was conducted after a 25-year hiatus (U.S. Department of the Navy 2006b). See Figure 2.1-5 for Naval Base Guam Apra Harbor locations.

Guam's Commercial Port is on Cabras Island. The Port Authority of Guam, which administers the Commercial Port, Agana Boat Basin, and the Agat Marina, has not conducted any dredging projects over the past 30 years (U.S. Department of the Navy 2006b). Historical dredging only occurred at the Agat Marina during its construction in 1992 (U.S. Department of the Navy 2006b).

3.1.2.1.2 Marine Debris, Military Expended Materials, and Sediments

In this discussion, marine debris and marine litter are synonymous. As defined by the United Nations, marine litter is any persistent, manufactured, or processed solid material discarded, disposed of, or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; or accidentally lost, including material lost at sea in bad weather (United Nations Environment Programme 2011). The main sea/ocean-based sources of marine litter are: (1) merchant shipping, ferries, and cruise liners; (2) fishing vessels; (3) military fleets and research vessels; (4) pleasure craft; (5) offshore oil and gas platforms; and (6) fish farming installations (United Nations Environment Programme 2011).

Because of their buoyancy, many types of plastic float and may travel thousands of miles in the ocean (U.S. Commission on Ocean Policy 2004). Many plastics remain in the water column, so additional discussion of marine debris is provided in Section 3.1.2.2.1 (Marine Debris and Water Quality). Although plastics are resistant to degradation, they do gradually break down into smaller particles because of sunlight and mechanical wear (Law et al. 2010). Thompson et al. (2004) found that microscopic particles were common in marine sediments at 18 beaches around the United Kingdom. They noted that such particles were ingested by small filter and deposit feeders, with unknown effects. The fate of plastics that sink beyond the continental shelf is largely unknown. However, analysis of debris in the center of an area near Bermuda with a high concentration of plastic debris on the surface showed no evidence of plastic as a substantial contributor to debris sinking at depths of 1,650–10,500 ft. (503–3,200 m) (Law et al. 2010). Marine microbes and fungi are known to degrade biologically produced polyesters, such as polyhydroxyalkanoates, a bacterial carbon and energy source (Doi et al. 1992) as well as other synthetic polymers, although the latter occurs more slowly (Shah et al. 2008).

During the 2010 International Coastal Cleanup sponsored by the Ocean Conservancy and conducted on September 25, 2010, marine litter collected along the shores and ocean/waterways near Guam totaled 17,987 pounds (lb.) (8,159 kilograms [kg]). In the Commonwealth of the Northern Mariana Islands (CNMI), collected marine litter along shores and ocean/waterways near Saipan, Tinian, and Rota totaled 5,147 lb. (2,335 kg); 2,572 lb. (1,167 kg); and 999 lb. (453 kg), respectively. A review of the data from the cleanup shows that items collected from underwater cleanups using certified scuba divers in the waters off of Guam and the CNMI included, among other things, rope, fishing line, fishing nets, plastic sheeting/tarps, buoys/floats, plastic bottles, and strapping bands (Ocean Conservancy 2011). Litter collected at these sites originated from ocean-based as well as land-based sources.

There are no readily available data regarding military expended materials in the Study Area. Keller et al. (2010) conducted a survey of marine litter collected from the seafloor off the coasts of Washington, Oregon, and California during annual groundfish surveys in 2007 and 2008, which included the Navy's west coast training complexes. Depth of trawling ranged from 180 to 4,200 ft. (55 to 1,280 m) and marine litter was recovered in 469 tows. Categories of marine litter collected included plastic, metal, glass, fabric and fiber, rubber, fishing, and others. Plastic and metallic litter occurred in the greatest number of hauls, followed by fabric and glass. Data regarding military materials as a component of materials recovered are provided in Table 3.1-2.

Table 3.1-2: Military Materials as Components of Materials Recovered on the West Coast, United States, 2007–2008

Category	Count	Percent of Total Count	Weight (lb.)	Percent of Total Weight
Plastic	29	7.4	62.3 (28.3 kg)	5.8
Metal	37	6.2	926.6 (420.3 kg)	42.7
Fabric, Fiber	34	13.2	51.4 (23.3 kg)	6.7
Rubber	3	4.7	32.8 (14.9 kg)	6.8

Notes: kg = kilograms, lb. = pounds
Source: Keller et al. 2010

3.1.2.1.3 Climate Change and Sediments

Aspects of climate change that influence sediments include increasing ocean acidity (pH), increasing sea surface water temperatures, and increasing storm activity. Breitbarth et al. (2010) referred to seawater temperature and pH as "master variables for chemical and biological processes," and noted that effects of changes on trace metal biogeochemistry "may be multifaceted and complex." Under more acidic conditions, metals tend to dissociate from particles to which they are bound in sediments, becoming more soluble and potentially more available.

As noted in the beginning of this section, tropical storms can have significant impacts on the resuspension and distribution of bottom sediments (Wren and Leonard 2005). If storm frequency and intensity increase from climate change, the additional disturbance of marine sediment may adversely impact water quality in nearshore and coastal areas. However, no consensus seems to exist as to whether there will be more tropical storms or whether those storms will be more intense. If storm frequency and intensity increase, the additional disturbance of sediments may negatively impact water quality in nearshore and coastal areas. This issue is addressed in more detail in Section 3.1.2.2.1 (Marine Debris and Water Quality).

3.1.2.2 Water Quality

Data on quality of surface waters are reported by the states to the U.S. EPA and are summarized in the Water Quality Assessment and Total Maximum Daily Loads Information database for waters listed under Section 303(d) of the Clean Water Act. The database includes information on rivers and streams; lakes, reservoirs and ponds; bays and estuaries; coastal shoreline; and wetlands. Only a small portion of the waters in and around Guam and the CNMI have been assessed and the summary presented here only relates to marine waters.

Forty-two percent of the assessed 4 percent of bays and estuaries and all (100 percent) of the assessed 14 percent of coastal shoreline in Guam were determined to be impaired as defined under Section 303(d) of the Clean Water Act. In bays and estuaries, the causes of impairment were determined to be polychlorinated biphenyls (as determined in fish tissue), pesticides, toxic organics and inorganics, metals (other than mercury), nutrients (nitrates), oxygen depletion, pathogens (*Enterococcus* bacteria), and dioxins. In coastal shoreline waters, the causes of impairment were identified to be pathogens (*Enterococcus* bacteria) and polychlorinated biphenyls.

Of the 225.3 miles (mi.) (362.6 kilometers [km]) of coastal shoreline waters assessed in the CNMI, 84.9 mi. (136.6 km) or 36 percent of the assessed coastal shoreline were determined to be impaired.

The causes of impaired coastal shoreline waters in the CNMI were determined to be nutrients (phosphate), pathogens (*Enterococcus* bacteria), oxygen depletion, and impaired biota.

The National Coastal Condition Reports describe the ecological and environmental conditions in U.S. coastal waters. Preparation of these reports represents a coordinated effort among the U.S. EPA, the National Oceanic and Atmospheric Administration, the U.S. Geological Survey, the U.S. Fish and Wildlife Service (USFWS), coastal states, and the National Estuary Programs. The draft National Coastal Condition Report IV reports on data collected from 2003 to 2006 and for the first time includes information on Guam, but not for the CNMI. The report relies heavily on coastal monitoring data from the U.S. EPA's National Coastal Assessment to assess coastal condition by evaluating five indices of condition—water quality, sediment quality, benthic community condition, coastal habitat loss, and fish tissue contaminants. The overall condition of coastal waters in Guam was rated "good" as shown in the National Coastal Condition Report IV factsheet (United Nations Environment Programme 2011).

In addition to the sediment studies conducted to support the *EIS for the Designation of an Ocean Dredged Material Disposal Site Offshore of Guam* (U.S. Environmental Protection Agency 2010a), water column characterization as well as chemical analysis of marine waters at the two alternative disposal sites and at the proposed reference site were conducted. The following paragraphs provide a summary of the information presented in this EIS/OEIS.

Water column characteristics, including temperature, salinity, transmissivity (the rate at which water is transmitted through a unit of the water column), turbidity and dissolved oxygen, measured across the entire study region were consistent with each other and followed oceanographic trends typical for tropical latitudes. Temperature remained relatively constant at around 82.8 degrees Fahrenheit (°F) (28.2 degrees Celsius [°C]) in the surface layer, decreased rapidly through a thermocline layer between water depths of approximately 490 to 1,310 ft. (150 to 400 m), and then steadily decreased to minimum average values of 35.6°F (2.0°C) observed near the seafloor. Salinity concentrations also remained constant in the mixed surface layer at 34.5 ppt, increased sharply near the top of the thermocline to an average value of 35.1 ppt, decreased to a minimum value near the base of the thermocline at an average concentration of 34.3 ppt, and remained relatively constant through the remainder of the water column at 34.6 ppt. Turbidity and transmissivity values were relatively constant throughout the entire water column with minor changes. Turbidity ranged from 43.5 Nephelometric Turbidity Units (NTU) to 44.9 NTU in surface waters, 42.1 NTU to 43.3 NTU just below the thermocline, and 43.5 NTU to 44.9 NTU near the seafloor. Transmissivity values ranged from 84.5 to 85.2 percent in surface waters. Dissolved oxygen concentrations in surface waters averaged approximately 5.98 mg/L; 2.21 mg/L at a depth of 1,800 ft. (549 m); and from 3.66 mg/L to 3.92 mg/L near the seafloor.

In general, chemical characteristics of water samples from the two alternative sites and the reference site were similar. Very few chlorinated pesticides or polyaromatic hydrocarbons were detected in any of the water samples. Concentrations of all chlorinated pesticides, including polychlorinated biphenyls, were not detected at each depth interval, except in one bottom water sample collected at a station at the northwest alternative site. At this station, 4,4'-DDT was detected at an estimated concentration of 4.8 nanograms/L (ng/L). Polyaromatic hydrocarbons analyzed from water samples were not detected except for naphthalene, 2-methylnaphthalene, 1-methylnaphthalene and perylene. Naphthalene was found at all three locations at maximum concentrations five orders of magnitude below the Criterion Maximum Concentration for naphthalene. The analyte 2-methylnaphthalene was detected in very low concentrations in the bottom sample from the north alternative site and the sample from the top of the thermocline at the northwest alternative site. The analyte 1-methylnapththalene was detected only in the surface sample from the north alternative site at a concentration of 1.5 ng/L. Perylene was detected in samples taken at the top of the thermocline from the northwest alternative site and the reference site at estimated concentrations below the 5 ng/L Maximum Residue Limit for perylene. With the exception of perylene, the polyaromatic hydrocarbons detected in the water samples may have been attributable to the proximity of the designated smoking area on board the sampling vessel to the deployment and retrieval area of the water samplers.

At the two alternative sites, nutrients tended to increase in concentration with increasing water depth, whereas total organic carbon tended to decrease in concentration with increasing water depth. Ammonia ranged from non-detectable levels at the surface to 0.03 mg/L near the bottom at the north alternative site, but was not detected at the surface and near the bottom at the northwest alternative site. Nitrate concentrations ranged from non-detectable levels in the surface sample to an average concentration of 0.5 mg/L in the near bottom sample. Dissolved orthophosphate concentrations ranged from non-detectable levels at the surface to a maximum concentration of 0.08 mg/L in the near bottom sample. Total organic carbon concentrations ranged from 0.4 to 0.6 mg/L in the surface sample to an estimated value of 0.1 mg/L in the near bottom sample.

At the reference site, ammonia was not detected in any of the depth specific samples. Nitrate concentration ranged from non-detectable levels in the surface to 0.33 mg/L in the near bottom sample. Dissolved orthophosphate concentrations ranged from non-detectable levels at the surface to 0.07 mg/L in the near bottom sample. Total organic carbon concentrations ranged from 0.4 mg/L in the surface to an estimated concentration of 0.1 mg/L in the near bottom sample.

Metals concentrations were relatively low compared to Criterion Continuous Concentration and Criterion Maximum Concentration values and were within the same order of magnitude of other deep ocean reference site samples. (Note: The Criterion Continuous Concentration is also known as the “chronic” aquatic life ambient water quality criterion. These criteria use toxicity tests from the same types of aquatic life used for acute toxicity testing, but these tests measure effects on long-term survival, growth, and reproduction of marine/estuarine aquatic life. Chronic criteria represent the highest four-day average concentration that should not result in unacceptable toxicity during a long time event. The Criterion Maximum Concentration is also known as the “acute” aquatic life ambient water quality criterion. These criteria use toxicity tests from eight different taxonomic families of marine/estuarine aquatic life in which mortality or immobility was the test endpoint. Acute criteria represent the highest one-hour average concentration that should not result in unacceptable effects on aquatic organisms.) All the dissolved metals concentrations were one to three orders below their respective Criterion Continuous Concentration values.

3.1.2.2.1 Marine Debris and Water Quality

The National Marine Debris Monitoring Program developed three categories of marine debris for its study of the extent of man-made materials in the oceans: land-based, ocean-based, and general (i.e., origin unspecified; Sheavly 2007). Land-based debris may blow in on the wind, wash in with storm water, arise from recreational use of coastal areas, and be generated by extreme weather such as hurricanes. Ocean sources of marine debris include commercial shipping and fishing, private boating, offshore mining and extraction, and legal and illegal dumping at sea. Ocean current patterns, weather and tides, and proximity to urban centers, industrial and recreational areas, shipping lanes, and fishing grounds influence the types and amount of debris found (Sheavly 2010). These materials are concentrated at the surface and in the water column.

Teuten et al. (2007) found that water-borne phenanthrene (a type of polycyclic aromatic hydrocarbon) adhered preferentially to small pieces of plastic that were ingested by a bottom-dwelling marine lugworm and incorporated into its tissue. Plastics also may transport various pollutants, whether through adsorption from seawater or from the constituents of the plastics themselves. Mato et al. (2001) noted that polypropylene resin pellets—precursors to certain manufactured plastics—collected from sites in Japan contained PCBs, dichlorodiphenyldichloroethylene (a breakdown product of DDT), and nonylphenol, a persistent organic pollutant that is a precursor to certain detergents. PCBs and DDT were adsorbed from seawater. The original source of nonylphenol is less clear; nonylphenol may have come from the pellets themselves or may have been adsorbed from the seawater.

3.1.2.2.2 Climate Change and Water Quality

Aspects of climate change that influence water quality include decreasing ocean pH (i.e., more acidic), increasing water temperatures, and increasing storm activity. Changes in pH outside the normal range can make it difficult for marine organisms with shells to maintain their shells (Fabry et al. 2008). Many of those creatures are at the base of the marine food chain, such as phytoplankton, so changes may reverberate through the ecosystem. Rising water temperatures can be detrimental to coastal ecosystems. For example, in waters warmer than normal, coral colonies appear to turn white (“bleaching”) because they expel symbiotic microbes (zooxanthellae) that give them some of their colors. These microbes are important for coral survival because they provide the coral with food and oxygen, while the coral provides shelter, nutrients, and carbon dioxide. Rising seawater temperatures combined with decreasing ocean pH can be especially detrimental to corals (Anthony et al. 2008). Water pollution and natural disturbance (e.g., hurricanes) can inflict additional stress on corals (Hughes and Connell 1999).

3.1.3 ENVIRONMENTAL CONSEQUENCES

This section evaluates how and to what degree the training and testing activities described in Chapter 2 (Description of Proposed Action and Alternatives) may impact sediments and water quality in the Study Area. Tables 2.8-1 through 2.8-4 present the baseline and proposed training and testing activity locations for each alternative (including number of events and ordnance expended). Each water quality stressor is introduced, analyzed by alternative, and analyzed for training and testing activities. Potential impacts could be from:

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

These potential impacts may result from four stressors: (1) explosives and explosive byproducts, (2) metals, (3) chemicals other than explosives, and (4) a miscellaneous category of other materials. The term “stressor” is used because materials in these four categories may directly impact sediment and water quality by altering their physical and chemical characteristics. The specific analysis of the training and testing activities presented in this section considers the relevant components and associated data within the geographic location of the activity (see Tables 2.8-1 and 2.8-2) and the resource.

In a previous study of the impact of amphibious landings on corals at Unai Chulu in Tinian during Tandem Thrust 1999, it was observed that sediment plumes were generated in the track of the amphibious vehicles. The plumes remained localized in the track area, dissipated within minutes, and were not qualitatively different from episodes of sediment resuspension during periods of storm-generated waves that occur routinely on Tinian (Marine Research Consultants 1999). Amphibious assault and amphibious raid training do not involve the introduction of military expended materials into the water, therefore, no further analysis of this training activity is provided here.

The potential impact of domestic wastewater was not analyzed as no additional DoD facilities to house temporary military personnel that would train in the Study Area would be constructed as part of the Proposed Action. Training activities on land-based ranges (with the exception of training activities on Farallon de Medinilla [FDM]) would remain at or slightly above existing levels and have been analyzed in the Mariana Islands Range Complex EIS/OEIS. Only the potential impact of runoff to surface drainage areas of FDM is analyzed in this EIS.

Because of the expansive area of the Study Area, recovery of any hazardous military expended materials is unlikely, except in confined shore- and land-based training areas. The Navy has defined best management practices and committed to mitigation measures to offset potential impacts from military training to sediment and water quality in the Study Area.

3.1.3.1 Explosives and Explosive Byproducts

3.1.3.1.1 Introduction

Explosives are complex chemical mixtures that may affect sediment and water quality as a result of byproducts left in the water and distribution of unconsumed byproducts in the sediment. Explosives that detonate on land could contaminate and loosen soils and subsequently get transported into surface drainage areas or nearshore waters. It should be noted that FDM is highly susceptible to natural causes of erosion because it is comprised of highly weathered limestone overlain by a thin layer of clay soil. Sediments entering the nearshore environment as a result of natural processes or explosives 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 Navy minimizes the potential for soil transport and, thus, water quality impacts.

Underwater explosions resuspend sediments in the water column. However, these impacts are minimal because, depending on site-specific conditions of wind and tidal currents, the sediment plume eventually dissipates as particles settle to the bottom or disperse. Therefore, this issue is not considered further.

The Proposed Action involves three categories of explosives:

- Nitroaromatics, such as trinitrotoluene (TNT), ammonium picrate, and tetryl (methyl-2,4,6-trinitrophenyl-nitramine);
- Nitramines, such as royal demolition explosive (hexahydro-1,3,5-trinitro-1,3,5-triazine) and high melting explosive (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine); and
- Nitrate esters, such as pentaerythritol tetranitrate.

The explosives TNT, royal demolition explosive, and high melting explosive are components of bombs, missile and rocket fuels, warheads, torpedoes, sonobuoys, medium- and large-caliber munitions, and charges used in a variety of training and testing activities, such as mine countermeasure and mine neutralization (Clausen et al. 2007). Pentaerythritol tetranitrate is most commonly used in blasting caps, detonation cord, and other initiators of explosions. Chemical stressors other than explosives are discussed in Section 3.1.3.3 (Chemicals Other Than Explosives).

When they are used, explosives may undergo high-order detonation, a low-order detonation, or may fail to detonate. High-order ("complete") detonations consume 98 to 99 percent of the explosive; the remainder is released into the environment as discrete particles. Low-order ("incomplete") detonations consume a lower percentage of the explosive and release larger amounts of explosives into the environment. If ordnance fails to detonate, the energetic materials it contains may be released to the environment over time as its casing corrodes. In this discussion, the term "explosives" means unconsumed explosives remaining after low-order detonations and detonation failures. The term "explosive byproducts" is used to refer to the liquids and gases that remain after detonation of explosives.

Explosions that occur above or at the surface are assumed to distribute nearly all explosive byproducts into the air, rather than into the water and are discussed in Section 3.2 (Air Quality). This analysis concerns only those explosions that occur underwater. However, military expended materials that explode in the air or at the water surface may deposit particles of unconsumed explosives in the marine environment. These materials are addressed in the next section on unconsumed explosives.

3.1.3.1.2 Background

Under the Proposed Action, explosives would be used: (1) above, at, or just beneath the water surface during training and testing activities that use bombs, medium- and large-caliber projectiles, missiles, and rockets; (2) underwater during mine countermeasure and mine neutralization training and testing activities and from training and testing activities that use explosive sonobuoys; and (3) on land (at FDM) during weapons firing. Mine countermeasure and neutralization activities occur beneath the surface and on or near the bottom, typically in fairly shallow areas. Explosive charges for training and testing activities range in size from 2 to 20 lb. (1 to 9 kg) net explosive weight (NEW).

Mine countermeasure and mine neutralization activities most often involve the explosive Composition 4 (C-4), which is composed of about 95 percent royal demolition explosive mixed with polyisobutylene, a plastic binding material. When it functions properly (i.e., complete detonation), 99.997 percent of the explosive is converted to inorganic compounds (Renner and Short 1980; Hewitt et al. 2003). Table 3.1-3 details the byproducts of underwater detonation (UNDET) of royal demolition explosive.

Table 3.1-3: Byproducts of Underwater Detonation of Royal Demolition Explosive

Byproduct	Percent of Total, by Weight	Byproducts	Percent of Total, by Weight
Nitrogen	37.0	Propane	0.2
Carbon dioxide	24.9	Methane	0.2
Water	16.4	Hydrogen cyanide	< 0.01
Carbon monoxide	18.4	Methyl alcohol	< 0.01
Ethane	1.6	Formaldehyde	< 0.01
Ammonia	0.9	Other compounds	< 0.01
Hydrogen	0.3		

Note: "<" means less than

3.1.3.1.3 Ordnance Failure and Low-Order Detonations

Table 3.1-4 provides information about the rates of failure and low-order detonations for explosives and other munitions.

Table 3.1-4: 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 et al. 2005; U.S. Army Corps of Engineers 2007

3.1.3.1.4 Approach to Analysis

Most activities involving explosives and explosive byproducts would be conducted more than 3 nm off shore in the Study Area. Out to 12 nm, these activities would be subject to federal sediment and water quality standards and guidelines.[3]

Explosives are also used onshore and in nearshore areas (low tide line to 3 nm) specifically designated for mine countermeasure and mine neutralization activities. These activities would be subject to state sediment and water quality standards and guidelines.

For explosive byproducts, "local" means the water column that is disturbed by an UNDET. For unconsumed explosives, "local" means the area of potential impact from explosives in a zone of sediment about 66 in. (167.6 cm) in diameter around the ordnance or unconsumed explosive where it settles on the sea floor.

3.1.3.1.4.1 State Standards and Guidelines

There are no existing Guam and CNMI standards and guidelines for sediments and water quality related to explosives and explosive byproducts.

3.1.3.1.4.2 Federal Standards and Guidelines

Table 3.1-5 summarizes the EPA criteria for explosives and explosive byproducts in saltwater.

Table 3.1-5: Federal Criteria for Explosives and Explosive Byproducts in Saltwater

Explosives, Explosive Byproducts	Criterion Maximum Concentration (µg/L)	Criterion Continuous Concentration (µg/L)
Cyanide	1	1

Notes: (1) "Criteria maximum concentration" is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. "Criterion continuous concentration" is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect; (2) µg/L = micrograms per liter
Source: U.S. Environmental Protection Agency 2009

[3] Proposed training and testing activities also occur beyond 200 nm, but U.S. legal and regulatory authority does not extend beyond 200 nm. In such cases, impacts will be evaluated against federal standards and guidelines.

3.1.3.1.5 Fate of Military Munitions in the Marine Environment

3.1.3.1.5.1 Explosives and Explosive Byproducts

Little data are available on the fate and degradation of unconsumed explosives in sediments (Zhao et al. 2004b). Cruz-Uribe et al. (2007) noted that "contamination of the marine environment by munitions constituents is not well documented," and Montgomery et al. (2008) noted there is "little published information on TNT degradation in seawater or sediments aside from the work of Carr and Nipper (2003)." Still, Zhao et al. (2004b) noted that leaching of unconsumed explosives is considered a major source of sediment contamination in seas and waterways, and that contaminants can subsequently move from sediments and accumulate in aquatic organisms. According to Nipper et al. (2002), their studies of Puget Sound sediments demonstrate "that the studied ordnance compounds were not a cause for environmental concern in the levels previously measured in sediments." The studied compounds included 2, 6-dinitrotoluene, tetryl, and picric acid. They remarked that "levels of ordnance compounds that would be of concern in sediments have not yet been identified."

The behavior of explosives and explosive byproducts in marine environments and the extent to which those constituents have adverse impacts are influenced by numerous processes, including the ease with which the explosive dissolves in a liquid such as water (solubility), the degree to which explosives are attracted to other materials in the water (e.g., clay-sized particles and organic matter, "sorption"), and the tendency of the explosives to evaporate (volatilization). These characteristics, in turn, influence the extent to which the material is subject to biotic (biological) and abiotic (physical and chemical) transformation and degradation (Pennington and Brannon 2002). The solubility of various explosives is provided in Table 3.1-6. In the table, higher values indicate greater solubility. For example, high melting explosive is virtually insoluble in water. Table salt, which dissolves easily in water, is included in the table for comparison.

Table 3.1-6: Water Solubility of Common Explosives and Explosive Degradation Products

Compound[1]	Water Solubility[2]
Table salt (sodium chloride)	357,000
Ammonium perchlorate (D)	249,000
Picric acid (E)	12,820
Nitrobenzene (D)	1,900
Dinitrobenzene (E)	500
Trinitrobenzene (E)	335
Dinitrotoluene (D)	160–161
TNT (E)	130
Tetryl (E)	51
Pentaerythritol tetranitrate (E)	43
Royal demolition explosive (E)	38
High melting explosive (E)	7

[1] "E" refers to explosive; "D" refers to explosive degradation product.
[2] Units are milligrams per liter at 20 degrees Celsius.
Source: U.S. Department of the Navy and U.S. Fleet Forces Command 2008

Solubility rates are not affected by pH but increase as temperature increases (Lynch et al. 2002). As Table 3.1-6 indicates, explosives associated with the Proposed Action dissolve slowly over time and thus are not very mobile in marine environments (Juhasz and Naidu 2007). Nitroaromatics such as TNT do not bind to metal hydroxides but may bind to clays, depending on the type (more so with potassium or ammonium ions but negligible for clays with sodium, calcium, magnesium, and aluminum ions). Sorption by nitroamines such as royal demolition explosive is very low (Haderlein et al. 1996).

According to Walker et al. (2006), TNT, royal demolition explosive, and high melting explosive experience rapid biological and photochemical degradation in marine systems. The authors 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. Juhasz and Naidu (2007) also noted that microbes use explosives as sources of carbon and energy.

Carr and Nipper (2003) indicated that conversion of TNT to carbon dioxide, methane, and nitrates in coastal sediments (a process referred to as "mineralization") occurred at rates that were typical for naturally occurring compounds such as phenanthrene, fluoranthene, toluene, and naphthalene. They noted that transformation of 2, 6-dinitrotoluene and picric acid by organisms in sediments is dependent on temperature and type of sediments (i.e., finer-grained). Pavlostathis and Jackson (2002) reported the uptake and metabolism of TNT by the marine microalgae *Anabaena* sp. Nipper et al. (2002) noted that enhanced degradation of 2,6-dinitrotoluene, tetryl, and picric acid occurred in fine-grained sediments high in organic carbon. Cruz-Uribe et al. (2007) noted that three species of marine macroalgae metabolize TNT to 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene, and they speculate that "the ability of marine macroalgae to metabolize TNT is widespread, if not generic."

Singh et al. (2009) indicated that biodegradation of royal demolition explosive and high melting explosive occurs with oxygen (aerobic) and without oxygen (anoxic or anaerobic), but that they were more easily degraded under anaerobic conditions. Crocker et al. (2006) indicated that the mechanisms of high melting explosive and royal demolition explosive biodegradation are similar, but that high melting explosive degrades more slowly. Singh et al. (2009) noted that royal demolition explosive and high melting explosive are biodegraded under a variety of anaerobic conditions by specific microbial species and by mixtures ("consortia") of such species. Zhao et al. (2004a) found that biodegradation of royal demolition explosive and high melting explosive occurs in cold marine sediments.

According to Singh et al. (2009), typical end products of royal demolition explosive degradation include nitrite, nitrous oxide, nitrogen, ammonia, formaldehyde, formic acid, and carbon dioxide. Crocker et al. (2006) stated that many of the primary and secondary intermediate compounds from biodegradation of royal demolition explosive and high melting explosive are unstable in water and spontaneously decompose. Thus, these explosives are degraded by a combination of biotic and abiotic reactions. Formaldehyde is subsequently metabolized to formic acid, methanol, carbon dioxide, or methane by various microorganisms (Crocker et al. 2006).

According to Juhasz and Naidu (2007), TNT, royal demolition explosive, and high melting explosive also degrade from photolysis (exposure to light) and hydrolysis (exposure to water). The byproducts of TNT photolysis include nitrobenzenes, benzaldehydes, azoxydicarboxylic acids, and nitrophenols. The byproducts of royal demolition explosive and high melting explosive photolysis include azoxy compounds, ammonia, formaldehyde, nitrate, nitrite, nitrous oxide, and *N*-nitroso-methylenediamine (Juhasz and Naidu 2007). Walker et al. (2006) speculated that degradation of TNT "below the photic (light) zone in coastal waters and sediments may be largely controlled by metabolism by heterotrophic bacteria." According to Monteil-Rivera et al. (2008), at the pH common in marine environments (i.e., pH of 8), there should be a "slow but significant removal" of royal demolition explosive and high melting explosive through alkaline hydrolysis. Under such conditions, and absent biodegradation, royal demolition explosive would take over 100 years to hydrolyze, while high melting explosive would require more than 2,100 years (Monteil-Rivera et al. 2008).

3.1.3.1.5.2 Unexploded Ordnance

Most studies of unexploded ordnance in marine environments have not detected explosives or have detected them in the range of parts per billion (ppb). Studies examining the impact of ordnance on marine organisms have produced mixed results. More information regarding these studies is provided below. The amount and concentration of ordnance deposited in the areas studied, however, were far in excess of those that would occur under the Proposed Action.

Several authors have studied the impact of unexploded ordnance in Halifax Harbor, Nova Scotia, Canada. Rodacy et al. (2000) noted that munitions explosions in 1917 and 1946 scattered ordnance across an area known as the Bedford Basin. Ordnance was both fully exposed on and partially buried in the sea floor. They reported that 34 of 59 water samples (58 percent) "produced detectable signatures" of ordnance, as did 26 of 27 sediment samples (96 percent). They also noted that marine growth was observed on most of the exposed ordnance, and that TNT metabolites were present and suspected as the result of biological decomposition. In a prior study (Darrach et al. 1998), sediments collected near unexploded, but broken, ordnance did not indicate the presence of TNT, but samples near ordnance targets that appeared intact showed trace explosives in the range of low ppb or high parts per trillion. The sampling distance was 6–12 in. (15–30 cm) from the munitions. The authors expressed the opinion that, after 50 years, the contents of broken munitions had dissolved, reacted, biodegraded, or photodegraded, and that intact munitions appear to be slowly releasing their contents through corrosion pinholes or screw threads. Studies by Zhao et al. (2004a) in Halifax Harbor documented the biodegradation of royal demolition explosive and high melting explosive in cold marine sediments.

Chemical and conventional munitions disposed on the ocean floor approximately 5 mi. (8 km) south of Pearl Harbor, Hawaii, were recently studied (Hawaii Undersea Military Munitions Assessment 2010). Documents indicate that sixteen thousand 100 lb. (45 kg), mustard-filled bombs may have been disposed in this area in October through November 1944. The condition of the munitions ranged from "nearly intact to almost completely disintegrated." The authors collected 94 sediment samples and 30 water samples from 27 stations at five locations. These samples were analyzed for chemical agents, explosives, metals (arsenic, copper, lead, and zinc), polycyclic aromatic hydrocarbons, pesticides, PCBs, phenols, and organic tin. No chemical agents or explosives were detected, and comparisons between the disposal site and reference sites showed no statistically significant differences in levels of munitions constituents, chemical agents, or metals. However, the sampling distance for this project was 3–6 ft. (1–2 m). The authors compared their sampling distance to that used by Durrach et al. (1998), that is, 6–12 in. (15.2–30.5 cm). They indicated that the project sampling distance may have been too far to detect any chemical agents or explosives and that sampling distance may be a significant factor determining whether munitions constituents can be detected near discarded munitions. Samples with elevated concentration of metals relative to typical deep-sea sediments were "most likely" the result of dumping of sediments dredged from Oahu harbors.

Hoffsommer et al. (1972) analyzed seawater and ocean floor sediments and fauna for military ordnance at known ocean dumping sites. The sites were 85 mi. (137 km) west of Cape Flattery, Washington, and

172 mi. (277 km) south-southeast of Charleston, South Carolina. Samples were tested for TNT, royal demolition explosive, tetryl, and ammonium perchlorate, none of which were detected in the samples. Detection limits were in the parts per trillion. Walker et al. (2006) sampled seawater and sediments at two offshore underwater demolition sites where 10 lb. (4.5 kg) charges of TNT and royal demolition explosive were used. Seawater concentrations of both explosives were below their detection limits, including samples collected in the detonation plume within five minutes of detonation.

According to Fisheries Research Services Report (1996), over one million tons of chemical and conventional munitions were disposed of at Beaufort's Dyke, a trench in the North Channel between Scotland and Ireland. The trench is more than 30 mi. (48.3 km) long and 2 mi. (3.2 km) wide. The average density of munitions is about 2,225 tons per square mile ($mi.^2$) (5,700 tons per square kilometer [km^2]). Seabed sediment samples were obtained from 105 sites. Sampling distance from the munitions was not noted. Sediment sampling results did not find detectable concentrations of the explosives nitroglycerine, TNT, royal demolition explosive, or tetryl, and analysis of metals indicated that levels within the survey area were within the ranges reported from other Scottish coastal areas.

Nipper et al. (2002) studied the impact of the explosives 2,6-dinitrotoluene, tetryl, and picric acid in sediments in Puget Sound. They noted that the levels measured did not account for the sediment's toxicity. Test subjects and processes included small marine crustaceans (amphipods), marine segmented worms (polychaetes), macro-algae germination and growth, and sea urchin embryo development. The authors acknowledged that "persistence of such degradation compounds in marine environments is not known."

An underwater explosion deposits a fraction of the chemical products of the reaction in the water in a roughly circular surface pool that moves with the current (Young and Willey 1977). In a land-based study, Pennington et al. (2006) noted that data demonstrate that explosives in the main charge of howitzer rounds, mortar rounds, and hand grenades are efficiently consumed (on average, 99.997 percent or more) during live-fire operations that result in high-order detonations. Explosives not consumed during these detonations are spread over an area that would, on average, contribute 10 µg/kg (ppb) per detonation or less to the ground surface. However, the applicability of the study by Pennington et al. (2006) to underwater marine systems remains uncertain.

Table 3.1-7 provides (1) the amount of explosive remaining after UNDET of 5 and 20 lb. charges of C-4 and (2) the volume of water required to meet the marine screening value for the remaining amount of C-4. A 5 lb. (2.3 kg) block of C-4 contains 2.7 lb. (1.0 kg) of royal demolition explosive; a 20 lb. block contains 18.2 lb. (8.3 kg) of royal demolition explosive. Pennington et al. (2006) assumed that 0.02 percent of royal demolition explosive residue remained after detonation. The failure rate is zero for C-4 because, during mine countermeasure and mine neutralization activities, personnel do not leave any undetonated C-4 on range at the end of training.

Table 3.1-7: Volume of Water Needed to Meet Marine Screening Value for Royal Demolition Explosive

Screening Value for Ecological Marine Surface Water	5-Pound (2.26 kg) Charge		20-Pound (9 kg) Charge	
	Amount of Royal Demolition Explosive Remaining after Detonation	Attenuation Needed to Meet Screening Value	Amount of Royal Demolition Explosive Remaining after Detonation	Attenuation Needed to Meet Screening Value
5,000 µg/L	0.01 ounce (0.41 gram)	22 gallons (82.6 liters)	0.06 ounce (1.65 grams)	87 gallons (330 liters)

Notes: kg = kilograms, µg/L = micrograms per liter
Source: U.S. Department of the Navy 2010

The amount of pentaerythritol tetranitrate in detonation cord associated with any UNDET activity is low (approximately 13.4 ounces [381 grams {g}]). Assuming 5 percent is not consumed in the detonation, 0.7 ounce (19.0 g) of pentaerythritol tetranitrate would be present. This amount would attenuate to a level below the DoD Range and Munitions Use working group benchmark risk screening value for marine surface water in 60 gallons (gal.) (227.1 liters [L]) of water (U.S. Department of the Navy 2010).

3.1.3.1.5.3 Farallon de Medinilla Specific Impacts

The Navy has conducted annual marine dive surveys in waters surrounding FDM from 1999 to 2010. No survey was conducted in 2011, and the most recent survey was conducted in 2012 (U.S. Department of the Navy 2013a). The dive surveys have included marine ecologists from the National Marine Fisheries Service, USFWS, CNMI Division of Fish and Wildlife, and Navy contractors. All the surveys conducted after 2004 were performed by the Naval Facilities Engineering and Expeditionary Warfare Center Scientific Diving Services group. The Explosive Ordnance Disposal Unit Detachment Marianas provided identification of ordnance items located in waters off of FDM. Figure 3.1-1 shows the location of approximate dive survey tracks in waters surrounding FDM during the most recent dive survey, which was completed in August 2012 (U.S. Department of the Navy 2013a).

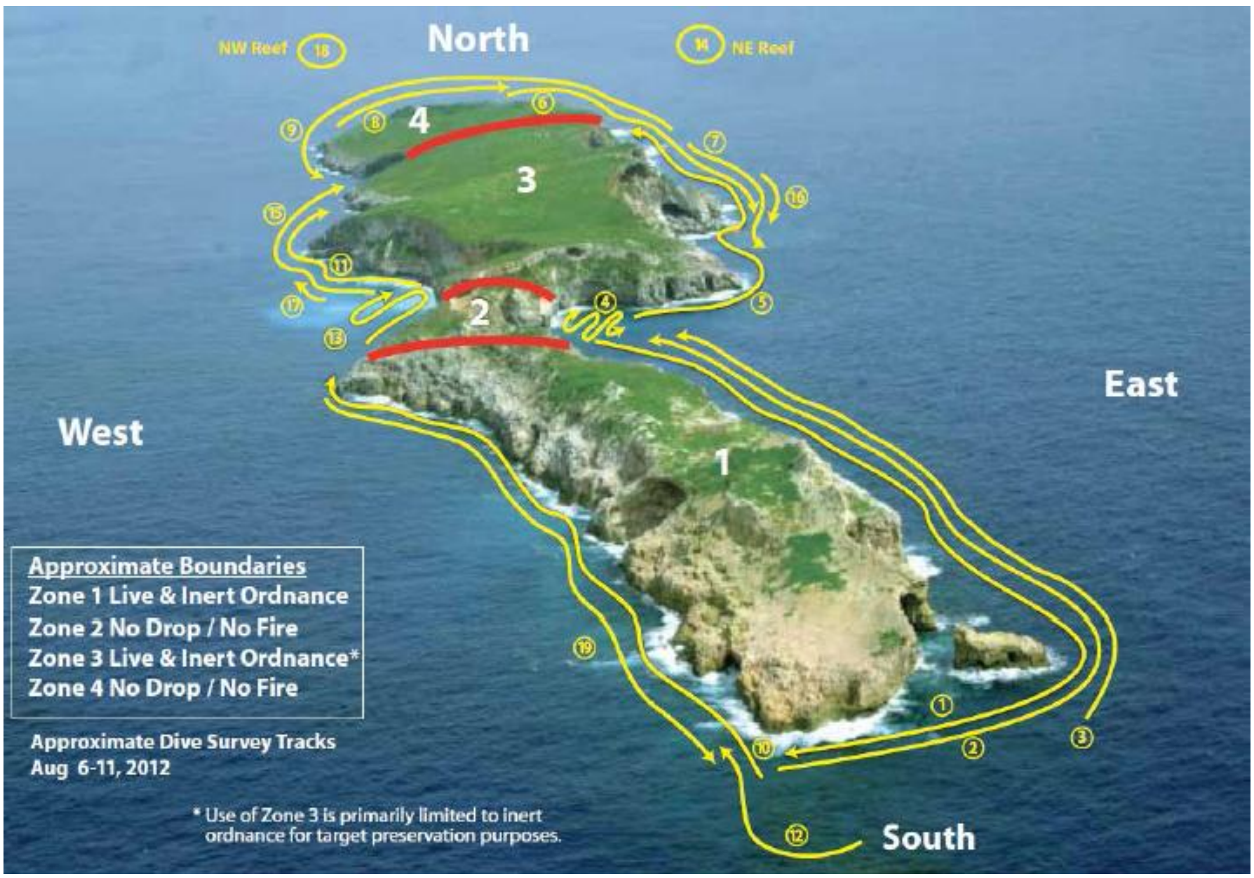

Figure 3.1-1: Location of Approximate Dive Survey Tracks off of Farallon de Medinilla (View from the South)

Based on these surveys, there is no evidence that long-term adverse impacts to the nearshore environment have taken place as a result of military training activities. These findings are based on the number of detectable impacts, the size of those impacts, and the apparent recovery time for the resource to recover. Impacts to the physical environment clearly attributable to military training activities were noted in 2007, 2008, 2010, and 2012 (U.S. Department of the Navy 2013a). 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. The 2004 report included the following conclusion (U.S. Department of the Navy 2005):

> "*Although some damage can be directly attributed to ordnance impacts, natural factors also contribute to the changes. Examination of photographs from 1944 indicates that changes in the geologic structure of the island by erosion and mass wasting…have been going on for decades.*"

The dive surveys completed in 2004 were completed shortly after Typhoon Ting Ting, which passed through the Mariana Islands in June 2004 and afforded an opportunity to observe damage to the island and nearshore environment of FDM from typhoons. Observations of fresh coral branch breakages, fresh boulder/rock slides, and submerged exposure of bright yellow-orange patches of underlying rock were attributed to concussive force of waves generated by Typhoon Ting Ting (U.S. Department of the Navy 2005).

Dive surveys completed in 2005 noted that disturbed sites in 2004 showed no color differences with surrounding undamaged areas, and new small (less than 3 cm) scattered colonies of coral and custose coralline algae. By 2006 and observed again through 2012, no visual evidence of abnormalities, damaged, or diseased coral could be detected (U.S. Department of the Navy 2013a). Further, no new submerged cliff blocks were observed between 2005 and 2012. Small to medium size fresh rock fragments (generally less than 1 ft. [30 cm]) 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 and Marx 2009). It should be noted that 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 were eroded or washed off of FDM at a later date (Smith and Marx 2009).

Based on these direct observations of damage off the coast of FDM, the majority of disturbances to the seafloor sediments, substrates, and mass wasting of FDM can be attributed to typhoons and storm surges. Further, damage attributed to military training activities recovered within 2–3 years at the same rate of damage associated with natural phenomenon.

The dive surveys have also monitored water quality indicators that have been associated with diminished water quality in other locations. 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 (Hughes and Jackson 1980, Riegl 1995, Stafford-Smith and Ormond 1992, Stafford-Smith 1993, Wild et al. 2005, Bruno 2003, Sutherland et al. 2004, and Cooper 2008). A moderate bleaching event was noted in 2007, and a barnacle infestation was noted in 2012 (U.S. Department of the Navy 2013a). The bleaching event was regional and extended from southern Japan through the Mariana Islands and south through waters surrounding Palau. Subsequent surveys observed soft and fire corals had recovered completely and 75 percent of the stony corals had recovered by 2008 (Smith and Marx 2009).

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.

3.1.3.1.6 Evaluation of Alternatives

In most instances, explosive bombs, projectiles, missiles, and rockets detonate above the surface of the water, at the water surface, or just beneath the surface. UNDETs always occur during mine countermeasure and mine neutralization training and testing, explosives testing, and during the use of explosive torpedoes, percussion grenades, and explosive sonobuoys.

The amount of explosive material in, or NEW of, each military expended material used during training and testing activities in the Study Area was identified using several resources. The amount of residual explosive material was estimated by combining the estimated amount of residual explosive materials after high-order detonations, low-order detonations, and ordnance failures.

3.1.3.1.6.1 No Action Alternative

<u>Training Activities</u>

Subsurface High-Order Explosions and Explosive Byproducts

Under the No Action Alternative, most training activities that use underwater explosives would be during mine countermeasure and neutralization training, with charges up to 10 lb. (4.5 kg). These underwater explosives would occur at Piti Point Floating Mine Neutralization Site, Apra Harbor UNDET Site (located within Outer Apra Harbor), and Agat Bay Floating Mine Neutralization Site. The impacts of explosive byproducts on sediment and water quality would be short term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

High-Order Explosions at FDM and Explosive Byproducts

Explosive ordnance is used on FDM during strike warfare exercises. The impacts of explosive byproducts on sediment and water quality on FDM and in waters surrounding FDM would be indirect, short term, local, and negative. See Section 3.1.3.1.5.3 (Farallon de Medinilla Specific Impacts) for a discussion of direct observations of impacts related to military use of FDM. Explosive ordnance could result in erosion of soil and runoff of contaminated sediments into surrounding waters. However, chemical, physical, or biological changes in the sediment or water quality would not be detectable because of rapid mineralization and dissolution of explosive byproducts in marine environments.

Unconsumed Explosives

Under the No Action Alternative, approximately 1,687 lb. (767 kg) per year of residual explosives would remain from high-explosive ordnance used during training activities because of ordnance failure and low-order detonations. Over 98 percent of residual explosive materials would result from ordnance failures. Ordnance failure rates are listed in Table 3.1-4. The amount of residual explosive materials is based on the rate of failure multiplied by the number of explosive ordnance and weight of explosives of each ordnance item expended during training activities.

In the event of an ordnance failure, the energetic materials it contains would remain intact. These materials would leach from the item slowly because they would have little or no direct exposure to marine waters. Small amounts of explosives may be released into sediment and into the surrounding water column as the ordnance item degrades and decomposes. Ocean currents would quickly disperse leached explosive constituents, and these constituents would not result in water toxicity.

Sinking exercises require the highest concentrations of high-explosive ordnance. During each sinking exercise, an estimated 440 high-explosive ordnance items would be expended, most of which would consist of large-caliber projectiles. Approximately 725 lb. (329 kg) of explosive materials would be released per sinking exercise from low-order detonations and ordnance failures. The sinking exercise training area is approximately 2 square nautical miles (nm^2) in size. Thus, during each exercise, approximately 222 items per nm^2 (64 items per km^2) and 361 lb. (164 kg) of explosive material per nm^2 (105 lb. [48 kg] of explosive material per km^2) would sink to the ocean floor.

Testing Activities

Under the No Action Alternative, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area (refer to Table 2.4-4 for a complete description). No explosives are involved with this ongoing testing activity; therefore, there are no impacts on sediments and water quality from explosives and explosive byproducts from testing under the No Action Alternative.

3.1.3.1.6.2 Alternative 1

Training Activities

Subsurface High-Order Explosions and Explosive Byproducts

Under Alternative 1, most training activities that use underwater explosives would occur during mine countermeasure and neutralization training. Charges up to 10 lb. NEW would occur at Piti Point Floating Mine Neutralization Site and Apra Harbor UNDET Site (located within Outer Apra Harbor). Charges up to 20 lb. NEW would occur at Agat Bay Floating Mine Neutralization Site. The impacts of explosive byproducts on sediment and water quality would be short term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

High-Order Explosions at FDM and Explosive Byproducts

Under Alternative 1, strike warfare training activities on FDM would include the use of explosive ordnance. The impacts of explosive byproducts on sediment and water quality would be indirect, short term, local, and negative. Explosive ordnance could loosen the soil on FDM, and runoff containing soil and explosive byproducts could contaminate sediments and the surrounding ocean water. Chemical, physical, or biological changes in sediment or water quality would not be detectable because of the rapid mineralization and dissolution of explosive byproducts in marine environments.

Unconsumed Explosives

Alternative 1 would increase the number of training activities and the amount of explosive ordnance used. The estimated amounts of associated residual explosive materials would increase to about 9,772 lb. (4,433 kg) per year. The deposition of explosive materials from sinking exercises would be the same as under the No Action Alternative. While the amount of residual explosive materials would increase by about 500 percent under Alternative 1, impacts on water quality of explosive materials would be short term and localized due to rapid degradation in water. Residual explosive materials would be limited to a small area surrounding military expended materials. Based on previous studies and the low residence time of residual explosive materials in marine sediments, residual explosive materials would have short-term, localized impacts on marine sediments under Alternative 1, similar to those under the No Action Alternative.

Testing Activities

Under Alternative 1, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area. The Navy would also conduct harpoon shots, anti-submarine warfare tracking tests (using sonobuoys), torpedo testing, broad area maritime surveillance testing (refer to Table 2.8-2), mission (ASW, MCM, and ASUW) package testing and torpedo testing (refer to Table 2.8-3) under Alternative 1. Residual explosive materials from harpoon and surface to surface missiles, sonobuoys, medium caliber explosive rounds and explosive torpedoes during testing are estimated at 1,075 lb. (775 kg) per year. A percent increase for residual explosive materials released from testing activities under Alternative 1 cannot be evaluated because these proposed testing activities are not currently conducted under the No Action Alternative. Based on the amount of residual explosive materials deposited in the Study Area, low leaching rates, and rapid degradation of explosive materials and the low residence time of residual explosive materials in marine sediments, impacts of residual explosive materials on sediments and water quality under Alternative 1 would be localized and short-term.

3.1.3.1.6.3 Alternative 2

Training Activities

Subsurface High-Order Explosions and Explosive Byproducts

Under Alternative 2, charges up to 10 lb. NEW would occur at Piti Point Floating Mine Neutralization Site and Apra Harbor UNDET Site (located within Outer Apra Harbor). Charges up to 20 lb. NEW would occur at Agat Bay Floating Mine Neutralization Site. The impacts of explosive byproducts on sediment and water quality would be short term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

High-Order Explosions at FDM and Explosive Byproducts

Under Alternative 2, strike warfare training activities on FDM would include the use of explosive ordnance. The impacts of explosive byproducts on sediment and water quality would be indirect, short term, local, and negative. Explosive ordnance could loosen the soil on FDM, and runoff containing soil and explosive byproducts could contaminate sediments and the surrounding ocean water. Chemical, physical, or biological changes in sediment or water quality would not be detectable because of the rapid mineralization and dissolution of explosive byproducts in marine environments.

Unconsumed Explosives

Alternative 2 would increase the number of training activities, which would result in an increase in the amount of explosive ordnance used, compared to the No Action Alternative and Alternative 1. The estimated associated residual explosive materials from Alternative 2 would increase from 1,687 lb. (767 kg) to about 12,141 lb. (5,507 kg) per year from the No Action Alternative. Impacts on sediments and water quality from explosive materials would be similar to those identified under the No Action Alternative and Alternative 1. Change in sediments and water quality would be undetectable because of the low solubility of explosive materials in sea water and because of dilution over a large volume of ocean.

Testing Activities

Under Alternative 2, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area. Alternative 2 would increase the number of testing activities, which would result in an increase in the amount of explosive ordnance used, compared to the No Action Alternative and Alternative 1. The estimated associated residual explosive materials would increase to about 2,009 lb. (913 kg) per year. A percent increase for residual explosive materials released from testing activities under Alternative 2 cannot be evaluated because these proposed testing activities are not currently conducted under the No Action Alternative. Based on the amount of residual explosive materials deposited in the Study Area under Alternative 2, impacts on sediments and water quality from explosive materials would be similar to those identified under Alternative 1.

3.1.3.1.6.4 Summary and Conclusions for Explosives and Explosive Byproducts

Over 98 percent of residual explosive materials would result from ordnance failures. In the event of an ordnance failure, the energetic materials it contained would remain mostly intact. The explosive materials in failed ordnance items would leach slowly because they would have little or no direct exposure to marine waters. Residual explosive materials deposited in sediments would be limited to small areas surrounding the ordnance item. Ocean currents would quickly disperse leached explosive materials in the water column, and residual explosive materials would not result in water toxicity.

Short-term impacts arise from explosive byproducts; long-term impacts arise from unconsumed explosives. Most high-order explosions occur at or above the surface of the ocean and would have no impacts on sediments and minimal impacts on water quality. Chemical, physical, or biological changes in sediment or water quality would not be detectable. 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 be measurable, but neither state nor federal standards or guidelines would be violated. This conclusion about the level of impact is based on (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; (3) the amounts of explosives used would be small relative to the area within 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.

3.1.3.2 Metals

3.1.3.2.1 Introduction

Many metals occur naturally in seawater, and several are necessary for marine organisms and ecosystems to function properly, such as iron, zinc, copper, and manganese. Other metals have adverse impacts on sediments and water quality (e.g., cadmium, chromium, lead, and mercury), but zinc, copper, and manganese may also be harmful to plants and animals at high concentrations.

Metals are introduced into sediments and seawater by the Proposed Action. These metals represent parts or the whole of vessels, manned aircraft and unmanned aerial vehicles, ordnance (bombs, projectiles, missiles, and torpedoes), sonobuoys, chaff cartridges, batteries, electronic components, and anti-corrosion compounds coating the exterior surfaces of some munitions. Because of the physical and chemical reactions that occur with metals in marine systems (e.g., precipitation), metals often concentrate in sediments. Thus, metal contaminants in sediments are a greater issue than metals in the water column.

Military expended materials such as steel bomb bodies or fins, missile casings, small arms projectiles, and naval gun projectiles may contain small percentages (less than 1 percent by weight) of lead, manganese, phosphorus, sulfur, copper, nickel, tungsten, chromium, molybdenum, vanadium, boron, selenium, columbium, or titanium. Small-caliber projectiles are composed of steel with small amounts of aluminum and copper and brass casings that are 70 percent copper and 30 percent zinc. Medium- and large-caliber projectiles are composed of steel, brass, copper, tungsten, and other metals. The 20 mm cannon shells used in close-in weapons systems are composed mostly of tungsten alloy. Some projectiles have lead cores (U.S. Department of the Navy 2008). Torpedo guidance wire is composed of copper and cadmium coated with plastic (U.S. Department of the Navy and U.S. Fleet Forces Command 2008). Sonobuoy components include metal housing, batteries and battery electrodes, lead solder, copper wire, and lead used for ballast. Thermal batteries in sonobuoys are contained in a hermetically sealed and welded stainless steel case 0.03 to 0.1 in. (0.1 to 0.25 cm) thick and resistant to the battery electrolytes (Naval Facilities Engineering Command 1993). Rockets are usually composed of steel and steel alloys, although composite cases made of glass, carbon, or Kevlar® fiber are also used (Missile Technology Control Regime 1996).

Non-explosive practice munitions consist of ammunition and components that contain no explosive material and may include: (1) ammunition and components that have had all explosive material removed and replaced with inert material, (2) empty ammunition or components, and (3) ammunition or components manufactured with inert material in place of all explosive material. These practice munitions vary in size from 25 lb. (11 kg) to 500 lb. (227 kg) and can be built to simulate different explosive capabilities. Some non-explosive practice munitions may also contain unburned propellant (e.g., rockets), and some may contain spotting charges or signal cartridges for locating the point of impact (e.g., smoke charges for daylight spotting or flash charges for night spotting) (U.S. Department of the Navy 2010). Non-explosive bombs—also called "bomb dummy units"—are composed mainly of iron and steel casings filled with sand, concrete, or vermiculite. These materials are similar to those used to construct artificial reefs. Non-explosive bombs are configured to have the same weight, size, center of gravity, and ballistics as live bombs (U.S. Department of the Navy 2006a). Practice bombs do not contain the energetic materials found in live bombs.

Decommissioned vessels used as targets for sinking exercises are selected from a list of U.S. Navy-approved vessels that have been cleaned or remediated in accordance with EPA guidelines. By rule, vessel-sinking exercises must be conducted at least 50 nm offshore and in water at least 6,000 ft. (1,829 m) deep (40 C.F.R. 229.2). The EPA considers the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.).

On FDM, bomb fragments and unexploded bombs could be a source of metal contamination in terrestrial and marine sediments. In accordance with DoD Directive 4715.11, "Environmental and Explosives Safety Management on Operational Ranges within the United States" (U.S. Department of Defense 2004), the Navy has in place an Operational Range Clearance Plan for FDM (U.S. Department of the Navy 2013b). The operational range clearance plan on FDM includes range clearance, inspection, certification, demilitarization, and recycling or disposal procedures. The plan requires range surfaces at FDM to be cleared of ordnance above a certain size, inert ordnance debris, inert munitions, and other material that may potentially present an explosive hazard. Material greater than 2 ft. (0.6 m) in size is removed from impact areas on FDM. Range clearance on FDM occurs every 2–4 years, which reduces the potential for soil contamination and contamination of nearshore habitats receiving surface runoff.

3.1.3.2.2 Approach to Analysis

Most activities involving military expended materials with metal components would be conducted more than 3 nm offshore in the Study Area. These activities would be subject to federal sediment and water quality standards and guidelines. Military expended materials with metal components are also used onshore and in nearshore areas specifically designated for mine countermeasure and mine neutralization activities in and around Naval Base Guam Apra Harbor. These activities would be subject to state sediment and water quality standards and guidelines. For metals, “local” means the zone of sediment about 0.4 in. (1.0 cm) surrounding the metal where it comes to rest.

3.1.3.2.2.1 State Standards and Guidelines

There are no existing Guam and CNMI standards and guidelines for sediments and water quality related to metals. Guam and the CNMI have adopted the National Recommended Water Quality Criteria in Table 3.1-8, although the specific EPA reference citations in their regulations differ.

3.1.3.2.2.2 Federal Standards and Guidelines

Table 3.1-8 summarizes the EPA “threshold values” for metals in marine waters.

Table 3.1-8: Threshold Values for Exposure to Selected Metals in Saltwater

Metal	Criteria (µg/L)	
	Acute Toxicity (1-hour exposure)[1]	Chronic Toxicity (4-day average exposure)[2]
Cadmium	40	8.8
Chromium	1,000	50
Copper	4.8	3.1
Lead	210	8.1
Lithium	6,000	n/a
Mercury	1.8	0.94
Nickel	74	8.2
Silver	1.9	n/a
Zinc	90	81

[1] “Acute toxicity” means a negative response to a substance observed in 96 hours or less (e.g., mortality, disorientation, or immobilization).

[2] “Chronic toxicity” means the lowest concentration of a substance that causes an observable effect (e.g., reduced growth, lower reproduction, or mortality). This effect occurs over a relatively long period of time, such as one-tenth of the life span of the species. A 28-day test period is used for small fish test species (U.S. Environmental Protection Agency 1991).

Notes: (1) No threshold value established by the Environmental Protection Agency. Value shown is from Kszos et al.(2003). (2) n/a = no chronic value is available, µg/L = micrograms per liter

Source: U.S. Environmental Protection Agency 2009

3.1.3.2.3 Impacts from Metals

The analysis of metals in marine systems begins with a review of studies involving metals used in military training and testing activities that may be introduced into the marine environment. The discussion below summarizes studies that investigated the impacts of metals in military expended materials on the marine environment.

The majority of metals in military expended materials come from the use of ordnance. During training, the Navy expends about 87,575 pieces of ordnance in the Study Area annually and proposes to expend up to 185,047 and 187,575 pieces of ordnance, respectively, under Alternative 1 and Alternative 2 annually while training. In addition, two ship hulls are also used during Sinking Exercises under the No Action Alternative annually. The same number of ship hulls is proposed under Alternative 1 and Alternative 2 annually. Use of ordnance during proposed testing activities under Alternatives 1 and 2 are minimal compared to those for training.

In general, three things happen to materials that come to rest on the ocean floor: (1) they lodge in sediments where there is little or no oxygen below 4 in. (10 cm), (2) they remain on the ocean floor and begin to react with seawater, or (3) they remain on the ocean floor and become encrusted by marine organisms. As a result, rates of deterioration depend on the metal or metal alloy and the conditions in the immediate marine and benthic environment. If buried deep in ocean sediments, materials tend to decompose at much lower rates than when exposed to seawater (Ankley 1996). With the exception of torpedo guidance wires and sonobuoy parts, sediment burial appears to be the fate of most ordnance used in marine warfare (Klink et al. 2005).

When metals are exposed to seawater, they begin to slowly corrode, a process that creates a layer of corroded material between the seawater and uncorroded metal. This layer of corrosion removes the metal from direct exposure to the corrosiveness of seawater, a process that further slows movement of the metals into the adjacent sediments and water column. This is particularly true of aluminum. Elevated levels of metals in sediments would be restricted to a small zone around the metal, and any release to the overlying water column would be diluted. In a similar fashion, as materials become covered by marine life, the direct exposure of the material to seawater decreases and the rate of corrosion decreases. Dispersal of these materials in the water column is controlled by physical mixing and diffusion, both of which tend to vary with time and location.

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 included in the analysis. Table 3.1-9 compares the sediment concentrations of several metals from those naval training areas with sediment screening levels established by the National Oceanic and Atmospheric Administration (Buchman 2008).

Table 3.1-9: Concentrations and National Oceanic and Atmospheric Administration Screening Levels for Selected Metals in Sediments, Vieques, Puerto Rico

Metal	Sediment Concentration (µg/g)			Sediment Guidelines – National Oceanic and Atmospheric Administration (µg/g)	
	Minimum	Maximum	Average	Threshold Effect Level[1]	Probable Effect Level[2]
Cadmium	0	1.92	0.15	0.68	4.21
Chromium	0	178	22.58	52.3	160
Copper	0	103	25.9	18.7	390
Lead	0	17.6	5.42	30.24	112
Mercury	N/R	0.112	0.019	130	700
Nickel	N/R	38.3	7.80	15.9	42.8
Zinc	N/R	130	34.4	124	271

[1] The "threshold effect level" is the concentration of a contaminant above which adverse biological effects are expected to rarely occur.
[2] The "probable effect level" is the concentration of a contaminant above which adverse biological effects are expected to occur frequently (MacDonald et al. 1996).
Notes: N/R = not reported, µg/g = micrograms per gram
Source: Buchman 2008

As shown in Table 3.1-9, average sediment concentrations of the metals evaluated, except for copper, were below both the threshold and probable effects levels. The average copper concentration was above the threshold effect level, but below the probable effect level. For other elements, (1) the mean sediment concentration of arsenic at Vieques was 4.37 micrograms/gram (µg/g), and the highest concentration was 15.4 µg/g. Both values were below the sediment quality guidelines examined; and (2) the average sediment concentration of manganese in sediment was 301 µg/g, and the highest concentration was 967 µg/g (Pait et al. 2010). The National Oceanic and Atmospheric Administration did not report threshold or probable effects levels for manganese. Limited data is available for the amount of explosive ordnance and small arms ammunition expended on Vieques. The Navy has estimated approximately 300,000 items with a combined total NEW of 11.5 million, and 1.8 million rounds of small arms ammunition were expended between 1974 and 1998 (Department of the Navy 2006c).

The impacts of lead and lithium were studied at the Canadian Forces Maritime Experimental and Test Ranges near Nanoose Bay, British Columbia, Canada (Klink et al. 2005). These materials are common to Expendable Mobile Anti-Submarine Warfare Training Targets, acoustic device countermeasures, sonobuoys, and torpedoes. The study noted that lead is a naturally occurring metal in the environment, and that typical concentrations of lead in seawater in the test range were between 0.01 and 0.06 ppm in seawater, and from 4 to 16 ppm in sediments. Cores taken of marine sediments in the test range show a steady increase in lead concentration from the bottom of the core to a depth of approximately 8 in. (20 cm). This depth corresponds to the late 1970s and early 1980s and the lead concentration was attributed to atmospheric deposition of lead from gasoline additives. The sediment cores showed a general reduction in concentration to the present time, coincident with the phasing out of lead in gasoline by the mid-1980s. The study also noted that other training ranges showed minimal impacts of lead ballasts because they were usually buried deep in marine sediments, and were not biologically available. The study concluded that the lead ballasts would not adversely impact marine organisms because of the low probability of mobilization of lead.

A study by the Navy examined the impacts of materials from activated seawater batteries in sonobuoys that freely dissolve in the water column (e.g., lead, silver, and copper ions), as well as nickel-plated steel housing, lead solder, copper wire, and lead shot used for sonobuoy ballast (Naval Facilities Engineering Command 1993). The study concluded that constituents released from saltwater batteries as well as the decomposition of other sonobuoy components did not exceed state or federal standards and that the reaction products are short-lived in seawater.

3.1.3.2.3.1 Lead

Lead is used as ballast in torpedoes, in batteries in torpedoes and sonobuoys, and in various munitions. Lead is nearly insoluble in water, particularly at the near-neutral pH levels of seawater. While some dissolution of lead could occur, such releases into the water column would be small and would be diluted (U.S. Department of the Navy 2006a).

Several studies have evaluated the potential impacts of batteries expended in seawater (Borener and Maugham 1998; Klink et al. 2005; Naval Facilities Engineering Command 1993; U.S. Coast Guard 1994). Sediment was sampled adjacent to and near fixed navigation sites where batteries are used, and the samples were analyzed for all metal constituents in the batteries. Results indicated that metals were either below or consistent with background levels or were below National Oceanic and Atmospheric Administration sediment screening levels (Buchman 2008), "reportable quantities" under the Comprehensive Environmental Response, Compensation, and Liability Act §103(a), or EPA toxicity criteria (U.S. Environmental Protection Agency 2008c).

A sonobuoy battery experiment employed lead (II) chloride batteries in a 17 gal. (64.4 L) seawater bath for 8 hours (Naval Facilities Engineering Command 1993). Under these conditions, the dilution assumptions are conservative relative to normal ocean bottom conditions. The concentration released from the battery was diluted to 200 µg/L (200 ppb) in 2 seconds, which is less than the acute criterion of 210 µg/L (210 ppb), a criterion applied as a 24-hour mean. Considering each milliliter as a discrete parcel, dilution by a current traveling at 2 in. per second (5.1 cm per second) would dilute the lead released from the battery to 200 µg/L (200 ppb) in 2 seconds, which is less than the acute criterion of 210 µg/L (210 ppb), a criterion applied as a 1-hour mean. Assuming the exponential factor of two dilutions, the concentration is less than the chronic limit of 8.1 µg/L (8.1 ppb) in 7 seconds. The calculated rate of leaching will decrease as the concentration of lead in the battery decreases.

Lead (II) chloride tends to dissolve more readily than either silver chloride or copper thiocyanate; this ensures that potential impacts of batteries employing silver chloride or copper thiocyanate are substantially lower than those for the lead (II) chloride battery. The copper thiocyanate battery also could release cyanide, a material often toxic to the marine environment. However, thiocyanate is tightly bound and can form a salt or bind to bottom sediments. Therefore, the risk from thiocyanate is low (U.S. Department of the Navy and U.S. Fleet Forces Command 2008). The peak concentration of copper released from a copper thiocyanate seawater battery was calculated to be 0.015 µg/L (0.015 ppb) (Naval Facilities Engineering Command 1993), which is substantially lower than EPA acute and chronic toxicity criteria.

3.1.3.2.3.2 Tungsten and Tungsten Alloys

Because of environmental concerns associated with lead, tungsten has replaced lead in munitions (Defense Science Board 2003). Tungsten was chosen because it was considered nonreactive in the environment under normal circumstances. However, concerns have arisen lately about that assessment. Adverse health consequences arise with inhalation, and movement of tungsten into groundwater is an issue (Agency for Toxic Substances and Disease Registry 2005). However, no drinking water standard exists for tungsten, and it is not listed as a carcinogen (U.S. Environmental Protection Agency 2008c). Neither inhalation nor groundwater is an issue relative to sediments and water quality.

The natural concentration of tungsten reported in seawater is about 0.1 µg/L (Agency for Toxic Substances and Disease Registry 2005). It arises naturally from weathering of tungsten-rich deposits and from underwater hydrothermal vents; elevated levels in marine sediments from natural sources have been reported. Industrial processes also contribute tungsten to the environment (Koutsospyros et al. 2006). In water, tungsten can exist in several different forms depending on pH, and it has a strong tendency to form complexes with various oxides and with organic matter. The rate at which tungsten dissolves or dissociates increases as pH decreases below 7.0. (pH of seawater is normally between 7.5 and 8.4.) The speed of the process also depends on the metal with which tungsten is alloyed. For instance, iron tends to enhance the dissolution of tungsten, while cobalt slows the process (Agency for Toxic Substances and Disease Registry 2005). Tungsten is a component of metabolic enzymes in various microbes (Kletzin and Adams 1996). Much is known about the physical and chemical properties of tungsten. Less is known about the behavior of the various complexes that tungsten forms, making predictions about its behavior in the environment difficult. For instance, it is not known whether the organic complexes that tungsten forms affect its bioavailability (Koutsospyros et al. 2006).

3.1.3.2.3.3 Lithium

Silver chloride, lithium, or lithium iron disulfide thermal batteries are used to power subsurface units of sonobuoys. Lithium iron disulfide thermal batteries are used in some type of sonobuoys. Lithium-sulfur batteries typically contain lithium sulfur dioxide and lithium bromide but may also contain lithium carbon monofluoroxide, lithium manganese dioxide, sulfur dioxide, and acenitrile (a cyanide compound). During battery operation, the lithium reacts with the sulfur dioxide to form lithium dithionite. Thermal batteries are contained in a hermetically sealed and welded stainless steel case 0.03–0.1 in. (0.08–0.25 cm) thick and resistant to the battery electrolytes.

Lithium always occurs as a stable mineral or salt, such as lithium chloride or lithium bromide (Kszos et al. 2003). Lithium is naturally present in seawater at 180 µg/L, and its incorporation into clay minerals is a major process in its removal from solution (Stoffyn-Egli and Machenzie 1984). Kszos et al. (2003) demonstrated that sodium ions in saltwater mitigate the toxicity of lithium to sensitive aquatic species. Fathead minnows (*Pimephales promelas*) and the water flea (*Ceriodaphnia dubia*) were unaffected by lithium concentrations as high as 6 mg/L (6 ppm) in the presence of tolerated concentrations of sodium. Therefore, in the marine environment, where sodium concentrations are at least an order of magnitude higher than tolerance limits for the tested freshwater species, lithium would be essentially nontoxic.

Klink et al. (2005) reported that 99 percent of the lithium in a sonobuoy battery would be released to the environment over 55 years. The release will result in a dissolved lithium concentration of 83 mg/L (83 ppm) near the breach in the sonobuoy housing. At a distance of 0.2 in. (5.5 mm) from the breach, the concentration of lithium will be about 15 mg/L (15 ppm), or 10 percent of typical seawater lithium values (150 ppm); thus, it would be difficult to measure the change in the seawater concentration of lithium resulting from lithium leaking out of the battery (Klink et al. 2005). Cores of marine sediments collected in the Canadian Forces Maritime Experimental and Test Ranges near Nanoose Bay, British Columbia, Canada, showed fairly consistent lithium concentrations with depth, indicating little change in lithium deposition with time. Compared with lithium concentrations taken outside the range, the report concluded that "it is difficult to demonstrate an environmental impact of lithium caused by (test range activities)" (Klink et al. 2005).

3.1.3.2.3.4 Metals in Non-Explosive Practice Munitions

On the ocean bottom, non-explosive practice munitions and fragments are exposed to seawater or lodge in sediments. Once settled, metal components slowly corrode in seawater. Over time, natural encrustation of exposed surfaces occurs and reduces the rate of corrosion. Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble, and scavenged by particulates and transported to the bottom sediments (Monterey Bay Research Institute 2010). Practice bombs are made of materials similar to those used to construct artificial reefs. The steel and iron, though durable, corrode over time, with no noticeable environmental impacts (U.S. Department of the Navy 2006a).

3.1.3.2.3.5 Metals in Vessels Used as Targets

Target vessels are used only during sinking exercises. Sinking exercises are conducted at least 50 nm offshore and in waters at least 6,000 ft. (1,829 m) deep, in accordance with 40 C.F.R. §229.2. Target vessels are selected from a list of Navy-approved vessels that have been cleaned in accordance with EPA guidelines.

The metal structure of a target vessel can be a suitable substrate for the development of hardbottom marine habitat. Hard reef materials such as rock, concrete, and steel become encrusted with a variety of marine life. Certain bait fish school around sunken ships, and open water ("pelagic") species use these structures as sources of prey (Carberry 2008).

3.1.3.2.4 Evaluation of Alternatives

3.1.3.2.4.1 No Action Alternative

Training Activities

Under the No Action Alternative, approximately 234 U.S. tons (212,281 kg) of metals with known toxicity would be expended per year in the Study Area. During two sinking exercises per year, approximately 440 objects would be expended, including large bombs, missiles, large projectiles, and two target vessels (with an average weight of 5,826 U.S. tons [5,285,258 kg]). Approximately 58 U.S. tons (52,616 kg) of metals with potential toxicity would be expended during a sinking exercise. Thus, during a sinking exercise, approximately 32 objects per km^2 and 8.5 U.S. tons (7,711 kg) of metals with potential toxicity per km^2 would sink to the ocean floor.

In addition, non-reactive metals would be expended under the No Action Alternative. These materials consist of metals with no known toxicity, such as steel, and filler materials (i.e., sand, concrete) used in inert munitions. These materials are not expected to affect water quality because of their non-toxic properties, and would be incorporated into marine sediments. No further consideration of the impacts of these materials on water quality is warranted.

Leaching metals would be from military expended materials on the sea floor. Metals tend to adsorb to sediments, particularly fine sediments and sediments with high organic content. Based on this assumption, concentrations of metals in the water column would be less than estimated concentrations of metals in marine sediments. Concentrations of metals would be greatest where military expended materials are in contact with seawater. Initial rates would decrease as corrosion and biological processes occur, and most leaching metals would bind with suspended sediments and particles and fall out of the water column. Within the immediate area where metals are deposited, metals from military expended materials would have short-term, localized impacts on sediments in the Study Area.

As discussed previously, the Navy has an operational range clearance plan in effect on FDM, which requires removal of ordnance (potential sources of metal pollution on land) every 2–4 years depending on the type of ordnance. The operational range clearance program removes land-based sources of contamination that may impact terrestrial sediments, marine sediments, and nearshore waters.

Under the No Action Alternative, impacts on sediments and water quality from metals from military expended materials would be short term and localized.

<u>Testing Activities</u>

Under the No Action Alternative, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area (refer to Table 2.4-4 for a complete description). Research vessels, acoustic test sources, side scan sonars, ocean gliders, existing moored acoustic tomographic array and distributed vertical line array, and other oceanographic data collection equipment are used to collect information. At the conclusion of these studies, with the exception of the moorings, the data collection equipment will be removed. This activity would continue within the Study Area until May 2019. There would be no impacts on sediments and water quality from the deployment of testing equipment under the No Action Alternative.

Summary of Impacts from Metals

Metals with potential toxicity would be incorporated with benign metals (i.e., steel) in military expended materials. Metal components settling on the sea floor would be exposed to seawater or, more likely, would be gradually buried in sea floor sediments. These metals would slowly corrode over years or decades and would release small amounts of metal compounds to adjacent sediments and waters.

The potential impacts of metal components from training and testing activities on sediment and water quality would be long term, local, and negative. However, because of slow corrosion rates and prevailing ocean currents, chemical, physical, and biological changes in sediment or water quality would not be detectable beyond the vicinity of the corroding metals. This conclusion is based on (1) most of the metals are benign, and those of potential concern are a small percentage of those munitions; (2) metals released through corrosion would be diluted by currents or bound up and sequestered in adjacent sediments; (3) impacts would be limited to a small area around the expended material; (4) the areas within which metal components would be distributed would be large; and (5) most of the metals would be small-caliber projectiles. Neither state nor federal standards or guidelines would be violated.

3.1.3.2.4.2 Alternative 1

<u>Training Activities</u>

Under Alternative 1, training activities would increase, which would result in additional metals from military expended materials being introduced into the Study Area. Approximately 237 U.S. tons (215,002 kg) of metals with known toxicity would be expended in the Study Area per year, or an increase of 1.3 percent from the No Action Alternative. Under Alternative 1, impacts on sediments and water quality from metals from military expended materials would be short term and localized.

The Navy's operational range clearance plan would be in effect for FDM under Alternative 1. The operational range clearance program removes land-based sources of contamination that may impact terrestrial sediments, marine sediments, and nearshore waters.

Testing Activities

Under Alternative 1, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area. The Navy would also conduct additional testing activities, which would involve the use of 793 sonobuoys for anti-submarine warfare tracking tests, 8 harpoon and 16 surface to surface missiles, explosive and non-explosive medium caliber rounds and 60 torpedoes. Under Alternative 1, approximately 0.27 U.S. tons (245 kg) of metals with known toxicity would be expended in the Study Area per year. A percent increase for metals with known toxicity released from testing activities under Alternative 1 cannot be evaluated because these proposed testing activities are not currently conducted under the No Action Alternative. Under Alternative 1, impacts on sediments and water quality from metals from military expended materials would be short term and localized.

Summary of Impacts from Metals

Although the amount of expended materials associated with training and testing under Alternative 1 would represent a notable increase over the No Action Alternative, impacts are judged to be similar to the No Action Alternative for the reasons enumerated under the No Action Alternative. Metal components would come to rest on the sea floor and would be exposed to seawater when resting on the bottom or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters. Potential impacts on sediments and water quality would be long term, local, and negative. Chemical, physical, or biological changes to sediments or water quality would be measurable, but neither state nor federal standards or guidelines would be violated.

3.1.3.2.4.3 Alternative 2

Training Activities

Under Alternative 2, training activities would increase slightly over those proposed in Alternative 1, which would result in a minor increase in metals from military expended materials being introduced in the Study Area. Approximately 238 U.S. tons (215,909 kg) of metals with known toxicity would be expended in the Study Area per year or an increase of 1.7 percent from the No Action Alternative. Impacts on sediments and water quality would be similar to those described under the No Action Alternative due to the minimal increase in metals with potential toxicity.

The Navy's operational range clearance plan would be in effect for FDM under Alternative 2. The operational range clearance program removes land-based sources of contamination that may impact terrestrial sediments, marine sediments, and nearshore waters.

Testing Activities

Under Alternative 2, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area. The Navy would also conduct additional and increased testing activities, which would involve the use of 884 sonobuoys for anti-submarine warfare tracking tests, 8 harpoon and 18 surface to surface missiles, and 70 torpedoes. Under Alternative 2, approximately 0.31 U.S. ton (281 kg) of metals with known toxicity would be expended in the Study Area per year. A percent increase for metals with known toxicity released from testing activities under Alternative 2 cannot be evaluated because these proposed testing activities are not currently conducted under the No Action Alternative. Under Alternative 2, impacts on sediments and water quality from metals from military expended materials would be short term and localized.

Summary of Impacts from Metals

Although the amount of expended materials associated with training and testing under Alternative 2 would represent a notable increase over the No Action Alternative, impacts are judged to be similar to the No Action Alternative for the reasons enumerated under the No Action Alternative (Section 3.1.3.2.4.1). Metal components would come to rest on the sea floor exposed to seawater when resting on the bottom or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters. Potential impacts on sediments and water quality would be long term, local, and negative. Chemical, physical, or biological changes to sediments or water quality would be measurable, but neither state nor federal standards or guidelines would be violated.

3.1.3.2.4.4 Summary and Conclusion for Metals

Corrosion and biological processes (e.g., colonization by marine organisms) would reduce exposure of military expended materials to seawater, decreasing the rate of leaching. Most leached metals would bind to sediments and other organic matter. Sediments near military expended materials would contain some metals, but their concentrations would not be at harmful levels because of the bottom substrate composition. Metals in batteries are readily soluble, which would result in faster releases of metals if batteries are exposed to seawater once they are expended. Batteries are sealed, however, and the exterior metal casing can become encrusted by marine organisms or coated by corrosion. Batteries continue to operate until most of their metals are consumed. Any leached metals would be present in seawater and sediments at low concentrations, and they would behave similarly to leached metals from other military expended materials.

On FDM, The Navy's operational range clearance plan would be in effect for all alternatives. The operational range clearance program removes land-based sources of contamination that may impact terrestrial sediments, marine sediments, and nearshore waters.

3.1.3.3 Chemicals Other Than Explosives

3.1.3.3.1 Introduction

Under the Proposed Action, 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, and (4) other chemicals associated with ordnance.

Hazardous air pollutants associated with explosives and explosive byproducts are discussed in Section 3.2 (Air Quality). Explosives and explosive byproducts are discussed in Section 3.1.3.1 (Explosives and Explosive Byproducts). Fuels onboard manned aircraft and vessels are not reviewed, nor are fuel-loading activities, onboard operations, or maintenance activities reviewed.

3.1.3.3.2 Missile and Rocket Propellant – Solid Fuel

The largest chemical constituent of missiles is solid propellant. Solid propellant contains both the fuel and the oxidizer, a source of oxygen needed for combustion. An extended-range Standard Missile-2 typically contains 1,822 lb. (828 kg) of solid propellant (U.S. Department of the Navy 2008). Ammonium perchlorate is an oxidizing agent used in most modern solid-propellant formulas. It normally accounts for 50 to 85 percent of the propellant by weight. Ammonium dinitramide may also be used as an oxidizing agent. Aluminum powder as a fuel additive makes up 5 to 21 percent by weight of solid propellant; it is added to increase missile range and payload capacity. Two explosives—high melting explosive (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) and royal demolition explosive (hexahydro-1,3,5-trinitro-1,3,5-triazine)—may be added, although they usually account for less than 30 percent of the propellant weight (Missile Technology Control Regime 1996).

The most common substance used as binding material for solid propellants is hydroxyl-terminated polybutadiene. Other binding materials include carboxyl-terminated polybutadiene and polybutadiene-acrylic acid-acrylonitrile. These materials also burn as fuels and contribute to missile thrust. Other materials found in solid-fuel propellants include curing agents and catalysts such as triphenyl bismuth; nitrate esters and nitrated plasticizers are liquid explosives added to increase the engine burn rate, and n-hexyl carborane and carboranylmethyl propionate are also used to increase propellant performance.

Double-base propellant is a solid fuel that is a mixture of fuels and small particulate oxidizers. Like other solid propellants, the most commonly used fuel component of these propellants is ammonium perchlorate. High melting explosive and royal demolition explosive may be added to improve performance, and the most common binder is hydroxyl-terminated polybutadiene. In addition to the binders listed in the preceding paragraph, polybutadiene-acrylic acid polymer, elastomeric polyesters, polyethers, and nitrocellulose plasticized with nitroglycerine or other nitrate esters may be used. To reduce decomposition of propellant, 2-nitrodiphenylamine and N-methyl-4-nitroaniline may be added (Missile Technology Control Regime 1996).

3.1.3.3.3 Torpedo Propellant – Otto Fuel II and Combustion Byproducts

The MK-48 torpedo weighs roughly 3,700 lb. (1,678 kg) and uses Otto Fuel II as a liquid propellant. Otto Fuel II is composed of propylene glycol dinitrate and nitro-diphenylamine (76 percent), dibutyl sebacate (23 percent) and 2-nitrodiphenylamine as a stabilizer (2 percent). Combustion byproducts of Otto Fuel II include nitrous oxides, carbon monoxide, carbon dioxide, hydrogen, nitrogen, methane, ammonia, and hydrogen cyanide. During normal venting of excess pressure or upon failure of the torpedo's buoyancy bag, the following constituents are discharged: carbon dioxide, water, hydrogen, nitrogen, carbon monoxide, methane, ammonia, hydrochloric acid, hydrogen cyanide, formaldehyde, potassium chloride, ferrous oxide, potassium hydroxide, and potassium carbonate (U.S. Department of the Navy 1996a, b).

3.1.3.3.4 Polychlorinated Biphenyls in Target Vessels

Target vessels are only used during sinking exercises. PCBs are a concern because they are present in certain solid materials (e.g., insulation, wires, felts, and rubber gaskets) on vessels used as targets for sinking exercises. These vessels are selected from a list of Navy-approved vessels that have been cleaned in accordance with EPA guidelines. By rule, a sinking exercise must be conducted at least 50 nm offshore and in water at least 6,000 ft. (1,829 m) deep (40 C.F.R. §229.2). A maximum of two sinking exercises per year are proposed in the Study Area under the No Action Alternative, Alternative 1, and Alternative 2.

The EPA estimates that as much as 100 lb. (45 kg) of PCBs remain onboard sunken target vessels. The EPA considers the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. §1341, et seq.) (U.S. Environmental Protection Agency 1999). Based on these considerations, PCBs will not be considered further.

3.1.3.3.5 Other Chemicals Associated with Ordnance

Table 3.1-10 lists ordnance constituents remaining after low-order detonations and in unconsumed explosives. These constituents are in addition to the explosives contained in the ordnance.

Lead azide, titanium compounds, perchlorates, barium chromate, and fulminate of mercury are not natural constituents of seawater. Lead oxide is a rare, naturally occurring mineral. It is one of several lead compounds that form films on lead objects in the marine environment (Agency for Toxic Substances and Disease Registry 2007). Metals are discussed in more detail in Section 3.1.3.2 (Metals).

3.1.3.3.6 Approach to Analysis

Training and testing activities related to the chemicals discussed above would be conducted more than 3 nm offshore in the Study Area. These activities would be subject to federal sediment and water quality standards and guidelines, however, there are no state or federal sediment and water quality standards or guidelines specific to the chemicals discussed above. For properly functioning expended materials, the term "local" means the volume of water that a self-propelled subsurface training or testing device passes through. In these situations, water quality would be impacted by combustion byproducts. For lost or malfunctioning expended training items, the term "local" means a small zone around noncombusted propellant in sediments and seawater, perhaps a centimeter or two, and a smaller area if directly exposed to seawater.

Table 3.1-10: Constituents Remaining after Low-Order Detonations and from Unconsumed Explosives

Ordnance Component	Constituent
Pyrotechnics Tracers Spotting Charges	Barium chromate ($BaCrO_4$) Potassium perchlorate Chlorides Phosphorus Titanium compounds
Oxidizers	Lead (II) oxide (PbO)
Delay Elements	Barium chromate ($BaCrO_4$) Potassium perchlorate Lead chromate
Fuses	Potassium perchlorate
Detonators	Fulminate of mercury [$Hg(CNO)_2$] Potassium perchlorate
Primers	Lead azide [$Pb(N_3)_2$]

3.1.3.3.7 Impacts from Chemicals

The following sections discuss the potential impact on sediments and water quality from solid-fuel propellants in missiles and rockets, Otto Fuel II torpedo propellant, and combustion byproducts.

3.1.3.3.7.1 Solid-Fuel Propellants

Missiles and rockets typically consume 99 to 100 percent of their propellant when they function properly (U.S. Department of the Navy 2008). The failure rate of rockets is 3.8 percent (MacDonald et al. 2005; U.S. Army Corps of Engineers 2007). The remaining solid propellant fragments (i.e., 1 percent or less of the initial propellant weight) sink to the ocean floor and undergo physical and chemical changes in contact with sediments and seawater. Tests show that water penetrates about 0.06 in. (0.14 cm) into the propellant during the first 24 hours of immersion, and that fragments slowly release ammonium and perchlorate ions (Fournier and Brady 2005). These ions would disperse into the surrounding seawater, so local concentrations would be low. For example, a standard missile with 150 lb. (68 kg) of solid propellant would generate less than 1.5 lb. (0.7 kg) of propellant residue after completing its flight. If all the propellant deposited on the ocean floor were in the form of 4 in. (10 cm) cubes, about 0.42 percent of the propellant would be wetted during the first 24 hours of immersion. If all the ammonium perchlorate leached out of the wetted propellant, then approximately 0.01 lb. (4.54 g) would enter the surrounding seawater (U.S. Department of the Navy 2008). This leach rate would decrease over time as the concentration of perchlorate in the propellant declined. Aluminum in the binder would be converted to aluminum oxide by seawater.

Perchlorate

Ammonium perchlorate accounts for 50 to 85 percent of solid propellant by weight (Missile Technology Control Regime 1996). Perchlorates are highly soluble and stable in water. According to the Agency for Toxic Substances and Disease Registry (2008), perchlorate "does not readily bind to soil particles or to organic matter, and does not readily form ionic complexes with other materials in solution." Because of these characteristics, perchlorate is highly mobile in soil and does not readily leave solution through chemical precipitation. Thus, perchlorate could affect sediment and water quality because of its persistence in the environment.

Natural sources of perchlorate include Chilean caliche ore (U.S. Environmental Protection Agency 2008a) and ozone oxidation of atmospheric chlorine (Petrisor and Wells 2008). Martinelango (2006) stated that perchlorate was present in seawater at levels ranging from less than 0.07 µg/L to 0.34 µg/L (0.07 to 0.34 ppb). Studies indicate that it may accumulate in living organisms, such as fish and plants (Agency for Toxic Substances and Disease Registry 2008). Toxicity in plants and microbes is thought to result from adverse impacts on metabolic enzymes (van Wijk and Hutchinson 1995). Research by Martinelango (2006) found that perchlorate can concentrate in marine algae from 200 to 5,000 times, depending on the species. Chaudhuri et al. (2002) noted that several species of microbes can metabolize chlorate and perchlorate. The end product is chloride. Logan et al. (2001) used sediment samples from a variety of marine and saline environments to demonstrate that microbial perchlorate reduction can occur in saline solutions greater than three percent. Seawater salinity is about 3.5 percent. The organism responsible for the perchlorate reduction was not identified in the study. However, Okeke et al. (2002) identified three species of halophilic ("salt-loving") bacteria that biodegrade perchlorate. The EPA has established a drinking water standard for perchlorate, but no standards or guidelines were established for perchlorate in marine systems.

Polyesters

Regarding other solid-fuel components, marine microbes and fungi are known to degrade biologically produced polyesters, such as polyhydroxyalkanoates, a bacterial carbon and energy source (Doi et al. 1992). These organisms also can degrade other synthetic polymers, although at lower rates (Shah et al. 2008). The chemical structure of natural rubber is similar to that of polybutadiene (Tsuchii and Tokiwa 2006). Thus, although no specific studies were located that documented biodegradation of polybutadiene in marine ecosystems, the prospects seem likely based on the findings of researchers such as Tsuchii and Tokiwa (2006).

Nitriles

Nitriles are cyanide-containing organic compounds that are both natural and man-made. Several species of marine bacteria are capable of metabolizing acrylonitrile (Brandao and Bull 2003). The productivity of marine ecosystems is often limited by available nitrogen (Vitousek and Howarth 1991), so biodegradation of nitrate esters and nitrated plasticizers in the marine environment seems likely.

3.1.3.3.7.2 Otto Fuel II and Combustion Byproducts

Microbial degradation of the main components of Otto Fuel II (propylene glycol dinitrate and nitro-diphenylamine) has been demonstrated (Sun et al. 1996; Walker and Kaplan 1992). Although these studies did not involve marine microbes, other studies have demonstrated that marine bacteria in anaerobic sediments were able to degrade 2-nitrodiphenylamine (Drzyzga and Blotevogel 1997; Powell et al. 1998). According to the Agency for Toxic Substances and Disease Registry (1995), 2-nitrodiphenyl-amine tends to bind to sediments. The agency indicated that dibutyl sebacate "is readily degraded by environmental bacteria and fungi" (Agency for Toxic Substances and Disease Registry 1995).

Combustion byproducts from Otto Fuel II would be released into the ocean, where they would dissolve, dissociate, or be dispersed and diluted in the water column. Except for hydrogen cyanide, combustion byproducts are not a concern (U.S. Department of the Navy 1996a, b) for the reasons listed below:

- Most Otto Fuel II combustion products such as carbon dioxide, nitrogen, methane, and ammonia occur naturally in seawater.
- Several of the combustion products are bioactive. Nitrogen is converted into nitrogen compounds through nitrogen fixation by certain cyanobacteria, providing nitrogen sources and essential micronutrients for marine phytoplankton. Carbon dioxide and methane are integral parts of the carbon cycle in the oceans, and are taken up by many marine organisms.
- Carbon monoxide and hydrogen have low solubility in seawater and excess gases bubble to the surface.
- Trace amounts of oxides of nitrogen may be present, but they are usually below detectable limits. Oxides of nitrogen in low concentrations are not harmful to marine organisms, and are a micronutrient source of nitrogen for aquatic plant life.
- Ammonia can be toxic to marine organisms in high concentrations, but releases from the combustion of Otto Fuel II are quickly diluted to insignificant concentrations. Ammonia is present in exhaust from Otto Fuel II at estimated concentrations of 10 ppb (U.S. Department of the Navy 2007).

Hydrogen cyanide does not normally occur in seawater. Major releases of cyanide to water are from metal-finishing industries, iron and steel mills, and organic chemical industries (U.S. Environmental Protection Agency 1981). At high concentrations, cyanide can pose a risk to both humans and marine biota. Compared to recommendations of the EPA of 1.0 µg/L (1.0 ppb) (U.S. Environmental Protection Agency 2010b), hydrogen cyanide released from MK-48 torpedoes would result in ambient concentrations ranging from 140 to 150 µg/L (140 to 150 ppb) (U.S. Department of the Navy 1996b), well above the recommended levels. However, because hydrogen cyanide is soluble in seawater, it would be diluted to less than 1 µg/L (1.0 ppb) at a distance of 18 ft. (5 m) from the center of the torpedo's path when first discharged. Additional dilution would occur thereafter.

Approximately 30,000 exercise tests of the MK-48 torpedo have been conducted over the last 25 years. Most of these launches have been on Navy test ranges, where there have been no reports of harmful impacts on water quality from Otto Fuel II or its combustion products. Furthermore, U.S. Navy studies conducted at torpedo test ranges that have lower flushing rates than the open ocean did not detect residual Otto Fuel II in the marine environment (U.S. Department of the Navy 1996a, b).

3.1.3.3.7.3 Operational Failure – Torpedoes, Missiles, and Rockets

Some materials are recovered after use, such as torpedoes. However, sometimes these recoverable items are lost or they fail to perform correctly. For instance, the failure rate of rockets is 3.8 percent (MacDonald et al. 2005; U.S. Army Corps of Engineers 2007). Corrosion of munitions in the marine environment is discussed in more detail in Section 3.1.3.2 (Metals).

3.1.3.3.8 Evaluation of Alternatives

Potential impacts on sediments and water quality from chemicals other than explosives should be viewed in the following context: (1) nearshore sediments and water quality in many areas have been negatively impacted; in particular, a wide variety of chemicals are delivered to the ocean by major river systems; and (2) the vast majority of those impacts are from human-generated and land-based activities. The numbers of military expended materials discussed below reflect amounts expended annually for each type of material under each alternative.

3.1.3.3.8.1 No Action Alternative

<u>Training Activities</u>

Under the No Action Alternative, approximately 639 lb. (290 kg) per year of residual solid propellant would be expended during training activities in the Study Area. The amount of perchlorates released to the environment from residual solid propellant would be minimal. Although perchlorate is persistent in the marine environment, the low concentrations of perchlorates in ocean waters that result from Navy training and testing activities would not have an impact on water quality. Based on the small amount of residual propellant and low affinity for sediment, perchlorate from residual solid propellant would not be expected to have an impact on sediments.

Under the No Action Alternative, 53 torpedoes would be expended during training. During torpedo operation, the majority of Otto Fuel would be consumed. Torpedo training in the Study Area is mostly simulated and the torpedoes used are not fully functional torpedoes. Any Otto Fuel II released to the marine environment would be quickly diluted, and would not result in concentrations harmful to marine organisms. Based on these assumptions and past studies of water quality at torpedo testing areas, Otto Fuel II is not expected to have an impact on sediments and water quality.

For properly functioning ordnance items, chemical, physical, or biological changes in sediment or water quality would not be detectable. Impacts would be minimal for the following reasons: (1) the size of the area in which expended materials would be distributed is large; (2) most propellant combustion byproducts are benign, while those of concern would be diluted to below detectable levels within a short time; (3) most propellants are consumed during normal operations; (4) the failure rate is low for such expended materials; and (5) most of the constituents of concern are biodegradable by various marine organisms or by physical and chemical processes common in marine ecosystems.

<u>Testing Activities</u>

Under the No Action Alternative, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area (refer to Table 2.4-4 for a complete description). Research vessels, acoustic test sources, side scan sonars, ocean gliders, existing moored acoustic tomographic array and distributed vertical line array, and other oceanographic data collection equipment are used to collect information. None of these equipment use solid propellants or Otto Fuel, therefore, testing activities under the No Action Alternative would not have an impact on sediments and water quality in the Study Area.

3.1.3.3.8.2 Alternative 1

Training Activities

Alternative 1 would result in an increase in deposits of associated residual propellant due to increased training activities, compared to the No Action Alternative. Approximately 3,988 lb. (1,809 kg) of residual solid propellant would be deposited in the Study Area from expended missiles and rockets under Alternative 1, an increase of 3,349 lb. (1,522 kg) over the No Action Alternative. Under Alternative 1, impacts on sediments and water quality from residual solid propellants would be similar to those of the No Action Alternative.

Under Alternative 1, 63 torpedoes would be expended during training. This represents an increase of 10 additional torpedoes or 19 percent relative to the No Action Alternative. Analysis under the No Action Alternative concludes that Otto Fuel from the torpedo operation would not impact sediments and water quality; the same conclusion applies to Alternative 1.

Although these changes would be a notable increase compared to the No Action Alternative, impacts would be similar to the No Action Alternative for the reasons enumerated above. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long term, local, and negative. In both cases, chemical, physical, or biological changes in sediment or water quality would not be detectable.

Testing Activities

Under Alternative 1, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area. The Navy would also conduct additional testing activities, which would involve the use of 60 torpedoes for anti-surface warfare testing, 8 harpoon missiles and 16 surface to surface missiles. As discussed previously, Otto Fuel from torpedo operation would be quickly diluted, and would not result in concentrations harmful to marine organisms; therefore, Otto Fuel used during testing activities under Alternative 1 would not impact sediments or water quality. Residual propellant from missiles would amount to 465 lb. (211 kg). A percent increase for residual propellant released from testing activities under Alternative 1 cannot be evaluated because these proposed testing activities are not currently conducted under the No Action Alternative.

Although these changes would be a notable increase compared to the No Action Alternative, impacts would be similar to impacts from training under Alternative 1 for the reasons enumerated above. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long term, local, and negative. In both cases, chemical, physical, or biological changes in sediment or water quality would not be detectable.

3.1.3.3.8.3 Alternative 2

Training Activities

The amount of associated residual solid propellant under Alternative 2 would increase compared to Alternative 1. Approximately 9,370 lb. (4,250 kg) of solid propellant would be deposited in the Study Area from expended missiles and rockets under Alternative 2, an increase of 8,731 lb. (3,969 kg) from the No Action Alternative. Under Alternative 2, 63 torpedoes would be expended during training activities. This represents an increase of 10 additional torpedoes or 19 percent relative to the No Action Alternative. Analysis under the No Action Alternative concludes that Otto Fuel from the torpedo operation would not impact sediments and water quality; the same conclusion applies to Alternative 2.

Although these changes would be a notable increase compared to the No Action Alternative, impacts would be similar to the No Action Alternative for the reasons enumerated above. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long term, local, and negative. In both cases, chemical, physical, or biological changes in sediment or water quality would not be detectable.

Testing Activities

Under Alternative 2, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area. The Navy would also conduct additional testing activities, which would involve the use of 64 torpedoes for anti-surface warfare testing, 10 harpoon missiles, and 18 surface-to-surface missiles. As discussed previously, Otto Fuel from torpedo operation would be quickly diluted in the water column, and would not result in concentrations harmful to marine organisms; therefore, Otto Fuel used during testing activities under Alternative 2 would not impact sediments or water quality. Residual propellant from missiles would amount to 503 lb. (229 kg). A percent increase for residual propellant released from testing activities under Alternative 2 cannot be evaluated because these proposed testing activities are not currently conducted under the No Action Alternative.

Although these changes would be a notable increase compared to the No Action Alternative, impacts would be similar to impacts from training under Alternative 2 for the reasons enumerated above. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long term, local, and negative. In both cases, chemical, physical, or biological changes in sediment or water quality would not be detectable.

3.1.3.3.8.4 Summary and Conclusions for Chemicals Other Than Explosives

Chemicals other than explosives from military expended materials in the Study Area would be from residual solid propellant, Otto Fuel II, and pyrotechnic materials. Solid propellants would leach perchlorates. Perchlorates are readily soluble, with a low affinity for sediments. Based on the small amount of residual propellant from training and testing activities, perchlorates would not be expected in concentrations that would be harmful to aquatic organisms in the water column or in marine sediments. Otto Fuel II and its combustion byproducts would be introduced into the water column in small amounts. All torpedoes would be recovered following training and testing activities, and Otto Fuel II would not be expected to come into direct contact with marine sediments. Most combustion byproducts would form naturally occurring gases in the water column, and cyanide concentrations would be well below harmful concentrations.

3.1.3.4 Other Materials

Other materials include marine markers and flares, chaff, towed and stationary targets,[4] and miscellaneous components of other materials. 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 sea floor sediments, (3) become encrusted by chemical processes such as rust, (4) slowly dissolve, or (5) be covered by marine organisms such as coral. Plastics may float or descend to the bottom, depending on their buoyancy. Markers and flares are largely consumed during use.

Steel in ordnance normally contains a variety of metals, some of potential concern. However, these other metals are present in low quantities (1 to 5 percent of content) such that steel is not generally considered a potential source of metal contamination. Metals are discussed in more detail in Section 3.1.3.2 (Metals). Various chemicals and explosives are present in small amounts (mostly as components of flares and markers), but are not considered likely to cause negative impacts. Chemicals other than explosives are discussed in more detail in Section 3.1.3.3 (Chemicals Other Than Explosives) and explosives and explosive byproducts are discussed in more detail in Section 3.1.3.1 (Explosives and Explosive Byproducts).

Other materials as described here are not used on FDM or are not components of ordnance used on FDM, other than those already previously described (explosives and explosive byproducts and metals). Therefore, no further analysis is provided here for the impact of other materials on FDM.

3.1.3.4.1 Marine Markers and Flares

Marine markers are pyrotechnic devices dropped on the water's surface during training exercises to mark a position on the ocean surface, for search and rescue activities, or as bomb targets. The MK-58 marker is a tin tube that weighs about 12 lb. (5 kg). Markers release smoke at the water surface for 40 to 60 minutes. After the pyrotechnics are consumed, the marine marker fills with seawater and sinks. Iron and aluminum constitute 35 percent of the marker weight. To produce the lengthy smoke effect, approximately 40 percent of the marker weight is made up of pyrotechnic materials. The propellant, explosive, and pyrotechnic constituents of the MK-58 include red phosphorus (2.19 lb. [1.0 kg]) and manganese (IV) dioxide (1.40 lb. [0.6 kg]). Other constituents include magnesium powder (0.29 lb. [0.1 kg]), zinc oxide (0.12 lb. [0.05 kg]), nitrocellulose (0.000017 lb. [0.008 g]), nitroglycerin (0.000014 lb. [0.006 g]), and potassium nitrate (0.2 lb. [9.1 g]). The failure rate of marine markers is approximately 5 percent (U.S. Department of the Navy 2010).

Flares are used to signal, to illuminate surface areas at night in search and attack operations, and to assist with search and rescue activities. They range in weight from 12 to 30 lb. (5 to 14 kg). The major

[4] Towed and stationary targets include floating steel drums, towed aerial targets, the trimaran, and inflatable, floating targets. Potential impacts from floating steel drums are considered as part of the analysis of non-explosive practice munitions. The trimaran is a three-hulled boat with a four-foot-square sail that is towed as a moving target. Large, inflatable, plastic targets can be towed or left stationary. Towed aerial targets are either: (1) rectangular pieces of nylon fabric 7.5 ft. by 40 ft. (2.3 m by 12.2 m) that reflects radar or lasers; or (2) aluminum cylinders with a fiberglass nose cone, aluminum corner reflectors (fins), and a short plastic tail section. This second target is about 10 ft. long (3 m) and weighs about 75 lb. (34.02 kg). These four targets are recovered after use and will not be considered further.

constituents of flares include magnesium granules and sodium nitrate. Containers are constructed of aluminum, and the entire assembly is usually consumed during flight. Flares may also contain a primer such as TNT, propellant (ammonium perchlorate), and other explosives. These materials are present in small quantities (e.g., 1.0×10^{-4} ounce of ammonium perchlorate and 1.0×10^{-7} ounce of explosives). Small amounts of metals are used to give flares and other pyrotechnic materials bright and distinctive colors. Combustion products from flares include magnesium oxide, sodium carbonate, carbon dioxide, and water. Illuminating flares and marine markers are usually entirely consumed during use; neither is intended to be recovered. Table 3.1-11 summarizes the components of markers and flares.

Table 3.1-11: Summary of Components of Marine Markers and Flares

Flare or Marker	Constituents
LUU-2 Paraflare	Magnesium granules, sodium nitrate, aluminum, iron, trinitrotoluene (TNT), royal demolition explosive, ammonium perchlorate, potassium nitrate, lead, chromium, magnesium, manganese, nickel
MK-45 Paraflare	Aluminum, sodium nitrate, magnesium powder, nitrocellulose, TNT, copper, lead, zinc, chromium, manganese, potassium nitrate, pentaerythritol tetranitrate, nickel, potassium perchlorate
MK-58 Marine Marker	Aluminum, chromium, copper, lead, lead dioxide, manganese dioxide, manganese, nitroglycerin, red phosphorus, potassium nitrate, silver, zinc, zinc oxide

Source: U.S. Department of the Navy 2010

3.1.3.4.2 Chaff

Chaff consists of small, thin glass fibers coated in aluminum light enough to remain in the air anywhere from 10 minutes to 10 hours. Chaff is an electronic countermeasure designed to confuse enemy radar by deflecting radar waves and thereby obscuring aircraft, ships, and other equipment from radar tracking sources. Chaff is typically packaged in cylinders approximately 6 in. x 1.5 in. (15.2 cm x 3.8 cm) that weigh about 5 ounces (140 g) and contain a few million fibers. Chaff may be deployed from an aircraft or may be launched from a surface vessel. The chaff fibers are approximately the thickness of a human hair (generally 25.4 microns in diameter), and range in length from 0.3 to 2 in. (0.75 to 5.1 cm). The major components of the chaff glass fibers and the aluminum coating are provided in Table 3.1-12.

3.1.3.4.3 Additional Examples of Other Materials

Miscellaneous components of other materials include small parachutes used with sonobuoys and flares, nylon cord, plastic casing, and antenna float used with sonobuoys; natural and synthetic rubber, carbon, or Kevlar® fibers used in missiles; and plastic end-caps and pistons used in chaff cartridges.

3.1.3.4.4 Approach to Analysis

Most activities involving ordnance containing the other materials discussed above would be conducted more than 3 nm offshore in the Study Area. Most of the other materials are benign. In the analysis of alternatives, “local” means the area in which the material comes to rest. No state or federal sediment and water quality standards or guidelines specifically apply to major components of other materials discussed above.

Table 3.1-12: Major Components of Chaff

Component	Percent by Weight
Glass Fiber	
Silicon dioxide	52–56
Alumina	12–16
Calcium oxide, magnesium oxide	16–25
Boron oxide	8–13
Sodium oxide, potassium oxide	1–4
Iron oxide	≤ 1
Aluminum Coating	
Aluminum	99.45 (min.)
Silicon and Iron	0.55 (max.)
Copper	0.05
Manganese	0.05
Zinc	0.05
Vanadium	0.05
Titanium	0.05
Others	0.05

Note: "≤" means less than or equal to
Source: U.S. Air Force 1994

3.1.3.4.5 Impacts from Other Materials

The rate at which materials deteriorate in marine environments depends on the material and conditions in the immediate marine and benthic environment. Usually, when buried deep in ocean sediments, materials decompose at lower rates than when exposed to seawater (Ankley 1996). With the exception of plastic parts, sediment burial appears to be the fate of most ordnance used in marine warfare (Klink et al. 2005). The behavior of these other materials in marine systems is discussed in more detail below.

3.1.3.4.5.1 Marine Markers and Flares

Most of the pyrotechnic components of marine markers are consumed and released as smoke in the air. Thereafter, the aluminum and steel canisters sink to the bottom. Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms. The amount of flare residue is negligible. Phosphorus contained in the marker settles to the sea floor, where it reacts with the water to produce phosphoric acid until all phosphorus is consumed by the reaction. Phosphoric acid is a variable, but normal, component of seawater (U.S. Department of the Navy 2006a). The aluminum and iron canisters are expected to be covered by sand and sediments over time, to become encrusted by chemical corrosion, or to be covered by marine plants and animals. Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble, and adheres to particulates, and transported to the bottom sediments (Monterey Bay Research Institute 2010).

Red phosphorus, the primary pyrotechnic ingredient, constitutes 18 percent of the marine marker weight. Toxicological studies of red phosphorus revealed an aquatic toxicity in the range of 10 to 100 mg/L (10 to 100 ppm) for fish, *Daphnia* (a small aquatic crustacean), and algae (European Flame Retardants Association 2011). Red phosphorus slowly degrades by chemical reactions to phosphine and phosphorus acids. Phosphine is very reactive and usually undergoes rapid oxidation (California Environmental Protection Agency 2003). The final products, phosphates, are harmless (U.S. Department of the Navy 2010). A study by the U.S. Air Force (1997) found that, in salt water, the degradation products of flares that do not function properly include magnesium and barium.

3.1.3.4.5.2 Chaff

Chaff can remain suspended in air from 10 minutes to 10 hours, and can travel considerable distances from its release point (Arfsten et al. 2002; U.S. Air Force 1997). Factors influencing chaff dispersion include the altitude and location where it is released, prevailing winds, and meteorological conditions (Hullar et al. 1999). Doppler radar has tracked chaff plumes containing approximately 31.8 ounces (900 g) of chaff drifting 200 mi. (321.9 km) from the point of release with the plume covering a volume of greater than 400 cubic miles (1,666 cubic kilometers) (Arfsten et al. 2002). Based on the dispersion characteristics of chaff, large areas of open water would be exposed to chaff, but the chaff concentrations would be low. For example, Hullar et al. (1999) calculated that an area 4.97 mi. by 7.46 mi. (8 km x 12 km) (37.1 $mi.^2$ or 28 nm^2) would be affected by deployment of a single cartridge containing 5.3 ounces (150 g) of chaff. The resulting chaff concentration would be about 5.4 g/nm^2. This concentration corresponds to less than 179,000 $fibers/nm^2$ or less than 0.005 fibers per $ft.^2$, assuming that each cartridge contains five million fibers.

Chaff is generally resistant to chemical weathering and likely remains in the environment for long periods. However, all components of chaff's aluminum coating are present in seawater in trace amounts except magnesium, which is present at 0.1 percent (Nozaki 1997). Aluminum and silicon are the most common minerals in the earth's crust as aluminum oxide and silicon dioxide, respectively. Aluminum itself is the most common metal in the Earth's crust and is a trace element in natural waters. Ocean waters are constantly exposed to crustal materials, so the addition of small amounts of chaff should not affect water or sediment composition (Hullar et al. 1999).

The dissolved concentration of aluminum in seawater ranges from 1 to 10 µg/L (1 to 10 ppb). For comparison, the concentration in rivers is 50 µg/L (50 ppb). In the ocean, aluminum concentrations tend to be higher on the surface, lower at middle depths, and higher again at the bottom (Li et al. 2008). Aluminum is a very reactive element, and is seldom found as a free metal in nature except under highly acidic (low pH) or alkaline (high pH) conditions. It is found combined with other elements, most commonly with oxygen, silicon, and fluorine. These chemical compounds are commonly found in soil, minerals, rocks, and clays (Agency for Toxic Substances and Disease Registry 2008; U.S. Air Force 1994). Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble, and is scavenged by particulates and transported to bottom sediments (Monterey Bay Research Institute 2010).

Because of their light weight, chaff fibers tend to float on the water surface for a short period. The fibers are quickly dispersed by waves and currents. They may be accidentally or intentionally ingested by marine life, but the fibers are nontoxic, do not clump (due to a slip coating), and are very small (ranging from 0.7 to 1 mm in diameter). Chemicals leached from the chaff will be diluted by the surrounding seawater, reducing the potential for chemical concentrations reaching levels that can affect sediment quality and benthic habitats.

Systems Consultants, Inc. (1977) placed chaff samples in Chesapeake Bay water for 13 days. No increases greater than 1 ppm of aluminum, cadmium, copper, iron, or zinc were detected. Accumulation and concentration of chaff constituents is not likely under natural conditions. A U.S. Air Force study of chaff analyzed nine elements under various pH conditions: silicon, aluminum, magnesium, boron, copper, manganese, zinc, vanadium, and titanium. Only four elements were detected above the

0.02 mg/L (0.02 ppm) detection limit: magnesium, aluminum, zinc, and boron (U.S. Air Force 1994). Tests of marine organisms detected no negative impacts of chaff exposure at levels above those expected in the Study Area (Systems Consultants 1977; Farrell and Siciliano 2007).

3.1.3.4.5.3 Additional Components of Other Materials

Most components of other materials are plastics. Although plastics are resistant to degradation, they do gradually breakdown into smaller particles as a result of photodegradation and mechanical wear (Law et al. 2010). The fate of plastics that sink beyond the continental shelf is largely unknown, although marine microbes and fungi are known to degrade biologically produced polyesters (Doi et al. 1992) as well as other synthetic polymers, although the latter occurs more slowly (Shah et al. 2008).

Parachutes and other plastic items expended during training and testing activities are designed to sink. Parachutes are typically made of nylon. Nylon and other plastic materials are generally resistant to natural biodegradation. On the seafloor, photodegradation and mechanical wear are limited, and parachutes break down slowly, most likely taking years to fully degrade. Nylon is not toxic and is not expected to affect sediment or water quality. Over time, the breakdown of parachutes and other plastic materials into increasingly smaller fragments could produce microplastics. While microplastics are not generally toxic, persistent organic pollutants present in seawater may adhere to microplastics and be incorporated into the water column and sediments, as described in Section 3.1.2.1.2 (Marine Debris, Military Expended Materials, and Sediments) and Section 3.1.2.2.1 (Marine Debris and Water Quality). Because plastic materials themselves do not affect sediment or water quality, these materials are not analyzed further in this section. Potential effects of ingesting or becoming entangled in plastic materials or parachutes are discussed in the biological resources sections.

3.1.3.4.6 Evaluation of Alternatives

Potential impacts on sediments and water quality from other materials should be viewed in the following context: (1) nearshore sediments and water quality in many areas have been negatively impacted; and (2) the vast majority of those impacts are from human-generated and land-based activities, especially plastics and other ocean debris. The numbers of military expended materials discussed below reflect amounts expended annually for each type of material under each alternative.

3.1.3.4.6.1 No Action Alternative

Training Activities

Under the No Action Alternative, approximately 11,822 military expended materials composed of other materials would be used during training activities. Chaff cartridges represent 50 percent of these materials, and flares represent 49 percent. Potential impacts on sediments and water quality from training activities involving other materials would be short and long term, local, and negative. Chemical, physical, or biological changes to sediments or water quality would not be detectable and would be below or within existing conditions or designated uses.

Testing Activities

Under the No Action Alternative, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area. This testing activity does not involve the use of other materials; therefore, testing activities under the No Action Alternative would not have an impact on sediments and water quality in the Study Area.

3.1.3.4.6.2 Alternative 1

Training Activities

Under Alternative 1, approximately 51,755 military expended materials composed of other materials would be used during training activities, or an increase of over 300 percent. The components of other materials such as plastics, steel, and silicon degrade very slowly in seawater. Aluminum is converted to aluminum hydroxide in seawater and remains insoluble. Other components such as red phosphorus from flares undergo rapid oxidation in seawater, rendering them harmless. For these reasons, the increased use of other materials would have little to no impact on water quality and sediments. Chaff cartridges represent 50 percent of these materials, and flares represent 49 percent. The analysis presented under the No Action Alternative for training with regards to the use of other materials also applies to training activities under Alternative 1. Potential impacts on sediments and water quality from training activities under Alternative 1 involving other materials would be short and long term, local, and negative. Chemical, physical, or biological changes to sediment or water quality would not be detectable and would be below or within existing conditions or designated uses.

Testing Activities

Under Alternative 1, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area. Additional testing activities proposed under Alternative 1 involve the use of other materials from torpedoes and sonobuoys. Approximately 853 military expended materials composed of other materials would be used during testing activities. A percent increase for other materials released from testing activities under Alternative 1 cannot be evaluated because these proposed testing activities are not currently conducted under the No Action Alternative. There would be no impact from other materials from testing activities on sediments and water quality under Alternative 1.

3.1.3.4.6.3 Alternative 2

Training Activities

Under Alternative 2, a total of about 57,099 military expended materials composed of other materials would be used during training activities, or an increase of almost 400 percent. The components of other materials such as plastics, steel, and silicon degrade very slowly in seawater. Aluminum is converted to aluminum hydroxide in seawater and remains insoluble. Other components such as red phosphorus from flares undergo rapid oxidation in seawater, rendering them harmless. For these reasons, the increased use of other materials would have little to no impact on water quality and sediments. Chaff cartridges represent 50 percent of these materials, and flares represent 49 percent. The analysis presented under the No Action Alternative for training with regards to the use of other materials also applies to training activities under Alternative 2. Potential impacts on sediments and water quality from training under Alternative 2 involving other materials would be short and long term, local, and negative. Chemical, physical, or biological changes to sediments or water quality would not be detectable and would be below or within existing conditions or designated uses.

Testing Activities

Under Alternative 2, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area. Additional testing activities proposed under Alternative 2 involve the use of other materials from torpedoes and sonobuoys. Approximately 954 military expended materials composed of other materials would be used during testing activities. A percent increase for other materials released from testing activities under Alternative 2 cannot be evaluated because these proposed testing activities are not currently conducted under the No Action Alternative. There would be no impact from other materials from testing activities on sediments and water quality under Alternative 2.

3.1.3.4.6.4 Summary and Conclusions from Other Materials

Other military expended materials include plastics, marine markers, flares, and chaff. Some expended plastics from training and testing activities are unavoidable because they are used in ordnance or targets. Targets, however, would typically be recovered following training and testing activities. Chaff fibers are composed of nonreactive metals and glass, and would be dispersed by ocean currents as they float and slowly sink toward the bottom. The fine, neutrally buoyant chaff streamers would act like particulates in the water, temporarily increasing the turbidity of the ocean's surface. The chaff fibers would quickly disperse, and turbidity readings would return to normal.

3.1.4 Summary of Potential Impacts (Combined Impact of All Stressors) on Sediments and Water Quality

The stressors that may impact sediments and water quality include explosives and explosive byproducts, metals, chemicals other than explosives, and other military expended materials.

3.1.4.1 No Action Alternative

When considered together, the impact of the four stressors would be additive. Under the No Action Alternative, chemical, physical, or biological changes in sediment or water quality would not be detectable and would be below or within existing conditions or designated uses. This conclusion is based on the following reasons:

- Although individual training and testing activities may occur within a fairly small area, overall military expended materials and activities are widely dispersed in space and time.
- When multiple stressors occur at the same time, it is usually for a brief period.
- Many components of expended materials are inert or corrode slowly.
- Numerically, most of the metals expended are small- and medium-caliber projectiles, metals of concern comprise a small portion of the alloys used in expended materials, and metal corrosion is a slow process that allows for dilution.
- Most of the components are subject to a variety of physical, chemical, and biological processes that render them benign.
- Potential areas of negative impacts would be limited to small zones immediately adjacent to the explosives, metals, or chemicals other than explosives.
- The failure rate is low for explosives and materials with propellant systems, limiting the potential impacts from the chemicals other than explosives.

3.1.4.2 Alternative 1

Under Alternative 1, when considered separately, the impacts of the four stressors would not be additive:

- The impact of chemicals other than explosives and other materials on sediment and water quality would be short and long term and local. Chemical, physical, or biological changes in sediment or water quality would not be detectable and would be below or within existing conditions or designated uses.
- The impact of explosives, explosive byproducts, and metals on sediment and water quality would also be short and long term and local. However, chemical, physical, or biological changes

in sediment or water quality would be measurable but below applicable standards and guidelines, and the changes would be below or within existing conditions or designated uses.

When considered together, the impact of the four stressors would be additive. Chemical, physical, or biological changes in sediment or water quality would be measurable but would still be below applicable standards and guidelines. Although most types of expended materials would increase, some considerably, over the No Action Alternative, this conclusion is based on the reasons provided under the No Action Alternative (Section 3.1.4.1).

3.1.4.3 Alternative 2

Under Alternative 2, when considered separately, the impact of the four stressors on sediment and water quality would be the same as discussed under Alternative 1 because the types and amounts of military expended materials are similar under the two alternatives.

When considered together, the impact of the four stressors would be additive, and changes in sediment or water quality would be measurable, but would still be below applicable standards and guidelines. Because the types and amounts of military expended materials are similar under Alternatives 1 and 2, the reasons for this conclusion are the same as those discussed under the No Action Alternative (Section 3.1.4.1).

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3.2 Air Quality

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3.2 AIR QUALITY

AIR QUALITY SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following have been analyzed for air quality:

- Criteria pollutants
- Hazardous air pollutants

Preferred Alternative (Alternative 1)

- Criteria Pollutants: All reasonably foreseeable direct and indirect emissions of criteria pollutants in nonattainment and maintenance areas would not equal or exceed applicable *de minimis* levels.
- Hazardous Air Pollutants: The public would not be exposed to substantial concentrations of hazardous air pollutants.

3.2.1 INTRODUCTION AND METHODS

3.2.1.1 Introduction

Air pollution can threaten public health and damage the environment (U.S. Environmental Protection Agency 2007). Congress passed the Clean Air Act (CAA) and its amendments, which set regulatory limits on air pollutant emissions and help to ensure basic public health and environmental protection from air pollution. Air pollution damages trees, crops, other plants, lakes, and animals. In addition to damaging the natural environment, air pollution damages the exteriors of buildings, monuments, and statues. It can create haze or smog that reduces visibility in national parks and cities or that interferes with aviation.

Air quality is defined by atmospheric concentrations of specific air pollutants—pollutants the United States (U.S.) Environmental Protection Agency (USEPA) determined may affect the health or welfare of the public. The six major pollutants of concern, called "criteria pollutants," are carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), suspended particulate matter (PM), and lead (Pb). Suspended particulate matter is further categorized as particulates less than or equal to 10 microns in diameter (PM_{10}) and fine particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$). The USEPA established National Ambient Air Quality Standards for these criteria pollutants.

In addition to the six criteria pollutants, the USEPA designated 188 substances as hazardous air pollutants under the federal CAA. Hazardous air pollutants are air pollutants known to cause or suspected of causing cancer or other serious health effects, or adverse environmental effects (U.S. Environmental Protection Agency 2010). National Ambient Air Quality Standards have not been established for these pollutants. However, the USEPA has developed rules that limit emissions of hazardous air pollutants from specific industrial sources. These emissions control standards are known as "maximum achievable control technologies" and "generally achievable control technologies." They are intended to achieve the maximum degree of reduction in emissions of hazardous air pollutants, taking into consideration the cost of emissions control, non-air quality health and environmental impacts, and energy requirements. Examples of hazardous air pollutants include benzene, which is found in gasoline; perchloroethene, which is emitted from some dry cleaning facilities; and methylene chloride, a solvent and paint stripper used in some industries. Hazardous air pollutants are regulated under the CAA's National Emission Standards for Hazardous Air Pollutants, which apply to specific sources of hazardous air pollutants, and under the Urban Air Toxics Strategy, which applies to area sources.

Air pollutants are classified as either primary or secondary pollutants, based on how they are formed. Primary air pollutants are emitted directly into the atmosphere from the source and retain their chemical form. Examples of primary pollutants are the CO produced by a power plant burning fuel and volatile organic compounds emitted by a dry cleaner (U.S. Environmental Protection Agency 2010). Secondary air pollutants are those formed through atmospheric chemical reactions—reactions that usually involve primary air pollutants (or pollutant precursors) and normal constituents of the atmosphere (U.S. Environmental Protection Agency 2010). O_3, a major component of photochemical smog, is a secondary air pollutant. O_3 precursors consist of two groups of chemicals: nitrogen oxides (NO_X) and organic compounds. NO_X consists of nitric oxide (NO) and NO_2. Organic compound precursors of O_3 are routinely described by various terms, including volatile organic compounds, reactive organic compounds, and reactive organic gases. Finally, some air pollutants are a combination of primary and secondary pollutants. PM_{10} and $PM_{2.5}$ are both emitted as primary air pollutants by various mechanical processes (e.g., abrasion, erosion, mixing, or atomization) or combustion processes. They are generated as secondary pollutants through chemical reactions or through the condensation of gaseous pollutants into fine aerosols.

Air pollutant emissions are reported as the rate (by weight or volume) at which specific compounds are emitted into the atmosphere by a source. Typical units for emission rates from a source or source activity are pounds (lb.) per thousand gallons (gal.) of fuel burned, lb. per U.S. ton of material processed, and grams (g) per vehicle-mile (mi.) travelled.

Ambient air quality is reported as the atmospheric concentrations of specific air pollutants at a particular time and location. The units of measure are expressed as a mass per unit volume (e.g., micrograms per cubic meter [$\mu g/m^3$] of air) or as a volume fraction (e.g., parts per million [ppm] by volume). The ambient air pollutant concentrations measured at a particular location are determined by the pollutant emissions rate, local meteorology, and atmospheric chemistry. Wind speed and direction, the vertical temperature gradient of the atmosphere, and precipitation patterns affect the dispersal, dilution, and removal of air pollutant emissions from the atmosphere.

3.2.1.2 Methods

Section 176(c)(1) of the CAA, commonly known as the General Conformity Rule, requires federal agencies to ensure their actions conform to applicable implementation plans for achieving and maintaining the National Ambient Air Quality Standards for criteria pollutants.

3.2.1.2.1 Application of Regulatory Framework

3.2.1.2.1.1 National Ambient Air Quality Standards

The National Ambient Air Quality Standards for criteria pollutants are set forth in Table 3.2-1. 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.

Table 3.2-1: National Ambient Air Quality Standards

Pollutant	Primary Standards		Secondary Standards	
	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide (CO)	9 ppm (10 mg/m^3)	8-hour[1]	None	
	35 ppm (40 mg/m^3)	1-hour[1]	None	
Lead (Pb)	0.15 $\mu g/m^3$ [2]	Rolling 3-month average	Same as Primary	
Nitrogen Dioxide (NO_2)	53 ppb[3]	Annual (arithmetic mean)	Same as Primary	
	100 ppb	1-hour[4]	None	
Particulate Matter (PM_{10})	150 $\mu g/m^3$	24-hour[5]	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual[6] (arithmetic mean)	Same as Primary	
	35 $\mu g/m^3$	24-hour[7]	Same as Primary	
Ozone (O_3)	0.075 ppm (2008 std)	8-hour[8]	Same as Primary	
	0.08 ppm (1997 std)	8-hour[9]	Same as Primary	
	0.12 ppm	1-hour[10]	Same as Primary	
Sulfur Dioxide (SO_2)	0.03 ppm[11] (1971 std)	Annual (arithmetic mean)	0.5 ppm	3-hour[1]
	0.14 ppm[11] (1971 std)	24-hour[1]		
	75 ppb[12]	1-hour	None	

[1] Not to be exceeded more than once per year.

[2] Final rule signed 15 October 2008. The 1978 lead standard (1.5 micrograms per cubic meter [$\mu g/m^3$] as a quarterly average) remains in effect until 1 year after an area is designated for the 2008 standard, except in areas designated nonattainment for the 1978 standard, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

[3] The official level of the annual NO_2 standard is 0.053 parts per million (ppm), equal to parts per billion (53 ppb), which is shown here for the purpose of clearer comparison to the 1-hour standard.

[4] To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective 22 January 2010).

[5] Not to be exceeded more than once per year on average over 3 years.

[6] To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 $\mu g/m^3$.

[7] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 $\mu g/m^3$ (effective 17 December 2006).

[8] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective 27 May 2008).

[9] (a) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as the U.S. Environmental Protection Agency undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.
(c) The U.S. Environmental Protection Agency is reconsidering these standards (established in March 2008).

[10] (a) The U.S. Environmental Protection Agency revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").
(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is $\leq$ 1.

[11] The 1971 sulfur dioxide standards remain in effect until one year after an area is designated for the 2010 standard, except that in areas designated nonattainment for the 1971 standards, the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved.

[12] Final rule signed 2 June 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

Notes: mg/m^3 = milligrams per cubic meter, ppb = parts per billion, ppm = parts per million, std = standard

Source: U.S. Environmental Protection Agency 2011b, last updated 4 August 2011

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:

- O_3 – marginal, moderate, serious, severe, and extreme
- CO – moderate and serious
- PM – moderate and serious

The USEPA delegates the regulation of air quality to the state once the state has an approved State Implementation Plan. The CAA also allows states to establish air quality standards more stringent than the National Ambient Air Quality Standards.

The Mariana Islands Training and Testing (MITT) Study Area (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.

3.2.1.2.1.2 Conformity Analyses in Nonattainment and Maintenance Areas

General Conformity Evaluation

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 [C.F.R.] §§51 and 93). The purpose of the General Conformity Rule is to demonstrate that the Proposed Action would not cause or contribute to a violation 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 frequency or 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 [U.S.C.] §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. *De minimis* thresholds are shown in Table 3.2-2.

Table 3.2-2: *De Minimis* Thresholds for Conformity Determinations

Pollutant	Nonattainment or Maintenance Area Type	*De Minimis* Threshold (TPY)
Ozone (VOC or NO_x)	Serious nonattainment	50
	Severe nonattainment	25
	Extreme nonattainment	10
	Other areas outside an ozone transport region	100
Ozone (NO_x)	Marginal and moderate nonattainment inside an ozone transport region	100
	Maintenance	100
Ozone (VOC)	Marginal and moderate nonattainment inside an ozone transport region	50
	Maintenance within an ozone transport region	50
	Maintenance outside an ozone transport region	100
CO, SO_2 and NO_2	All nonattainment & maintenance	100
PM_{10}	Serious nonattainment	70
	Moderate nonattainment and maintenance	100
Lead (Pb)	All nonattainment & maintenance	25

Notes: CO = carbon monoxide, NO_X = nitrogen oxides, Pb = lead, PM_{10} = particulate matter under 10 microns, SO_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

Source: U.S. Environmental Protection Agency 2011a

Certain U.S. Department of the Navy training and testing activities take place within specific nonattainment or maintenance areas. These nonattainment and maintenance areas are identified by Air Basin or by Air Quality Control Region (federally designated areas within which communities share common air pollution problems). Coastal waters within 3 nautical miles (nm) of the coast are under the same air quality jurisdiction area as the contiguous land area.

The attainment status of most of the Study Area is unclassified because only areas within Guam and the Commonwealth of the Northern Mariana Islands (CNMI) boundaries are classified; there is no provision in the federal CAA for the classification of waters outside of the boundaries of state waters. As discussed below, however, air quality in adjacent onshore areas may be affected by releases of air pollutants from sources within the offshore areas of the Study Area. The National Ambient Air Quality Standard attainment status of the onshore areas is considered in determining appropriate controls on air pollution sources in onshore areas.

Guam. The Proposed Action includes activities on Guam and its coastal areas. Guam has two areas classified as non-attainment areas for the federal 8-hour SO_2 standard based on monitored and modeled exceedances in the 1970s. These are areas within a 2.2 mi. (3.5-kilometer [km]) radius of the Piti Power Plant and the Tanguisson Power Plant. Since that time, changes have been made to these power generation facilities, including rebuilding the power plants and upgrading their emission controls in the 1990s. Based on these improvements, Guam has submitted a redesignation request to the USEPA for the Piti area showing the area as meeting the ambient standard for SO_2. However, on 3 June 2010, the USEPA issued a new health standard for SO_2, setting the one-hour SO_2 health standard at 75 parts per billion (ppb), a level designed to protect against short-term exposures ranging from 5 minutes to 24 hours. The USEPA revoked the previous 1971 24-hour and annual SO_2 health standards (although the 1971 sulfur dioxide standards remain in effect until one year after an area is designated for the 2010 standard, except that in areas designated nonattainment for the 1971 standards, the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved). The attainment designation based on the new standard was anticipated to occur in 2012 (U.S. Department of the Navy 2010b).

The General Conformity Rule states that a federal action is exempt from the requirements of a full conformity demonstration for those criteria pollutants for which emissions increases are below specific *de minimis* emissions levels. The Proposed Action and its alternatives are required to demonstrate conformity with the currently approved state implementation plan for Guam. In accordance with the General Conformity Rule, the *de minimis* level for SO_2 in the non-attainment areas of Guam is 100 tons per year (TPY) (91 metric TPY).

Commonwealth of the Northern Mariana Islands. The Proposed Action includes activities that occur on islands of the CNMI, specifically, Farallon de Medinilla, Tinian, Saipan and Rota. The USEPA designated the Northern Mariana Islands to be in attainment or unclassified for all criteria pollutants (40 C.F.R. 81.354). Because the CNMI is in attainment of the National Ambient Air Quality Standards, a state implementation plan is not required and the General Conformity Rule does not apply. Except for power generating facilities (e.g., large power plants, hotel generators), there are no significant sources of air emissions within the CNMI (U.S. Department of the Navy 2010a).

3.2.1.2.1.3 Prevention of Significant Deterioration

Class I areas are defined by the CAA as federally owned properties for which air quality-related values are highly prized and for which very little decrease in air quality, including visibility, can be tolerated. The Proposed Action does not include any stationary sources constructed or modified after enactment of the CAA regulations, so the Prevention of Significant Deterioration Class I requirements do not apply.

On 13 May 2010, the USEPA issued a final rule that established a common sense approach to addressing greenhouse gas emissions from stationary sources under the CAA permitting programs (U.S. Environmental Protection Agency 2010). This final rule sets thresholds for greenhouse gas emissions that define when permits under the New Source Review Prevention of Significant Deterioration and Title V Operating Permit programs are required for new and existing industrial facilities. The Navy aircraft, vessel, system, and munitions training and testing included in the Proposed Action do not involve any new or existing industrial facilities or stationary sources subject to the greenhouse gas tailoring rule. On December 18, 2014, Council on Environmental Quality released revised draft guidance for public comment that describes how Federal departments and agencies should consider the effects of greenhouse gas emissions and climate change in their NEPA reviews. The revised draft guidance supersedes the draft greenhouse gas and climate change guidance released by Council on Environmental Quality in February 2010. This guidance explains that agencies should consider both the potential effects of a proposed action on climate change, as indicated by its estimated greenhouse gas emissions, and the implications of climate change for the environmental effects of a proposed action. The guidance also emphasizes that agency analyses should be commensurate with projected greenhouse gas emissions and climate impacts, and should employ appropriate quantitative or qualitative analytical methods to ensure useful information is available to inform the public and the decision-making process in distinguishing between alternatives and mitigations (Council on Environmental Quality 2014).

3.2.1.2.2 Approach to Analysis

The air quality impact evaluation requires two separate analyses: (1) impacts of air pollutants emitted by military training and testing on land and in U.S. territorial seas (i.e., within 12 nm of the coast) are assessed under the National Environmental Policy Act (NEPA), and (2) impacts of air pollutants emitted by military training and testing activities outside of U.S. territorial seas are evaluated under Executive Order (EO) 12114. State waters are within the jurisdiction of the respective State and, because each state has a distinct State Implementation Plan and supplementary state and local regulations, the air quality evaluation separately addresses those activities that emit air pollutants within each state's jurisdiction. Portions of the Study Area that lie more than 3 nm, but less than 12 nm, offshore are under federal jurisdiction.

The analysis of health-based air quality impacts under NEPA includes estimates of criteria pollutants for all training and testing activities for which aircraft, missiles, or targets operate at or below 3,000 feet (ft.) (914 meters [m]) above ground level or which involve vessels in U.S. territorial seas. The analysis of health-based air quality impacts under EO 12114 includes emissions estimates of only those training and testing activities in which aircraft, missiles, or targets operate at or below 3,000 ft. (914 m) above ground level or that involve vessels outside of U.S. territorial seas. Air pollutants emitted more than 3,000 ft. (914 m) above ground level are considered to be above the atmospheric inversion layer and, therefore, do not affect ground-level air quality (U.S. Environmental Protection Agency 1992). These emissions thus do not affect the concentrations of air pollutants in the lower atmosphere, measured at ground-level monitoring stations, upon which federal, state, and local regulatory decisions are based. For the analysis of the impacts on global climate change, however, all emissions of greenhouse gases from aircraft and vessels participating in training and testing activities, as well as targets and ordnance expended, are included regardless of altitude (Chapter 4, Cumulative Impacts).

Criteria pollutants are generated by the combustion of fuel by surface vessels, by fixed-wing and rotary-wing aircraft, and ground-based vehicles and equipment. They also are generated by the combustion of explosives and propellants in various types of munitions. Propellants used in small-, medium-, and large-caliber projectiles generate criteria pollutants when detonated. Non-explosive practice munitions contain spotting charges and propellants that generate criteria pollutants when they function. Powered targets require fuel, generating criteria pollutants during their operation, and towed targets generate criteria pollutants secondarily because another aircraft or vessel is required to provide power. Targets may generate criteria pollutants if portions of the item burn in a high-order detonation. Chaff cartridges used by ships and aircraft are launched by an explosive charge that generates small quantities of criteria pollutants. Countermeasure flares, decelerator/parachute flares, and smoke floats are designed to burn for a prescribed period, emitting criteria pollutants in the process.

The air quality analysis also includes estimating the amounts of hazardous air pollutants emitted by the proposed activities and assessing their potential impacts on air quality. Trace amounts of hazardous air pollutants would be emitted by combustion sources and use of ordnance. Hazardous air pollutants, such as rocket motor exhaust and unspent missile fuel vapors, may be emitted during missile and target use. Hazardous air pollutants are generated, in addition to criteria pollutants, by combustion of fuels, explosives, propellants, and the materials of which targets, munitions, and other training and testing materials are constructed (e.g., plastic, paint, wood). Fugitive volatile and semi-volatile petroleum compounds also may be emitted whenever mechanical devices are used. These emissions are typically one or more orders of magnitude smaller than concurrent emissions of criteria pollutants, and only become a concern when large amounts of fuel, explosives, or other materials are consumed during a single activity or in one location.

Emissions of hazardous air pollutants are intermittent and dispersed over a vast ocean area. Because only small quantities of hazardous air pollutants are emitted into the lower atmosphere, which is well mixed over the ocean, the potential for exposure is very low and the risk presented by the emissions is similarly very low. The primary emissions from many munition types are CO_2, CO, and particulate matter; hazardous air pollutants are emitted at low levels (U.S. Environmental Protection Agency 2008). A quantitative evaluation of hazardous air pollutant emissions is thus not warranted and was not conducted.

Electronic warfare countermeasures generate emissions of chaff, a form of particulate not regulated under the federal CAA as a criteria pollutant (virtually all radio frequency chaff is 10 to 100 times larger than particulate matter under PM_{10} and $PM_{2.5}$ [Spargo 1999]). The types of training and testing that produce these other emissions may take place throughout the Study Area but occur primarily within special use airspace. Chaff emissions during training and testing primarily occur 3 nm or more from shore and at altitudes over 3,000 ft. (914 m) (above the mixing layer). Chaff released over the ocean would disperse in the atmosphere and then settle onto the ocean surface. The air quality impacts of chaff were evaluated by the Air Force in *Environmental Effects of Self-Protection Chaff and Flares* (U.S. Air Force 1997). The study concluded that most chaff fibers maintain their integrity after ejection. Although some fibers are likely to fracture during ejection, it appears this fracturing does not release particulate matter. Tests indicated that the explosive charge in the impulse cartridge results in minimal releases of particulate matter. A later study at Naval Air Station Fallon found that the release of 50,000 cartridges of chaff per year over 10,000 $mi.^2$ (26,000 km^2) would result in an annual average PM_{10} or $PM_{2.5}$ concentration of 0.018 $\mu g/m^3$, far below the then National Ambient Air Quality Standard of 50 $\mu g/m^3$ for PM_{10} and 15 $\mu g/m^3$ for $PM_{2.5}$.[1] Therefore, chaff is not further evaluated as an air quality stressor in this EIS/OEIS.

The NEPA analysis includes a CAA General Conformity Analysis to support a determination pursuant to the General Conformity Rule (40 C.F.R. Part 93B). This analysis focuses on training and testing activities that could impact the nonattainment area within the region of influence. The Study Area overlies the Guam Air Quality Control Region. To evaluate the conformity of the Proposed Action with the State Implementation Plan elements of Guam, air pollutant emissions generated within the nonattainment areas of Guam are estimated based on the proposed training and testing activities that would be conducted in the Guam nonattainment areas. The CAA Conformity Applicability Analysis addresses the applicability of the General Conformity Rule. Air pollutant emissions outside U.S. territorial seas are estimated and their potential impacts on air quality are assessed through the EO 12114 compliance analysis. Emissions outside U.S. territorial seas are calculated in the same manner as emissions over territorial waters. The General Conformity Rule does not apply to activities outside of U.S. territorial seas because the CAA does not apply to actions outside of the United States.

Data for the air quality analysis are based, wherever possible, on information from military subject matter experts and established training and testing requirements. These data were used to estimate the numbers and types of aircraft, surface ships and vessels, submarines, munitions and ground-based vehicles and equipment (i.e., potential sources of air emissions) that would be involved in training and testing activities under each alternative. Emissions sources and the approach used to estimate emissions under the No Action Alternative, Alternative 1, and Alternative 2 are presented herein.

[1] The current standard for PM_{10} is 150 $\mu g/m^3$ over a 24-hour average time (See Table 3.2-1).

3.2.1.2.3 Emissions Estimates

3.2.1.2.3.1 Aircraft Activities

To estimate aircraft emissions, the operating modes (e.g., "cruise" mode), number of hours of operation, and types of engine for each type of aircraft were evaluated. For estimating purposes, training and testing aircraft flights are assumed to originate offshore from aircraft carriers or other Navy vessels outfitted with flight decks and from North Field at Andersen Air Force Base. With the exception of helicopters, all aircraft are assumed to travel to and from training ranges at or above 3,000 ft. (914 m) above mean sea level and, therefore, their transits to and from the ranges do not affect surface air quality. Air combat maneuvers and air-to-air missile exercises are primarily conducted at altitudes well in excess of 3,000 ft. (914 m) above ground level and, therefore, are not included in the estimated emissions of criteria pollutants. Activities or portions of those training or testing activities occurring below 3,000 ft. (914 m) are included in emissions estimates. Examples of activities typically occurring below 3,000 ft. (914 m) include those involving helicopter platforms such as mine warfare, anti-surface warfare, and anti-submarine warfare training and testing activities.

The types of aircraft used and the numbers of sorties flown under the No Action Alternative are those analyzed in the Mariana Islands Range Complex EIS/OEIS under the preferred alternative, which are incorporated in this EIS/OEIS by reference. For Alternatives 1 and 2, estimates of future aircraft sorties are based on evolutionary changes in the military's force structure and mission assignments. Where there are no major changes in types of aircraft, future activity levels are estimated from the distribution of baseline activities.

Time on range (activity duration) was based on the operational limit of the aircraft. The same time on range for each aircraft activity under the No Action Alternative was used in Alternatives 1 and 2. With the exception of helicopters, estimated altitudes of activities for all aircraft were assumed to be above 3,000 ft. (914 m) except during landing and takeoff. Testing activities are similar to training activities, and therefore similar assumptions were made for such activities in terms of aircraft type, altitude, and flight duration.

Air pollutant emissions were estimated based on the Navy's Aircraft Environmental Support Office Memorandum Reports for individual aircraft categories (Aircraft Emission Estimates: Mission Operations). For aircraft for which Aircraft Environmental Support Office emission factors were not available, emission factors were obtained from other published sources.

The emissions calculations for each alternative conservatively assume that each aircraft activity listed in Tables 2.8-1 to 2.8-4, is separately conducted. In practice, a testing activity may be conducted during a training flight. Two or more training activities also may be conducted during one flight (e.g., chaff or flare exercises may occur during electronic warfare activities, or air-to-surface gunnery and air-to-surface bombing activities may occur during a single flight operation). Using conservative assumptions may produce elevated aircraft emissions estimates but accounts for the possibility (however remote) that each aircraft training and testing activity is separately conducted.

3.2.1.2.3.2 Surface Ship Activities

Marine vessel traffic in the Study Area includes military ship and boat traffic, unmanned surface vessels, and range support vessels providing services for military training and testing activities. Non-military commercial vessels and recreational vessels also are regularly present. These commercial vessels are not evaluated in the air quality analysis because they are not part of the Proposed Action. The methods for estimating marine vessel emissions involve evaluating the type of activity, the number of hours of operation, the type of propulsion, and the type of onboard generator for each vessel type.

The types of surface ships and numbers of activities for the No Action Alternative are derived from range records and Navy subject matter experts regarding vessel participant data. For Alternatives 1 and 2, estimates of future ship activities are based on anticipated evolutionary changes in the Navy's force structure and mission assignments. Where there are no major changes in types of ships, estimates of future activities are based on the historical distribution of ship use. Navy aircraft carriers and submarines are nuclear-powered and have no air pollutant emissions associated with propulsion.

For surface ships, the durations of activities were estimated by taking an average over the total number of activities for each type of training and testing. Emissions for baseline activities and for future activities were estimated based on discussions with exercise participants. In addition, information provided by subject-matter experts was used to develop a breakdown of time spent at each operational mode (i.e., power level) used during activities in which marine vessels participated. Several testing activities are similar to training activities, and therefore similar assumptions were made for such activities in terms of vessel type, power level, and activity duration.

Emission factors for marine vessels are obtained from the database developed for Naval Sea Systems Command by John J. McMullen Associates, Inc. (2001). Emission factors were provided for each marine vessel type and power level. The resulting calculations provided information on the time spent at each power level in each part of the Study Area, emission factors for that power level (in pounds of pollutant per hour), and total emissions for each marine vessel for each operational type and mode.

The pollutants for which calculations were made include exhaust total hydrocarbons, CO, NO_x, PM, CO_2, and SO_2. For non-road engines, all particulate matter emissions are assumed to be smaller than PM_{10}, and 92 percent of the particulate matter from gasoline and diesel-fueled engines is assumed to be smaller than $PM_{2.5}$ (U.S. Environmental Protection Agency 2002). For gaseous-fueled engines (liquefied petroleum gas/compressed natural gas), 100 percent of the particulate matter emissions are assumed to be smaller than $PM_{2.5}$ (U.S. Environmental Protection Agency 2002).

The emissions calculations for each alternative conservatively assume that each vessel activity listed in Chapter 2, Tables 2.8-1 to 2.8-4 is separately conducted and separately produces vessel emissions. In practice, one or more testing activities may take advantage of an opportunity to travel at sea aboard and test from a vessel conducting a related or unrelated training activity. It is also probable that two or more training activities may be conducted during one training vessel movement (e.g., a ship may conduct large-, medium-, and small-caliber surface-to-surface gunnery exercises during one vessel movement). Furthermore, multiple unit-level training activities may be conducted during a larger composite training unit exercise. Using conservative assumptions may produce elevated vessel emissions estimates but accounts for the possibility (however remote) that each training and testing activity is separately conducted.

3.2.1.2.3.3 Submarine Activities

No U.S. submarines burn fossil fuel under normal operating conditions (they are nuclear-powered); therefore, no air pollutants are emitted during submarine training or testing activities except those non-nuclear submarines owned by participating nations in joint exercises during training activities in the Study Area. Activities of foreign participants are not covered in this air quality analysis.

3.2.1.2.3.4 Naval Gunfire, Missiles, Bombs, Other Munitions, and Military Expended Materials

Naval gunfire, missiles, bombs, and other types of munitions used in training and testing activities emit air pollutants. To estimate the amounts of air pollutants emitted by ordnance during use, the numbers and types of munitions used during training or testing activities are first totaled. Then, generally accepted emissions factors (AP-42, Compilation of Air Pollutant Emission Factors, Chapter 15: Ordnance Detonation [U.S. Environmental Protection Agency 1995]) for criteria pollutants are applied to the total amounts. Finally, the total amounts of air pollutants emitted by each munition type are summed to produce total amounts of each criteria pollutant under each alternative.

3.2.1.2.4 Sensitive Receptors

Identification of sensitive receptors is part of describing the existing air quality environment. Sensitive receptors are individuals in residential areas, schools, parks, hospitals, and other sites for whom there is a reasonable expectation of continuous human exposure during periods of peak ambient air pollutant concentrations. In the oceanic portions of the Study Area, crews of vessels and recreational users of the western Pacific Ocean and the Philippine Sea may encounter air pollutants generated by the Proposed Action. Few such individuals are typically present, however, and the durations of their exposure to substantial concentrations of these pollutants is limited because the areas are cleared of nonparticipants before activities commence. These potential receptors are not considered sensitive.

3.2.1.3 Climate Change

Greenhouse gases are compounds that contribute to the greenhouse effect—a natural phenomenon in which gases trap heat in the lowest layer of the earth's atmosphere (surface-troposphere system), causing heating (radiative forcing) at the surface of the earth. The primary long-lived greenhouse gases directly emitted by human activities are CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF_6). CO_2, CH_4, and N_2O occur naturally in the atmosphere. However, their concentrations increased from the pre-industrial era (1750) to 2007–2008: CO_2 (38 percent), CH_4 (149 percent), and N_2O (23 percent) (U.S. Environmental Protection Agency 2009b). These gases influence global climate by trapping heat in the atmosphere that would otherwise escape to space. The heating effect of these gases is considered the probable cause of the global warming observed over the last 50 years (U.S. Environmental Protection Agency 2009b, c). Climate change can affect many aspects of the environment. Not all impacts of greenhouse gases are related to climate. For example, elevated concentrations of CO_2 can lead to ocean acidification and stimulate terrestrial plant growth, and CH_4 emissions can contribute to higher O_3 levels.

The administrator of the USEPA determined that six greenhouse gases taken in combination endanger both the public health and the public welfare of current and future generations. The USEPA specifically identified CO_2, CH_4, N_2O, hydrofluorocarbons, perfluorocarbons, and SF_6 as greenhouse gases (U.S. Environmental Protection Agency 2009c; 74 Federal Register 66496, 15 December 2009).

To estimate global warming potential, the United States quantifies greenhouse gas emissions using the 100-year timeframe values established in the Intergovernmental Panel on Climate Change Fourth Assessment Report (Intergovernmental Panel on Climate Change 2007), in accordance with United Nations Framework Convention on Climate Change (United Nations Framework Convention on Climate Change 2004) reporting procedures. All global warming potentials are expressed relative to a reference gas, CO_2, which is assigned a global warming potential equal to 1. The five other greenhouse gases have a greater global warming potential than CO_2, ranging from 21 for CH_4, 310 for N_2O, 140 to 6,300 for hydrofluorocarbons, 6,500 to 9,200 for perfluorocarbons, and up to 23,900 for SF_6. To estimate the CO_2

equivalency of a non-CO_2 greenhouse gas, the appropriate global warming potential of that gas is multiplied by the amount of the gas emitted. All six greenhouse gases are multiplied by their global warming potential and the results are added to calculate the total equivalent emissions of CO_2 (CO_2e). The dominant greenhouse gas emitted is CO_2, mostly from fossil fuel combustion (85.4 percent) (U.S. Environmental Protection Agency 2009b, c). Weighted by global warming potential, CH_4 is the second largest component of emissions, followed by N_2O. Global warming potential-weighted emissions are presented in terms of equivalent emissions of CO_2, using units of teragrams (1 million metric tons or 1 billion kilograms [Tg]) of carbon dioxide equivalents (Tg CO_2 Eq). The Proposed Action is anticipated to release greenhouse gases to the atmosphere. These emissions are quantified for the proposed Navy training and testing in the Study Area, and estimates are presented in Chapter 4 (Cumulative Impacts).

The potential effects of proposed greenhouse gas emissions are by nature global; individual sources of greenhouse gas emissions are not large enough to have any noticeable effect on climate change but may have cumulative impacts. Therefore, the impact of proposed greenhouse gas emissions on climate change is discussed in the context of cumulative impacts in Chapter 4 (Cumulative Impacts).

3.2.1.4 Other Compliance Considerations, Requirements and Practices

3.2.1.4.1 Executive Order 12088

Executive Order 12088, *Federal Compliance with Pollution Control Standards*, requires each federal agency to comply with applicable pollution control standards, defined as, "the same substantive, procedural, and other requirements that would apply to a private person." The EO further requires federal agencies to cooperate with USEPA, state, and local environmental regulatory officials.

3.2.1.4.2 Chief of Naval Operations Instruction 5090.1

The Navy developed Chief of Naval Operations Instruction (OPNAVINST) 5090.1 series, which contains guidance for environmental evaluations. Chapter 7 and Appendix F of this series contain guidance for air quality analysis and general conformity determinations. The analysis in this EIS/OEIS was performed in compliance with this instruction.

3.2.1.4.3 Current Requirements and Practices

Equipment used by military units in the Study Area, including ships and other marine vessels, aircraft, and other equipment, are properly maintained and fueled in accordance with applicable military requirements. Operating equipment meets federal and state emission standards, where applicable. For example, in accordance with the OPNAVINST 5090.1 series, Chapter 7, Navy commands shall comply with Navy and regulatory requirements for composition of fuels used in all motor vehicles, equipment, and vessels. To prevent misfueling, installations shall enforce appropriate controls to ensure that any fuel that does not meet low-sulfur requirements is not dispensed to commercial motor vehicles, equipment, or vessels not covered under a national security exemption.

The USEPA's Region 9 Air Division manages, implements, and enforces programs covering indoor and outdoor air quality, radiation, control of air pollution from stationary and mobile sources, stratospheric O_3 protection, and other air quality related programs for the Pacific Southwest. Region 9 also has an active and direct role over islands west and south of Hawaii, including the U.S. territories of Guam and American Samoa, the CNMI, and other unincorporated U.S. Pacific possessions.

Guam. Guam has an approved state implementation plan which was developed to allow the Territory to achieve attainment of the National Ambient Air Quality Standard for sulfur oxides in an area where the standard is exceeded (area where power production facilities [Tanguisson and Piti power plants] burning high sulfur content fuel oil are located). In lieu of the USEPA's Title V operating permit program, Guam has an approved alternate operating permit program (40 C.F.R. Part 69, Subpart A – Guam).

The Air and Land Programs Division of the Guam Environmental Protection Agency administers the air pollution control program in Guam by implementing and enforcing Guam's Air Pollution Control Standards and Regulations. The Air Pollution Control Act of Guam or Public Law 10-74 was promulgated and codified under Chapter 49, Title 10 of the Guam Code Annotated (GCA) to support requirements of the CAA.

The CAA Amendments of 1990 established a new standard of 500 ppm maximum sulfur content and a minimum cetane index (calculated based on the fuel's density and distillation range) of 40 for on-highway diesel, which took effect in October 1993. Guam and the CNMI, upon submitting petitions requesting exemption from the sulfur content requirement, were granted exemptions. The 500 ppm standard was reduced further to 15 ppm in 2006 and both Guam and the CNMI were exempt from the new standard. However, in August 2010, Senate Bill 414-30 was passed by the Guam legislature that requires that "all diesel imported to Guam for the purpose of sale and distribution shall meet the USEPA standards for ultra low sulfur diesel" (I' Minatrenta Na Liheslaturan Guahan 2014), effective 1 January 2011. In effect all diesel on Guam contains no more than 15 ppm sulfur.

Commonwealth of the Northern Mariana Islands. The CNMI Department of Environmental Quality is the primary environmental regulatory agency in the Commonwealth. It is responsible for developing, implementing, and enforcing programs and regulations designed to protect human health and the environment. The CNMI Department of Environmental Quality's air pollution control regulations can be found in the Federal Register (FR) (52 FR 43574).

The CNMI Department of Environmental Quality is responsible for air quality within the Commonwealth. Air quality is not monitored in the Commonwealth, except for SO_2 related to volcanic activity from Anatahan, which is monitored by the CNMI Emergency Management Office (U.S. Department of the Navy 2010b).

3.2.2 AFFECTED ENVIRONMENT

3.2.2.1 Region of Influence

The region of influence for air quality is a function of the type of pollutant, emission rates of the pollutant source, proximity to other emission sources, and local and regional meteorology. For inert pollutants (all pollutants other than O_3 and its precursors), the region of influence is generally limited to a few miles downwind from the source. For a photochemical pollutant such as O_3, however, the region of influence may extend much farther downwind. O_3 is a secondary pollutant formed in the atmosphere by photochemical reactions of previously emitted pollutants, or precursors (volatile organic compounds and NO_X). The maximum effects of precursors on O_3 concentrations tend to occur several hours after the time of emission during periods of high solar load, and may occur many miles from the source. O_3 and O_3 precursors transported from other regions can also combine with local emissions to produce high local O_3 concentrations. Therefore, the region of influence for air quality includes the island air basins within the Study Area as well as adjoining land areas several miles inland, which may from time to time be downwind from emission sources associated with the Proposed Action.

3.2.2.2 Climate of the Study Area

The climate of the Study Area influences air quality. The climate of the Pacific Ocean and adjacent land areas is influenced by the temperatures of the surface waters and water currents as well as by wind blowing across the water. Offshore climates are moderate, and seldom have extreme seasonal variations because the ocean is slow to change temperature. Ocean currents influence climate by moving warm and cold water between regions. Adjacent land areas are affected by the wind that is cooled or warmed when blowing over these currents. In addition to its influence on temperature, the wind moves evaporated moisture from the ocean to adjacent land areas and is a major source of rainfall.

Atmospheric stability and mixing height provide a measure of the amount of vertical mixing of pollutants. Over water, the atmosphere tends to be neutral to slightly unstable because there is usually a positive heat and moisture flux. Over land, the atmospheric stability is more variable, being unstable during the daytime, especially in summer due to rapid surface heating, and stable at night, especially under clear conditions in winter. The mixing height over water typically ranges between 1,640 and 3,281 ft. (500 and 1,000 m), with a slight diurnal variation (U.S. Environmental Protection Agency 1972). The air quality analysis presented in this EIS/OEIS assumes that 3,000 ft. (914 m) is the typical maximum afternoon mixing height, and thus air pollutants emitted above this altitude do not affect ground-level air pollutant concentrations.

The climate in the Mariana Islands is characterized as tropical marine where the weather is warm and humid, and seasonal temperature variation is low. The average temperature in the Mariana Islands is 81 degrees Fahrenheit (°F) (27.2 degrees Celsius [°C]) (ClimateTemp.Info 2011). Daily temperatures on Guam average a low of 72°F (22°C) and a high of 86°F (30°C) (National Weather Service 2011). The average maximum temperature is 88°F (31°C) occurring in April, May, and June. The average minimum temperature is 73°F (23°C) occurring in February.

The average wind speed from December to May is 8–12 miles per hour (mph) (13–19 kilometers per hour [kph]), and from June to November is 4–7 mph (6–11 kph) (ClimateTemp.Info 2011).

There are two seasons, the dry season (January–June) and the wet season (July–December). During the dry season, prevailing winds are from the east and northeast. The dry season provides the most pleasant weather, with slightly lower humidity and a monthly rainfall average of just 4.5 inches (114 millimeters) (Joint Typhoon Warning Center 2010; National Weather Service 2011). The driest month is April and the wettest month is August.

Guam and the CNMI lie directly along the typhoon track, with typhoons most commonly occurring from August to December (Joint Typhoon Warning Center 2010; National Weather Service 2011).

3.2.2.3 Regional Emissions

Most stationary air pollutant sources in the Study Area are located on Guam and Saipan, with some minor contributions from stationary sources on Rota and Tinian. The largest point sources of major air pollutants in the Mariana Islands are power-generating stations, although Andersen Air Force Base on Guam is considered a major stationary source that requires a Title V operating permit (U.S. Department of the Navy 2010a, b).

The small number of major sources, dispersed population centers, and generally good ventilation from daily trade winds result in good to excellent air quality in the Study Area. Volcanic organic gases from volcanic eruptions from several island stratovolcanos in the area, the most active of which is Anatahan, are a natural source of sulfur dioxide and other air pollutants in the Study Area.

3.2.2.4 Existing Air Quality

Air quality in offshore ocean areas is generally better than the air quality of adjacent onshore areas because there are few or no large sources of criteria pollutants offshore. Much of the air pollutants found in offshore areas are transported there from adjacent land areas by offshore winds, so concentrations of criteria pollutants generally decrease with increasing distance from land. No criteria pollutant monitoring stations are located in offshore areas, so air quality in the offshore areas of the Study Area are inferred from the air quality on Guam and the CNMI.

In general terms, the air quality on Guam and the CNMI is considered very good (i.e., Guam and the CNMI have been designated in attainment or unclassified for all criteria pollutants, with the exception of SO_2 around the Tanguisson and Piti power facilities on Guam). This is reflective of the pollutant concentrations, the size and topography of the Mariana Islands, and the prevailing meteorological conditions. The nearly constant easterly trade winds, which average about 4–12 mph (6–19 kph), are dominant throughout the year and prevent the occurrence of inversion layers and the build-up of pollutants.

Recent ambient air quality data are not available for the islands of Guam and the CNMI. Because of the lack of ambient air quality data, the existing conditions on the islands in the Study Area cannot be evaluated by a direct comparison of the ambient pollutant concentration levels with the National Ambient Air Quality Standards (refer to Section 3.2.1.2.1.1, National Ambient Air Quality Standards).

3.2.3 Environmental Consequences

This section evaluates how and to what degree the activities described in Chapter 2 (Description of the Proposed Action and Alternatives) could impact air quality within the Study Area. Tables 2.8-1 through 2.8-4 present the baseline and proposed training and testing activity locations for each alternative (including number of activities and ordnance expended). The air quality stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors applicable to air quality in the Study Area are analyzed below and include the following:

- Criteria pollutants
- Hazardous air pollutants

In this analysis, criteria pollutant emissions were estimated for vessels, aircraft, ordnance and ground-based vehicles and equipment. For each alternative, emissions estimates were developed and totaled for the Study Area. Hazardous air pollutants are analyzed qualitatively in relation to the prevalence of the sources emitting hazardous air pollutants during training and testing activities.

3.2.3.1 Criteria Pollutants

The potential impacts of criteria pollutants are evaluated by first estimating the emissions from training and testing activities in the Study Area for each alternative. These estimates are then used to determine the potential impact of the emissions on the attainment status of the adjacent air quality control region. Emissions of criteria pollutants may affect human health directly by degrading local or regional air quality or indirectly by their impacts on the environment. Air pollutant emissions may also have a regulatory effect separate from their physical effect, if additional air pollutant emissions change the attainment status of an air quality control region.

The estimates of criteria pollutant emissions for each alternative are organized by activity (i.e., either training or testing).Total air pollutant emissions for Navy training and testing activities in the Study Area under each alternative are also estimated.

3.2.3.1.1 No Action Alternative

3.2.3.1.1.1 Training Activities

Table 3.2-3 lists training-related criteria pollutant and precursor emissions in the Study Area. Calculation details are presented in spreadsheets in Appendix D (Air Quality Calculations and Record of Non-Applicability). Totals include emissions from aircraft, vessels, ordnance, and ground-based vehicles and equipment that are anticipated to be involved in training activities.

Table 3.2-3: Annual Criteria Pollutant Emissions from Training under the No Action Alternative

Source	Air Pollutant Emissions (TPY)					
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	124	120	17	7	57	52
Vessels	218	273	88	330	60	54
Ordnance	93	2	0	0	3	3
Other Equipment	39	98	12	0	40	36
Total	**474**	**493**	**117**	**337**	**160**	**145**

Notes: CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter under 2.5 microns, PM_{10} = particulate matter <10 microns, SO_x= sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

Under the No Action Alternative, the annual numbers of military training activities in the Study Area would remain at baseline (existing) levels. The criteria pollutants that would be emitted in the greatest quantities by aircraft are typically CO, NO_x, and PM (PM_{10} and $PM_{2.5}$). These emissions are associated with aircraft in a variety of training activities, including anti-air warfare, electronic warfare, and mine warfare. The air pollutants emitted in the greatest quantities from surface vessels are typically NO_x, CO, and SO_x. These emissions are associated with vessels in a variety of training activities, including anti-submarine warfare, anti-surface warfare, and electronic warfare. The air pollutants emitted in the greatest quantities by ordnance are CO and PM (PM_{10} and $PM_{2.5}$), which would be emitted under the No Action Alternative by a variety of ordnance, including bombs, rockets, missiles, smokes, flares, and gun rounds. Other equipment, which include assault vehicles, high mobility multipurpose wheeled vehicles, trucks, generators, water purification units, bulldozers, forklifts, cranes, and others, are used on land and also contribute to emissions from training.

While pollutants emitted in the Study Area include emissions generated on land and near shore (within 3 nm of the shoreline), emissions would also be generated in areas more than 3 nm offshore. Natural mixing would substantially disperse the majority of the pollutants before they reach land and the boundaries of the adjacent air quality control region or air basin. The contributions of air pollutants generated from the Proposed Action to onshore and near shore air quality would have no substantial effect and are unlikely to measurably add to existing onshore and near shore pollutant concentrations because (1) the pollutants are emitted over a large area (i.e., the Study Area is an area source), (2) the distances the offshore pollutants would be transported are often large, and (3) the pollutants are substantially dispersed during transport.

3.2.3.1.1.2 Testing Activities

Under the No Action Alternative, the Navy would continue conducting deep water sound propagation and temperature-sound velocity profile studies of the water column in the Study Area (refer to Table 2.4-4 for a complete description). Active data collection by research vessels is scheduled during May and July of 2018 and passive data collection by remotely sensing gliders later in the year. The final phases of the experiment will be completed during March through May 2019. Since this is a nonrecurring activity with emission sources limited to research vessels over a short duration and that would occur in an isolated area of the Study Area, associated air pollutant emissions from this testing activity would be minimal and are unlikely to have an impact on the air quality of the Study Area. No further consideration of this testing activity's impact on air quality is warranted under the other alternatives.

3.2.3.1.1.3 Criteria Pollutant Emissions in Nonattainment and Maintenance Areas

The nonattainment areas in the Study Area are areas within 2.2 mi. (3.5 km) of the Piti and Tanguisson Power Plants in Guam. These areas have been designated as nonattainment areas for SO_2 only; therefore, this analysis will be limited to SO_2 emissions. There are no nonattainment and maintenance areas in the CNMI for any criteria pollutants.

Training Activities

Under the No Action Alternative, SO_2 emissions from training in the nonattainment areas were estimated at 172 tons per year (based on a worst case assumption that all training activities that *may* take place in the nonattainment areas would take place in the nonattainment areas (refer to calculation details presented in Appendix D, Air Quality Calculations and Record of Non-Applicability). However, these training activities can occur in other areas outside of the nonattainment areas, such as in the CNMI, Andersen Air Force Base, Naval Base Guam Munitions Site, Naval Base Guam Telecommunications Site, and many other training locations in the Study Area (see Figures 2.1-1 through 2.1-12 for training and testing areas within the MITT Study Area). In addition, all ships and aircraft associated with a training activity were fully accounted for, even though they may operate within the nonattainment area for a very limited amount of time or may not operate there at all (e.g., outside of the 2.2 mi. [3.5 km] distance from the center of the nonattainment area, at altitudes above 3,000 ft. [914 m]).

Testing Activities

Under the No Action Alternative, there are no testing activities that occur in the nonattainment areas in the Study Area.

3.2.3.1.1.4 General Conformity Threshold Determinations

The No Action Alternative is exempt from the federal General Conformity Rule because training and testing activities would not increase criteria pollutant emissions above baseline levels in the nonattainment areas of Guam.

3.2.3.1.1.5 Summary – No Action Alternative

Criteria pollutant emissions under the No Action Alternative are summarized in Table 3.2-4. While criteria pollutants emitted within the territorial waters of the Study Area may be transported ashore, they would not affect the attainment status of coastal air quality control regions. The amounts of air pollutants emitted in the Study Area and subsequently transported ashore would have no substantial effect on air quality because (1) the pollutants are emitted over large areas (i.e., the Study Area is an area source), (2) the distances the air pollutants would be transported are often large, and (3) the pollutants are substantially dispersed during transport. The criteria pollutants emitted over non-territorial waters within the Study Area would be dispersed over vast areas of open ocean and thus would not cause significant harm to environmental resources in those areas.

Table 3.2-4: Estimated Annual Criteria pollutant Emissions in MITT Study Area, No Action Alternative

Source	Emissions by Air Pollutant (TPY)						
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Training Activities	474	493	117	337	160	145	1,726
Testing Activities	0	0	0	0	0	0	0
Total MITT Study Area	**474**	**493**	**117**	**337**	**160**	**145**	**1,726**

Notes: CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter under 2.5 microns, PM_{10} = particulate matter <10 microns, SO_x= sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

3.2.3.1.2 Alternative 1

3.2.3.1.2.1 Training Activities

Under Alternative 1, the annual numbers of various military training activities in the Study Area would increase according to Table 2.8-1. Therefore, emissions rates for criteria pollutants also would increase relative to emissions under the No Action Alternative. The total amounts of criteria pollutants emitted by military aircraft, vessels, ordnance and ground-based vehicles and equipment during training activities in the Study Area under Alternative 1 are shown in Table 3.2-5. Calculation details are presented in spreadsheets in Appendix D (Air Quality Calculations and Record of Non-Applicability). The percent increases in criteria pollutants range from 79 percent (for VOC) to almost 200 percent (for NO_x). Air pollutants from training activities under Alternative 1 would not have a measurable impact on air quality in coastal waters or on adjacent land areas because of the distances from land at which about half of the pollutants are emitted and the generally strong ventilation resulting from regional meteorological conditions. About 47 percent of training emissions would be produced beyond 3 nm (also includes emissions beyond 12 nm) from shore. About 29 percent of emissions are generated beyond 12 nm from shore.

Table 3.2-5: Annual Criteria Pollutant Emissions from Training under Alternative 1

Source	Air Pollutant Emissions (TPY)					
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	318	699	44	32	280	252
Vessels	453	611	151	645	122	108
Ordnance	233	4	0	0	6	6
Other Equipment	48	122	15	0	51	46
Total	**1,052**	**1,436**	**210**	**677**	**459**	**412**

Notes: CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter under 2.5 microns, PM_{10} = particulate matter <10 microns, SO_x= sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

3.2.3.1.2.2 Testing Activities

Sources of emissions from testing activities in the Study Area are from Navy aircraft and vessels as listed in Tables 2.8-2 to 2.8-3. Naval Air Systems Command testing activity consists of anti-submarine warfare tracking test using maritime patrol aircraft and anti-surface warfare missile tests. Naval Sea Systems Command testing activities involve mostly ship-related activities such as ship signature testing, countermeasure acoustic system testing, at-sea sonar testing and mission packages (anti-submarine warfare, anti-surface warfare, and mine countermeasure) testing. Table 3.2-6 presents emissions from Navy testing activities. Calculation details are presented in spreadsheets in Appendix D (Air Quality Calculations and Record of Non-Applicability). Air pollutants from testing activities under Alternative 1 would not have a measurable impact on air quality in coastal waters or on adjacent land areas because a majority of the emissions are generated beyond 3 nm from shore, and the generally strong ventilation in the area resulting from regional meteorological conditions would quickly disperse the emissions. A percent increase for criteria emissions from testing activities under Alternative 1 cannot be evaluated because, with the exception of the existing testing conducted by the Office of Naval Laboratory (which was not evaluated because of its distant location from the potential impact areas), these proposed testing activities are not currently conducted under the No Action Alternative.

Table 3.2-6: Annual Criteria Pollutant Emissions from Testing under Alternative 1

Source	Air Pollutant Emissions (TPY)					
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	5	19	1	1	9	8
Vessels	260	167	24	35	10	8
Ordnance	0	0	0	0	1	1
Other Equipment	0	0	0	0	0	0
Total	**265**	**186**	**25**	**36**	**20**	**17**

Notes: CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter under 2.5 microns, PM_{10} = particulate matter <10 microns, SO_x = sulfur oxides, TPY = tons per year; *emissions estimates are preliminary*

3.2.3.1.2.3 Criteria Pollutant Emissions in Nonattainment and Maintenance Areas

Training Activities

Under Alternative 1, SO_2 emissions from training in the nonattainment areas were estimated at 263 tons per year (based on a worst case assumption that all training activities that may take place in the nonattainment areas would take place in the nonattainment areas (refer to calculation details presented in Appendix D, Air Quality Calculations and Record of Non-Applicability). The increase in SO_2 emissions from training in the nonattainment areas of Guam under Alternative 1 is estimated at 91 tons per year compared to SO_2 emissions from training in the nonattainment areas of Guam under the No Action Alternative, a 47-percent increase. However, these training activities can occur in other areas outside of the nonattainment areas, such as in the CNMI, Andersen Air Force Base, Naval Base Guam Munitions Site, Naval Base Guam Telecommunications Site, and many other training locations in the Study Area (see Figures 2.1-1 through 2.1-12 for training and testing areas within the MITT Study Area. In addition, all ships and aircraft associated with a training activity were fully accounted for, even though they may operate within the nonattainment area for a very limited amount of time or may not operate there at all (e.g., outside of the 2.2 mi. [3.5 km] distance from the center of the nonattainment area, at altitudes above 3,000 ft. [914 m]).

Testing Activities

Shipboard protection systems and swimmer defense testing would take place at Naval Base Guam Apra Harbor, which is within the nonattainment area around the Piti Power Plant. Broad area maritime surveillance testing may also occur within 3 nm of shore as part of Civilian Port Defense exercises, even though not all testing occurs within the nonattainment areas of Guam. SO_2 emissions from these testing activities under Alternative 1 were estimated at 0.1 ton per year. A percent increase for SO_2 emissions from testing activities in the nonattainment areas under Alternative 1 cannot be evaluated because these proposed testing activities are not currently conducted under the No Action Alternative.

3.2.3.1.2.4 General Conformity Threshold Determinations

Under Alternative 1, the emissions increase for SO_2 from all training and testing activities in the nonattainment areas of Guam above the No Action Alternative is estimated to be 91 tons per year. The *de minimis* threshold for a full conformity determination is an SO_2 emissions increase of 100 tons per year. The General Conformity Rule, therefore, does not apply under Alternative 1.

3.2.3.1.2.5 Summary – Alternative 1

Total criteria pollutant emissions under Alternative 1 are summarized in Table 3.2-7. Under Alternative 1, the annual numbers of Navy training and testing activities in the Study Area would increase. Emissions of all criteria pollutants would increase. 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. The amounts of air pollutants emitted in the Study Area and subsequently transported ashore would be minor because (1) the pollutants are emitted over large areas (i.e., the Study Area is an area source), (2) the distances the air pollutants would be transported are often large, and (3) the pollutants would be substantially dispersed during transport. The criteria pollutants emitted over nonterritorial waters within the Study Area would be dispersed over vast areas of open ocean and thus would not cause significant harm to environmental resources in those areas.

Table 3.2-7: Estimated Annual Criteria pollutant Emissions in MITT Study Area, Alternative 1

Source	Emissions by Air Pollutant (TPY)						
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Training Activities	1,052	1,436	210	677	459	412	4,246
Testing Activities	265	186	25	36	20	17	549
Total MITT Study Area	**1,317**	**1,622**	**235**	**713**	**479**	**429**	**4,759**

Notes: CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter under 2.5 microns, PM_{10} = particulate matter <10 microns, SO_x= sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

3.2.3.1.3 Alternative 2

3.2.3.1.3.1 Training Activities

Under Alternative 2, the annual numbers of various military training activities in the Study Area would increase according to Table 2.8-1. Therefore, emissions rates for criteria pollutants also would increase relative to emissions under the No Action Alternative. The total amounts of criteria pollutants emitted by military aircraft, vessels, ordnance and ground-based vehicles and equipment during training activities in the Study Area under Alternative 2 are shown in Table 3.2-8. Calculation details are presented in spreadsheets in Appendix D (Air Quality Calculations and Record of Non-Applicability). The percent increases in criteria pollutants range from 84 percent (for VOC) to a little above 200 percent (for NO_x). Air pollutants from training activities under Alternative 2 would not have a measurable impact on air quality in coastal waters or on adjacent land areas because of the distances from land at which the pollutants are emitted and the generally strong ventilation resulting from regional meteorological conditions. About 49 percent (including emissions beyond 12 nm) and 31 percent of training emissions would be produced beyond 3 nm and 12 nm from shore, respectively.

Table 3.2-8: Annual Criteria Pollutant Emissions from Training under Alternative 2

Source	Air Pollutant Emissions (TPY)					
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	324	751	45	33	302	272
Vessels	492	635	155	659	124	111
Ordnance	251	4	0	0	7	7
Others	48	122	15	0	51	46
Total	**1,115**	**1,512**	**215**	**692**	**484**	**436**

Notes: TPY = tons per year, CO = carbon monoxide, NO_X = nitrogen oxides, ROG/HC = reactive organic gases/hydrocarbons, SO_x = sulfur oxides, PM_{10} = particulate matter <10 microns, $PM_{2.5}$ = particulate matter under 2.5 microns

3.2.3.1.3.2 Testing Activities

Under Alternative 2, testing activities in the Study Area would increase over those in Alternative 1. Therefore, emissions rates for criteria pollutants from Navy testing activities also would increase relative to emissions under Alternative 1. Table 3.2-9 presents criteria pollutant emissions from Navy testing activities under Alternative 2. Calculation details are presented in spreadsheets in Appendix D (Air Quality Calculations and Record of Non-Applicability). Air pollutants from testing activities under Alternative 2 would not have a measurable impact on air quality in coastal waters or on adjacent land areas because a majority of the emissions are generated beyond 3 nm from shore, and the generally strong ventilation in the area resulting from regional meteorological conditions would quickly disperse the emissions. A percent increase for criteria emissions from testing activities under Alternative 2 cannot be evaluated because, with the exception of the existing testing conducted by the Office of Naval Laboratory (which was not evaluated because of its distant location from the potential impact areas), these proposed testing activities are not currently conducted under the No Action Alternative.

Table 3.2-9: Annual Criteria Pollutant Emissions from Testing under Alternative 2

Jurisdiction	Emissions by Criteria Pollutant (TPY)					
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$
Aircraft	5	22	1	1	10	9
Vessels	293	180	28	40	11	10
Ordnance	1	1	0	0	1	1
Other Equipment	0	0	0	0	0	0
Total	**299**	**203**	**29**	**41**	**22**	**20**

Notes: CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter under 2.5 microns, PM_{10} = particulate matter <10 microns, SO_x= sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

3.2.3.1.3.3 Criteria Pollutant Emissions in Nonattainment and Maintenance Areas

Training Activities

Under Alternative 2, SO_2 emissions from training in the nonattainment areas was estimated at 263 tons per year (based on a worst case assumption that all training activities that may take place in the nonattainment areas would take place in the nonattainment areas). The increase in SO_2 emissions from training in the nonattainment areas of Guam under Alternative 2 is 91 tons per year compared to SO_2 emissions from training in the nonattainment areas of Guam under the No Action Alternative, a 47 percent increase. However, these training activities can occur in other areas outside of the nonattainment areas, such as in the CNMI, Andersen Air Force Base, Naval Base Guam Munitions Site, Naval Base Guam Telecommunications Site, and many other training locations in the Study Area (see Figures 2.1-1 through 2.1-12 for training and testing areas within the MITT Study Area). In addition, all ships and aircraft associated with a training activity were fully accounted for, even though they may operate within the nonattainment area for a very limited amount of time or may not operate there at all (e.g., outside of the 2.2 mi. [3.5 km] distance from the center of the nonattainment area, at altitudes above 3,000 ft. [914 m]).

Testing Activities

Shipboard protection systems and swimmer defense testing would take place at Naval Base Guam Apra Harbor, which is within the nonattainment area around the Piti Power Plant. Broad area maritime surveillance testing may also occur within 3 nm of shore as part of Civilian Port Defense exercises, even though not all testing occurs within the nonattainment areas of Guam. SO_2 emissions from this testing activity under Alternative 2 were estimated at 0.1 ton per year. A percent increase for SO_2 emissions from testing activities in the nonattainment areas under Alternative 2 cannot be evaluated because these proposed testing activities are not currently conducted under the No Action Alternative.

3.2.3.1.3.4 General Conformity Threshold Determinations

Under Alternative 2, the emissions increase for SO_2 from all training and testing activities in the nonattainment areas of Guam above the No Action Alternative is estimated to be 91 tons per year. The *de minimis* threshold for a full conformity determination is an SO_2 emissions increase of 100 tons per year. The General Conformity Rule, therefore, does not apply under Alternative 2.

3.2.3.1.3.5 Summary – Alternative 2

Total criteria pollutant emissions under Alternative 2 are summarized in Table 3.2-10. Under Alternative 2, the annual numbers of Navy training and testing activities in the Study Area would increase. Emissions of all criteria pollutants would increase. 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. The amounts of air pollutants emitted in the Study Area and subsequently transported ashore would be minor because (1) the pollutants are emitted over large areas (i.e., the Study Area is an area source), (2) the distances the air pollutants would be transported are often large, and (3) the pollutants would be substantially dispersed during transport. The criteria pollutants emitted over non-territorial waters within the Study Area would be dispersed over vast areas of open ocean and thus would not cause significant harm to environmental resources in those areas.

Table 3.2-10: Estimated Annual Criteria Pollutant Emissions by MITT Study Area, Alternative 2

Source	Emissions by Air Pollutant (TPY)						
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Training Activities	1,115	1,512	215	692	484	436	4,454
Testing Activities	299	203	29	41	22	20	614
Total MITT Study Area	**1,414**	**1,715**	**244**	**733**	**506**	**456**	**5,068**

Notes: CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter under 2.5 microns, PM_{10} = particulate matter <10 microns, SO_x= sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

3.2.3.1.4 Impact Conclusions for Criteria Pollutants

Based on the estimated levels of air pollutant emissions presented in Tables 3.2-3 through 3.2-10, (1) most of the air pollutants from training and testing activities would be released to the environment in offshore areas with few other sources of air pollutants, and (2) training and testing emissions would rapidly disperse over a large ocean area where few individuals would be exposed to them.

3.2.3.2 Hazardous Air Pollutants

3.2.3.2.1 No Action Alternative

The USEPA has designated 188 substances as hazardous air pollutants under Title III (Hazardous Air Pollutants), Section 112(g) of the CAA. Hazardous air pollutants are emitted by several processes associated with military training and testing activities, including fuel combustion. Trace amounts of hazardous air pollutants are emitted by combustion sources participating in training and testing activities, including aircraft, vessels, targets, munitions, and ground-based vehicles and equipment. The amounts of hazardous air pollutants emitted are small compared to the emissions of criteria pollutants; emission factors for most hazardous air pollutants from combustion sources are roughly three or more orders of magnitude lower than emission factors for criteria pollutants (California Air Resources Board 2007). Emissions of hazardous air pollutants from munitions use are smaller still, with emission factors ranging from roughly 10^{-5} to 10^{-15} lb. of individual hazardous air pollutant per item for cartridges to 10^{-4} to 10^{-13} lb. of individual hazardous air pollutants per item for mines and smoke cartridges (U.S. Environmental Protection Agency 2009a). As an example, 10^{-5} is equivalent to 0.0001 and 10^{-15} is equivalent to 0.00000000000001. In other words, to generate one pound of hazardous air pollutants would require the expenditure of 10,000–10,000,000,000 lb. of munitions, respectively.

3.2.3.2.1.1 Training Activities

Human health would not be impacted by training emissions of hazardous air pollutants in the Study Area under the No Action Alternative because (1) hazardous air pollutant emissions from training activities would be released to the environment mostly in offshore areas with few existing sources of air pollutants, (2) hazardous air pollutant emissions of training activities would be distributed over the entire Study Area and rapidly dispersed over a large ocean area where few individuals would be exposed to them, and (3) hazardous air pollutant emissions from training activities would be diluted through mixing in the atmosphere to a much lower ambient concentration. Residual hazardous air pollutant impacts when training is not being conducted would not be detectable. Therefore, hazardous air pollutant emissions from training for the No Action Alternative will not be quantitatively estimated in this EIS/OEIS.

3.2.3.2.1.2 Testing Activities

Human health would not be impacted by testing emissions of hazardous air pollutants in the Study Area under the No Action Alternative because (1) hazardous air pollutant emissions from testing activities would be released to the environment in a remote area with few existing sources of air pollutants, (2) hazardous air pollutant emissions of testing activities would be distributed over the entire Study Area and rapidly dispersed over a large ocean area where few individuals would be exposed to them, and (3) hazardous air pollutant emissions from testing activities would be diluted through mixing in the atmosphere to a much lower ambient concentration. Residual hazardous air pollutant impacts when testing is not being conducted would not be detectable. Therefore, hazardous air pollutant emissions from testing for the No Action Alternative will not be quantitatively estimated in this EIS/OEIS.

3.2.3.2.2 Alternative 1

3.2.3.2.2.1 Training Activities

Trace amounts of hazardous air pollutants would be emitted from sources participating in Alternative 1 training activities, including aircraft, vessels, targets, munitions, and ground-based vehicles and equipment. Hazardous air pollutants emissions under Alternative 1 would increase relative to the No Action Alternative emissions. As noted for the No Action Alternative in Section 3.2.3.2.1.1 (Training Activities), hazardous air pollutant emissions are not quantitatively estimated, but the increase in hazardous air pollutant emissions under Alternative 1 would be roughly proportional to the increase in emissions of criteria pollutants. Therefore, the amounts that would be emitted as a result of Alternative 1 activities would be somewhat greater than those emitted under the No Action Alternative, but would remain very small compared to the emissions of criteria pollutants. Training activities in the Study Area under Alternative 1 would emit hazardous air pollutants throughout the year. The potential health impacts of training-related hazardous air pollutant emissions under Alternative 1 would be the same as those discussed under the No Action Alternative.

3.2.3.2.2.2 Testing Activities

Trace amounts of hazardous air pollutants would be emitted from sources participating in Alternative 1 testing activities, including aircraft, vessels, targets, and munitions. Hazardous air pollutant emissions would increase under Alternative 1 relative to emissions under the No Action Alternative. As noted for the No Action Alternative in Section 3.2.3.2.1, hazardous air pollutant emissions are not quantitatively estimated, but the increase in hazardous air pollutant emissions under Alternative 1 would be roughly proportional to the increase in emissions of criteria pollutants. Therefore, the amounts that would be emitted as a result of Alternative 1 testing activities would be somewhat greater than those emitted under the No Action Alternative but would remain very small compared to the emissions of criteria pollutants. The potential health impacts of testing-related hazardous air pollutant emissions under Alternative 1 would be the same as those discussed under the No Action Alternative.

3.2.3.2.3 Alternative 2

3.2.3.2.3.1 Training Activities

The amounts and distribution of training-related hazardous air pollutants emitted under Alternative 2 would be similar to those described under Alternative 1. The potential health impacts of training-related hazardous air pollutants emitted under Alternative 2 would be the same as those discussed under the No Action Alternative.

3.2.3.2.3.2 Testing Activities

The amounts and distribution of testing-related hazardous air pollutants emitted under Alternative 2 would be similar to those described under Alternative 1. The potential health impacts of testing-related hazardous air pollutants emitted under Alternative 2 would be the same as those discussed under the No Action Alternative.

3.2.4 Summary of Potential Impacts (Combined Impacts of All Stressors) on Air Quality

3.2.4.1 No Action Alternative

As described in Section 3.2.3.1 (Criteria Pollutants) and Section 3.2.3.2 (Hazardous Air Pollutants), emissions associated with Study Area training and testing primarily occur offshore. Fixed-wing aircraft emissions typically occur above the 3,000 ft. (914 m) mixing layer. Even though these stressors can co-occur in time and space, atmospheric dispersion would occur, so the impacts would be short term. Changes in criteria and hazardous air pollutant emissions are not expected to be detectable, so the air quality is expected to fully recover before a subsequent activity. For these reasons, impacts on air quality from combining these resource stressors are expected to be similar to the impacts on air quality for any of these stressors taken individually with no additive, synergistic, or antagonistic interactions.

3.2.4.2 Alternative 1

As described in Section 3.2.3.1 (Criteria Pollutants) and Section 3.2.3.2 (Hazardous Air Pollutants), emissions associated with Study Area training and testing under Alternative 1 primarily occur offshore. Fixed-wing aircraft emissions typically occur above the 3,000 ft. (914 m) mixing layer. Even though these stressors can co-occur in time and space, atmospheric dispersion would occur so that the impacts would be short term. Changes in criteria and hazardous air pollutant emissions are not expected to be detectable, so the air quality is expected to fully recover before a subsequent activity. For these reasons, impacts on air quality from combining these resource stressors are expected to be similar to the impacts on air quality for any of these stressors taken individually with no additive, synergistic, or antagonistic interactions. Emissions of most criteria pollutants and hazardous air pollutants are expected to increase under Alternative 1.

3.2.4.3 Alternative 2

As described in Section 3.2.3.1 (Criteria Pollutants) and Section 3.2.3.1.4 (Hazardous Air Pollutants), emissions associated with Study Area training and testing under Alternative 2 primarily occur offshore. Fixed-wing aircraft emissions typically occur above the 3,000 ft. (914 m) mixing layer. Even though these stressors can co-occur in time and space, atmospheric dispersion would occur so that the impacts would be short term. Changes in criteria and hazardous air pollutant emissions are not expected to be detectable, so the air quality is expected to fully recover before a subsequent activity. For these reasons, impacts on air quality from combining these resource stressors are expected to be similar to the impacts on air quality for any of these stressors taken individually with no additive, synergistic, or antagonistic interactions. Emissions of most criteria pollutants and hazardous air pollutants are expected to increase under Alternative 2.

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3.3 Marine Habitats

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3.3 Marine Habitats

MARINE HABITATS SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following have been analyzed for marine habitats as a substrate for biological communities:

- Acoustic (underwater explosives)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices)

Preferred Alternative (Alternative 1)

- Acoustic: Most of the high-explosive military expended materials would detonate at or near the water surface. Only bottom-laid explosives could affect bottom substrate and, therefore, marine habitats. Habitat utilized for underwater detonations would primarily be soft-bottom sediment. The surface area of bottom substrate affected would be less than 1 percent of the total training and testing area available in the Study Area.
- Physical Disturbance and Strike: Ocean approaches would not be expected to affect marine habitats because of the nature of high-energy surf and shifting sands. Seafloor devices would be located in areas that would be primarily soft-bottom habitat. Most seafloor devices would be placed in areas that would result in minor bottom substrate impacts. Once on the seafloor, military expended material would be buried by sediment, corroded from exposure to the marine environment, or colonized by benthic organisms. The surface area of bottom substrate affected would be a fraction of the total training and testing area available in the Study Area.
- Pursuant to the Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom, military expended materials, and seafloor devices during training and testing activities may have an adverse effect on Essential Fish Habitat by reducing the quality and quantity of non-living substrates that constitute Essential Fish Habitat and Habitat Areas of Particular Concern. Essential Fish Habitat conclusions for associated marine vegetation and sedentary invertebrates are summarized in corresponding resource sections (e.g., marine vegetation, invertebrates). Impacts to the water column as Essential Fish Habitat are summarized in corresponding resource sections (e.g., invertebrates, fish) because they are impacts on the organisms themselves.

3.3.1 Introduction

This section analyzes potential impacts on marine nonliving (abiotic) substrates found in the Mariana Islands Training and Testing (MITT) Study Area (Study Area). The Study Area covers a range of marine habitats, each supporting communities of organisms that can vary by season and location. The intent of this chapter is to cover abiotic habitat features that were not addressed in the individual biological resource chapters (i.e., disturbance of bottom substrate). The water column and bottom substrate provide the necessary habitats for living resources that form biotic habitats (i.e., aquatic beds and attached invertebrates), which are discussed in other sections. The Essential Fish Habitat Assessment (EFHA) for the MITT Study Area is a supporting technical document (U.S. Department of the Navy 2014). The United States (U.S.) Department of the Navy (Navy) has consulted with the National Marine Fisheries Service (NMFS) on the EFHA.

Table 3.3-1 lists the types of habitats that will be discussed in this section in relation to the open-ocean areas, and bays and estuaries in which they occur. Habitat types are derived from the Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979). Habitat types and subtypes presented in Table 3.3-1 are grouped based on similar stressor responses to locations within the aquatic environment (e.g., depth, illumination, waves, and currents) as well as remote detection signatures for mapping. As such, these classifications may or may not overlap with the Coastal and Marine Ecological Classification Standard (Federal Geographic Data Committee 2012) catalog of terms that provides a means for classifying ecological units using a simple, standard format and common terminology. Therefore, Table 3.3-2 aligns the habitat groupings used in this analysis with the Coastal and Marine Ecological Classification Standard.

Description and distribution information for the water column itself are not provided here, because it is unaffected by the physical and acoustic impacts of military training and testing activities. The direct impacts of the Proposed Action are on living marine resources in the water column and on abiotic habitats forming the bottom. The distribution of water column features is described in Section 3.0.3 (Ecological Characterization of the Mariana Islands Training and Testing Study Area). Impacts on federally managed species via the water column (e.g., noise, contaminants), are summarized in corresponding resource sections (e.g., marine vegetation, invertebrates, fish).

The rationale for evaluating the impact of stressors on marine substrate differs from the rationale applied to other biological resources. Unlike organisms, habitats are valued mainly for their function, which is largely based on their structural components and ability to support a variety of marine organisms. Accordingly, the assessment focuses on the ability of substrates to function as habitats. An impact on abiotic marine habitat is anticipated where training, testing, or associated transit activities could convert one substrate type into another (i.e., bedrock or consolidate limestone to unconsolidated soft bottom, or soft bottom to parachute canvas). Whereas the impacts on the biotic growth (i.e., vegetation and algae) are covered in their respective resource sections, the impacts on bottom substrate itself are considered here.

Table 3.3-1: Habitat Types within the Open Ocean and Coastal Portions of the Mariana Islands Training and Testing Study Area

Habitat Type	Subtypes	Location in the Study Area		
		Open Ocean	Coastal Ocean	Estuaries
Soft Shores[1]	Beach		✓	
	Tidal Delta/mudflats and tidal riverine and estuarine streambeds		✓	✓
Rocky Shores[1]	Rocky Shores		✓	
Vegetated Shores[2]	Salt/Brackish Marsh			✓
	Mangrove		✓	✓
Aquatic Beds[2]	Seagrass		✓	
	Sargassum		✓	
Soft Bottoms[1]	Lagoons		✓	✓
	Abyssal Plain	✓		
	Trench	✓		
Hard Bottoms[1]	Biotic/Reef		✓	
	Seamount	✓		
	Hydrothermal vents	✓		
Artificial Structures[1]	Artificial Reefs		✓	
	Shipwrecks	✓	✓	
	FADs		✓	

[1] See Section 3.8 (Marine Invertebrates) for living habitat component assessment.
[2] See Section 3.7 (Marine Vegetation) for living habitat component assessment.
Notes: FAD = Fish Aggregating Device, Study Area = Mariana Islands Training and Testing Study Area

Table 3.3-2: Coastal and Marine Ecological Classification Standard Crosswalk

MITT EIS/OEIS Habitat Type and Subtypes	Relationship to CMECS	CMECS Class/ Subclass	Confidence[2]	Relationship Notes
Soft Shores[1]	<	Unconsolidated Substrate	Certain	CMECS Unconsolidated Substrate = Cowardin Unconsolidated Shore + Unconsolidated bottom. Shore is considered in the CMECS Geoform Component.
Beach	=	Beach	Somewhat Certain	
Tidal Delta/mudflats and tidal riverine and estuarine streambeds	<	Flat	Somewhat Certain	MITT habitat type = CMECS ebb tidal delta flat + flood tidal delta flat + tidal flat+ wind tidal flat
Rocky Shores[1]	<	Rock Substrate	Certain	CMECS Rock substrate = Cowardin Rocky Shore + Rock Bottom. Shore is considered in the CMECS Geoform Component.
Vegetated Shores[1]	=	Emergent Wetland	Certain	
Salt/Brackish Marsh	≈	Emergent Tidal Marsh	Somewhat Certain	

Table 3.3-2: Coastal and Marine Ecological Classification Standard Crosswalk (continued)

MITT EIS/OEIS Habitat Type and Subtypes	Relationship to CMECS	CMECS Class/ Subclass	Confidence[2]	Relationship Notes
Mangrove	>	Tidal Mangrove Forest, Tidal Mangrove Shrubland	Somewhat Certain	MITT Mangrove = CMECS Tidal Mangrove Shrubland + Tidal Mangrove Forest. MITT Mangrove has no height threshold.
Aquatic Beds[1]	=	Aquatic Vegetation Bed	Certain	
Seagrass	≈	Aquatic Vascular Vegetation	Somewhat Certain	MITT Seagrass = CMECS Freshwater and Brackish Tidal Aquatic Vegetation + Seagrass bed. MITT Seagrass has no salinity threshold.
Sargassum	<	Bethic Macroalgae	Somewhat Certain	
Soft Bottoms[1]	<	Unconsolidated Substrate	Certain	CMECS Unconsolidated Substrate = Cowardin Unconsolidated Shore + Unconsolidated Bottom.
Lagoons	≈	Lagoon	Somewhat Certain	
Abyssal Plain	≈	Abyssal Plain	Somewhat Certain	
Mariana Trench	≈	Tectonic Trench	Somewhat Certain	CMECS Tectonic Trench = General description of trenches. Mariana Trench is specific to Study Area.

Table 3.3-2: Coastal and Marine Ecological Classification Standard Crosswalk (continued)

MITT EIS/OEIS Habitat Type and Subtypes	Relationship to CMECS	CMECS Class/ Subclass	Confidence[2]	Relationship Notes
Hard Bottoms[1]	<	Rock Substrate	Certain	CMECS Rock Substrate = Cowardin Rocky Shore + Rock Bottom
Biotic/Reef	≈	Shallow/Mesophotic Coral Reef Biota	Somewhat Certain	
Seamount	>	Seamount (Level 1)	Somewhat Certain	MITT Seamount = CMECS Guyot + Knoll + Pinnacles. MITT Seamounts does not have shape delimiters.
Hydrothermal vents	>	Hydrothermal Vent (Level 2), Hydrothermal Vent Field (Level 1 and 2)	Somewhat Certain	MITT Hydrothermal Vent does not have a number of vents threshold.
Artificial Structures	<	Anthropogenic Substrate	Somewhat Certain	Anthropogenic Substrate = includes classes dependent on the anthropogenic material; however, materials in the Study Area vary.
Artificial Reefs	≈	Artificial Reef	Somewhat Certain	
Shipwrecks	≈	Wreck (Level 2)	Somewhat Certain	
FADs	≈	Buoy (Level 2)	Somewhat Certain	

[1] These habitat types were derived directly from Cowardin 1979.
[2] "Confidence" is a CMECS classification to describe the relative strength of the relationship between the CMECS unit and the unit being compared. There are three levels of confidence: Certain, Somewhat Certain, and Not Certain.
Notes: CMECS = Coastal and Marine Ecological Classification Standard, EIS = Environmental Impact Statement, FAD = Fish Aggregating Device, MITT = Mariana Islands Training and Testing, OEIS = Overseas Environmental Impact Statement, Study Area = Mariana Islands Training and Testing Study Area

3.3.2 Affected Environment

The majority of the Study Area lies within open-ocean areas. 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. The distribution of abiotic marine habitats among the open oceans, estuaries, and coastal areas is described in their respective sections and is generalized to each area in Table 3.3-1.

Abiotic marine habitats vary according to geographic location, underlying geology, hydrodynamics, atmospheric conditions, and suspended particles. Flows and sediments from creeks and rivers create channels, tidal deltas, intertidal and subtidal flats, and shoals of unconsolidated material along the shorelines and estuaries. The influence of land-based nutrients and sediment increases with proximity to nearshore and inland waters. In the pelagic ocean, gyres, eddies, and oceanic currents create dynamic microhabitats that influence the distribution of organisms. A patchwork of diverse habitats exists on the open ocean floor, where there is no sunlight, low nutrient levels, and minimal sediment movement (Levinton 2009). Major bottom features in offshore areas include shelves, banks, guyots, breaks, slopes, trenches, plains, deep-water reefs, volcanoes, and seamounts. Geologic features such as these affect the hydrodynamics of the ocean water column (e.g., currents, gyres, and upwelling) as well as the biological resources present.

Estuarine and ocean environments worldwide are under increasing pressure from human development and expansion, accompanied by increased ship traffic, pervasive pollution, invasive species, destructive fishing practices, vertical shoreline stabilization, offshore energy infrastructure, and global climate change (Crain et al. 2009; Lotze et al. 2006; Pandolfi et al. 2003). The stressors associated with these activities are not distributed randomly across the patchwork of habitat types and ecosystems (Halpern et al. 2008). Areas where heavy concentrations of human activity co-occur with military training or testing activities have the greatest potential for cumulative stress on the marine ecosystem (Chapter 4, Cumulative Impacts). Refer to individual biological resource chapters for specific stressors and impacts.

3.3.2.1 Soft Shores

3.3.2.1.1 Description

Soft shores include all wetland habitats having three characteristics: (1) unconsolidated substrates with less than 75 percent areal coverage of stones, boulders, accreted limestone, or bedrock; (2) less than 30 percent areal coverage of vegetation other than pioneering plants and algae; and (3) any of the following water regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded (Cowardin et al. 1979). Soft shores include stream beds of the tidal riverine and estuarine systems, tidal flats and deltas, and beaches.

Intermittent and intertidal channels of the riverine system and intertidal channels of the estuarine system are classified as streambed. Intertidal flats, also known as tidal flats or mudflats, consist of loose mud, silt, and fine sand with organic-mineral mixtures that are regularly exposed and flooded by the tides (Mitsch and Gosselink 2000). Muddy fine sediment is deposited in sheltered inlets and estuaries where wave energy is low (Holland and Elmore 2008). Mudflats are typically unvegetated, but may be covered with mats of green algae and benthic diatoms (single-celled algae), or sparsely vegetated with low-growing aquatic species. The muddy intertidal habitat occurs most often as part of a patchwork of intertidal habitats that may include rocky shores, tidal creeks, sandy beaches, salt marshes, and mangroves.

Beaches form through the interaction of waves and tides, as particles are sorted by size and deposited along the shoreline (Karleskint et al. 2006). Wide flat beaches with fine-grained sands occur where wave energy is limited. Narrow steep beaches of coarser sand form where energy and tidal ranges are high

(Speybroeck et al. 2008). Three zones characterize beach habitats: (1) dry areas above the mean high water, (2) the area where seaweed and debris is deposited at high tide, and (3) a high-energy intertidal zone (area between high and low tide). Refer to biological resources chapters for more information on species use of tidal deltas, intertidal flats, and beaches.

3.3.2.1.2 Distribution

On the island of Guam, the majority of the coastline is comprised of rocky intertidal regions. Interspersed among this rocky shoreline are 58 beaches composed of calcareous or volcanic sands (Eldredge 1983). The west coast of Saipan contains well developed fine-sand beaches protected by the Saigon and Tanapag Lagoons (Scott 1993). All other beaches of Saipan consist of coral-algal-mollusk rubble. The island of Tinian contains 13 beaches (10 located on the west coast and 3 on the east coast). These beaches are not well developed (except Tinian Harbor on the southwest coast, and Unai Dankulo along the east coast) and are comprised mainly of medium to coarse grain calcareous sands, gravel, and coral rubble (Eldredge 1983; Kolinski et al. 2001). On Rota, the rare beaches are found scattered among limestone patches and are composed of rubble and sand (Eldredge 1983). The coastal area of Farallon de Medinilla (FDM) contains two small intertidal beaches that are inundated by high tide on the northeastern and western coastlines.

3.3.2.2 Rocky Shores

3.3.2.2.1 Description

Rocky shores include aquatic environments characterized by bedrock, stones, or boulders which singly or in combination have an aerial cover of 75 percent or more and an aerial coverage by vegetation of less than 30 percent (Cowardin et al. 1979). Water regimes are restricted to irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, or intermittently flooded. Rocky intertidal shores are areas of bedrock that alternate between periods of submergence and exposure to air, depending on whether the tide is high or low. Extensive rocky shorelines can be interspersed with sandy areas, estuaries, or river mouths.

Environmental gradients between hard shorelines and subtidal habitats are determined by wave action, depth and frequency of tidal inundation, and stability of substrate. Where wave energy is extreme, only rock outcrops may persist. In lower energy areas, a mixture of rock sizes will form the intertidal zone. Boulders scattered in the intertidal and subtidal areas provide substrate for attached macroalgae and sessile invertebrates. Refer to biological resources chapters for more information on species inhabiting hard shorelines.

3.3.2.2.2 Distribution

Rocky shores are the dominant marine habitat on all islands within the Study Area. This is due to the volcanic origin of all of the islands (Eldredge 1983). Coastlines within the Study Area are generally lined with rocky intertidal areas, steep cliffs and headlands, and the occasional sandy beach or mudflat (Eldredge 1983). The water erosion of rocky coastlines in the Study Area has produced wave-cut cliffs (produced by undercutting and mass wasting), and sea-level benches (volcanic and limestone and wave cut notches at the base of the cliffs (Eldredge 1979, 1983). Large block and boulders often buttress the foot of these steep cliffs in the Study Area.

3.3.2.3 Vegetated Shores

Vegetated shorelines are characterized by erect, rooted, herbaceous aquatic plants, excluding mosses and lichens, which grow above the water line (Cowardin et al. 1979). This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. All water regimes are included except subtidal and irregularly exposed (Cowardin et al. 1979). Vegetated shorelines in the Study Area are formed by salt marsh or mangrove plant species. Salt marsh and mangrove plants are living marine resources and biotic habitat where they dominate the intertidal zone, and are therefore not covered in this chapter. Refer to Section 3.7 (Marine Vegetation) for information on marsh and mangrove plant species.

3.3.2.4 Aquatic Beds

Aquatic beds include wetlands and permanently submerged habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years (Cowardin et al. 1979). Water regimes include subtidal, irregularly exposed, regularly flooded, permanently flooded, intermittently exposed, semi-permanently flooded, and seasonally flooded. Seagrasses and floating macroalgae (i.e., *Sargassum*) are living marine resources and biotic habitats where they dominate the intertidal or shallow subtidal zone, and are therefore not covered in this chapter. Refer to Section 3.7 (Marine Vegetation) for information on seagrasses and macroalgae.

3.3.2.5 Soft Bottoms

3.3.2.5.1 Description

Soft bottoms include all wetland and deepwater habitats with at least 25 percent cover of particles smaller than stones (10–24 inches [in.] [25.4–61.0 centimeters {cm}]), and a vegetative cover less than 30 percent (Cowardin et al. 1979). Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semi-permanently flooded. Soft bottom forms the substrate of channels, shoals, subtidal flats, and other features of the bottom. Sandy channels emerge where strong currents connect estuarine and ocean waters. Shoals form where sand is deposited along converging, sediment-laden currents forming capes. Subtidal flats occur between the soft shores and the channels or shoals. The continental shelf extends seaward of the shoals and inlet channels, and includes an abundance of coarse-grained, soft-bottom habitats. Finer-grained sediments collect beyond the shelf break on the continental slope, along the continental rise at the base of the continental slope and on the abyssal plain. These areas are inhabited by soft-sediment communities of mobile invertebrates fueled by benthic algae production, chemosynthetic microorganisms, and detritus sinking through the water column. Refer to biological resources chapters for more information on species use of soft-bottom habitats.

One type of soft-bottom habitat that occurs in the Study Area is lagoons. A lagoon can be described as a semi-enclosed bay found between the shoreline and the landward edge of a fringing reef or barrier reef (National Centers for Coastal Ocean Science and National Oceanic and Atmospheric Administration 2005). Lagoons typically contain three distinct zones: freshwater zone, transitional zone, and saltwater zone (Thurman 1997). Most tropical reef-associated lagoons are not brackish and lack significant freshwater input. The bottoms of the lagoons are mostly sandy and can be flat, rippled, or filled with sand mounds created by burrowing organisms. Coral rubble, coral mounds, seagrass, and algae are found within the lagoons. Coral mounds tend to be more abundant in the outer lagoons and are widely scattered or absent in the inner lagoons (National Centers for Coastal Ocean Science and National Oceanic and Atmospheric Administration 2005; Pacific Basin Environmental Consultants 1985).

3.3.2.5.2 Distribution

Soft-bottom substrates in coastal regions of the Study Area are not common. This is due to the fact that the intertidal and subtidal regions are often characterized by limestone pavement interspersed with coral colonies and submerged boulders (Kolinski et al. 2001). Shorelines are often rocky with interspersed sand beaches or mud flats (Eldredge 1983; Pacific Basin Environmental Consultants 1985).

Lagoons of coastal Guam are associated with Apra Harbor (Inner Harbor, Outer Harbor, and Sasa Bay), Cocos Lagoon, and numerous embayments along the western coastline. Apra Harbor is the only deep lagoon on Guam and is the busiest port in the Mariana Islands. The Outer Harbor is enclosed by the Glass Breakwater. Sasa Bay, located on the edge of the Outer Harbor, is a shallow coastal lagoon populated with patchy corals (Scott 1993). The Inner Apra Harbor is a human-made lagoon created by dredging in the 1940s. Cocos Lagoon, a shallow lagoon (40 feet [ft.] [12.2 meters {m}]) deep, is located on the southern tip of Guam and is encompassed by a series of barrier and fringing reefs (Paulay et al. 2002). The majority of the substrate in Apra Harbor is sand, as depicted in Figure 3.3-2; however, there are intermittent patches of harder substrates (shoals and reefs) within the harbor.

The western coastline of Saipan is lined with sandy beaches protected by a barrier reef which forms Tanapag and Saipan Lagoons (Scott 1993). Tanapag Lagoon is a typical high-island barrier reef lagoon. Tanapag Lagoon is located on the northwestern coast of Saipan. Also, on the western coastline of Saipan, the barrier reefs form two additional lagoons, creating the largest lagoon system in the Mariana Islands, Garapan Lagoon and Chalan Kanoa Lagoon (Environmental Services Duenas & Associates 1997). The western side of Tinian has limited lagoon development near the harbor, whereas Rota does not have any well-developed lagoon formations (Pacific Basin Environmental Consultants 1985). Offshore of FDM, at a depth of approximately 65 ft. (19.8 m), the sandy soft-bottom seafloor slopes abruptly downward toward the abyssal plain (U.S. Department of the Navy 2005). Most of the other islands in the Marianas also have sandy slopes below the fore reef, typically starting at 100–130 ft. (30.48–39.62 m), with some variations (U.S. Department of the Navy 2005). See Figure 3.3-1, Figure 3.3-2, Figure 3.3-3, Figure 3.3-4, and Figure 3.3-5 for information on the distribution of soft-bottom habitats as derived by satellite imagery by the National Oceanic and Atmospheric Administration, near Guam, Apra Harbor, Saipan, Tinian, and FDM, respectively.

In the open ocean portion of the Study Area the soft-bottom habitat is located in the Mariana Trough. The Mariana Trough is comprised of a large relatively flat abyssal plain with water depths ranging from approximately 11,500 to 13,100 ft. (3,505.2 to 3,992.9 m) (Thurman 1997). Very little data regarding the Mariana Trough within the Study Area has been obtained. However, in general abyssal plains can be described as large and relatively flat regions covered in a thick layer of fine silty sediments with the topography interrupted by occasional mounds and seamounts (Kennett 1982; Thurman 1997). The abyssal plain and similar deepwater areas were originally thought to be devoid of life; however recent research has shown that these areas are host to thousands of species of invertebrates and fish ("The Mariana Trench - Biology - Part 1" 2003). Refer to biological resources chapters for more information on species inhabiting the abyssal plain.

3.3.2.6 Hard Bottoms

3.3.2.6.1 Description

Hard-bottom habitat in the coastal portion of the Study Area includes both biogenic reefs and rocky bottoms covered by a thin veneer of living and dead sedentary invertebrates. Biogenic reefs include ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates (Cowardin et al. 1979). Water regimes are restricted to subtidal, irregularly exposed, regularly flooded, and irregularly flooded. Corals and associated calcareous organisms form reefs that are living marine resources and biotic habitats. Coral reefs tend to dominate intertidal shores or subtidal bottoms, and are not covered in this section. Refer to Section 3.8 (Marine Invertebrates) for more information on coral reefs. "Rock Bottom" includes all wetlands and deepwater habitats with substrates having a surface of stones, boulders, or bedrock (75 percent or greater coverage) with vegetative coverage of less than 30 percent (Cowardin et al. 1979). Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semi-permanently flooded.

Subtidal rocky bottom occurs as extensions of intertidal rocky shores and as isolated offshore outcrops. The shapes and textures of the larger rock assemblages and the fine details of cracks and crevices are determined by the type of rock, the wave energy, and other local variables (Davis 2009). Maintenance of rocky reefs requires wave energy sufficient to sweep sediment away (Lalli and Parsons 1997) or offshore areas lacking a significant sediment supply; therefore, rocky reefs are rare on broad coastal plains near sediment-laden rivers and are more common on high-energy shores and beneath strong bottom currents, where sediments cannot accumulate. The shapes of the rocks determine, in part, the type of community that develops on a rocky bottom (Witman and Dayton 2001). Below a depth of about 650 ft. (200 m) on rocky reefs, light is insufficient to support much plant life (Dawes 1998). Rocky reefs in this zone are encrusted with invertebrates and algae such as sponges, soft and hard coral, worms, bryozoans, and coralline algae. Typically, a sea cucumber would not be thought of as an encrusting organism, and sea whips are a type of soft coral. Refer to living resource sections for more information on species inhabiting rock bottoms.

There are two types of hard-bottom habitats found in the open ocean portion of the Study Area, seamounts and hydrothermal vents. Seamounts are undersea mountains that rise steeply from the ocean floor to an altitude greater than 3,281 ft. (1,000 m) above the ocean basin (Thurman 1997). Hydrothermal vents are created from seawater permeating and entrained through the crust and upper mantle below the seafloor. The seawater is superheated by hot basalt and is chemically altered to form hydrothermal fluids as it rises through networks of fissures in newly-formed seafloor (Humphris 1995; McMullin 2000). The area immediately around hydrothermal vents, including the chimney structures that form from the tectonic activity, can be colonized by various organisms adapted to this deep sea environment (McMullin 2000).

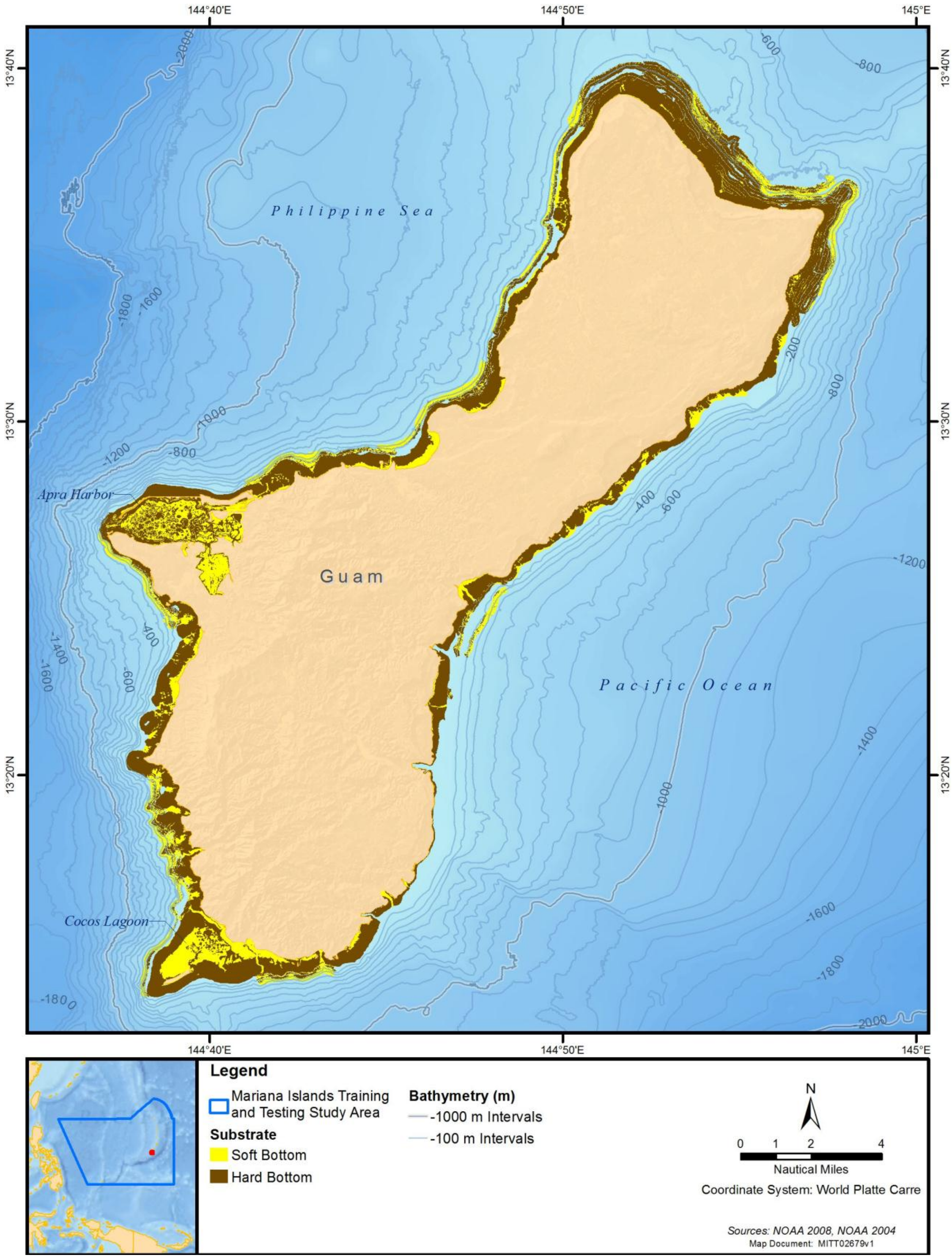

Figure 3.3-1: Nearshore Marine Habitats around Guam

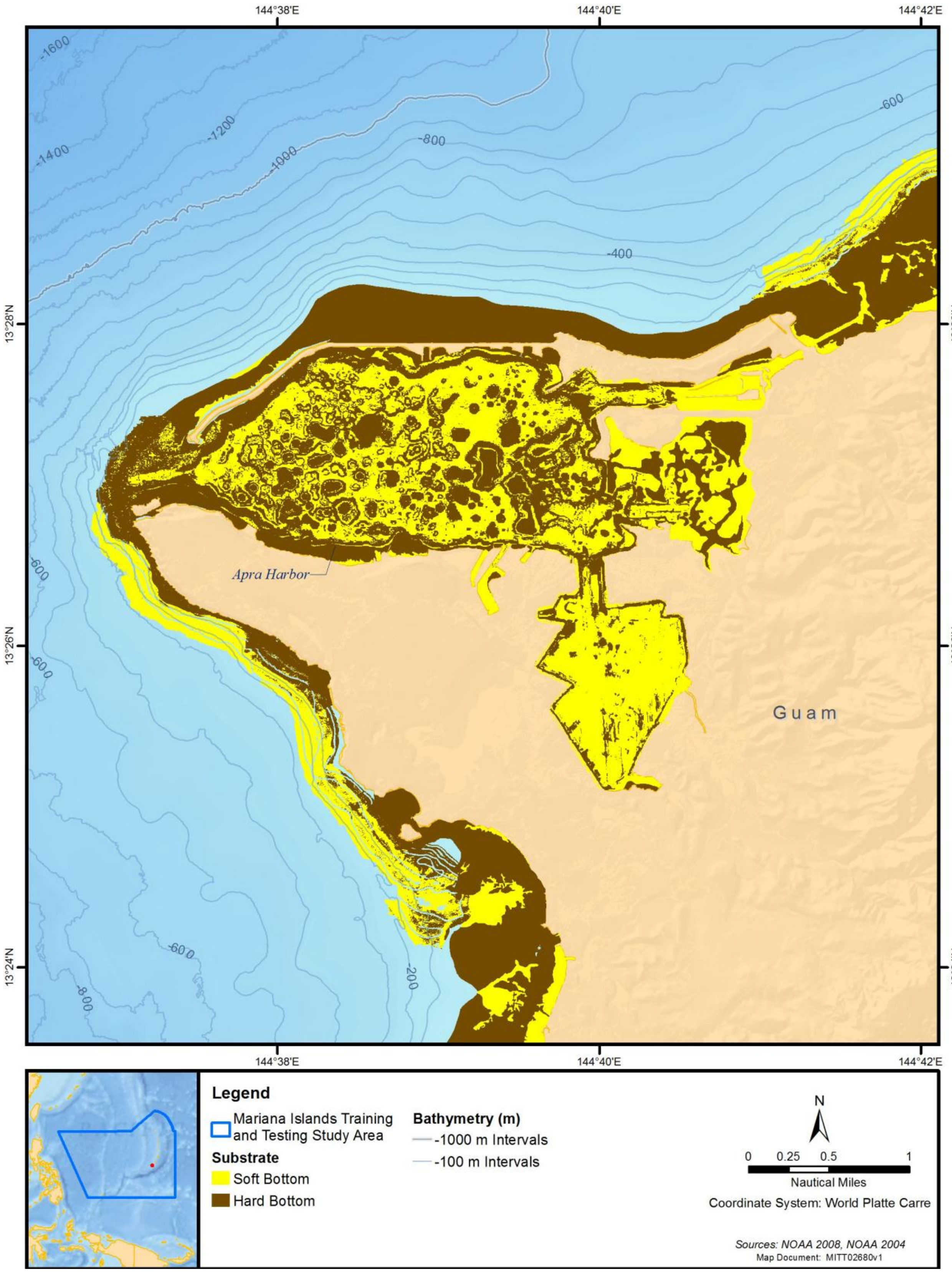

Figure 3.3-2: Marine Habitats of Apra Harbor, Guam

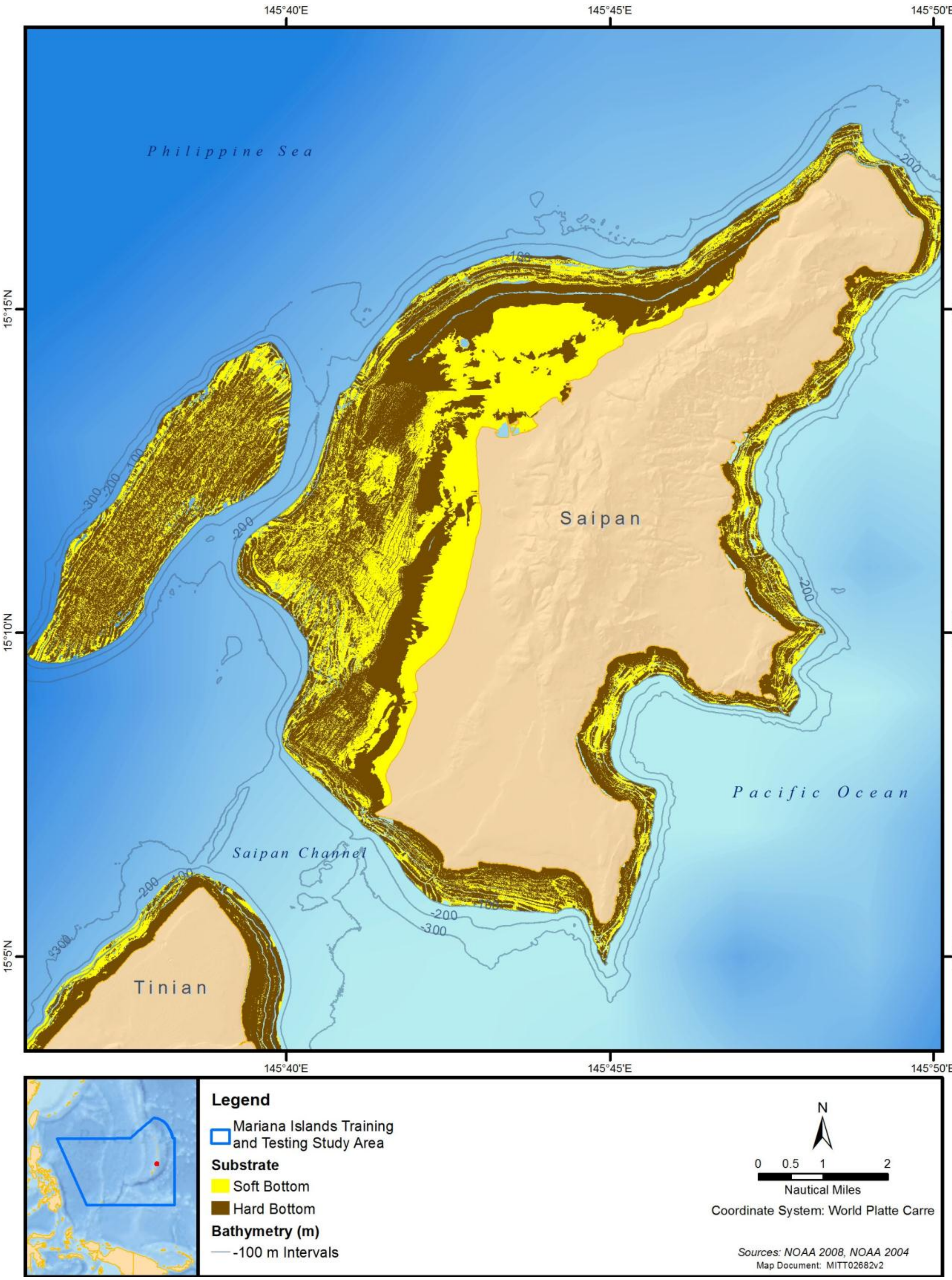

Figure 3.3-3: Nearshore Marine Habitats around Saipan

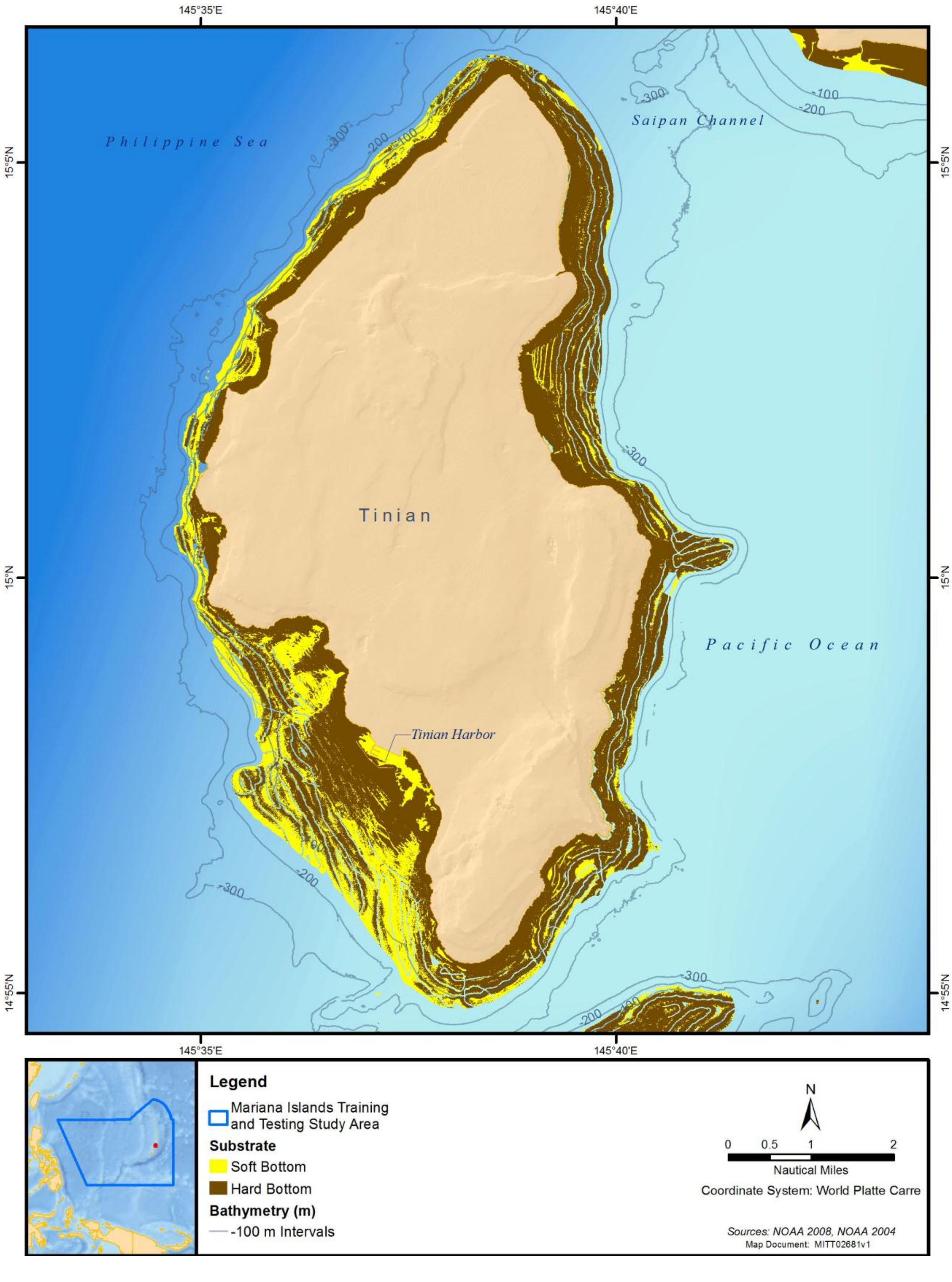

Figure 3.3-4: Nearshore Marine Habitats around Tinian

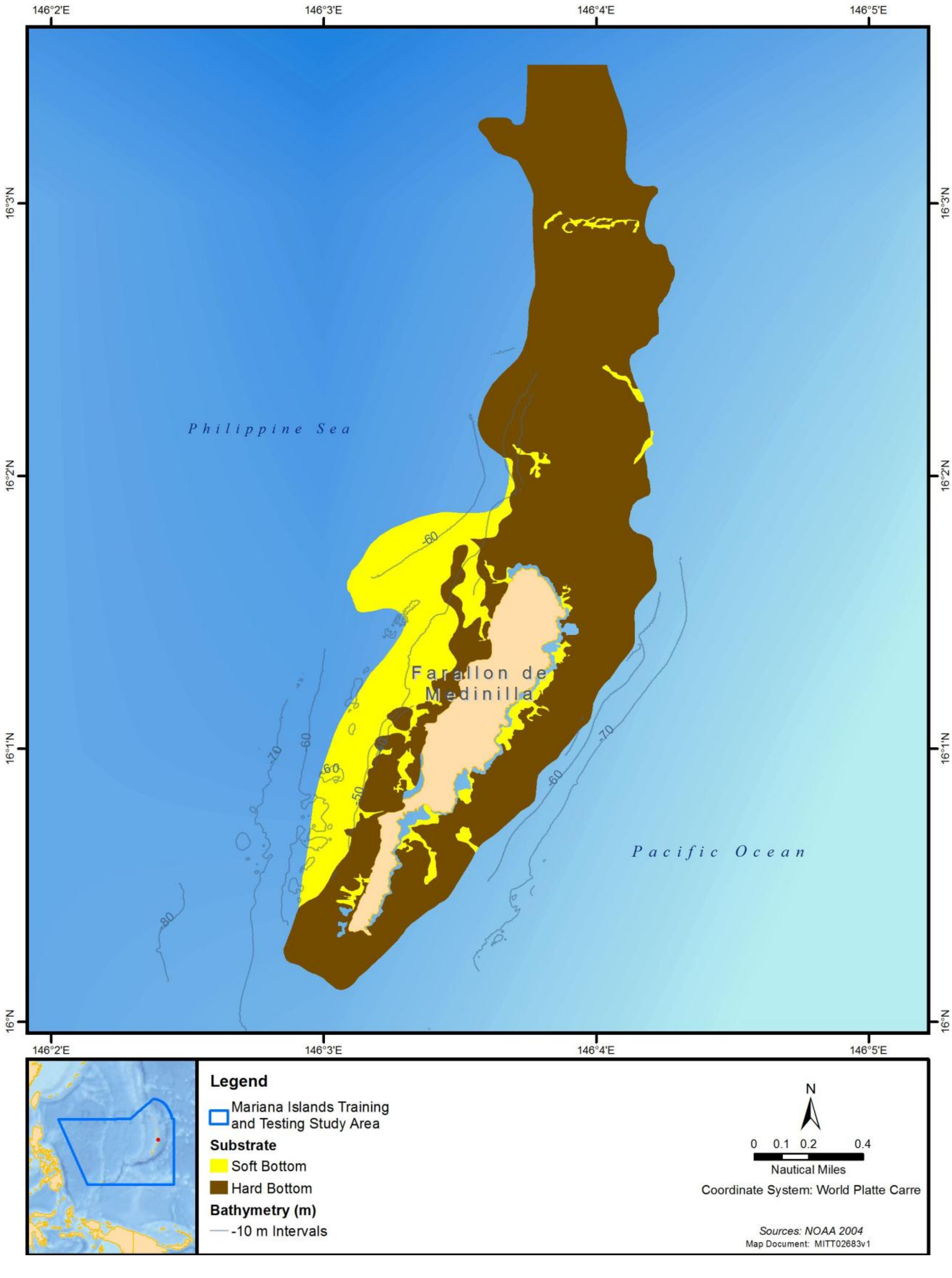

Figure 3.3-5: Nearshore Marine Habitats around Farallon de Medinilla

3.3.2.6.2 Distribution

Islands within the Study Area (Guam to FDM) support reefs as do islands north of FDM (Anatahan, Sarigan, Guguan, Alamagan, Maug, and Farallon de Pajaros). Reefs are also found on offshore banks including Galvez bank located 12 miles (mi.) (19.3 kilometers [km]) south of Guam, Santa Rosa Reef located 25 mi. (40.2 km) south-southwest of Guam, Arakane Bank located 200 mi. (321.9 km) west-northwest of Saipan, Tatsumi Reef located 1.2 mi. (1.93 km) southeast of Tinian, Pathfinder Bank located 170 mi. (273.6 km) west of Anahatan, and Supply Reef located 11.5 mi. (18.5 km) northwest of Maug Island (Starmer 2005). The degree of reef development depends on a number of environmental controls including the age of the islands; volcanic activity; the availability of favorable substrates and habitats; weathering caused by groundwater discharge, sedimentation, and runoff accentuated by the overgrazing of feral animals; and varying levels of exposure to wave action, trade winds, and storms (Eldredge 1983; Paulay 2003; Randall 1985, 1995; Randall et al. 1984; Starmer 2005). See Figure 3.3-1, Figure 3.3-2, Figure 3.3-3, Figure 3.3-4, and Figure 3.3-6, for information on the distribution of hard-bottom habitats near Guam, Apra Harbor, Saipan, Tinian, and the open ocean, respectively.

Within the open ocean portion of the Study Area, two types of hard-bottom habitat are seamounts and flat-topped seamounts known as guyots. Generally, seamounts tend to be conical in shape and volcanic in origin, although some seamounts are formed by vertical tectonic activity along converging plate margins (Rogers 1994). Both volcanic and tectonic seamounts are present in the open ocean portion of the Study Area. Seamount and guyot topography is a striking contrast to the surrounding flat, sediment-covered abyssal plain. Seamounts and guyots can affect local ocean circulation causing upwelling, which can supply nutrients to surface waters (Rogers 1994; Lalli and Parsons 1997). Seamount and guyot topography is a striking contrast to the surrounding flat, sediment-covered abyssal plain, and the effect seamounts can impart on local ocean circulation resulting in upwelling which can supply nutrients to surface waters (Rogers 1994; Lalli and Parsons 1997). Figure 3.3-5 shows the locations of both seamounts and guyots in the Study Area. Refer to biological resources chapters for more information on species inhabiting seamounts.

Deep-sea hydrothermal vents occur in areas of crustal formation near mid-ocean ridge systems (Humphris 1995). A number of hydrothermal vents have been located in the Study Area, and it is likely that more exist. Evidence of active hydrothermal venting has been identified in the vicinity of more than 12 submarine volcanoes and at two sites along the back-arc spreading center off to the west of the Mariana Islands (Embley et al. 2004; Kojima 2002). Hydrothermal vents located in the Mariana Trough experience high levels of site specific species due to their geographic isolation from other vent systems. At least 8 of the 30 identified genera known to occur only in the western Pacific hydrothermal vent systems are found in the Mariana Trough (Hessler and Lonsdale 1991; Paulay 2003). Hydrothermal vents at Esmeralda Bank, one of the active submarine volcanoes in the Study Area, span an area of 0.08 square miles ($mi.^2$) (0.207 square kilometers [km^2]) on the seafloor and expel water with temperatures exceeding 172 degrees (°) Fahrenheit (77.8° Celsius) (Stuben et al. 1992). West of Guam and on the Mariana Ridge, there are three known hydrothermal vent fields: Forecast Vent site (13°24'N, 143°55'E, depth 4,750 ft. [1,447.8 m]), TOTO Caldera (12°43'N, 143°32'E), and the 13°N Ridge (13°05'N, 143°41'E) (Kojima 2002). Refer to biological resources chapters for more information on species inhabiting hydrothermal vents.

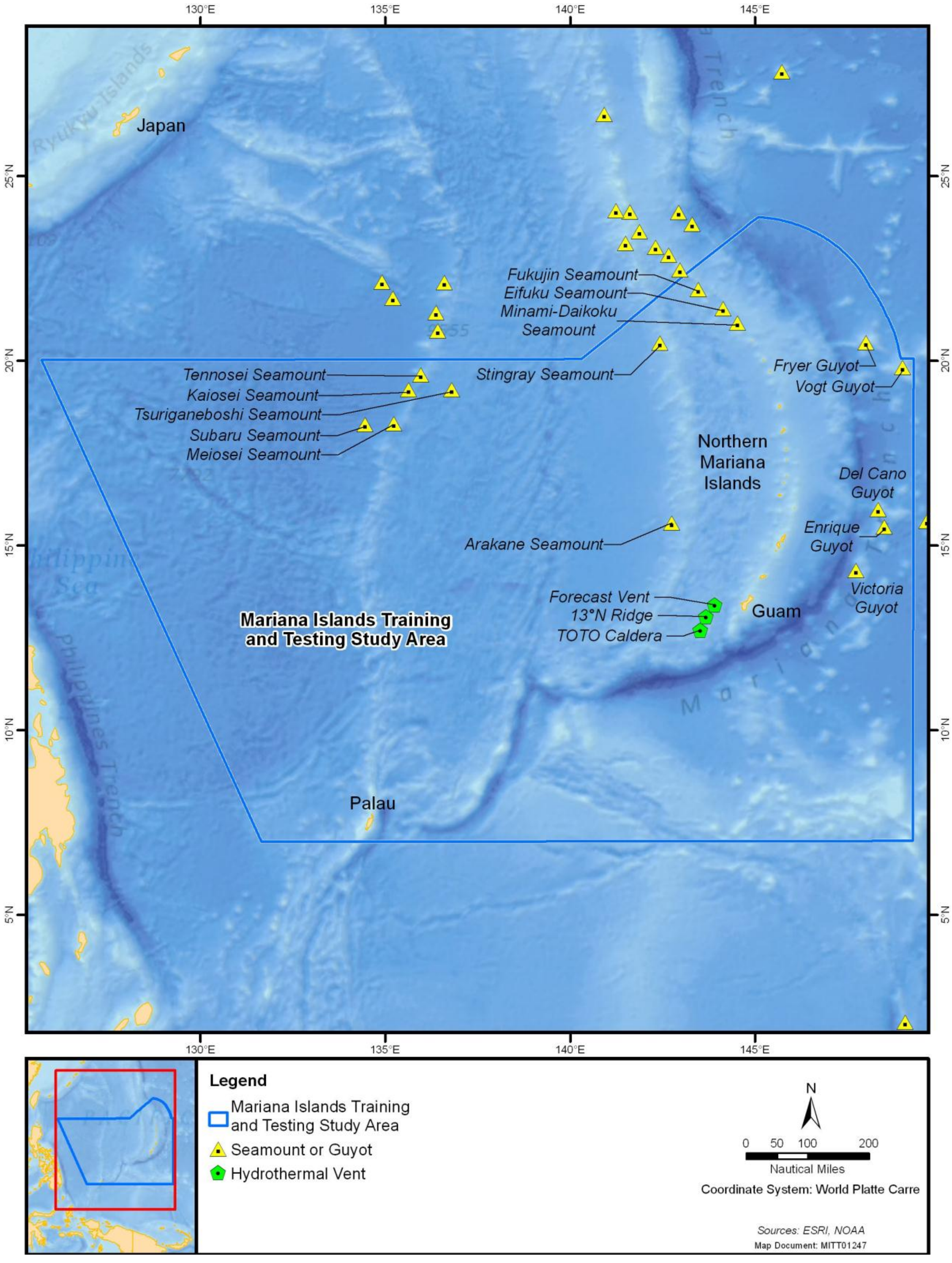

Figure 3.3-6: Deep Sea Habitat

3.3.2.7 Artificial Structures

3.3.2.7.1 Description

Artificial habitats are human-made structures that provide habitat for marine organisms. Artificial habitats occur in the marine environment either by design and are intended to be used as habitat (e.g., artificial reefs), by design but were intended for a function other than habitat (e.g., fish-aggregating devices, which are floating objects moored at specific locations in the ocean to attract fishes that live in the open ocean), or unintentionally (e.g., shipwrecks). Artificial structures function as hard bottom by providing structural attachment points for algae and sessile invertebrates, which in turn support a community of animals that feed, seek shelter, and reproduce there (National Oceanic and Atmospheric Administration 2007).

Artificial habitats in the Study Area include artificial reefs, shipwrecks (historic shipwrecks are analyzed in Section 3.11, Cultural Resources), human-made shoreline structures (i.e., piers, wharfs, docks, pilings), and fish-aggregating devices. Artificial reefs are designed and deployed to supplement the ecological services provided by coral or rocky reefs. Artificial reefs range from simple concrete blocks to highly engineered structures. Vessels that sink to the seafloor, including shipwrecks within the Study Area, are colonized by the common encrusting and attached marine organisms that attach to hard bases. Over time, the wrecks become functioning ecosystems. The submerged cultural resources within the Study Area are further discussed in Section 3.11 (Cultural Resources).

3.3.2.7.2 Distribution

Many shipwrecks are found within the Study Area, including grounded vessels and military wreckage. Vessels have probably wrecked upon the shores of the Mariana Islands since Spanish galleons sailed to these islands during the seventeenth century. There are abundant WWII-era remains (including sunken ships, airplanes, and tanks) along the shores of the Mariana Islands that resulted from the battles of Guam, Saipan, and Tinian (Commonwealth of the Northern Mariana Islands 2001). Most artificial reefs intended as habitat in marine waters have been placed and monitored by individual state programs; national and state databases indicating the locations of artificial reefs are not available (National Oceanic and Atmospheric Administration 2007). In the Study Area, there are dedicated artificial reefs found in two locations: Agat Bay, Guam and Apra Harbor, Guam. In 1969, 357 tires were tied together and scattered over a 5,000-square-foot ($ft.^2$) (4,645-square-meter [m^2]) area in Cocos Lagoon (Eldredge 1979). In the early 1970s, a second reef consisting of 2,500 tires was also placed in Cocos Lagoon (Eldredge 1979). These tire reefs have disintegrated and no longer serve as artificial reefs. In 1977, a 52.5 ft. (16.0 m) barge was modified to enhance fish habitat and was sunk in 60 ft. (18.3 m) of water in Agat Bay. In Apra Harbor, the “American Tanker” was sunk in 1944 at the entrance of the harbor to act as a breakwater. In 1944, the 76th Naval Construction Battalion (SEABEES) built the Glass Breakwater which forms the north and northwest sides of Apra Harbor (Thompson 2002). The enormous seawall is made of 1,200 acre-feet (148,000 cubic meters) of soil and coral extracted from Cabras Island (Thompson 2002). The Glass Breakwater is the largest artificial substrate in the Marianas.

Currently, Guam and the northern Mariana Islands maintain several fish aggregating devices within 20 nautical miles (nm) of the shoreline (Chapman 2004; Guam Department of Agriculture Division of Aquatic and Wildlife 2004). Figures 3.3-7 and 3.3-8 show the locations of the fish aggregating devices surrounding Guam, Tinian, and Saipan. Lost fish aggregating devices are replaced normally within 2 weeks (Chapman 2004). Fish aggregating device sites may change frequently; the U.S. Coast Guard is responsible for keeping track of these changes. Fish aggregating device buoys, with long chains, may be considered a safety hazard if the buoys become disconnected.

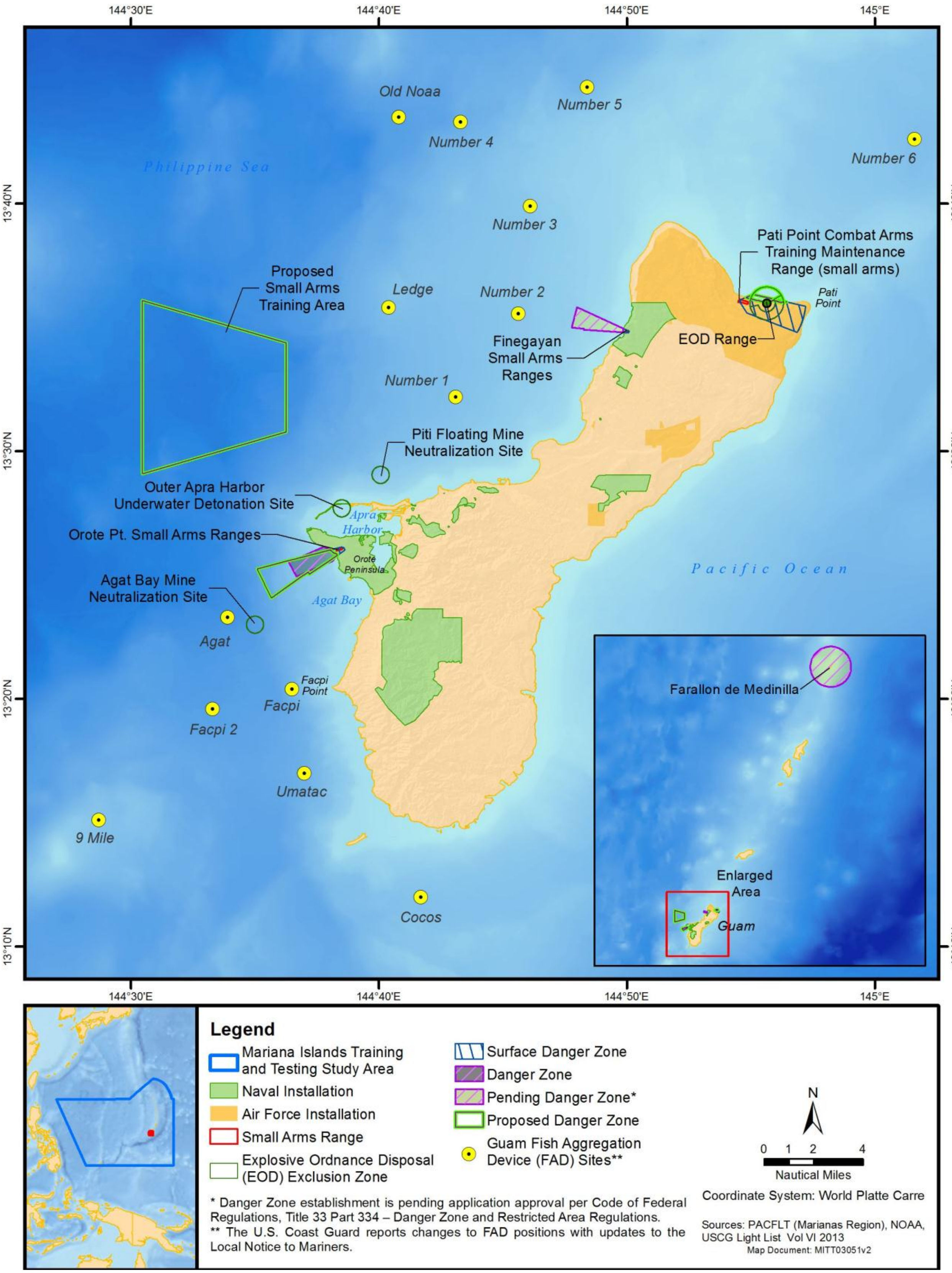

Figure 3.3-7: Fish Aggregating Devices near Guam

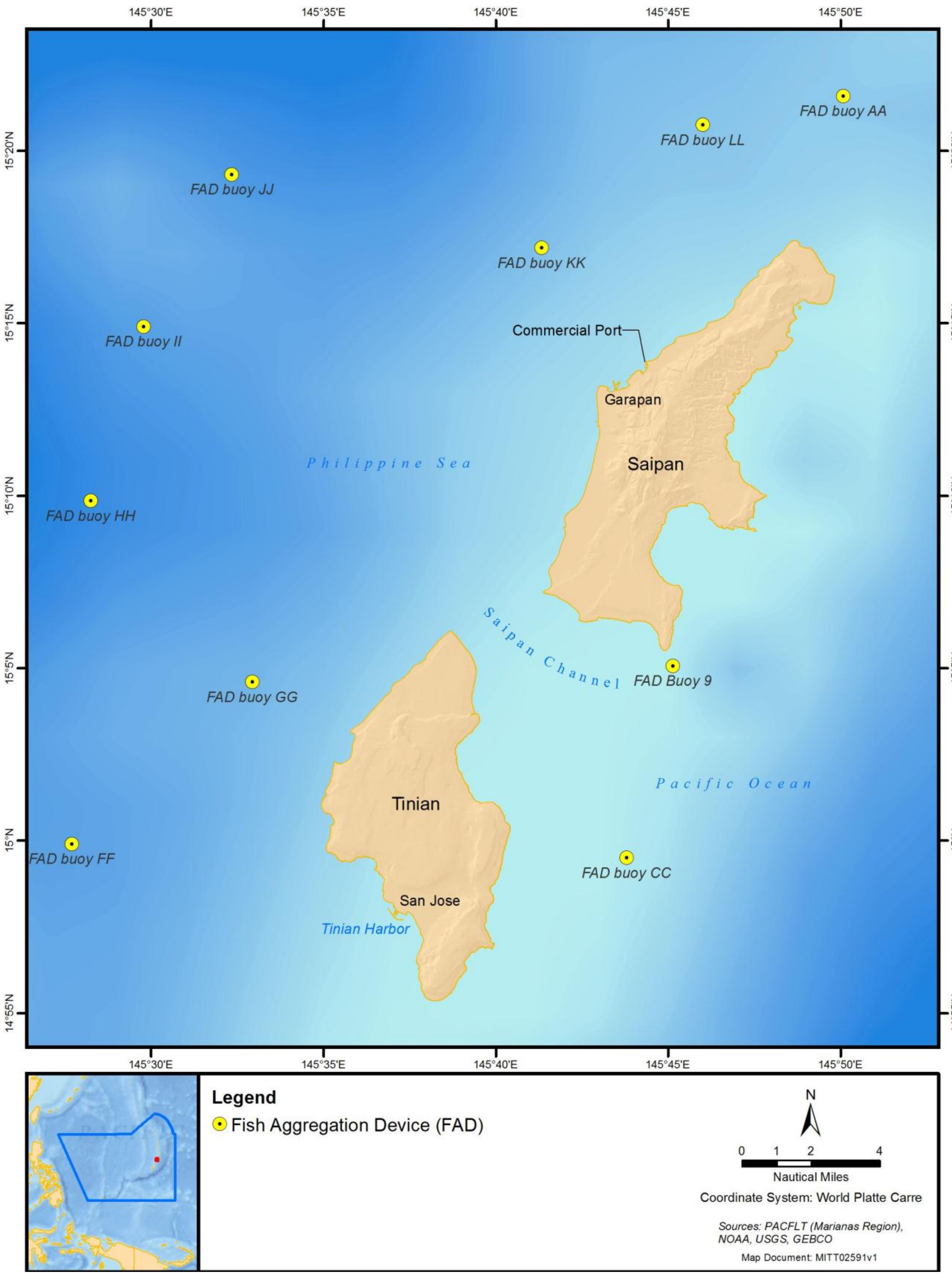

Figure 3.3-8: Fish Aggregating Devices near Tinian and Saipan

3.3.3 Environmental Consequences

This section evaluates how and to what degree training and testing activities described in Chapter 2 (Description of Proposed Action and Alternatives) could impact marine habitats in the Study Area. Tables 2.8-1 through 2.8-4 present the baseline and proposed training and testing activity locations for each alternative (including number of activities and ordnance expended). Each marine habitat stressor is introduced, analyzed by alternative, and analyzed for training activities and testing activities. Stressors vary in intensity, frequency, duration, and location within the Study Area. The following stressors are applicable to marine habitats in the Study Area and are analyzed because they have the potential to alter the quality or quantity of marine habitats for associated living resources:

- Acoustic (underwater explosives)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices)

Sonar sources do not change the substrate type of the bottom, and energy stressors do not change the substrate type by their surface orientation and nature. Entanglement and ingestion stressors are included as an aspect of military expended materials. In the remainder of this section, marine habitats will be referred to as marine substrates to reflect the subset of marine habitats being evaluated.

3.3.3.1 Acoustic Stressors

3.3.3.1.1 Impacts from Explosives

This section analyzes the potential impacts of underwater explosions on or near the bottom resulting from training and testing activities within the Study Area. Underwater detonations that occur on or near the bottom are primarily used during various mine warfare training activities. The impacts of underwater explosions vary with the bottom substrate type.

3.3.3.1.1.1 No Action Alternative

Training Activities

Mine neutralization training using divers and remotely operated vehicles, and airborne mine neutralization system AN/ASQ-235 training could involve explosions on or near the seafloor, which could affect marine habitats. Underwater demolitions qualification/certification would also be conducted in order to train and certify Navy divers in placing underwater demolition charges. Table 3.3-3 lists training and testing activities that include seafloor explosions, along with the location of the activity and the associated explosives charges. Soft bottoms are preferred for mine shape placement, and as such, most events would occur there, since this habitat type is likely to recover from these activities. Cobble, rocky reef, and other hard-bottom habitat may be scattered throughout the area, but those areas would be avoided during training to the maximum extent practicable.

Under the No Action Alternative, an estimated 50 underwater explosions would occur in the water column, and for purposes of this analysis, all are assumed to occur on or near the bottom within the Study Area, as identified in Table 3.3-3. Underwater explosions near the seafloor would primarily occur in the nearshore portions of the Study Area (see Figure 2.7-5) at appropriate mine countermeasure training sites. One site is located within Apra Harbor, where the main marine habitat is sand (see Figure 3.3-2).

Table 3.3-3: Annual Training and Testing Activities that Include Seafloor Explosions

Activity	Explosive Charge (NEW)[1]	Underwater Detonations			Location
		No Action[1]	Alternative 1	Alternative 2	
Training					
Mine Neutralization (Explosive Ordnance Disposal)	1–20 lb.	20	20	20	Agat Bay Mine Neutralization Site Piti Point Mine Neutralization Site Outer Apra Harbor Underwater Detonation Site
Underwater Demolition Qualification/ Certification	1–20 lb.	30	30	30	
Testing					
Mine Countermeasure Mission Package Testing	5 lb.	0	24	28	Study Area

[1] Under the No Action Alternative, the NEW would not exceed 10 lb. Under Alternatives 1 and 2 only the Agat Bay Mine Neutralization Site would increase the NEW to a maximum of 20 lb.
Notes: lb. = pound(s), MIRC = Mariana Islands Range Complex, NEW = net explosive weight

The determination of effect for training activities on the seafloor is based on the largest net-weight charge for the training activity, which is 20 pounds (lb.) (9.1 kilograms [kg]) net explosive weight (NEW) explosions. Explosions produce high energies that would be partially absorbed and partially reflected by the seafloor. Hard bottoms would mostly reflect the energy (Berglind et al. 2009), whereas a crater would be formed in soft bottom (Gorodilov and Sukhotin 1996). The area and depth of the crater would vary according to depth, bottom composition, and size of the explosive charge. The relationship between crater size and depth of water is non-linear, with relatively small crater sizes in the shallowest water, followed by a spike in size at some intermediate depth, and a decline to an average flat-line at greater depth (Gorodilov and Sukhotin 1996; O'Keeffe and Young 1984).

In general, training activities that include seafloor detonations occur in water depths ranging from 6 ft. (1.8 m) to about 100 ft. (30 m). Based on Gorodilov & Sukhotin (1996), the depth (h) and radius (R) of a crater from an underwater explosion over soft bottom is calculated using the charge radius (r_0)[1] multiplied by a number determined by solving for h or R along a non-linear relationship between [depth of water/r_0] and [h or R/r_0]. The area of impacted substrate for each 20 lb. (9.1 kg) underwater explosion on the seafloor would be approximately 366 $ft.^2$ (34 m^2). The radii of craters are expected to vary little among unconsolidated sediment types. On sediment types with non-adhesive particles (such as sand or mud), the impacts should be temporary; craters in clay may persist for years (O'Keeffe and Young 1984). The production of craters in soft bottom could uncover subsurface hard bottom, altering marine substrate types.

Hard substrates reflect more energy from bottom detonations than do soft bottoms (Keevin and Hempen 1997). The amount of consolidated substrate (i.e., bedrock) converted to unconsolidated sediment by surface explosions vary according to material types and degree of consolidation (i.e., rubble, bedrock). Because of a lack of accurate and specific information on hard bottom types, the impacted area is assumed to be equal to the area of soft bottom impacted. Potential exists for fracturing

[1] Pounds per cubic inch of trinitrotoluene (1.64 grams/cubic centimeter) x number of pounds, then solving for radius in the geometry of a spherical volume

and damage to hard-bottom habitat if underwater detonations occur over that type of habitat. Detonations on the seafloor would result in a maximum of approximately 11,500 $ft.^2$ (1,050 m^2) of disturbed substrate per year in the Study Area (Table 3.3-4).

Table 3.3-4: Bottom Detonations for Training Activities under the No Action Alternative, Alternative 1, and Alternative 2

Training Activity	Net Explosive Weight (lb.)[1]	Impact Footprint $ft.^2$ (m^2)	Number of Charges	Total Impact Area $ft.^2$ (m^2)
No Action Alternative				
Mine Neutralization (Explosive Ordnance Disposal)	10	230 (21)	20	4,600 (420)
Underwater Demolition Qualification/Certification	10	230 (21)	30	6,900 (630)
Total	-	-	50	11,500 (1,050)
Alternative 1 and Alternative 2				
Mine Neutralization (Explosive Ordnance Disposal)	20	366 (34)	20	7,320 (680)
Underwater Demolition Qualification/Certification	20	366 (34)	30	10,980 (1,020)
Total	-	-	50	18,300 (1,700)

[1] Analysis assumes the largest charge, in terms of net explosive weight, for the training activity. Table 3.3-3 lists the ranges of charges used for the training activity.
Notes: $ft.^2$ = square feet, lb. = pounds , m^2 = square meters

Training activities that include bottom-laid underwater explosions are infrequent (only about 50 explosions per year), and the percentage of training area affected is small (less than 1 percent of the total Study Area). Additionally, detonations are likely to occur in the same area, which would further decrease the total area impacted. Soft-bottom substrates of disturbed areas would be expected to recover their previous structure, with the fastest recovery occurring in areas with high waves and tidal energies. Recovery at the Outer Apra Harbor Underwater Detonation (UNDET) site would be expected to be prolonged due to lower tidal and wave energy in the area. The recovery for habitats in areas of repeated detonations would also be expected to be prolonged. Therefore, underwater explosions under the No Action Alternative would affect marine habitat structure in the Study Area, but these activities would occur in areas that have been previously disturbed, most impacts would be localized.

Testing Activities

No testing activities with seafloor detonations would occur under the No Action Alternative.

3.3.3.1.1.2 Alternative 1

Training Activities

Under Alternative 1, there would be the same number of underwater detonations as under the No Action Alternative (Table 3.3-4). However, the size of underwater detonations at the Agat Bay Mine Neutralization Site will change from 10 lb. to 20 lb. NEW. The size of underwater detonations at Piti Point Mine Neutralization Site and Outer Apra Harbor UNDET Site would remain at 10 lb. NEW. Underwater explosions associated with training activities under Alternative 1 would disturb approximately 18,300 $ft.^2$ (1,700 m^2) per year of substrate in the Study Area (see Table 3.3-4).

Training activities that include bottom-laid underwater explosions are infrequent (only about 50 explosions per year), and the percentage of training area affected is small (less than 1 percent of the total Study Area). Additionally, detonations are likely to occur in the same general area, which would further decrease the total area impacted. The recovery for habitats in areas of repeated detonations would be expected to be prolonged. Therefore, underwater explosions under Alternative 1 would affect marine habitat structure in the Study Area, but these activities would occur in areas that have been previously disturbed and most impacts would be localized.

Testing Activities

Under Alternative 1, there would be 24 underwater detonations (explosive neutralizers) used during mine countermeasure mission package testing activities. The maximum NEW of each detonation would be 5 lb., which could impact an area of 145 $ft.^2$ (13.5 m^2). Underwater explosions associated with testing activities under Alternative 1 could disturb approximately 3,480 $ft.^2$ (323.3 m^2) per year of substrate in the Study Area (Table 3.3-5).

Testing activities that include bottom-laid underwater explosions are infrequent (only about 24 explosions per year), and the percentage of area affected is small (less than 1 percent of the total Study Area). Additionally, detonations are likely to occur in the same area, which would further decrease the total area impacted. The recovery for habitats in areas of repeated detonations would be expected to be prolonged. Therefore, underwater explosions under Alternative 1 would affect marine habitat structure in the Study Area, but most impacts would be localized.

Table 3.3-5: Bottom Detonations for Testing Activities under Alternative 1 and Alternative 2

	Net Explosive Weight (lb.)[1]	Impact Footprint $ft.^2$ (m^2)	Number of Underwater Detonations	Total Impact Area $ft.^2$ (m^2)
Alternative 1	5	145 (13.5)	24	3,480 (323.3)
Alternative 2	5	145 (13.5)	28	4,060 (377.2)

[1] Analysis assumes the largest charge, in terms of net explosive weight, for the training activity.
Notes: $ft.^2$ = square feet, lb. = pound(s), m^2 = square meter(s)

3.3.3.1.1.3 Alternative 2

Training Activities

Under Alternative 2, there would be the same number of underwater detonations as under the No Action Alternative (Table 3.3-4). However, the size of underwater detonations at the Agat Bay Mine Neutralization Site will change from 10 lb. to 20 lb. NEW. The size of underwater detonations at Piti Point Mine Neutralization Site and Outer Apra Harbor UNDET Site would remain at 10 lb. NEW. Underwater explosions associated with training activities under Alternative 2 would disturb approximately 18,300 $ft.^2$ (1,700 m^2) per year of substrate in the Study Area (see Table 3.3-4).

Training activities that include bottom-laid underwater explosions are infrequent (only about 50 explosions per year) and the percentage of training area affected is small (less than 1 percent of the total Study Area). Additionally, detonations are likely to occur in the same area, which would further decrease the total area impacted. Soft-bottom substrates of disturbed areas would be expected to recover their previous structure, with the fastest recovery occurring in areas with high waves and tidal energies. The recovery for habitats in areas of repeated detonations would be expected to be prolonged. Therefore, underwater explosions under Alternative 2 would affect marine habitat structure in the Study Area, but these activities would occur in areas that have been previously disturbed and most impacts would be localized.

Testing Activities

Under Alternative 2, there would be 28 underwater detonations (explosive neutralizers) used during mine countermeasure mission package testing activities. The maximum NEW of each detonation would be 5 lb., which could impact an area of 145 $ft.^2$ (13.5 m^2). Underwater explosions associated with testing activities under Alternative 2 could disturb approximately 4,060 $ft.^2$ (377.2 m^2) per year of substrate in the Study Area (see Table 3.3-5).

Testing activities that include bottom-laid underwater explosions are infrequent (only about 28 explosions per year), and the percentage of area affected is small (less than 1 percent of the total Study Area). Additionally, detonations are likely to occur in the same area, which would further decrease the total area impacted. The recovery for habitats in areas of repeated detonations would be expected to be prolonged. Therefore, underwater explosions under Alternative 2 would affect marine habitat structure in the Study Area, but most impacts would be localized.

3.3.3.1.2 Substressor Impact on Marine Vegetation as Essential Fish Habitat from Explosives (Preferred Alternative)

Pursuant to the Essential Fish Habitat (EFH) requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom during training and testing activities may have an adverse effect on EFH by reducing the quality and quantity of non-living substrates that constitute EFH and Habitat Areas of Particular Concern. The MITT EFHA report states that explosive impacts to hard-bottom substrate are determined to be permanent and minimal throughout the Study Area. The impacts on soft bottom are determined to be short term and minimal. Mitigation measures should avoid impacts to surveyed hard bottom, as defined in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). Impacts on water column as EFH are summarized in corresponding resource sections (e.g., Section 3.8, Marine Invertebrates, and Section 3.9, Fish) because they are impacts on the organisms themselves.

3.3.3.2 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of various types of physical disturbance and strike stressors resulting from military training and testing activities within the Study Area. Bottom substrates could be disturbed by military expended materials and seafloor devices used for military training and testing.

Impacts of physical disturbances or strikes resulting from military training and testing activities on biogenic soft bottom (e.g., seagrass, 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. Potential impacts on the underlying substrates (soft, hard, or artificial) are analyzed in this section.

3.3.3.2.1 Impacts from Vessels and In-Water Devices

Vessels performing training and testing exercises in the Study Area are primarily large ocean-going ships and submarines operating in waters deeper than 328 ft. (100 m), transiting through the operating areas. Vessels used for training and testing activities range in size from small boats (35 ft. [10.7 m]) to large nuclear aircraft carriers (1,092 ft. [332.8 m]).

Some operations involve vessels towing in-water devices used in mine warfare activities but these are operated in a manner to ensure they avoid contacting the sea floor. Some vessels, such as amphibious vehicles, might contact portions of the reef crest or reef flat (although these areas are intentionally avoided to preserve equipment), but would contact the substrate in shallow water when transitioning onto land.

Prior to any amphibious over-the-beach training activity conducted with larger amphibious vehicles such as Air Cushioned Landing Crafts (LCACs) or Amphibious Assault Vehicles (AAVs) (e.g., Amphibious Assaults), a hydrographic survey and a beach survey would be required. The surveys would be conducted to identify and designate boat lanes and beach landing areas that are clear of coral, hard-bottom substrate, and obstructions. LCAC landing and departure activities would be scheduled at high tide. In addition, LCACs would stay fully on cushion or hover when over shallow reef to avoid corals and hard-bottom substrate. This is a standard operating procedure for safe operation of LCACs. Over-the-beach amphibious activity would only occur within designated areas based on the hydrographic and beach surveys. Similarly, AAV activities would only be scheduled within designated boat lanes and beach landing areas, and would conduct their beach landings and departures at high tide one vehicle at a time within their designated boat lane (Commander, U.S. Naval Forces Marianas Instruction 3500.4A). Based on the surveys, if the beach landing area and boat lane is clear, the activity could be conducted, and crews would follow procedures to avoid obstructions to navigation, including coral reefs; however, if there is any potential for impacts on corals or hard-bottom substrate, the Navy will coordinate with applicable resource agencies before conducting the activity. Hydrographic and beach surveys would not be necessary for beach landings with small boats, such as rigid hull inflatable boats.

Some anchored or expended in-water devices could impact any of the habitat types discussed in this section, including soft and hard shores, soft and hard bottoms, and artificial substrates. This could disturb the water column enough to stir up bottom sediments, temporarily and locally increasing the turbidity. The shore environment is typically highly dynamic because of its constant exposure to wave action and cycles of erosion and deposition. As a result, disturbed areas of soft-bottom habitat would be reworked by waves and tides shortly after the disturbance. In deeper waters where the tide or wave action has little influence, sediments suspended into the water column would quickly settle to the seafloor or would be carried along the bottom by currents before settling again. In either case, these disturbances would not alter the overall nature of the sediments to a degree that would impair their function as habitat or change the character of the substrate.

3.3.3.2.1.1 No Action Alternative

Training Activities

Amphibious landings would be associated with amphibious warfare training activities, which would include amphibious assault, amphibious assault-battalion landing, and amphibious raid training activities and could occur 10 times under the No Action Alternative. Boats and vessels (including Mechanized and Utility Landing Craft and LCAC) may transport personnel or equipment to the shore or beach in the Study Area. This beaching activity could affect marine habitats as the boat contacts and disturbs the sediment where it lands.

Amphibious vessels would approach the shore and could beach, which would disturb sediments and increase turbidity. The impact of vessels on the substrate in the surf zone would be minor because of the dispersed nature of the amphibious landings and the dynamic nature of sediments in these areas of high-energy surf. Amphibious Assault and Amphibious Raid training could be conducted in the nearshore area, including the surf zone up to the high tide line at Unai Chulu, Unai Babui, and Unai Dankulo, Tinian, as well as Dry Dock Island in Apra Harbor and Dadi Beach on Guam. Amphibious Raid activities could also be conducted on Rota, but they are restricted to approaches via boat docks (no beach landings). As is current practice, exposure of hard-bottom habitats would continue to be avoided in the No Action Alternative. Additionally, amphibious landing activities would be scheduled at high tide, pre-landing surveillance would be used to identify the best landing route, and crews would follow procedures to avoid obstructions to navigation, all of which would reduce the potential for the vessels to disturb sediments or marine habitats.

Under the No Action Alternative, vessels movements could affect bottom sediments during amphibious landings. Ocean approaches would not be expected to affect marine habitats because of the nature of surf and tidal energy in the area. The movement of sediment by wave and tidal energy would fill in disturbed soft-bottom habitat similar to sediment recovery from a severe storm. Impacts on substrate would be limited to suspended sediments that are carried away by ocean currents. Ocean currents, however, would carry sediments from other locations into the Study Area. Therefore, vessel movements in the Study Area would not be expected to affect marine habitats.

Testing Activities

Under the No Action Alternative, testing activities in the Study Area would not include activities, such as amphibious landings, where vessels would contact bottom substrates. Therefore, vessels and in-water devices for testing activities would have no effect on marine habitats under the No Action Alternative.

3.3.3.2.1.2 Alternative 1

Training Activities

Alternative 1 proposes to introduce new vessels (not replacement class vessel for existing vessels). The Littoral Combat Ship and the Joint High Speed Vessel are fast vessels that may operate in nearshore waters, but would not be expected to contact bottom substrates. The Navy would introduce unmanned undersea and surface systems under Alternative 1, which may contact bottom substrates. The number of amphibious warfare training activities with amphibious landings would increase by approximately 30 percent compared to the No Action Alternative.

Amphibious vessels would approach the shore and could beach, which would disturb sediments and increase turbidity. The impact of vessels on the substrate in the surf zone would be minor because of the dispersed nature of the amphibious landings and the dynamic nature of sediments in areas of these high-energy surf zones. Amphibious Assault and Amphibious Raids could occur up to six times each annually. These could occur at beaches at Una Babui, Una Chulu, and Unai Dankulo on Tinian and can also occur at Dry Dock Island in Apra Harbor, Dadi Beach on Guam. Amphibious Raid activities could also be conducted on Rota, but they are restricted to approaches via boat docks (no beach landings). As is current practice, exposure of hard-bottom habitats would continue to be avoided in the Proposed Action. Additionally, amphibious landing activities would be scheduled at high tide, pre-landing surveillance would be used to identify the best landing route, and crews would follow procedures to avoid obstructions to navigation, all of which would reduce the potential for the vessels to disturb sediments or marine habitats.

Under Alternative 1, vessels movements could affect bottom sediments during amphibious landings. Ocean approaches would not be expected to affect marine habitats because of the nature of surf and tidal energy in the area. The movement of sediment by wave and tidal energy would fill in disturbed soft-bottom habitat similar to sediment recovery from a severe storm. Impacts on substrate would be limited to suspended sediments that are carried away by ocean currents. Ocean currents, however, would carry sediments from other locations into the Study Area. Therefore, vessel movements in the Study Area would not be expected to affect marine habitats.

Testing Activities

Under Alternative 1, testing activities in the Study Area would not include activities, such as amphibious landings, where vessels would contact bottom substrates. Therefore, vessels and in-water devices for testing activities would have no effect on marine habitats under Alternative 1.

3.3.3.2.1.3 Alternative 2

Training Activities

The number of training activities under Alternative 2 would be slightly greater than under Alternative 1 (see Table 3.3-3). Vessels used under Alternative 2 would consist of the same proposed vessels and unmanned systems as described under Alternative 1. Therefore, the impacts of vessel movements under Alternative 2 would be as described for Alternative 1; they would not affect marine habitats.

Testing Activities

Under Alternative 2, testing activities in the Study Area would not include activities, such as amphibious landings, where vessels would contact bottom substrates. Therefore, vessels and in-water devices for testing activities would have no effect on marine habitats under Alternative 2.

3.3.3.2.1.4 Substressor Impact on Marine Habitat as Essential Fish Habitat from Vessels and In-Water Devices (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of vessels and in-water devices during training and testing activities may have an impact on EFH by reducing the quality and quantity of non-living substrates that constitute EFH and Habitat Areas of Particular Concern. The MITT EFHA report states that any impacts on marine habitats incurred by vessel movements and in-water devices would be minimal and short term.

3.3.3.2.2 Impacts from Military Expended Materials

The potential for physical disturbance of marine substrates by military expended materials from military training and testing activities exists throughout the Study Area, although the types of military expended materials vary by activity and region (see Tables 2.8-1 through 2.8-4 of Chapter 2, Description of Proposed Action and Alternatives) with some areas of greater concentration, such as the shoreline around FDM. Section 2.3.6 (Military Expended Materials) describes military expended materials, which include non-explosive practice munitions (projectiles, bombs, and missiles) that are used in military training and testing activities. Military expended materials could disturb marine substrates to the extent that they impair the substrate's ability to function as a habitat. These disturbances could result from several sources, including the impact of the expended material contacting the seafloor, the covering of the substrate by the expended material, or the alteration of the substrate from one type to another.

The potential of military expended materials to impact marine substrates as they contact the seafloor depends on several factors, including the size, type, mass, and speed of the material; water depth; the amount of material expended; the frequency of training or testing; and the type of substrate. Most of the kinetic energy of an expended item is dissipated within the first few yards of the object entering the water, causing it to slow considerably by the time it reaches the substrate. Because the damage caused by a strike is proportional to the force of the strike, slower speeds may result in lesser impacts. Because of the depth of the water in which most training and testing activities take place, a direct strike on either hard bottom or artificial structures (e.g., artificial reefs and shipwrecks) with sufficient force to damage the substrate is unlikely. Any damage would be limited to a small portion of the structural habitat. The value of these substrates as habitat, however, does not depend on the shape of the structure. An alteration in shape or structure caused by military expended materials is not expected to reduce the habitat value of either hard bottom or artificial structures. In softer substrates (e.g., sand, mud, silt, clay, and composites), the impact of the expended material on the seafloor, if large enough and striking with sufficient momentum, may create a depression and redistribute local sediments as they are temporarily re-suspended in the water column. During military training and testing, countermeasures such as flares and chaff are introduced into marine habitats. These types of military expended materials are not expected to impact marine habitats as strike stressors because of their size and low velocity when impacting water surface, compared to projectiles, bombs, and missiles.

Other potential impacts that military expended materials could have on marine substrates would be to cover them or to alter the type of substrate and, therefore, its function as habitat. The majority of military expended materials that settle on hard bottoms or artificial substrates, while covering the seafloor, would still provide the same habitat as the substrate it covers by providing a hard surface on which organisms can attach. An exception would be expended materials, such as decelerators/parachutes used to deploy sonobuoys, lightweight torpedoes, expendable mobile anti-submarine warfare training targets, and other devices from aircraft, that would not provide a hard or permanent surface for colonization. In these cases, the hard bottom or artificial substrate covered by the expended material would not be damaged, but its function as a habitat for colonizing or encrusting organisms would be impaired.

Most military expended materials that settle on soft-bottom habitats, while not damaging the substrate, would modify the habitat by covering the substrate with a hard surface. This event would alter the substrate from a soft surface to a hard structure and, therefore, would prevent the substrate from supporting a soft-bottom community. Expended materials that settle in the shallower, more dynamic environments of the nearshore coastal waters would likely be eventually covered over by sediments because of currents and other coastal processes or encrusted by organisms. In the deeper waters of the continental slope and beyond, where currents do not play as large of a role, larger expended materials (i.e., bombs, missiles) may remain exposed on the surface of the substrate with minimal change for extended periods. Softer expended materials, such as decelerators/parachutes, would not damage sediments. Decelerators/parachutes, however, could impair the function of the substrate as habitat because they could be a temporary barrier to interactions between the water column and the sediment.

One unique type of military expended material, because of its size, is a ship hulk. Sinking exercises use a target (ship hull or stationary artificial target) against which explosive and non-explosive ordnance are fired. These exercises eventually sink the target. The exercise lasts 4–8 hours over 1–2 days, and may use multiple targets. Sinking exercises would only occur in waters more than 6,000 ft. (1,828.8 m) deep. The potential impacts of sinking exercises depend on the amounts of ordnance and types of weapons used, which are situational and training-need dependent (U.S. Department of the Navy 2006). The potential military expended materials from sinking exercises include the ship hull and shell fragments. The expended materials that settle to the seafloor would not affect the stability of the seafloor or disturb natural ocean processes (U.S. Department of the Navy 2006). On sloping bottoms, some expended materials may disrupt the periodic turbidity currents or sand flows of the immediate area. The impact of a ship hull settling on marine substrates would depend on the size of the ship hull and the type of substrate it settles upon. Areas of hard bottom may fragment or break as the ship settles to the seafloor. While the ship would cover a portion of the seafloor, it may support communities similar to those found on the hard substrate it covered, and likely would provide more complexity and relief, which are important habitat features for hard-bottom communities. Areas of unconsolidated sediments would experience a temporarily large increase in turbidity as sediment is suspended in the water column. The settling of the ship to the seafloor would also likely displace sediment and create a large depression in the substrate. The soft substrates covered by the ship would no longer serve their function in supporting a soft-bottom community, having been replaced by a hard structure more suitable for attaching and encrusting organisms.

The analysis to determine the potential level of disturbance of military expended materials on marine substrates assumes that the impact of the expended material on the seafloor is twice the size of its footprint (Gorodilov and Sukhotin 1996). This assumption would more accurately reflect the potential disturbance to soft-bottom habitats, but could overestimate disturbance of hard-bottom habitats. For this analysis, explosive munitions were treated in the same manner as non-explosive practice munitions in terms of impacts on the seafloor, to be conservative, even though explosive ordnance would normally explode in the upper water column, and only fragments of the ordnance would settle on the seafloor.

Strike warfare activities such as Bombing Exercises (Land) and Missile Exercises involve the use of live munitions by aircrews that practice on ground targets on FDM. These warfare training activities occur on the FDM land mass and are limited to the designated impact zones along the central corridor of the island. Explosives that detonate on land could loosen soils and subsequently get transported into surface drainage areas or nearshore waters. It should be noted that FDM is highly susceptible to natural causes of erosion because it is comprised of highly weathered limestone overlain by a thin layer of clay soil. Sediments entering the nearshore environment 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 Navy minimizes the potential for soil transport and, thus, water quality impacts. Additionally, as described in Section 3.1.3.1.5.3 (Farallon de Medinilla Specific Impacts), the Navy has conducted annual marine dive surveys in waters surrounding FDM from 1999 to 2010. Throughout all dive surveys, the coral fauna at FDM was 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, and as such, marine habitats.

3.3.3.2.2.1 No Action Alternative

The numbers of military expended materials used for training and testing activities under the No Action Alternative are listed in Table 3.3-6. The physical impact area is estimated as twice the footprint of each type of military expended material.

Training Activities

Training activities involving military expended materials could impact the marine substrates within the areas where training would occur. A total of 116,241 military items, including several gun rounds and two ship hulks (Table 3.3-6), would be expended annually in the Study Area during training activities, which would result in a total impact area of approximately 1,505,166 ft.^{2} (139,738 m^2), which is less than 1 percent of the total Study Area. The majority of the impact area would be ship hulks expended during sinking exercises. With an impact area of 632,272 ft.^{2} (58,740 m^2) for each vessel and up to two sinking exercises per year, ship hulks would account for about 84 percent (1,265,000 ft.^{2} [117,480 m^2]) of the annual impact area for training activities under the No Action Alternative.

Table 3.3-6: Number and Impact Footprint of Military Expended Materials – No Action Alternative

Military Expended Material	Size ft.^{2} (m^2)	Impact Footprint ft.^{2} (m^2)	Study Area			
			Training Activities		Testing Activities	
			Number	Impact ft.^{2} (m^2)	Number	Impact ft.^{2} (m^2)
Bombs (Explosives)	16.17 (1.5022)	32.34 (3.0044)	32	1034.88 (96.1408)	0	0
Bombs (NEPM)	16.17 (1.5022)	32.34 (3.0044)	522	16,881.48 (1,568.29)	0	0
Small caliber	0.0301 (0.0028)	0.0603 (0.0056)	60,000	3,618 (336)	0	0
Medium caliber (Explosives)	0.056 (0.0052)	0.1119 (0.0104)	0	0	0	0
Medium caliber (NEPM)	0.056 (0.0052)	0.1119 (0.0104)	26,500	2,965.35 (275.6)	0	0
Large caliber (Explosives)	1.01 (0.0938)	2.0193 (0.1876)	1,240	1,242.02 (232.62)	0	0
Large caliber (NEPM)	1.01 (0.0938)	2.0193 (0.1876)	0	0	0	0
Missiles (Explosives)	37.37 (3.4715)	74.73 (6.9430)	58	4,334.34 (402.69)	0	0
Rockets (Explosives)	0.7987 (0.0742)	1.5974 (0.1484)	0	0	0	0
Rockets (NEPM)	0.7987 (0.0742)	1.5974 (0.1484)	0	0	0	0
Chaff (cartridges)	0.00108 (0.0001)	0.00215 (0.0002)	5,830	12.53 (1.16)	0	0
Flares	1.2196 (0.1133)	2.4391 (0.2266)	5,740	14,000.43 (1,300.68)	0	0
Acoustic countermeasures	0.3111 (0.0289)	0.6222 (0.0578)	0	0	0	0
Expendable Targets	96.88 (9)	193.8 (18)	159	30,814.2 (2,646)	0	0
Ship hulk (SINKEX)	316,136 (29,370)	632,272 (58,740)	2	1,264,540 (117,480)	0	0
Torpedo/accessories (Explosives)	7.53 (0.7)	15.1 (1.4)	53	800.3 (74.2)	0	0
Sonobuoys	1.2206 (0.1134)	2.4413 (0.2268)	8065	19,689.08 (1829.14)	0	0
Sonobuoys (explosives)	0.9752 (0.0906)	1.9504 (0.1812)	8	15.603 (1.45)	0	0
Decelerators/parachutes	9.04 (0.84)	18.08 (1.68)	8032	145,218.56 (13,493.76)	0	0
Total			**116,241**	**1,505,166 (139,738)**	0	0

Notes: ft.^{2} = square foot, m^2 = square meters, NEPM = Non-explosive Practice Munitions, SINKEX = Sinking Exercise

Under the No Action Alternative, the majority of military expended material would be used in open ocean areas, where the substrate is clays and silts. Explosive military expended material would typically fragment into small pieces. Ordnance that fails to function as designed and inert munitions would result in larger pieces of military expended material settling to the seafloor. Once on the seafloor, military expended material would be buried by sediments, corroded from exposure to the marine environment, or colonized by benthic organisms.

During sinking exercises, large amounts of military expended material and a vessel hulk would be expended. Sinking exercises in the Study Area, however, would occur over 50 nm from shore to the southwest of Guam, where the substrate would be primarily clays and silts. Clay and silt deep-water habitats would primarily consist of abyssal plains. Impacts of military materials expended over deep-water would be negligible because the military would typically avoid hard-bottom sub-surface features (e.g., sea mounts). Vessel hulks used during sinking exercises would alter the bottom substrate, converting soft-bottom habitat into an artificial, hard-bottom structure. The amount of area affected by vessel hulks would be a fraction of the available training area, and the vessel hulk would create a hard substrate which could act as an anchoring point for marine life in the open ocean where the predominant habitat is soft bottom.

Military expended material in the coastal portions of the Study Area would be limited to small-caliber projectiles, flares, and target fragments. These materials would be small, and would typically be covered by sediment or colonized by benthic organisms. The small size of military expended materials would not change the habitat structure. In heavily used coastal areas around FDM, annual monitoring since 1999 has determined that impacts to the marine habitats from military expended materials have been insignificant. Therefore, impacts to marine habitats from military expended material from training activities in the Study Area would be insignificant.

Testing Activities

Under the No Action Alternative, testing activities would not include military expended materials that may impact marine habitats.

3.3.3.2.2.2 Alternative 1

The numbers of military items expended for training and testing activities under Alternative 1 that may impact marine habitats are listed in Table 3.3-7.

Training Activities

A total of 261,482 military items that could impact marine habitats would be expended annually in the Study Area during training activities, which would result in a total impact area of approximately 1,705,266 $ft.^2$ (158,424 m^2) which is less than 1 percent of the total Study Area. Although there would be an approximate 120 percent increase in the number of military expended materials compared to the No Action Alternative, there would only be an increase of approximately 10 percent in the total area of bottom substrate affected.

Table 3.3-7: Number and Impact Footprint of Military Expended Materials – Alternative 1

Military Expended Material	Size ft.² (m²)	Impact Footprint ft.² (m²)	Study Area			
			Training Activities		Testing Activities	
			Number	Impact ft.²(m²)	Number	Impact ft.² (m²)
Bombs (Explosive)	16.17 (1.5022)	32.34 (3.0044)	212	6,856.08 (636.93)	0	0
Bombs (NEPM)	16.17 (1.5022)	32.34 (3.0044)	848	27,424.32 (2,547.73)	0	0
Small caliber	0.0301 (0.0028)	0.0603 (0.0056)	86,140	5,210.52 (482.34)	2,000	120.6 (11.2)
Medium caliber (Explosive)	0.056 (0.0052)	0.1119 (0.0104)	8,250	923.175 (85.8)	2,040	228.28 (21.21)
Medium caliber (NEPM)	0.056 (0.0052)	0.1119 (0.0104)	85,500	9,567.45 (889.2)	2,040	228.28 (21.21)
Large caliber (Explosive)	1.01 (0.0938)	2.0193 (0.1876)	1,300	2,625.9 (243.88)	3,920	7,915.66 (735.4)
Large caliber (NEPM)	1.01 (0.0938)	2.0193 (0.1876)	5,238	10,577.09 (982.65)	1,680	3,392.42 (315.168)
Missiles (Explosive)	37.37 (3.4715)	74.73 (6.9430)	113	8,444.5 (784.5)	20	1,494.6 (138.86)
Missiles (NEPM)	37.37 (3.4715)	74.73 (6.9430)	0	0	20	1,494.6 (138.86)
Rockets (Explosive)	0.7987 (0.0742)	1.5974 (0.1484)	114	182.10 (16.92)	0	0
Rockets (NEPM)	0.7987 (0.0742)	1.5974 (0.1484)	0	0 (0)	0	0
Chaff (cartridges)	0.00108 (0.0001)	0.00215 (0.0002)	25,840	55.56 (5.17)	600	1.29 (0.12)
Flares	1.2196 (0.1133)	2.4391 (0.2266)	25,600	62,440.96 (5,800.96)	300	731.73 (67.98)
Acoustic counter-measures	0.3111 (0.0289)	0.6222 (0.0578)	0	0	0	0
Expendable targets	96.88 (9)	193.8 (18)	426	82,558.8 (7,668)	360	69,768 (6,481.66)
Ship hulk (SINKEX)	316,136 (29,370)	632,272 (58,740)	2	1,264,544 (117,480)	0	0
Torpedo/ accessories (Explosive)	7.53 (0.7)	15.1 (1.4)	63	951.3 (88.2)	116	1,751.60 (162.40)
Sonobuoys	1.2206 (0.1134)	2.4413 (0.2268)	10,980	26,805.47 (2,490.26)	932	2,275.29 (211.37)
Sonobuoys (Explosive)	0.9752 (0.0906)	1.9504 (0.1812)	11	21.45 (1.99)	793	1,546.67 (143.69)
Decelerators/ parachutes	9.04 (0.84)	18.08 (1.68)	10,845	196,077.6 (18,219.6)	1,727	31,224.16 (2,901.36)
Total			**261,482**	**1,705,266 (158,424.2)**	**16,829**	**122,172 (11,348.83)**

Notes: ft.² = square foot, m² = square meters, NEPM = Non-explosive Practice Munitions, SINKEX = Sinking Exercise, The majority of military expended material would be used in the open ocean, where substrates would primarily be clays and silts with few benthic invertebrates. Military expended material in the coastal portions of the Study Area would be limited to small-caliber projectiles, flares, and target fragments. In heavily used coastal areas around FDM, annual monitoring since 1999 has determined that impacts to the marine habitats from military expended materials have been insignificant. While the number of activities would increase, the types of military expended materials under Alternative 1 would be the same as under the No Action Alternative. Therefore, military material expended from training activities in the Study Area would have a slightly greater impact on marine habitats compared to the No Action Alternative.

Testing Activities

A total of 16,829 military expended materials that may impact marine habitats would be expended annually in the Study Area during testing activities, which would result in a total impact area approximately 122,172 $ft.^2$ (11,348.83 m^2), which is less than 1 percent of the total Study Area.

The majority of military expended materials would be used in the open ocean, where substrates would primarily be clays and silts with few benthic invertebrates. Military expended material in the coastal portions of the Study Area would be limited to small-caliber projectiles, flares, and target fragments. In heavily used coastal areas around FDM, annual monitoring since 1999 has determined that impacts to the marine habitats from military expended materials have been insignificant. The types of military expended materials under Alternative 1 would be the same as those used for training under the No Action Alternative. Therefore, military material expended from testing activities in the Study Area would have a similar impact on marine habitats compared to those used under training activities in the No Action Alternative.

3.3.3.2.2.3 Alternative 2

The numbers of military items that would be expended for training and testing activities that may impact marine habitats under Alternative 2 are listed in Table 3.3-8.

Training Activities

A total of 269,352 military items that may impact marine habitats would be expended annually in the Study Area during training activities, which would result in a total impact area of approximately 1,717,415 $ft.^2$ (159,544.4 m^2), which is less than 1 percent of the total Study Area. Although there would be an approximate 130 percent increase in the number of military expended materials compared to the No Action Alternative, there would only be an increase of 12 percent in the total area of bottom substrate affected.

The majority of military expended material would be used in the open ocean, where substrates would primarily be clays and silts with few benthic invertebrates. Military expended material in the coastal portions of the Study Area would be limited to small-caliber projectiles, flares, and target fragments. In heavily used coastal areas around FDM, annual monitoring since 1999 has determined that impacts to the marine habitats from military expended materials have been insignificant. While the number of activities would increase, the types of military expended materials under Alternative 2 would be the same as under the No Action Alternative. Therefore, military material expended from training activities in the Study Area would have a slightly greater impact on marine habitats compared to the No Action Alternative.

Table 3.3-8: Number and Impact Footprint of Military Expended Materials – Alternative 2

Military Expended Material	Size ft.^{2} (m^2)	Impact Footprint ft.^{2} (m^2)	Study Area			
			Training Activities		Testing Activities	
			Number	Impact ft.^{2} (m^2)	Number	Impact ft.^{2} (m^2)
Bombs (Explosive)	16.17 (1.5022)	32.34 (3.0044)	212	6,856.08 (636.93)	0	0
Bombs (NEPM)	16.17 (1.5022)	32.34 (3.0044)	848	27,424.32 (2,547.73)	0	0
Small caliber	0.0301 (0.0028)	0.0603 (0.0056)	86,140	5,194.24 (482.38)	2,500	150.75 (14)
Medium caliber (Explosive)	0.056 (0.0052)	0.1119 (0.0104)	8,250	923.175 (85.8)	2,490	278.63 (25.9)
Medium caliber (NEPM)	0.056 (0.0052)	0.1119 (0.0104)	87,750	9,819.22 (912.6)	2,490	278.63 (25.9)
Large caliber (Explosive)	1.01 (0.0938)	2.0193 (0.1876)	1,300	2,625.09 (243.88)	4,900	9,894.57 (919.24)
Large caliber (NEPM)	1.01 (0.0938)	2.0193 (0.1876)	5,238	10,577.09 (982.64)	9,300	18,779.49 (1,744.68)
Missiles (Explosive)	37.37 (3.4715)	74.73 (6.9430)	125	9,341.25 (867.87)	25	1868.25 (173.58)
Missiles (NEPM)	37.37 (3.4715)	74.73 (6.9430)	0	0	25	1868.25 (173.58)
Rockets (Explosive)	0.7987 (0.0742)	1.5974 (0.1484)	380	607.01 (56.39)	0	0
Rockets (NEPM)	0.7987 (0.0742)	1.5974 (0.1484)	0	0	0	0
Chaff (cartridges) – aircraft	0.00108 (0.0001)	0.00215 (0.0002)	28,512	61.3 (5.7)	660	1.42 (0.13)
Flares	1.2196 (0.1133)	2.4391 (0.2266)	28,272	68,958.24 (6,406.44)	330	804.90 (74.77)
Acoustic counter-measures	0.3111 (0.0289)	0.6222 (0.0578)	0	0	0	0
Expendable targets	96.88 (9)	193.8 (18)	447	86,628.6 (8,046)	401	77,713.8 (7,218)
Ship hulk (SINKEX)	316,136 (29,370)	632,272 (58,740)	2	1,264,544 (117,480)	0	0
Torpedo/ accessories (Explosive)	7.53 (0.7)	15.1 (1.4)	63	951.3 (88.2)	154	2,325.4 (215.6)
Sonobuoys	1.2206 (0.1134)	2.4413 (0.2268)	10,980	26,805.47 (2,490.26)	1,025	2502.33 (242.47)
Sonobuoys (Explosive)	0.9752 (0.0906)	1.9504 (0.1812)	11	21.45 (1.99)	884	1,724.15 (160.18)
Decelerators /parachutes	9.04 (0.84)	18.08 (1.68)	10,845	196,077.6 (18,219.6)	1,912	34,568.96 (3,212.16)
Total			**269,375**	**1,717,415 (159,554.4)**	**27,096**	**152,759 (14,200.4)**

Notes: ft.^{2} = square feet, m^2 = square meters, NEPM = Non-explosive Practice Munitions, SINKEX = Sinking Exercise

Testing Activities

A total of 27,096 military expended materials that may impact marine habitats would be expended annually in the Study Area during testing activities, which would result in a total impact area of 152,759 $ft.^2$ (14,200.4 m^2), which is less than 1 percent of the total Study Area.

The majority of military expended material would be used in the open ocean, where substrates would primarily be clays and silts with few benthic invertebrates. Military expended material in the coastal portions of the Study Area would be limited to small-caliber projectiles, flares, and target fragments. In heavily used coastal areas around FDM, annual monitoring since 1999 has determined that impacts to the marine habitats from military expended materials have been insignificant. While the number of activities would increase, the types of military expended materials under Alternative 2 would be the same as under Alternative 1. Therefore, military material expended from testing activities in the Study Area would have a slightly greater impact on marine habitats compared to Alternative 1.

3.3.3.2.2.4 Substressor Impact on Marine Vegetation as Essential Fish Habitat from Military Expended Materials (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials during training and testing activities may have an adverse effect on EFH by reducing the quality and quantity of non-living substrates that constitute EFH and Habitat Areas of Particular Concern. The MITT EFHA report states that military expended material impacts to both soft- and hard-bottom substrates would be minimal with a duration period of long term to permanent within the MITT Study Area.

3.3.3.2.3 Impacts from Seafloor Devices

Seafloor devices are items used during training or testing activities that intentionally contact the seafloor. Seafloor devices include moored mine shapes, bottom placed instruments, and anchors.

Moored mines deployed by fixed-wing aircraft enter the water and impact the bottom, becoming partially buried in sediments. Upon impact, the mine casing separates and the semi-buoyant mine floats up through the water column until it reaches the end of the mooring line. Bottom mines are typically positioned manually and are allowed to free sink to the bottom to rest. Mine shapes are normally deployed over soft sediments and are recovered within 7–30 days following the completion of the training or testing activities.

Precision anchoring training exercises involve releasing anchors in precise locations throughout the Study Area. The intent of these training exercises is to practice anchoring the vessel within 100 yards (91.4 m) of the planned anchorage location. These training activities typically occur within predetermined shallow water anchorage locations near ports. In these locations the seafloors consist of hard and soft sediments. The level of impact on the sediments would depend on the size of the anchor used, which would vary according to vessel type.

3.3.3.2.3.1 No Action Alternative

Training Activities

Under the No Action Alternative, 480 mine shapes would be used during mine laying training activities. Mine shapes would be used primarily in Warning Area 517, which is located over predominately soft-bottom habitat in the open ocean offshore area (Figure 2.1-2). Based on the small area affected by mine shapes (approximately 8–15 $ft.^2$ [0.7–1.4 m^2]), and the substrate on which mine shapes are used, the use of mine shapes during training activities would not be expected to affect marine habitats. Additionally, the Portable Underwater Tracking Range (PUTR) would be deployed under the No Action Alternative. This would involve anchoring of approximately seven transponders normally in waters of depths greater than approximately 5,900 ft. (1,800 m). These locations would include seafloors consisting with soft-bottom habitat of unconsolidated sediments. Based on the use of areas of soft-bottom habitat the PUTR anchoring activities would not be expected to affect marine habitats.

Testing Activities

Under the No Action Alternative, seafloor devices are only utilized during testing activities at the North Pacific Acoustic Lab's Deep Water site. The deep water experimental site consists of an acoustic tomography array, a distributed vertical line array, and moorings in the deep-water environment (depths greater than 3,280 ft. [1,000 m]) of the northwestern Philippine Sea. The impact of seafloor devices on marine habitats is unlikely since these activities would occur over soft-bottom sediment in the deep sea.

3.3.3.2.3.2 Alternative 1

Training Activities

Under Alternative 1, 480 mine shapes would be used during mine laying training activities. Mine shapes would be used primarily in Warning Area 517, which is located over predominately soft-bottom habitat in the open ocean offshore area (see Figure 2.1-2). Based on the small area affected by mine shapes (approximately 8–15 $ft.^2$ [0.7–1.4 m^2]), and the substrate on which mine shapes are used, the use of mine shapes during training activities would not be expected to affect marine habitats. Additionally there would be 18 precision anchoring activities which would occur within predetermined shallow water anchorage locations near ports. These locations would include seafloors consisting of hard- and soft-bottom habitat. The level of impact on the sediments would depend on the size of the anchor used, which would vary according to vessel type. However, based on the use of areas that have been previously disturbed, precision anchoring activities would not be expected to affect marine habitats.

Testing Activities

Under Alternative 1, seafloor devices are utilized during pierside integrated swimmer defense activities, testing activities at the North Pacific Acoustic Lab's Deep Water site, and during the mine countermeasure mission package testing. The deep water experimental site consists of an acoustic tomography array, a distributed vertical line array, and moorings in the deep-water environment (depths greater than 3,280 ft. [1,000 m]) of the northwestern Philippine Sea. All equipment except for expendable transponders and anchors will be retrieved from the experiment area following the final phase of the PhilSea 10-11 Experiment. The locations for mine countermeasure mission testing would typically include seafloors consisting of soft-bottom habitat of unconsolidated sediments, such as Apra Harbor for the pierside integrated swimmer defense activities, which involve the retrieval of diver-placed items. Mine shapes could be used during the mine countermeasure mission package testing throughout the Study Area, though located over predominately soft-bottom habitat in the open ocean offshore area. Based on the small area affected by mine shapes (approximately 8–15 $ft.^2$ [0.7–1.4 m^2]), and the substrate on which mine shapes are used, the use of mine shapes during training activities would not be expected to affect marine habitats. Therefore, 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.

3.3.3.2.3.3 Alternative 2

Training Activities

Under Alternative 2, no additional seafloor devices would be used or implemented. Therefore, seafloor devices under Alternative 2 would have the same impacts on marine habitats as under Alternative 1.

Testing Activities

Under Alternative 2, seafloor devices are utilized during pierside integrated swimmer defense activities, testing activities at the North Pacific Acoustic Lab's Deep Water site, and during the mine countermeasure mission package testing. The deep water experimental site consists of an acoustic tomography array, a distributed vertical line array, and moorings in the deep-water environment (depths greater than 3,280 ft. [1,000 m]) of the northwestern Philippine Sea. The location of pierside integrated swimmer defense activities, such as Apra Harbor, include seafloors consisting of soft-bottom habitat of unconsolidated sediments, which involve the retrieval of diver-placed items. Mine shapes could be used during the mine countermeasure mission package testing throughout the Study Area, though located over predominately soft-bottom habitat in the open ocean offshore area. Similar to Alternative 1, based on the small area affected by mine shapes and the substrate on which mine shapes are used, the use of mine shapes during training activities would not be expected to affect marine habitats Therefore, 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 area, and the items are retrieved.

3.3.3.2.3.4 Substressor Impact on Marine Vegetation as Essential Fish Habitat from Seafloor Devices (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of seafloor devices during training and testing activities may have an adverse effect on bottom substrates that constitute EFH. 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 3 years) in duration. Artificial structures should not be adversely affected by the use of seafloor devices.

3.3.3.2.4 Summary of Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors that could affect bottom substrates include vessel and in-water strikes, seafloor devices, and military expended materials. Amphibious landings in marine habitats of concern would be located to limit the potentially affected area. Ocean approaches would not be expected to affect marine habitats because of the nature of surf and tidal energy, and shifting sands. Seafloor devices would be located in areas that would be primarily soft-bottom habitat. Most seafloor devices would be placed in areas that would result in minor bottom substrate impacts. Once on the seafloor, military expended material would be colonized by benthic organisms because military expended materials would be anchor points in the shifting bottom substrates. The total area impacted by both training and testing activities for each alternative is summarized in Table 3.3-9.

3.3.4 Summary of Potential Impacts (Combined Impacts of All Stressors) on Marine Habitats

Most of the explosive military expended materials would detonate at or near the water surface. Underwater explosions that could affect bottom substrate, and therefore marine habitats, would be underwater detonations on the seafloor. Habitat utilized for underwater detonations would primarily be soft-bottom sediment.

Physical stressors that could affect bottom substrates include vessel and in-water strikes, seafloor devices, and military expended materials. Seafloor devices are intended to be deployed in soft-bottom habitat. Once on the seafloor, most military expended material would be colonized by benthic organisms because these military expended materials would provide anchor points in the shifting, soft-bottom substrate.

3.3.4.1 No Action Alternative

Based on the analysis presented above for acoustic stressors, physical disturbances, and strike stressors proposed from the training and testing activities under the No Action Alternative, the combined impact area would not diminish the ability of soft shores, soft bottoms, hard shores, hard bottoms, or artificial substrates to function as habitat. The total area impacted by underwater explosions and military expended materials is less than 1 percent of the Study Area and is summarized in Table 3.3-9.

Table 3.3-9: Combined Impact of Acoustic Stressor (Underwater Explosions) and Physical Disturbances (Military Expended Materials) on Marine Substrates for All Alternatives

Alternative	Impact Footprint (ft.^{2})		
	Underwater Explosions[1]	Military Expended Materials[2]	Total
No Action Alternative	11,500	1,506,136	1,517,636
Alternative 1	21,780	1,842,260	1,864,040
Alternative 2	22,360	1,852,953	1,875,313

[1] Totals are derived from Tables 3.3-4 and 3.3-5
[2] Totals are derived from Tables 3.3-6, 3.3-7, and 3.3-8
Note: ft.^{2} = square feet

3.3.4.2 Alternative 1

Based on the analysis presented above for acoustic stressors, physical disturbances, and strike stressors proposed from the training and testing activities under Alternative 1, the combined impact area would not diminish the ability of soft shores, soft bottoms, hard shores, hard bottoms, or artificial substrates to function as habitat. The total area impacted by underwater explosions and military expended materials is less than 1 percent of the Study Area and is summarized in Table 3.3-9.

3.3.4.3 Alternative 2

Based on the analysis presented above for acoustic stressors, physical disturbances, and strike stressors proposed from the training and testing activities under Alternative 2, the combined impact area would not diminish the ability of soft shores, soft bottoms, hard shores, hard bottoms, or artificial substrates to function as habitat. The total area impacted by underwater explosions and military expended materials is less than 1 percent of the Study Area and is summarized in Table 3.3-9.

3.3.4.3.1 Essential Fish Habitat Determinations

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom, vessel movement, military expended materials, and seafloor devices may have an adverse effect on EFH by reducing the quality and quantity of non-living substrates that constitute EFH and Habitat Areas of Particular Concern. The MITT EFHA report states that individual stressor impacts to non-living substrates were all either no effect or minimal and ranged in duration from temporary to permanent, depending on the habitat impacted. As a result of consultation with NMFS for EFH, the Navy will not increase the amount of explosive used at the Outer Apra Harbor UNDET site from 10 lb. NEW to 20 lb. NEW. If the proposed increase becomes necessary at a later date, the Navy will conduct the appropriate analysis to assess potential effects on nearby EFH. The MITT EFHA report is available on the MITT project website (www.mitt-eis.com), and Appendix C (Agency Correspondence) provides agency correspondence and supporting documentation.

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3.4 Marine Mammals

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3.4 Marine Mammals

MARINE MAMMALS SYNOPSIS

The United States Department of the Navy considered all potential stressors, and analyzed the following for marine mammals:

- Acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise)
- Energy (electromagnetic devices)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices)
- Entanglement (fiber optic cables and guidance wires, and decelerators/parachutes)
- Ingestion (munitions and military expended materials other than munitions)
- Secondary (impacts associated with sediments and water quality)

Preferred Alternative (Alternative 1)

- Acoustic: Pursuant to the Marine Mammal Protection Act (MMPA), the use of sonar and other active acoustic sources, and underwater explosives may result in mortality, Level A harassment, or Level B harassment of certain marine mammals. The use of swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammals. Pursuant to the Endangered Species Act (ESA), the use of sonar and other active acoustic sources may affect and is likely to adversely affect certain ESA-listed marine mammals. The use of underwater explosives may affect, but is not likely to adversely affect marine mammals. Weapons firing, launch, and impact noise; vessel noise; and aircraft noise may affect but are not likely to adversely affect certain ESA-listed marine mammals. Swimmer defense airguns would have no effect on any ESA-listed marine mammal[1].
- Energy: Pursuant to the MMPA, the use of electromagnetic devices is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammals. Pursuant to the ESA, the use of electromagnetic devices may affect but is not likely to adversely affect certain ESA-listed marine mammals.
- Physical Disturbance and Strike: Pursuant to the MMPA, the use of vessels may result in mortality or Level A harassment of certain marine mammal species but is not expected to result in Level B harassment. The use of in-water devices, military expended materials, and seafloor devices is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, vessel use may affect and is likely to adversely affect certain ESA-listed species. The use of in-water devices and military expended materials may affect but is not likely to adversely affect certain marine mammal species. The use of seafloor devices would have no effect on any ESA-listed marine mammal.
- Entanglement: Pursuant to the MMPA, the use of fiber optic cables, guidance wires, and decelerators/parachutes is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, the use of fiber optic cables and guidance wires, and decelerators/parachutes may affect but is not likely to adversely affect certain ESA-listed marine mammals.
- Ingestion: Pursuant to the MMPA, the potential for ingestion of all types of military expended materials is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, the potential for ingestion of all types of military expended materials may affect but is not likely to adversely affect certain ESA-listed marine mammals.
- Secondary: Pursuant to the MMPA, secondary stressors are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, secondary stressors may affect but are not likely to adversely affect certain ESA-listed marine mammals.

[1] There is no marine mammal critical habitat in the Study Area.

3.4.1 INTRODUCTION

This section provides the analysis of potential impacts to marine mammals that are found in the Mariana Islands Training and Testing (MITT) Study Area (Study Area). Section 3.4 (Marine Mammals) provides a synopsis of the United States (U.S.) Department of the Navy's (Navy's) determination of impacts from the proposed action on marine mammals. Section 3.4.2 (Affected Environment) provides an introduction to the species that occur in the Study Area. The complete analysis and summary of potential impacts of the proposed action on marine mammals are found in Sections 3.4.3 (Environmental Consequences) and 3.4.4 (Analysis of Effects to Marine Mammals), respectively.

Marine mammals are a diverse group of approximately 130 species worldwide. Most live predominantly in the marine habitat, although some species, such as seals, spend time in terrestrial habitats or in some cases, in freshwater environments, such as certain freshwater dolphins (Jefferson et al. 2008; Rice 1998). The exact number of formally recognized marine mammal species changes periodically with new scientific understanding or findings (Rice 1998). Even the higher-level classification of marine mammals is controversial because the understanding of their origins and relationships continues to evolve (for a list of current species, see the formal list, *Marine Mammal Species and Subspecies,* maintained by the Society for Marine Mammalogy [Perrin et al. 2009a]).

Marine mammals are protected under the Marine Mammal Protection Act (MMPA), and some species receive additional protection under the Endangered Species Act (ESA). There are ESA-listed species known to occur in the region (Table 3.4-1); however, no critical habitat for marine mammals protected pursuant to the ESA has been designated within the MITT Study Area. Additionally, no Biologically Important Areas, as defined under 50 Code of Federal Regulations 216.191, have been designated by the National Marine Fisheries Service (NMFS) in the MITT Study Area. Within the framework of the MMPA, a marine mammal "stock" is defined as "a group of marine mammals of the same species or smaller taxon [species] in a common spatial arrangement that interbreed when mature." For management purposes under the MMPA, a stock is considered an isolated population or group of individuals within a whole species that is found in the same area. However, in practice, recognized management stocks may fall short of this ideal because of a lack of information or other reasons and in some cases may even include multiple species, such as with certain beaked whales (Carretta et al. 2011). In the MITT Study Area in particular, where there is a paucity of systematic survey data, little is known about the stock structure of the majority of marine mammal species in the region and as a result, little is known about potential critical habitat in the area.

Prior to 2007 there was little information available on the occurrence of marine mammals in the Study Area, and much of what was known came from whaling records, stranding records, and anecdotal sighting reports. Eldredge (1991) compiled the first list of published and unpublished records for the greater Micronesia area, reporting 19 marine mammal species, later refining the list to 13 cetacean species thought to occur around Guam (Eldredge 2003). Wiles (2005) provided a list of birds and mammals recorded in the Micronesia area through March of 2005, including all records of marine mammals. Some sighting data are available from scientific surveys conducted in the western and central Pacific, although most of these efforts focused on waters off Japan, Taiwan, the Philippines, and lower latitude regions (Darling and Mori 1993; Dolar et al. 2006; Ohizumi et al. 2002; Wang et al. 2001; Yang et al. 1999), and provide limited to no data specific to the Study Area.

The Navy conducted the first comprehensive marine mammal survey of waters off the Mariana Islands from 13 January to 13 April 2007 (Fulling et al. 2011). The survey was conducted using systematic line transect survey protocol consistent with that used by the NMFS Southwest Fisheries Science Center

(Barlow 2003, 2006). Both visual and acoustic detection methods were used during the survey (Fulling et al. 2011). The Navy also conducted a 5-day aerial survey in August 2007, providing additional sighting data specific to the Study Area (Mobley 2007). Subsequent to the 2007 surveys, both the Navy and NMFS, Pacific Islands Fisheries Science Center have conducted dedicated small boat surveys around Guam and the Commonwealth of the Northern Mariana Islands (CNMI), including: (1) surveys off Guam and Saipan from 9 February to 3 March 2010 (Ligon et al. 2011; Oleson and Hill 2010), (2) surveys off Guam from 17 February to 3 March 2011 (HDR 2011), (3) surveys off Guam and other islands in the CNMI from 26 August to 29 September 2011 (Hill et al. 2011), (4) surveys off Guam and Saipan from 15 to 29 March 2012 (HDR EOC 2012), and (5) surveys off Guam and other islands in the CNMI at various times between May and July 2012 (Hill et al. 2013). In addition, NMFS Pacific Islands Fisheries Science Center conducted a large vessel cetacean and oceanographic survey between Honolulu and Guam and within the Exclusive Economic Zones (EEZs) of Guam and CNMI from 20 January to 3 May 2010 (Oleson and Hill 2010). Information on the cetaceans sighted during the Navy and Pacific Islands Fisheries Science Center surveys are summarized within the species-specific subsections included in Section 3.4.2 (Affected Environment).

Table 3.4-1 provides a list of marine mammal species that have confirmed or potential occurrence in the MITT Study Area. Relevant information on their status, distribution, abundance, and ecology is presented in Section 3.4.2 (Affected Environment). For summaries of the general biology and ecology of marine mammals beyond the scope of this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), see Rice (1998), Reynolds and Rommel (1999), Twiss and Reeves (1999), Hoelzel (2002), Berta et al. (2006), Jefferson et al. (2008), and Perrin et al. (2009b). Additional species profiles and information on the biology, life history, species distribution and conservation of marine mammals can also be found on the following organizations' websites:

- NMFS Office of Protected Resources (includes species distribution maps)
- Ocean Biographic Information System (OBIS)-Spatial Ecological Analysis of Megavertebrate Populations (SEAMAP) species profiles
- National Oceanic and Atmospheric Administration (NOAA) Cetacean Density and Distribution Mapping Working Group
- International Whaling Commission
- International Union for Conservation of Nature, Cetacean Specialist Group
- The Marine Mammal Commission
- Society for Marine Mammalogy

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Mariana Islands Training and Testing Study Area[1]

Species Name and Regulatory Status				Occurrence in Study Area[4]	
Common Name	Scientific Name[1]	ESA Status[2]	MMPA Status[3]	Summer (June–Nov)	Winter (Dec–May)
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Humpback whale	*Megaptera novaeangliae*	Endangered	Depleted	Rare	Regular
Blue whale	*Balaenoptera musculus*	Endangered	Depleted	Rare	Rare
Fin whale	*Balaenoptera physalus*	Endangered	Depleted	Rare	Rare
Sei whale	*Balaenoptera borealis*	Endangered	Depleted	Rare	Regular
Bryde’s whale	*Balaenoptera brydei/edeni*	-	-	Regular	Regular
Minke whale	*Balaenoptera acutorostrata*	-	-	Rare	Regular
Omura’s whale	*Balaenoptera omurai*	-	-	Rare	Rare
Suborder Odontoceti (toothed whales)					
Sperm whale	*Physeter macrocephalus*	Endangered	Depleted	Regular	Regular
Pygmy sperm whale	*Kogia breviceps*	-	-	Regular	Regular
Dwarf sperm whale	*Kogia sima*	-	-	Regular	Regular
Killer whale	*Orcinus orca*	-	-	Regular	Regular
False killer whale	*Pseudorca crassidens*	-	-	Regular	Regular
Pygmy killer whale	*Feresa attenuata*	-	-	Regular	Regular
Short-finned pilot whale	*Globicephala macrorhynchus*	-	-	Regular	Regular
Melon-headed whale	*Peponocephala electra*	-	-	Regular	Regular
Common bottlenose dolphin	*Tursiops truncatus*	-	-	Regular	Regular
Pantropical spotted dolphin	*Stenella attenuata*	-	-	Regular	Regular

[1] Little is known about the stock structure of the majority of marine mammal species in the region. Therefore, in this table there is no specific Study Area information on the stocks recognized and managed by NMFS. For those species for which stock information exists, it is included in the species-specific Status and Management summaries.

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Mariana Islands Training and Testing Study Area (continued)

Species Name and Regulatory Status				Occurrence in Study Area[4]	
Common Name	Scientific Name[1]	ESA Status[2]	MMPA Status[3]	Summer (June–Nov)	Winter (Dec–May)
Striped dolphin	*Stenella coeruleoalba*	-	-	Regular	Regular
Spinner dolphin	*Stenella longirostris*	-	-	Regular	Regular
Rough-toothed dolphin	*Steno bredanensis*	-	-	Regular	Regular
Fraser's dolphin	*Lagenodelphis hosei*	-	-	Regular	Regular
Risso's dolphin	*Grampus griseus*	-	-	Regular	Regular
Cuvier's beaked whale	*Ziphius cavirostris*	-	-	Regular	Regular
Blainville's beaked whale	*Mesoplodon densirostris*	-	-	Regular	Regular
Longman's beaked whale	*Indopacetus pacificus*	-	-	Regular	Regular
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	-	-	Rare	Rare

[1] Taxonomy follows Perrin et al. (2009a).
[2] ESA listing status from Carretta et al. (2013).
[3] All marine mammals are protected under the MMPA. Populations or stocks that have fallen below the optimum sustainable population level are depleted. Due to the paucity of survey data, little is known about the stock structure of species in the region.
[4] 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. Occurrence designations from the Navy's Mariana Islands Marine Resource Assessment (MRA; U.S. Department of the Navy 2005), updated with new information as described in U.S. Department of the Navy (2013a). The MRA compiles species occurrence information based on peer-reviewed papers, unpublished technical reports, and other information sources.
Notes: ESA = Endangered Species Act, MMPA = Marine Mammal Protection Act

3.4.1.1 Species Unlikely to Be Present in the Mariana Islands Training and Testing Study Area

The species carried forward for analysis are those likely to be found in the MITT Study Area based on the most recent data available, and do not include species that may have once inhabited or transited the area but have not been sighted in recent years (e.g., species which 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*), Hawaiian monk seal (*Neomonachus schauinslandi*), northern elephant seal (*Mirounga angustirostris*), and dugong (*Dugong dugon*), which have been excluded from subsequent analysis for the reasons explained below.

3.4.1.1.1 North Pacific Right Whale (*Eubalaena japonica*)

The likelihood of a North Pacific right whale being present in the Study Area is extremely low as this species has only been observed in the Bering Sea and Gulf of Alaska in recent years. The most recent estimated population for the North Pacific right whale is between 28 and 31 individuals and although this estimate may be reflective of a Bering Sea subpopulation, the total eastern North Pacific population is unlikely to be much larger (Wade et al. 2010). A right whale was last observed in the Maui Basin (Hawaiian waters) in April 1996 (Salden and Mickelsen 1999). Later that year (July 1996), this same whale was observed in the Bering Sea and observed again in 2000 and 2008–2010 (Kennedy et al. 2011). Rare sightings of individual animals are typical of historical sightings, such as those of a single right whale on three occasions between 25 March and 11 April 1979 in Hawaiian waters (Herman et al. 1980; Rowntree et al. 1980). Based on this information, it is highly unlikely for this species to be present in the Study Area; consequently, this species will not be considered in greater detail in the remainder of this analysis.

3.4.1.1.2 Gray Whale Western Subpopulation (*Eschrichtius robustus*)

Gray whales are geographically separated into two subpopulations based on their occurrence along the eastern and western coastlines of the North Pacific. The western subpopulation of gray whale was once considered extinct but now small numbers are known to exist, although their migration routes are poorly known (Weller et al. 2002). Previous sighting data suggested that the remaining population of western gray whale had a limited range extent between the Okhotsk Sea off the coast of Sakhalin Island and the South China Sea (Weller et al. 2002). However, recent long-term studies of radio-tracked whales indicate that the coastal waters of eastern Russia, the Korean Peninsula, and Japan are part of the migratory route (Weller et al. 2012). There is also photographic evidence of a match between a whale found off Sakhalin and the Pacific coast of Japan, more than 932 miles (mi.) (1,500 kilometers [km]) south of the Sakhalin feeding area (Weller et al. 2008). Further, photo-catalog comparisons of eastern and western North Pacific gray whale populations suggest that there is more exchange between the western and eastern populations than previously thought, since “Sakhalin” whales were found off Santa Barbara, California; British Columbia, Canada; and Baja California, Mexico (Weller et al. 2013). A 14-year old male western gray whale tagged off northeastern Sakhalin Island on 4 October 2010, was located in the northeast Pacific off Oregon on 5 February 2011 (Mate et al. 2011). Based on telemetry data, the whale migrated across the Okhotsk Sea, Bering Sea, and Gulf of Alaska to reach its last recorded position off the Oregon coast. While the migration route of this single animal does not preclude other migration routes, there currently are no data available to suggest that western gray whales would transit the Study Area when migrating from the western to eastern Pacific. There have only been 13 records of gray whales in Japanese waters since 1990 (Nambu et al. 2010). The Okhotsk Sea and Sakhalin Island are located far to the north off Russia, and the South China Sea begins approximately 1,458 nautical miles (nm) east of the MITT Study Area. Given what is known of their present range, nearshore affinity, and extralimital occurrence in tropical waters, it is highly unlikely that this species would be present in the Study Area (Reilly et al. 2000; Weller et al. 2002; Wiles 2005; Nambu et al. 2010); consequently, this species will not be considered in greater detail in the remainder of this analysis.

3.4.1.1.3 Short-Beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin is found worldwide in temperate, tropical, and subtropical seas. The range of this species may extend entirely across the tropical and temperate north Pacific (Heyning and

Perrin 1994); however, this species prefers areas with large seasonal changes in surface temperature and thermocline depth (the point between warmer surface water and colder water) (Au and Perryman 1985). They are one of the most abundant species found in temperate waters off the U.S. west coast (Barlow and Forney 2007). In tropical seas, they are typically sighted in upwelling-modified waters such as those in the eastern tropical Pacific (Au and Perryman 1985; Ballance and Pitman 1998; Reilly 1990). The absence of known areas of major upwelling in the western tropical Pacific suggests that common dolphins will not be found there (Hammond et al. 2008).

3.4.1.1.4 Indo-Pacific Bottlenose Dolphin (*Tursiops aduncus*)

The Indo-Pacific bottlenose dolphin generally occurs over shallow coastal waters on the continental shelf. Although typically associated with continental margins, they do occur around oceanic islands; however, the MITT Study Area is not included in their known geographic range, and there are no documented sightings there (Hammond et al. 2008). Miyashita (1993) reported that all of his sightings of bottlenose dolphins in the western Pacific were of a larger, unspotted type (presumably the bottlenose dolphin, as opposed to the similar Indo-Pacific bottlenose dolphin). Because the Indo-Pacific bottlenose dolphin is considered to be a species associated with continental margins, it does not appear to occur around offshore islands great distances from a continent, such as the Marianas. Given the low likelihood of this species occurrence in the Study Area, the Indo-Pacific bottlenose dolphin will not be considered in the remainder of this analysis.

3.4.1.1.5 Hawaiian Monk Seal (*Monachus schauinslandi*)

The likelihood of a Hawaiian monk seal being present in the Study Area is extremely low. There are no confirmed records of Hawaiian monk seals in the Micronesia region; however, Reeves et al. (1999) and Eldredge (1991, 2003) have noted occurrence records for unidentified seals species in the Marshall and Gilbert islands. It is possible that Hawaiian monk seals wander from the Hawaiian Islands to appear at the Marshall or Gilbert Islands in the Micronesia region (Eldredge 1991). However, the Marshall Islands are located approximately 1,180 mi. (1,900 km) from Guam and the Gilbert Islands are located even farther to the east. Given the extremely low likelihood of this species occurrence in the Study Area, this species will not be considered in greater detail in the remainder of this analysis.

3.4.1.1.6 Northern Elephant Seal (*Mirounga angustirostris*)

Northern elephant seals are common on island and mainland haul-out sites in Baja California, Mexico north through central California. Elephant seals spend several months at sea feeding and travel as far north as the Gulf of Alaska and forage in the mid-Pacific as far south as approximately 40 degrees north (°N) latitude. Vagrant individuals do sometimes range to the western north Pacific. The most far-ranging individual appeared on Nijima Island off the Pacific coast of Japan in 1989 (Kiyota et al. 1992). Although elephant seals may wander great distances it is very unlikely that they would travel to Japan and then continue traveling to the Study Area. Given the extremely low likelihood of this species occurrence in the Study Area, this species will not be considered in greater detail in the remainder of this analysis.

3.4.1.1.7 Dugong (*Dugong dugon*)

The likelihood of a dugong being present in the Study Area is extremely low. This species inhabits nearshore shallow water locations (Davis 2004). A total of 27 individuals were counted during the course of aerial surveys at Palau in 2003. This is the only location in the Micronesia region with a dugong population (Davis 2004), and Palau is located approximately 680 nm from Guam. The likelihood of a dugong occurring in the Study Area is extremely low; therefore, this species will not be considered in greater detail in the remainder of this analysis.

3.4.2 AFFECTED ENVIRONMENT

Four main types of marine mammals are generally recognized: cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses; none of which are expected to occur in the Study Area), sirenians (manatees, dugongs, and sea cows; none of which are expected to occur in the Study Area), and several species of marine carnivores (marine otters and polar bears; none of which occur in the Study Area) (Jefferson et al. 2008; Rice 1998).

The Order Cetacea is divided into two suborders. The toothed whales, dolphins, and porpoises (suborder Odontoceti) range in size from slightly longer than 3 feet (ft.) (1 meter [m]) to more than 60 ft. (18 m) and have teeth, which they use to capture and consume individual prey. The baleen whales (suborder Mysticeti) are universally large (more than 15 ft. [4.6 m] as adults). They are called baleen whales because, instead of teeth, they have a fibrous structure made of keratin that is suspended from their upper jaws and is called baleen. Keratin is a type of protein similar to that found in human fingernails. The baleen enables the whales to filter and trap food from the water for feeding. They are batch feeders that use baleen instead of teeth to engulf, suck, or skim large numbers of small prey from the water or ocean floor sediments (Heithaus and Dill 2008). Detailed reviews of the different groups of cetaceans can be found in Perrin et al. (2009b).

The different feeding strategies between mysticetes and odontocetes affect their distribution and occurrence patterns. Cetaceans inhabit virtually every marine environment in the Study Area, from coastal waters to open ocean environments of the Pacific Ocean. Their distribution is influenced by a number of factors, but primary among these are patterns of major ocean currents, which, in turn, affect prey productivity. The continuous movement of water from the ocean bottom to the surface creates a nutrient-rich, highly productive environment for marine mammal prey (Jefferson et al. 2008). For most cetaceans, prey distribution, abundance, and quality largely determine where they occur at any specific time (Heithaus and Dill 2008). Most of the large cetaceans are migratory, but many small cetaceans do not migrate in the strictest sense. Instead, they undergo seasonal dispersal, or shifts in density (e.g., Forney and Barlow 1998). For recent summaries of the general biology and ecology of marine mammals, beyond the scope of this section, see Reynolds and Rommel (1999), Twiss and Reeves (1999), Hoelzel (2002), Berta et al. (2006), Jefferson et al. (2008), and Perrin et al. (2009b).

3.4.2.1 Group Size

Many species of marine mammals, particularly odontocetes, are highly social animals that spend much of their lives living in groups or schools ranging from several to several thousand individuals. Similarly, aggregations of baleen whales may form during particular breeding or foraging seasons, although they do not persist through time as a social unit. Group behavior is important for the purposes of mitigation and monitoring because larger groups are easier to detect. In addition, group size is an important consideration when conducting acoustic exposure analyses. A comprehensive and systematic review of relevant published and unpublished literature was conducted and the results were compiled into a Technical Report (Watwood and Buonantony 2012) that includes tables of group size information by species along with relevant citations.

3.4.2.2 Diving

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 for shorter durations. The diving behavior of a particular species or individual has implications for the ability to detect them for mitigation and monitoring. In addition, their relative distribution through the water column is an important consideration when conducting acoustic exposure analyses. Information and data on diving behavior for each species of marine mammal were compiled and summarized in a Technical Report (Watwood and Buonantony 2012) that provides the detailed summary of time at depth.

3.4.2.3 Vocalization and Hearing of Marine Mammals

All marine mammals that have been studied can produce sounds and use sounds to forage; orient and navigate; monitor their environment; detect and respond to predators; and socially interact with others. Measurements of marine mammal sound production and hearing capabilities provide some basis for assessment of whether exposure to a particular sound source may affect a marine mammal behaviorally or physiologically. Marine mammal hearing abilities are quantified using live animals either via behavioral audiometry or electrophysiology (see Au 1993; Nachtigall et al. 2007; Schusterman 1981; Wartzok and Ketten 1999). Behavioral audiograms, which are plots of animals' exhibited hearing threshold versus frequency, are obtained from captive, trained live animals using standard testing procedures with appropriate controls, and are considered to be a more accurate representation of a subject's hearing abilities. Behavioral audiograms of marine mammals are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain for experiments in captivity.

Electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans. Hearing response in relation to frequency for both methods of evaluating hearing ability is a generalized U-shaped curve or audiogram showing the frequency range of best sensitivity (lowest hearing threshold) and frequencies above and below with higher threshold values.

Consequently, our understanding of a species' hearing ability may be based on the behavioral audiogram of a single individual or a small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that may impact their hearing abilities whether positively or negatively, and may not accurately reflect the hearing abilities of free-swimming animals (Houser et al. 2008). For animals not available in captive or stranded settings (including large whales and rare species), estimates of hearing capabilities are made based on morphology and neuroanatomy structures, vocal characteristics, and extrapolations from related species.

Direct measurement of hearing sensitivity exists for approximately 25 of the nearly 130 species of marine mammals. Table 3.4-2 provides a summary of sound production and general hearing capabilities for marine mammal species in the Study Area (note that values in this table are not meant to reflect absolute possible maximum ranges, rather they represent the best known ranges of each functional hearing group). For purposes of the analyses in this document, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities (note that these categories are not the same as the sonar source categories described in Chapter 2, Description of Proposed Action and Alternatives) high-frequency cetaceans, mid-frequency cetaceans, and low-frequency cetaceans (mysticetes).

Note that frequency ranges for high-, mid-, and low-frequency cetacean hearing differ from the frequency range categories defined using similar terms to describe active sonar systems. For discussion of all marine mammal functional hearing groups and their derivation see Finneran and Jenkins (2012).

Table 3.4-2: Hearing and Vocalization Ranges for All Marine Mammal Functional Hearing Groups and Species Potentially Occurring within the Study Area

Functional Hearing Group	Species Which May Be Present in the Study Area	Sound Production[1]		General Hearing Ability Frequency Range
		Frequency Range	Source Level (dB re 1 µPa @ 1 m)	
High-Frequency Cetaceans	*Kogia* Species (Dwarf Sperm Whale and Pygmy Sperm Whale)	100–200 kHz	120–205	200 Hz–180 kHz
Mid-Frequency Cetaceans	Sperm Whale, Beaked Whales (*Indopacetus*, *Mesoplodon*, and *Ziphius* species), Bottlenose Dolphin, Fraser's Dolphin, Killer Whale, False Killer Whale, Pygmy Killer Whale, Melon-headed Whale, Short-finned Pilot Whale, Risso's Dolphin, Rough-toothed Dolphin, Spinner Dolphin, Pantropical Spotted Dolphin, Striped Dolphin	100 Hz–100 kHz	118–236	150 Hz–160 kHz
Low-Frequency Cetaceans	Blue Whale, Bryde's Whale, Fin Whale, Humpback Whale, Minke Whale, Omura's Whale, Sei Whale	10 Hz–20 kHz	129–195	7 Hz–22 kHz

[1] Sound production levels and ranges and functional hearing ranges are generalized composites for all members of the functional hearing groups, regardless of their presence in this Study Area.

Sound production data adapted and derived from: Aburto et al. 1997; Kastelein et al. 2002; Kastelein et al. 2003; Marten 2000; McShane et al. 1995; Møhl et al. 2003; Philips et al. 2003; Richardson et al. 1995; Villadsgaard et al. 2007; Dunlop et al. 2013a

Hearing data adapted and derived from Southall et al. 2007.

These frequency ranges and source levels include social sounds for all groups and echolocation sounds for mid- and high-frequency groups.

Notes: dB re 1 µPa at 1 m = decibels (dB) referenced to (re) 1 micropascal (µPa) at 1 meter (m), Hz = Hertz, kHz = kilohertz

3.4.2.3.1 High-Frequency Cetaceans

Marine mammals within the high-frequency cetacean functional hearing group are all odontocetes (toothed whales; suborder: Odontoceti) and includes eight species and subspecies of porpoises (family: Phocoenidae); dwarf and pygmy sperm whales (family: Kogiidae); six species and subspecies of river dolphins; the franciscana; and four species of cephalorhynchus. The following members of the high-frequency cetacean group are present in the Study Area: dwarf sperm whale (*Kogia sima*) and pygmy sperm whale (*K. breviceps*). Functional hearing in high-frequency cetaceans occurs between approximately 200 Hertz (Hz) and 180 kilohertz (kHz) (Southall et al. 2007).

Sounds produced by high-frequency cetaceans range from approximately 100–200 kHz with source levels of 120–205 decibels (dB) referenced to (re) 1 micropascal (µPa) at 1 m (Richardson et al. 1995; Verboom and Kastelein 2003; Villadsgaard et al. 2007). Recordings of sounds produced by dwarf and pygmy sperm whales consist almost entirely of the click/pulse type (Marten 2000). High-frequency cetaceans also generate specialized clicks used in biosonar (echolocation) at frequencies above 100 kHz that are used to detect, localize and characterize underwater objects such as prey (Richardson et al. 1995).

An electrophysiological audiometry measurement on a stranded pygmy sperm whale indicated best sensitivity between 90 and 150 kHz (Ridgway and Carder 2001).

3.4.2.3.2 Mid-Frequency Cetaceans

Marine mammals within the mid-frequency cetacean functional hearing group are all odontocetes, and include the sperm whale (family: Phystereidae); 32 species and subspecies of dolphins (family: Delpinidae), the beluga and narwhal (family: Monodontidae), and 19 species of beaked and bottlenose whales (family: Ziphiidae). The following members of the mid-frequency cetacean group are present or have a reasonable likelihood of being present in the Study Area: sperm whale (*Physeter macrocephalus*), killer whale (*Orcinus orca*), false killer whale (*Pseudorca crassidens*), pygmy killer whale (*Feresa attenuata*), short-finned pilot whale (*Globicephala macrorhynchus*), melon-headed whale (*Peponocephala electra*), common bottlenose dolphin (*Tursiops truncatus*), pantropical spotted dolphin (*Stenella attenuata*), striped dolphin (*S. coeruleoalba*), spinner dolphin (*S. longirostris*), rough-toothed dolphin (*Steno bredanensis*), Fraser's dolphin (*Lagenodelphis hosei*), Risso's dolphin (*Grampus griseus*), and beaked whales (*Indopacetus, Mesoplodon*, and *Ziphius* species). Functional hearing in mid-frequency cetaceans is conservatively estimated to be between approximately 150 Hz and 160 kHz (Southall et al. 2007).

Hearing studies on cetaceans have focused primarily on odontocete species (Houser and Finneran 2006; Kastelein et al. 2002; Nachtigall et al. 2005; Szymanski et al. 1999; Yuen et al. 2005). Hearing sensitivity has been directly measured for a number of mid-frequency cetaceans, including Atlantic white-sided dolphins (*Lagenorhynchus acutus*) (Houser et al. 2010), common dolphins (Houser et al. 2010), Atlantic bottlenose dolphins (Johnson 1967; Finneran 2010), Indo-Pacific bottlenose dolphins (Houser et al. 2008), Black Sea bottlenose dolphins (Popov et al. 2007), striped dolphins (Kastelein et al. 2003), white-beaked dolphins (*Lagenorhynchus albirostris*) (Nachtigall et al. 2008), Risso's dolphins (Nachtigall et al. 2005), belugas (*Delphinapterus leucas*) (Finneran et al. 2005; White et al. 1978), long-finned pilot whales (*Globicephala melas*) (Pacini et al. 2010), false killer whales (Yuen et al. 2005), killer whales (Szymanski et al. 1999), Gervais' beaked whales (*Mesoplodon europaeus*) (Finneran and Schlundt 2009; Finneran et al. 2009), and Blainville's beaked whales (*M. densirostris*) (Pacini et al. 2011).

All audiograms exhibit the same general U-shape, with a wide nominal hearing range between approximately 150 Hz–160 kHz.

In general, odontocetes produce sounds across the widest band of frequencies. Their social vocalizations range from a few hundreds of hertz to tens of kilohertz (Southall et al. 2007) with source levels in the range of 100–170 dB re 1 µPa at 1 m (see Richardson et al. 1995). As mentioned earlier, they also generate specialized clicks used in echolocation at frequencies above 100 kHz that are used to detect, localize and characterize underwater objects such as prey (Au 1993). Echolocation clicks have source levels that can be as high as 229 dB re 1 µPa peak-to-peak (Au et al. 1974).

3.4.2.3.3 Low-Frequency Cetaceans

Marine mammals within the low-frequency functional hearing group are all mysticetes. This group is comprised of 13 species and subspecies of mysticete whales in six genera: *Eubalaena, Balaena, Caperea, Eschrichtius, Megaptera*, and *Balaenoptera*. The following members of the low-frequency cetacean group (mysticetes) are present or have a reasonable likelihood of being present in the Study Area: humpback (*Megaptera novaeangliae*), blue (*Balaenoptera musculus*), fin (*B. physalus*), sei (*B. borealis*), Bryde's (*B. edeni*), minke (*B. acutorostrata*), and Omura's (*B. omurai*) whales. Functional hearing in low-frequency cetaceans is conservatively estimated to be between approximately 7 Hz and 22 kHz (Southall et al. 2007).

Because of animal size and availability of live specimens, direct measurements of mysticete whale hearing are unavailable, although there was one effort to measure hearing thresholds in a stranded grey whale (Ridgway and Carder 2001). Because hearing ability has not been directly measured in these species, it is inferred from vocalizations, ear structure, and field observations. Vocalizations are audible somewhere in the frequency range of production, but the exact range cannot be inferred (Southall et al. 2007). Ketten (2014) developed predicted audiograms for blue whales and minke whales indicating the species are most sensitive to frequencies between 1 and 10 kHz, and Ketten and Mountain (2014) produced a predicted humpback whale audiogram using a mathematical model based on the internal structure of the ear. Estimated sensitivity was from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 6 kHz.

Mysticete cetaceans produce low-frequency sounds that range in the tens of Hz to several kHz that most likely serve social functions such as reproduction, but may serve an orientation function as well (Green et al. 1994). Humpback whales are the notable exception within the mysticetes, with some calls exceeding 10 kHz. These sounds can be generally categorized as low-frequency moans; bursts or pulses; or more complex songs (Edds-Walton 1997; Ketten 1997). Source levels of most mysticete cetacean sounds range from 150 to 190 dB re 1 µPa at 1 m (see Richardson et al. 1995).

3.4.2.4 General Threats

Marine mammal populations can be influenced by various factors and human activities. These factors can affect marine mammal populations directly, by activities such as hunting and whale watching, or indirectly, through reduced prey availability or lowered reproductive success of individuals. Twiss and Reeves (1999) provide a general discussion of marine mammal conservation.

Marine mammals are influenced by natural phenomena, such as storms and other extreme weather patterns. 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 (Marsh 1989; Rosel and Watts 2008). The global climate is changing and is having impacts on some populations of marine mammals (Salvadeo et al. 2010; Simmonds and Eliott 2009; Hazen et al. 2012). Climate change can affect marine mammal species directly through habitat loss (especially for species that depend on ice or terrestrial areas) and indirectly via impacts on prey, changing prey distributions and locations, and changes in water temperature (Hazen et al. 2012). Changes in prey can impact marine mammal foraging success, which in turn affects reproduction success, and survival. Climate change also may influence marine mammals through effects on human behavior, such as increased shipping and oil and gas extraction, resulting from sea ice loss (Alter et al. 2010).

Mass die offs of some marine mammal species have been linked to toxic algal blooms, that is, they consume prey that have consumed toxic plankton, such as die offs of California sea lions (*Zalophus californiaus*) and northern fur seals (*Callorhinus ursinus*) because of poisoning caused by the diatom *Pseudo-nitzschia* spp. (Doucette et al. 2006; Fire et al. 2008; Thomas et al. 2010; Johnson and Rivers 2009; Lefebrve et al. 2010; Torres de la Riva et al. 2009). All marine mammals have parasites that, under normal circumstances, probably do little overall harm, but under certain conditions, they can cause serious health problems or even death (Bull et al. 2006; Fauquier et al. 2009; Jepson et al. 2005). Disease affects some individuals (especially older animals), and occasionally disease epidemics can injure or kill a large percentage of the population (Keck et al. 2010; Paniz-Mondolfi and Sander-Hoffmann 2009). Recently the first case of morbillivirus in the central Pacific was documented for a whale (*Indopacetus pacificus*) at Homa Beach, Hana, Maui (West et al. 2012).

Human impacts on marine mammals have received much attention in recent decades, and include hunting (both commercial and native practices), fisheries interactions (such as gear entanglement or shootings by fishers), bycatch (accidental or incidental catch), indirect effects of fisheries through takes of prey species, ship strikes, chemical pollution, noise pollution, and general habitat deterioration or destruction.

Direct 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 and Reeves 1999, Rocha et al. 2015). However, fishery bycatch is likely the most impactful problem presently and may account for the deaths of more marine mammals than any other cause (Hamer et al. 2010; Northridge 2008; Read 2008; Geijer and Read 2013). In 1994, the MMPA was amended to formally address bycatch. Estimates of bycatch in the Pacific declined by a total of 96 percent from 1994 to 2006 (Geijer and Read 2013). Cetacean bycatch declined by 85 percent from 342 in 1994 to 53 in 2006, and pinniped bycatch declined from 1,332 to 53 over the same time period. Another general threat to marine mammals is ship strikes, which are a growing issue for most marine mammals, particularly baleen whale species.

Chemical pollution is also of great concern, although for the most part, its effects on marine mammals are just starting to be understood (Aguilar Soto et al. 2008). Recently, the 5.5-year expedition of the *Odyssey* collected 955 biopsy samples from sperm whales around the world to provide a consistent baseline database of ocean contamination and to measure future effects (Ocean Alliance 2010). Chemical pollutants found in pesticides and other substances flow into the marine environment from human use on land and are absorbed into the bodies of marine mammals, accumulating in their blubber, internal organs, or are transferred to the young from mother's milk (Fair et al. 2010). Important factors that determine the levels of pesticides, heavy metals, and industrial pollutants that accumulate in marine mammals are gender (i.e., adult males have no way to transfer pesticides whereas females may pass pollutants to their calves through milk), habitat, and diet. Living closer to the source of pollutants and feeding on higher-level organisms increase the potential to accumulate toxins (Moon et al. 2010). The buildup of human-made persistent compounds in marine mammals not only increases their likelihood of contracting diseases or developing tumors but also compromises the function of their reproductive systems (Fair et al. 2010).

Oil and other chemical spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species (see Matkin et al. 2008; Marine Mammal Commission 2011; Ackleh et al. 2012). Although information on effects of oil spills on marine mammals is limited, new information gained from study of the recent Deep Water Horizon oil spill in the Gulf of Mexico has provided insight on assessment of long-term effects (Ackleh et al. 2012; Marine Mammal Commission 2011), as has continued study of the 1989 Exxon Valdez in Prince William Sound, Alaska (see Matkin et al. 2008; Bodkin et al. 2012). In short, marine mammals can be affected directly by contact or ingestion of the oil, indirectly by activities during the containment and cleanup phases, and through long-term impacts on prey and habitat.

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals, especially those that live in rivers or estuaries, and it may include such factors as depleting a habitat's prey base and the complete loss of habitat (Kemp 1996; Smith et al. 2009; Ayres et al. 2012). In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise is also being increasingly considered as a potential habitat level stressor. 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 to cause stress (Hildebrand 2009; Tyack et al. 2011; Erbe et al. 2012; Rolland et al. 2012). 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 (National Research Council 2003, 2005; Nowacek et al. 2007; Southall et al. 2009a; Tyack 2009; Würsig and Richardson 2008). Anthropogenic noise is generated from a variety of sources including commercial shipping, oil and gas exploration and production activities, commercial and recreational fishing (including noise from fish finding sonar, fathometers, and acoustic deterrent and harassment devices), recreational boating and whale watching activities, offshore power generation, research (including sound from airguns, sonar, and telemetry), and military training and testing activities. Vessel noise in particular is a large contributor to noise in the ocean. Commercial shipping's contribution to ambient noise in the ocean has increased by as much as 12 dB over the last few decades (Hildebrand 2009; McDonald et al. 2008).

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

3.4.2.5 Humpback Whale (*Megaptera novaeangliae*)

3.4.2.5.1 Status and Management

Humpback whales are listed as depleted under the MMPA and endangered pursuant to the ESA. Based on evidence of population recovery in many areas, the species is being considered by NMFS for removal or down listing from the U.S. Endangered Species List (National Marine Fisheries Service 2009c).

In the Pacific, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al. 2013). NMFS has designated four stocks: (1) the Central North Pacific stock, with feeding areas from Southeast Alaska to the Alaska Peninsula; (2) the Western North Pacific stock, with feeding areas from the Aleutian Islands, Bering Sea, and Russia; (3) the California, Oregon, Washington, and Mexico stock, with feeding areas off the U.S. west coast; and (4) the American Samoa Stock, with feeding areas as far south as the Antarctic Peninsula (Carretta et al. 2013). Humpback whales in the MITT Study Area are most likely part of the Western North Pacific stock.

3.4.2.5.2 Geographic Range and Distribution

Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs (Herman et al. 2010). In the north Pacific, humpback whales feed primarily along the Pacific Rim from California to Russia (Barlow et al. 2011). Wintering (breeding) areas for North Pacific humpback whales include the coasts of Central America and Mexico, offshore islands of Mexico, Hawaii, and the western Pacific (Calambokidis et al. 2001). The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75 degrees Fahrenheit [°F]–82°F) (24 degrees Celsius [°C]–28°C) and relatively shallow, low-relief ocean bottom in protected areas, created by islands or reefs (Clapham 2000; Craig and Herman 2000; Smultea 1994). There is known to be some interchange of whales among different wintering grounds, for example, some of these interchanges have been noted between Hawaii and Japan and between Hawaii and Mexico (Darling et al. 1996; Calambokidis et al. 2001). Although interchange does occur among all the breeding stocks in the wintering grounds, it is not common (Calambokidis et al. 2001; Calambokidis et al. 1997). Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al. 2001; Clapham and Mattila 1990).

Humpback whales have been sighted during the Navy's routine aerial surveys of Farallon de Medinilla (FDM) on several occasions, including two sightings in 2006 (January and March), both close to the island, and another sighting in February of 2007, 18 mi. (29 km) north of Saipan (Vogt 2008). During a ship survey in the Study Area (January–April 2007), humpback whales were observed in both deep (2,625–3,940 ft. [800–1,200 m]) and shallow (1,234 ft. [374 m]) waters northeast of Saipan (Fulling et al. 2011). Acoustic detections of humpback song were also made during these sightings as well as on other occasions (Fulling et al. 2011). These observations suggest that there could be a small wintering population of humpback whales in or transiting during migration through the MITT Study Area, although additional research is needed for confirmation (Fulling et al. 2011; Ligon et al. 2011).

3.4.2.5.3 Population and Abundance

The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation [CV] = 0.04; this is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the population mean, with a lower number representing less variation), 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). Data indicate the North Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year, so approximately doubling every 10 years (Calambokidis et al. 2008). Campbell et al (2015) reported no significant changes to the population of humpback whales in Southern California, indicating that the population is at least steady. Of the different stocks of humpback whales recognized in the Pacific Ocean, the Western North Pacific stock is the one most likely to be encountered within the MITT Study Area. The current population estimate for this stock is 938–1,107 animals (Allen and Angliss 2013).

3.4.2.5.4 Predator-Prey Interactions

Humpback whales feed on a variety of invertebrates and small schooling fish. The most common invertebrate prey are krill (tiny crustaceans); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham and 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). It is believed that minimal feeding occurs in wintering grounds, although there have been scattered reports of single animals feeding (Salden 1989; Baraff et al. 1991).

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 (Whitehead and Glass 1985).

3.4.2.5.5 Species-Specific Threats

Entanglement in fishing gear and other types of manmade lines pose a threat to individual humpback whales throughout the Pacific. Humpback whales from the Central North Pacific stock have been reported seriously injured and killed from entanglement in fishing gear while in their Alaskan feeding grounds (Neilson et al. 2009; Allen and Angliss 2010). From 2003 to 2007, an average of 3.4 humpback whales per year were seriously injured or killed due to entanglements with commercial fishing gear in Alaskan waters. This number is considered a minimum since observers have not been assigned to several fisheries known to interact with this stock and quantitative data on Canadian fishery entanglements are uncertain (Allen and Angliss 2010). With the exception of one reported stranding in 2007, for which stock identification is uncertain, there have been no strandings or sighting entanglement reports of individuals belonging to the Western North Pacific stock (Allen and Angliss 2011). However, effort in western Alaskan waters is low.

Between 2002 and 2006, the average annual mortality of Western North Pacific humpback whales from observed fisheries (Bering Sea/Aleutian Islands sablefish pot fishery) was 0.20 animals (Allen and Angliss 2011). Because stock identification is not certain, this estimate could include animals belonging to the Central North Pacific stock. However, since there are no data for mortalities resulting from Japanese or Russian fisheries, this estimate is considered a minimum regardless of uncertainties related to stock distinctions (Allen and Angliss 2011).

3.4.2.6 Blue Whale (*Balaenoptera musculus*)

3.4.2.6.1 Status and Management

The blue whale is listed as endangered pursuant to the ESA and as depleted under the MMPA. The NMFS considers blue whales found in the MITT Study Area as part of the Central North Pacific stock (Carretta et al. 2013) due to differences in call types with the Eastern North Pacific stock (Stafford et al. 2001; Stafford 2003).

3.4.2.6.2 Geographic Range and Distribution

The blue whale inhabits all oceans and typically occurs in nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration (Mate et al. 1999). Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al. 2004). Blue whales belonging to the Central Pacific stock feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western Pacific and less frequently to the central Pacific (Stafford et al. 2004; Watkins et al. 2000). There are no recent sighting records for the blue whale in the MITT Study Area, although this area is in the distribution range for this species (Reilly et al. 2008). The Pacific Islands Fisheries Science Center has deployed several High-frequency Acoustic Recording Packages (HARPs) to monitor marine mammals and ambient noise levels in U.S. EEZ waters off the Mariana Islands. Recordings from these instruments are currently being analyzed but it has been confirmed that blue whales have been acoustically detected (Oleson 2013); however, since blue whale calls can travel up to 621 mi. (1,000 km), it is unknown whether the animals were actually within the study area. Blue whales would be most likely to occur in the MITT Study Area during the winter.

3.4.2.6.3 Population and Abundance

Widespread whaling over the last century is believed to have decreased the blue whale population to approximately 1 percent of its pre-whaling population size (Širović et al. 2004, Branch et al. 2007, Rocha et al 2015). The best available abundance estimate for the Eastern North Pacific stock of blue whales is 1,647 (Carretta et al. 2014) and 1,400 animals for the Eastern Tropical Pacific (Wade and Gerrodette 1993). Data collected during a 2010 systematic surveys off Hawaii resulted in an abundance estimate of 81 blue whales within the Hawaiian Islands EEZ during summer and fall (Bradford et al. 2013). Although the majority of blue whales are expected to be at higher latitude feeding grounds during summer/fall, this is currently considered the best abundance estimate for the Central North Pacific stock (Carretta et al. 2014). Campbell et al (2015) reported no significant changes to the population of blue whales in Southern California, indicating that the population is at least steady.

The information available on the status and trend of blue whale populations precludes any conclusions on the extinction risks facing blue whales as a species, or particular populations of blue whales. The possible exception is the Eastern North Pacific blue whale stock, which may not have been subject to as much commercial whaling as other blue whale populations. Recent literature suggest that this population may be recovering to a stable level since the cessation of commercial whaling in 1971 despite the impacts of ship strikes, interactions with fishing gear, and increased levels of ambient sound in the Pacific Ocean (Monnahan et al. 2014a, Monnahan et al. 2014b, Campbell et al. 2015).No blue whales were detected during a 2007 winter survey of the Study Area (Fulling et al. 2011).

3.4.2.6.4 Predator-Prey Interactions

This species preys almost exclusively on various types of zooplankton, especially krill. They lunge feed and consume approximately 6 tons (5,500 kilograms [kg]) of krill per day (Mori and Butterworth 2004; Jefferson et al. 2008). They sometimes feed at depths greater than 330 ft. (100 m), where their prey maintains dense groupings (Acevedo-Gutiérrez et al. 2002).

Blue whales have been documented to be preyed on by killer whales (Jefferson et al. 2008; Pitman et al. 2007).

3.4.2.6.5 Species-Specific Threats

Blue whales are susceptible to both ship strikes and entanglement in fishing gear (Carretta et al. 2011); however, no specific data are available for the Central North Pacific stock (Calambokidis et al. 2009a; Berman-Kowalewski et al. 2010). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.7 Fin Whale (*Balaenoptera physalus*)

3.4.2.7.1 Status and Management

The fin whale is listed as endangered pursuant to the ESA and as depleted under the MMPA. Pacific fin whale population structure is not well known, and NMFS has designated three stocks of fin whale in the North Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2013). The International Whaling Commission recognizes two management stocks in the North Pacific: a single widespread stock in the North Pacific and a smaller stock in the East China Sea (Donovan 1991). Little is known about the stock structure of fin whales in the MITT Study Area.

3.4.2.7.2 Geographic Range and Distribution

Fin whales are found in all the world's oceans, typically between approximately 20°–75°N and south (S) latitudes (Calambokidis et al. 2008). In the northern hemisphere, most fin whales migrate seasonally from high latitude feeding areas in summer to low latitude breeding and calving areas in winter (Kjeld et al. 2006; MacLeod et al. 2006a). The fin whale is typically found in continental shelf and oceanic waters (Gregr and Trites 2001; Reeves et al. 2002). Globally, it tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, although those locations may shift seasonally or annually (Kenney et al. 1997; Notarbartolo-di-Sciara et al. 2003; Payne et al. 1990; Payne et al. 1986). Fin whales in the North Pacific spend the summer feeding along the cold eastern boundary currents (Perry et al. 1999, Campbell et al. 2015). Falcone and Schorr (2014) provide further evidence based on Southern California visual sighting records, photographic ID matches, and satellite tagging from 2006-2013 for a Southern California permanent or semi-permanent resident population of fin whales displaying seasonal distribution shifts within the region. In waters of the NorthwesternHawaiian Islands, fins whales have been recorded in the winter and spring months (Meigs et al. 2013).

Fin whales are typically not expected south of 20°N during summer, and less likely to occur near Guam (Miyashita et al. 1996; National Marine Fisheries Service 2006). Miyashita et al. (1996) presented a compilation of at-sea sighting results by species, from commercial fisheries vessels in the Pacific Ocean from 1964 to 1990. For fin whales in August, Miyashita et al. (2006) reported no sightings south of 20°N, and significantly more sightings north of 40°N. However, they also showed limited search effort south of 20°N. There were no fin whale sightings during the winter 2007 survey of the Study Area (Fulling et al. 2011). The Pacific Islands Fisheries Science Center has deployed several HARPs to monitor marine mammals and ambient noise levels in U.S. EEZ waters off the Mariana Islands. Recordings from these instruments are currently being analyzed but it has been confirmed that fin whales have been acoustically detected (Oleson et al. 2013).

3.4.2.7.3 Population and Abundance

In the north Pacific, the total pre-exploitation population size of fin whales is estimated at 42,000–45,000 whales (Ohsumi and Wada 1974). In 1973, fin whale abundance in the entire North Pacific basin was estimated between 13,620 and 18,680 whales (Ohsumi and Wada 1974). Moore and Barlow (2011) reported an increase in fin whale abundance from 1991-2008. Over a 10-year window from 2004-2013, Campbell et al (2015) reported no significant changes to the population of fin whales in Southern California, indicating that the population is at least steady. The lack of sighting data precludes an estimate of fin whale abundance specific to the MITT Study Area.

3.4.2.7.4 Predator-Prey Interactions

Fin whales prey on small invertebrates such as copepods as well as squid, and schooling fish, such as capelin, herring, and mackerel (Goldbogen et al. 2006; Jefferson et al. 2008).

The fin whale is not known to have a significant number of predators (Vidal and Pechter 1989). 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 2008).

3.4.2.7.5 Species-Specific Threats

Fin whales are susceptible to both ship strikes and entanglement in fishing gear (Douglas et al. 2008; Carretta et al. 2011); however, no specific data are available for fin whales in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.8 Sei Whale (*Balaenoptera borealis*)

3.4.2.8.1 Status and Management

The sei whale is listed as endangered pursuant to the ESA and as depleted under the MMPA. The International Whaling Commission groups all of sei whales in the entire north Pacific Ocean into one stock (Donovan 1991). However, some mark-recapture, catch distribution, and morphological research, indicate that more than one stock exists; one between 175 degrees west (°W) and 155°W longitude, and another east of 155°W longitude (Masaki 1976, 1977). NMFS has designated three stocks of sei whale in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2013). Little is known about the stock structure of sei whales in the MITT Study Area.

3.4.2.8.2 Geographic Range and Distribution

Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. Sei whales spend the summer feeding in high latitude subpolar latitudes and return to lower latitudes to calve in winter. On feeding grounds, their distribution is largely associated with oceanic frontal systems (Horwood 1987). Characteristics of preferred breeding grounds are unknown, since they have generally not been identified. Whaling data provide some evidence of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood 1987; Perry et al. 1999).

Various scientists have described the seasonal distribution of sei whales as occurring from 20°N to 23°N during the winter and from 35°N to 50°N during the summer (Horwood 2009; Masaki 1976, 1977; Smultea et al. 2010). However, sei whales were sighted during the 2007 survey of the Study Area, thus providing evidence that this species occurs south of 20°N in the winter (Fulling et al. 2011). They are considered absent or at very low densities in most equatorial areas.

Sei whales are most often found in deep oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins between banks and ledges (Best and Lockyer 2002; Gregr and Trites 2001; Kenney and Winn 1987; Schilling et al. 1992). These reports are consistent with observations during the 2007 survey of the Study Area, as sightings most often occurred in deep water 10,381–30,583 ft. (3,164–9,322 m). Most sei whale sightings were also associated with steep bathymetric relief (e.g., steeply sloping areas), including sightings adjacent to the Chamorro Seamounts east of the CNMI (Fulling et al. 2011). All confirmed sightings of sei whales were south of Saipan (approximately 15°N) with concentrations in the southeastern corner of the Study Area (Fulling et al. 2011). Sightings also often occurred in mixed groups with Bryde's whales. It is often difficult to distinguish sei whales from Bryde's whales at sea, and if a positive species identification cannot be made, sightings are typically categorized as sei/Bryde's whale.

3.4.2.8.3 Population and Abundance

In the north Pacific, the pre-exploitation sei whale population was estimated at 42,000 whales (Tillman 1977). The most current population estimate for sei whales in the entire north Pacific is 9,110 (Calambokidis et al. 2008). Sei whales were considered to be extralimital in the Study Area but during the 2007 systematic survey, sei whales were sighted on 16 occasions with a resulting abundance estimate of 166 individuals (coefficient of variation [CV] = 0.49) (Fulling et al. 2011).

3.4.2.8.4 Predator-Prey Interactions

Feeding occurs primarily around dawn, which appears to be correlated with vertical migrations of prey species (Horwood 2009). Unlike other rorquals, the sei whale skims to obtain its food, although it does some lunging and gulping similar to other rorqual species (Horwood 2009). 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 2009; Nemoto and Kawamura 1977).

Sei whales, like other large baleen whales, are likely subject to occasional attacks by killer whales (Ford and Reeves 2008).

3.4.2.8.5 Species-Specific Threats

Sei whales, like other large baleen whales, are likely susceptible to both ship strikes and entanglement in fishing gear (Carretta et al. 2011); however, no specific data are available for sei whales in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.9 Bryde's Whale (*Balaenoptera edeni*)

3.4.2.9.1 Status and Management

The Bryde's whale is protected under the MMPA and is not listed pursuant to the ESA. The International Whaling Commission recognizes three management stocks of Bryde's whales in the north Pacific: (1) western north Pacific, (2) eastern north Pacific, and (3) east China Sea (Donovan 1991), although the biological basis for defining separate stocks of Bryde's whales in the central north Pacific is not clear (Carretta et al. 2010). In the most recent Stock Assessment Report, NMFS has designated two areas for Bryde's whale in the north Pacific: (1) waters in the eastern Pacific (east of 150°W and including the Gulf of California and waters off California), and (2) waters around Hawaii (Carretta et al. 2013). Little is known about the stock structure of Bryde's whales in the MITT Study Area.

3.4.2.9.2 Geographic Range and Distribution

Bryde's whales are found year-round in tropical and subtropical waters, generally not moving poleward of 40° in either hemisphere (Jefferson et al. 1993; Kato 2002). Limited shifts in distribution toward and away from the equator, in winter and summer, respectively, have been observed (Cummings 1985; Best 1996). Data suggest that winter and summer grounds partially overlap in the central north Pacific, from 5°S to 40°N (Kishiro 1996; Ohizumi et al. 2002). They have been reported to occur in both deep and shallow waters globally. Bryde's whales in some areas of the world are sometimes seen very close to shore and even inside enclosed bays (Baker and Madon 2007; Best et al. 1984). Bryde's whales are the most common baleen whales likely to occur in the Study Area (Eldredge 1991, 2003; Kishiro 1996; Miyashita et al. 1996; Okamura and Shimada 1999). Occurrence patterns are expected to be the same throughout the year.

Historical records show a consistent presence of Bryde's whales in the Mariana Islands. Miyashita et al. (1996) sighted Bryde's whales in the Mariana Islands during a 1994 survey, commenting that in the western Pacific these whales are typically only seen when surface water temperature was greater than 68°F (20°C) although Yoshida and Kato (1999) reported a preference for water temperatures between approximately 59° and 68°F (15° and 20°C). A single Bryde's whale washed ashore on Masalok Beach on Tinian in February, 2005 (Trianni and Tenorio 2012). There is also one reported stranding for this area that occurred in August 1978 (Eldredge 1991, 2003). During marine mammal monitoring activities for Valiant Shield 07, a single Bryde's whale was observed about 87 nm east of Guam at the edge of the Mariana Trench (Mobley 2007).

Bryde's whales were identified 18 times during the 2007 survey of the Study Area (Fulling et al. 2011). They were observed in groups of one to three, with several sightings including calves. Bryde's whales were sighted in deep waters, ranging from 8,363 to 24,190 ft. (2,534 to 7,330 m). Most sightings were associated with steep bathymetric relief (e.g., steeply sloping areas and seamounts), including sightings adjacent to the Chamorro Seamounts east of CNMI and over the West Mariana Ridge. There were several sightings in waters over and near the Mariana Trench, as well as in the southeast corner of the Study Area. Multi-species aggregations with sei whales were observed on several occasions (Fulling et al. 2011). As noted previously, Bryde's whales are often difficult to distinguish from sei whales at sea; if a positive species identification cannot be made, sightings are typically categorized as sei/Bryde's whale.

3.4.2.9.3 Population and Abundance

Little is known of population status and trends for most Bryde's whale populations. Based on Japanese and Soviet fishing records, the stock size of Bryde's whale in the north Pacific was estimated to decline from approximately 22,500 animals in 1,971 to 17,800 animals in 1977 (Tillman 1978). Based on line-transect estimates from the 2007 survey, an estimated 233 (CV = 0.45) Bryde's whales were present in the Study Area (Fulling et al. 2011).

3.4.2.9.4 Predator-Prey Interactions

Bryde's whales are lunge feeders and primarily feed on schooling fish. Prey includes anchovy, sardine, mackerel, herring, krill, and other invertebrates, such as pelagic red crab (Baker and Madon 2007; Jefferson et al. 2008; Nemoto and Kawamura 1977). Bryde's whales have been observed using "bubble nets" to herd prey (Jefferson et al. 2008; Kato and Perrin 2008). 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 they 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 (Silber et al. 1990).

3.4.2.9.5 Species-Specific Threats

Bryde's whales are susceptible to both ship strikes and entanglement in fishing gear (Carretta et al. 2011); however, no specific data are available for Bryde's whales in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.10 Minke Whale (*Balaenoptera acutorostrata*)

Until recently, all minke whales were classified as the same species. Three subspecies of the common minke whale are now recognized: *Balaenoptera acutorostrata davidsoni* in the north Atlantic, *Balaenoptera acutorostrata scammoni* in the north Pacific (including the Study Area), and a third—formally unnamed but generally called the dwarf minke whale—that mainly occurs in the southern hemisphere (Arnold et al. 1987).

3.4.2.10.1 Status and Management

The minke whale is protected under the MMPA and is not listed pursuant to the ESA. The International Whaling Commission recognizes three stocks of minke whales in the north Pacific: (1) the Sea of Japan, (2) the rest of the western Pacific west of 180°N, and (3) one in the "remainder of the Pacific" (Donovan 1991). These broad designations basically reflect a lack of knowledge about the population structure of minke whales in the north Pacific (Carretta et al. 2011). NMFS has designated three stocks of minke whale in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2013). Little is known about the stock structure of minke whales in the MITT Study Area.

3.4.2.10.2 Geographic Range and Distribution

Minke whales are present in the north Pacific from near the equator to the Arctic (Horwood 1990; Jefferson et al. 1993). In the winter, minke whales are found south to within 2° of the equator (Perrin and Brownell 2002). There is no obvious migration from low-latitude, winter breeding grounds to high-latitude, summer feeding locations in the western North Pacific, as there is in the North Atlantic (Horwood 1990); however, there are some monthly changes in densities in both high and low latitudes (Okamura et al. 2001). Some coastal minke whales restrict their summer activities to exclusive home ranges (Dorsey 1983) and exhibit site fidelity to these areas between years (Borggaard et al. 1999).

Minke whales generally occupy waters over the continental shelf, including inshore bays, and even occasionally enter estuaries. However, records from whaling catches and research surveys worldwide indicate an open ocean component to the minke whale's habitat (Horwood 1990; Mellinger et al. 2000; Mitchell 1991; Roden and Mullin 2000; Slijper et al. 1964).

Due to the cryptic behavior of this species it is not unusual to have acoustic sightings with no visual confirmation (Rankin et al. 2007). Minke whale vocalizations in the Pacific Islands have been reported during the winter months, and in November during a 2002 survey of the U.S. EEZ waters around Hawaii, a minke whale was sighted while "off effort"[2] after the animal was detected acoustically (Barlow 2006; Rankin and Barlow 2005). Minke whales were the most frequently acoustically detected species of baleen whale during the 2007 survey of the Study Area and were mostly found in the southwestern area near the Mariana Trench (Fulling et al. 2011).

3.4.2.10.3 Population and Abundance

There are no population estimates for minke whales in the entire north Pacific, and despite confirmed sightings and acoustic detections, abundance estimates have not been made for the Hawaiian stock of minke whales (Carretta et al. 2014). Recent line-transect analyses of acoustic detections of minke whales during the 2007 survey of the Study Area resulted in an estimate of approximately 183–227 animals (Norris et al. 2011); however, methods for estimating density from acoustic detections are currently being developed and numerous assumptions are associated with the calculations. These estimates should thus be considered preliminary.

3.4.2.10.4 Predator-Prey Interactions

Similar to other rorquals, minke whales are "gulpers," or lunge feeders, often plunging through patches of shoaling fish or krill (Hoelzel et al. 1989; Jefferson et al. 2008). In the north Pacific, major food items include krill, Japanese anchovy, Pacific saury, and walleye pollock (Perrin and Brownell 2002; Tamura and Fujise 2002).

Minke whales are prey for killer whales (Ford et al. 2005); a common minke was observed being attacked by killer whales near British Columbia (Ford et al. 2005; Weller 2008).

3.4.2.10.5 Species-Specific Threats

Minke whales are susceptible to both ship strikes and entanglement in fishing gear (Carretta et al. 2011); however, no specific data are available for minke whales in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.11 Omura's Whale (*Balaenoptera omurai*)

3.4.2.11.1 Status and Management

Omura's whale is protected under the MMPA and is not listed under the ESA. Until recently, all medium-sized baleen whales were considered members of one of two species, *Balaenoptera edeni* (Bryde's whale) or *Balaenoptera borealis* (sei whale). However, at least three genetically-distinct types of these whales are now known, including the so-called pygmy or dwarf Bryde's whales (*Balaenoptera brydei*) (Kato and Perrin 2008; Rice 1998). In 2003, a new species, Omura's whale, was first described from records from the Philippines, eastern Indian Ocean, Indonesia, Sea of Japan, and the Solomon Islands (Wada et al. 2003). Whales in the Solomon Islands were found to be distinct from Bryde's whales found

[2] "Off effort" means the ship is not on a systematic survey line and/or specified survey conditions are not met (e.g., the sea state is too high) so species sightings made while off effort are not typically used to estimate abundance using line-transect methods. In this case, the ship presumably went off effort to investigate the minke whale acoustic detection.

in the offshore waters of the western north Pacific and the East China Sea (Wada and Numachi 1991; Yoshida and Kato 1999). Later it became evident that the term "pygmy Bryde's whale" had been mistakenly used for specimens of *Balaenoptera omurai* (Reeves et al. 2004). Given the general paucity of data on this species, nothing is known of the stock structure of Omura's whale.

3.4.2.11.2 Geographic Range and Distribution

Little is known of the geographic range of Omura's whale since few sightings of this species have been confirmed. Omura's whale is known to occur in the tropical and subtropical waters of the western Pacific and eastern Indian Oceans (Jefferson et al. 2008). It generally occurs alone or in pairs, and has been sighted primarily over the continental shelf in nearshore waters (Jefferson et al. 2008). It is possible that this species may occur in the Study Area, although there are no confirmed sightings to date.

3.4.2.11.3 Population and Abundance

There are currently no global estimates of the population size of Omura's whale. Ohsumi (1980) used sighting data to estimate an abundance of 1,800 animals for the Solomon Islands "Bryde's whale" stock; given the previous mistaken identity of the species, this estimate may relate to Omura's whale. Given the likelihood that some of the animals may have actually been Bryde's whales, and that the estimate was based on a small sample size, it is not considered reliable. There are no abundance estimates specific to the Study Area.

3.4.2.11.4 Predator-Prey Interactions

Little is known of the prey interactions of this species. Like other rorquals, Omura's whales are lunge feeders, and are assumed to feed on a variety of krill and fish (Hoelzel et al. 1989; Jefferson et al. 2008).

Similar to other baleen whales, it is likely that Omura's whales are subject to occasional attacks by killer whales.

3.4.2.11.5 Species-Specific Threats

Similar to other baleen whale species, Omura's whales are likely susceptible to both ship strikes and entanglement in fishing gear, although there are no specific data available for this species. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.12 Sperm Whale (*Physeter macrocephalus*)

3.4.2.12.1 Status and Management

The sperm whale has been listed as endangered since 1970 under the precursor to the ESA (National Marine Fisheries Service 2009d), and is depleted under the MMPA. The International Whaling Commission divided the north Pacific into two management regions to define a western and eastern stock of sperm whales; the boundary consists of a zigzag pattern that starts at 150°W at the equator, is at 160°W between 40 and 50°N, and ends up at 180°W north of 50°N (Donovan 1991). NMFS has designated three stocks of sperm whale in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2013). Little is known about the stock structure of sperm whales in the MITT Study Area.

3.4.2.12.2 Geographic Range and Distribution

Sperm whales are found throughout the North Pacific, and are distributed broadly from equatorial to polar waters (Whitehead et al. 2008). Mature female and immature sperm whales of both sexes are found in more temperate and tropical waters from the equator to around 45˚N throughout the year; these groups are rarely found at latitudes higher than 50˚N and 50˚S (Reeves and Whitehead 1997). In some tropical areas, sperm whales appear to be largely resident, with pods of females with calves remaining on the breeding grounds throughout the year (Rice 1989; Whitehead 2003; Whitehead et al. 2008). Sexually mature males join these groups throughout the winter. During the summer, mature male sperm whales are thought to move north into the Aleutian Islands, Gulf of Alaska, and the Bering Sea. In the northern hemisphere, "bachelor" groups (males typically 15–21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al. 2007).

Sperm whales show a strong preference for deep waters (Rice 1989; Whitehead 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters. Although this species shows a preference for deep waters, in some areas adult males are reported to consistently frequent waters with bottom depths less than 330 ft. (100 m) and as shallow as 130 ft. (40 m) (Jefferson et al. 2008; Romero et al. 2001). Typically, sperm whale concentrations correlate with areas of high productivity. These areas are generally near drop offs and areas with strong currents and steep topography (Gannier and Praca 2007; Jefferson et al. 2008).

Sightings collected by Kasuya and Miyashita (1988) suggest that that there are two stocks of sperm whales in the western North Pacific, a northwestern stock with females that summer off the Kuril Islands and winter off Hokkaido and Sanriku, and the southwestern North Pacific stock with females that summer in the Kuroshio Current System and winter around the Bonin Islands. The males of these two stocks are found north of the range of the corresponding females, i.e., in the Kuril Islands/Sanriku/Hokkaido and in the Kuroshio Current System, respectively, during the winter.

Whaling records demonstrate sightings year-round in the Study Area (Townsend 1935). There are also two stranding records for this area (Eldredge 1991, 2003; Kami and Lujan 1976). During the Navy-funded survey in 2007, there were multiple sightings that included young calves and large bulls (Fulling et al. 2011). These findings are consistent with an earlier sighting of a group of sperm whales that included a newborn calf off the west coast of Guam (Eldredge 2003). During the 2007 survey, sperm whales were observed in waters 2,670–32,584 ft. (809–9,874 m) deep (Fulling et al. 2011). During a small boat survey around Guam and Saipan in February and early March of 2010, there were two sperm whale sightings: (1) a group of nine animals off Orote Point, Guam, inshore from the 1,640 ft. (500 m) isobath; and (2) a group of six animals northwest of Saipan in waters greater than 3,281 ft. (1,000 m) deep (Ligon et al. 2011). A group of 10 sperm whales was also sighted during small boat surveys off western Guam in waters approximately 3,940 ft. deep (1,200 m) on 19 March 2012 (HDR EOC 2012).

3.4.2.12.3 Population and Abundance

It is estimated that there are between 200,000 and 1,500,000 sperm whales worldwide (National Marine Fisheries Service 2010). A ship survey conducted in the eastern temperate North Pacific in spring of 1997 resulted in estimates of 26,300 (CV = 0.81)–32,100 (CV = 0.36) animals based on visual sightings or acoustic detections, respectively (Barlow and Taylor 2005).

The sperm whale was the most frequently sighted cetacean (21 sightings) during the 2007 survey with acoustic detections almost three times higher (61) than visual detections in the field (Norris et al. 2012). Post processing of the acoustic data resulted in 91 distinct localizations of individual sperm whales. Based on a preliminary analysis, the distribution of sperm whales appeared to be clustered in three main regions of the Study Area, the northeast, central, and southwest portions, with a few others in the trench and offshore regions (Norris et al. 2012). Line-transect abundance estimates derived from these survey data yielded an estimate of 705 (CV = 0.60) sperm whales in the Study Area (Fulling et al. 2011).

3.4.2.12.4 Predator-Prey Interactions

Sperm whales socialize for predator defense and foraging purposes. Sperm whales forage during deep dives that routinely exceed a depth of 1,314 ft. (398 m) and 30-minute duration (Watkins et al. 2002). 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; Palacios and Mate 1996; Pitman et al. 2001; Baird 2009).

3.4.2.12.5 Species-Specific Threats

Sperm whales are susceptible to entanglement in fishing gear, ingestion of marine debris, and ship strikes. In U.S. waters in the Pacific, sperm whales are known to have been incidentally taken in drift gillnet operations (Carretta et al. 2011). Interactions between longline fisheries and sperm whales in the northeast Pacific and Gulf of Alaska have also been reported (Hill and DeMaster 1999; Rice 1989; Sigler et al. 2008; Mathias et al. 2012). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.13 Pygmy Sperm Whale (*Kogia breviceps*)

There are two species of *Kogia* that could occur in the Study Area: the pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale (*Kogia sima*). Before 1966 they were considered to be the same species until morphological distinction was shown (Handley 1966). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al. 2008).

3.4.2.13.1 Status and Management

The pygmy sperm whale is protected under the MMPA and is not listed pursuant to the ESA. NMFS recognizes two discrete non-contiguous stocks of pygmy sperm whales in the U.S. EEZ: (1) California, Oregon, and Washington; and (2) Hawaiian (Carretta et al. 2013). Little is known about the stock structure of pygmy sperm whales in the MITT Study Area.

3.4.2.13.2 Geographic Range and Distribution

Pygmy sperm whales have a worldwide distribution in tropical and temperate waters (Jefferson et al. 1993). The pygmy sperm whale appears to frequent more temperate habitats than the other *Kogia* species, which is more of a tropical species. For example, during boat surveys between 2000 and 2003 in the main Hawaiian Islands, the pygmy sperm was observed, but less commonly than the dwarf sperm whale (Baird 2005; Baird et al. 2003; Barlow et al. 2004). They are most often observed in waters along the continental shelf break and over the continental slope (e.g., Baumgartner et al. 2001; Baird 2005; McAlpine 2009). Little is known about possible migrations of this species. Pygmy sperm whales are difficult to photograph or tag, and thus, additional data are needed to be able to define migration routes or seasonality (Baird et al. 2011).

There were no *Kogia* species sighted during the 2007 survey of the Study Area (Fulling et al. 2011). However, this species is difficult to detect in high sea states and more than half of this survey was conducted in rough conditions (i.e., Beaufort sea states greater than 4). On 4 December 1997, a pygmy sperm whale was found stranded at Sugar Dock, Saipan (Trianni and Tenorio 2012). 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).

3.4.2.13.3 Population and Abundance

Few abundance estimates have been made for this species, and too little information is available to obtain a reliable population estimate for pygmy sperm whales in the Western Pacific. There are no available population estimates for pygmy sperm whales in the Study Area.

3.4.2.13.4 Predator-Prey Interactions

Pygmy sperm whales feed on cephalopods and, less often, on deep-sea fishes and shrimps (Caldwell and Caldwell 1989; Santos et al. 2006; Beatson 2007). A recent study in Hawaiian waters showed cephalopods were the primary prey of pygmy sperm whales, making up 78.7 percent of prey abundance and 93.4 percent contribution by mass (West et al. 2009). Stomach samples revealed an extreme diversity of cephalopod prey, with 38 species from 17 different families (West et al. 2009).

Pygmy sperm whales have been documented to be prey to white sharks (Long 1991; Tirard et al. 2010) and are likely subject to occasional killer whale predation like other whale species.

3.4.2.13.5 Species-Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to pygmy sperm whales (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.14 Dwarf Sperm Whale (*Kogia sima*)

There are two species of *Kogia*: the pygmy sperm whale (discussed in Section 3.4.2.13, Pygmy Sperm Whale) and the dwarf sperm whale, which until recently had been considered to be the same species. Genetic evidence suggests that there might also be two separate species of dwarf sperm whales globally, one in the Atlantic and one in the Indo-Pacific (Jefferson et al. 2008). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Chivers et al. 2005; Jefferson et al. 2008).

3.4.2.14.1 Status and Management

The dwarf sperm whale is protected under the MMPA and is not listed pursuant to the ESA. NMFS recognizes two discrete non-contiguous stocks of dwarf sperm whales in the U.S. EEZ: (1) California, Oregon, and Washington; and (2) Hawaiian (Carretta et al. 2013). Little is known about the stock structure of dwarf sperm whales in the MITT Study Area.

3.4.2.14.2 Geographic Range and Distribution

Dwarf sperm whales have been observed in both outer continental shelf and more oceanic waters (MacLeod et al. 2004). Although the dwarf sperm whale appears to prefer more tropical waters than the pygmy sperm whale, the exact habitat preferences of this species are not well understood. Records of this species have been documented from the western Pacific (Taiwan) and the eastern Pacific (California) (Scott and Cordaro 1987; Sylvestre 1988; Wang et al. 2001; Wang and Yang 2006; Jefferson et al. 2008; Carretta et al. 2010).

There were no species of *Kogia* sighted during the 2007 survey of the Study Area (Fulling et al. 2011). However, similar to the pygmy sperm whale, this species is difficult to detect in high sea states and more than half of this survey was conducted in rough conditions (i.e., Beaufort sea states greater than 4). On 24 August 1993, a dwarf sperm whale was found stranded at San Jose Beach, Saipan (Trianni and Tenorio 2012). 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). There was one sighting of a single dwarf sperm whale in the Marpi Reef area, northeast of Saipan, during small boat surveys conducted in August and early September of 2011 (Hill et al. 2011).

3.4.2.14.3 Population and Abundance

Few abundance estimates have been made for this species, and too little information is available to obtain a reliable population estimate for dwarf sperm whales in the Western Pacific. There are no available population estimates for dwarf sperm whales in the Study Area.

3.4.2.14.4 Predator-Prey Interactions

Dwarf sperm whales feed on cephalopods and, less often, on deep sea fishes and shrimps (Caldwell and Caldwell 1989; Sekiguchi et al. 1992). Dwarf sperm whales generally forage near the seafloor (McAlpine 2009).

Killer whales are predators of dwarf sperm whales (Dunphy-Daly et al. 2008).

3.4.2.14.5 Species-Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to dwarf sperm whales (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.15 Killer Whale (*Orcinus orca*)

A single species of killer whale is currently recognized, but strong and increasing evidence indicates the possibility of several different species of killer whales worldwide, many of which are called "ecotypes" (Ford 2008; Pilot et al. 2009; Morin et al. 2010). The different geographic forms of killer whale are distinguished by distinct social and foraging behaviors and other ecological traits (Morin et al. 2010).

3.4.2.15.1 Status and Management

The killer whale is protected under the MMPA, and the overall species is not listed pursuant to the ESA (although the southern resident population found in the Northeast Pacific is listed as endangered pursuant to the ESA and as depleted under the MMPA). Little is known of stock structure of killer whales in the North Pacific, with the exception of the northeastern Pacific where resident, transient, and offshore "ecotypes" have been described for coastal waters of Alaska, British Columbia, and Washington to California (Carretta et al. 2004). These ecotypes are defined specifically for these northeastern Pacific coastal waters, where regularly occurring populations have been studied for decades (Hoelzel and Dover 1991; Hoelzel et al. 1998). For stock assessment purposes, NMFS currently recognizes eight stocks of killer whale in the Pacific: (1) the Eastern North Pacific Alaska Resident stock; (2) the Eastern North Pacific Northern Resident stock; (3) the Eastern North Pacific Southern Resident stock; (4) the Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock; (5) the AT1 Transient stock; (6) the West Coast Transient stock; (7) the Eastern North Pacific offshore stock; and (8) the Hawaiian stock (Carretta et al. 2013). Little is known about killer whales in other tropical regions of the Pacific (Guinet and Bouvier 1995; Pitman and Ensor 2003; Forney and Wade 2006; Andrews et al. 2008). Given the lack of information, NMFS currently does not define a stock specific to the MITT Study Area.

3.4.2.15.2 Geographic Range and Distribution

Killer whales are found in all marine habitats from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning 1999; Forney and Wade 2006). Killer whales are known to inhabit both the western and eastern temperate Pacific and likely have a continuous distribution across the North Pacific (Dahlheim et al. 2008). In most areas of their range, killer whales do not show movement patterns that would be classified as traditional migrations. However, there are often seasonal shifts in density, both onshore/offshore and north/south (Morin et al. 2010). Data from satellite telemetry showed that killer whales made seasonal, fast and direct round-trip movements to subtropical waters when foraging near the Antarctic Peninsula (Durban and Pitman 2012).

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). Rock (1993) reported that killer whales have been reported in the tropical waters around Guam, Yap, and Palau. There are a few sightings of killer whales off Guam (Eldredge 1991), including a sighting 14.6 nm west of Tinian during January 1997 reported to the NMFS Platforms of Opportunity Program. There was also a badly decomposed killer whale found stranded on Guam in August 1981 (Kami and Hosmer 1982). On 25 May 2010, a group of approximately five killer whales, including one calf, was sighted about 20 mi. (32 km) south of FDM, apparently having just killed an unidentified large whale (Wenninger 2010).

3.4.2.15.3 Population and Abundance

There are no abundance estimates available for the killer whale in the Study Area and there were no sightings of this species during the 2007 systematic line-transect survey (Fulling et al. 2011).

3.4.2.15.4 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; Jefferson et al. 2008). Some populations are known to specialize in specific types of prey (Krahn et al. 2004; Jefferson et al. 2008; Wade et al. 2009).

The killer whale has no known natural predators; it is considered to be the top predator of the oceans (Ford 2008).

3.4.2.15.5 Species-Specific Threats

Boat traffic has been shown to affect the behavior of the endangered southern resident killer whale population around San Juan Island, Washington (Williams and Ashe 2007; Lusseau et al. 2009). In the presence of boats, whales were significantly less likely to be foraging and significantly more likely to be traveling (Lusseau et al. 2009). These changes in behavior were particularly evident when boats were within 330 ft. (100 m) of the whales. While this population of killer whales is not present in the Study Area, their behavior may be indicative of other killer whale populations that are present. Additionally, there are widespread reports of killer whale interactions with fisheries including entanglement (Visser 2000; Purves et al. 2004; Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.16 False Killer Whale (*Pseudorca crassidens*)

3.4.2.16.1 Status and Management

The false killer whale is protected under the MMPA, and in the MITT Study Area is not listed pursuant to the ESA. The main Hawaiian Islands insular stock was recently listed as endangered under the ESA (National Marine Fisheries Service 2012) but this stock is considered a resident to the islands and is not likely to be present in the Study Area. Not much is known about most false killer whale populations globally. While the species is not considered rare, few areas of high density are known. For stock assessment purposes, NMFS currently recognizes five stocks of false killer whale in the Pacific: (1) the main Hawaiian Islands insular stock includes the animals that occur in waters within 100 mi. (140 km) of the main Hawaiian Islands; (2) the Northwestern Hawaiian Islands stock, which includes animals inhabiting waters within 58 mi. (93 km) of the Northwestern Hawaiian Islands and Kauai; (3) the Hawaii pelagic stock includes animals that inhabit waters greater than 25 mi. (40 km) from the main Hawaiian Islands; (4) the Palmyra Atoll stock includes whales found within the U.S. EEZ of Palmyra Atoll; and (5) the American Samoa stock, which includes false killer whales found within the U.S. EEZ of American Samoa (Carretta et al. 2013). Little is known about the stock structure of false killer whales in other regions of the world and, given the lack of information, NMFS currently does not define a stock specific to the MITT Study Area (Chivers et al. 2007).

3.4.2.16.2 Geographic Range and Distribution

The false killer whale is an oceanic species, occurring in deep waters of the Pacific (Carretta et al. 2010; Miyashita et al. 1996; Wang et al. 2001), and is known to occur close to shore near oceanic islands (Baird et al. 2012). They are found in tropical and temperate waters, generally between 50°S and 50°N latitude with a few records north of 50°N in the Pacific and the Atlantic (Odell and McClune 1999). 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 and 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 2009).

During the 2007 survey of the Study Area, there were 10 false killer whale sightings in waters with bottom depths ranging from 10,095 to 26,591 ft. (3,059 to 8,058 m), and group sizes ranging from 2 to 26 individuals, with several including calves (Fulling et al. 2011). Several sightings were made over the Mariana Trench and the southeast corner of the Study Area, in waters with a bottom depth greater than 16,404 ft. (5,000 m). There was also a sighting in deep water west of the West Mariana Ridge

(Fulling et al. 2011). There is one reported false killer whale stranding which occurred in the Saipan Lagoon in 2000 (Trianni and Tenorio 2012).

3.4.2.16.3 Population and Abundance

There are estimated to be about 6,000 false killer whales in the area surrounding the Mariana Islands (Miyashita 1993). 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).

3.4.2.16.4 Predator-Prey Interactions

False killer whales feed primarily on deep-sea cephalopods and fish (Odell and McClune 1999). Twenty-five false killer whales that stranded off the coast of the Strait of Magellan were examined and found to feed primarily on cephalopods and fish. Squid beaks were found in nearly half of the stranded animals, and the most important prey species were found to be the squid species, *Martialiabyadesi* and *Illex argentinus,* followed by the coastal fish, *Macruronus magellanicus* (Alonso et al. 1999). 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. 2010). False killer whales have been observed to attack other cetaceans, including dolphins, and large whales, such as humpback and sperm whales (Baird 2009). They are known to behave aggressively toward small cetaceans in tuna purse seine nets (National Marine Fisheries Service 2012). This species is believed to be preyed on by large sharks and killer whales (Baird 2009). Because false killer whales feed on large prey at the top of the food chain (e.g., squid, tunas) they may be impacted by competition with fisheries (Cascadia Research 2010). This species is believed to be preyed on by large sharks and killer whales (Baird 2009).

3.4.2.16.5 Species-Specific Threats

False killer whales are particularly susceptible to fishery interactions and entanglements (Baird and Gorgone 2005; Carretta et al. 2011), although there are no specific data available for this species in the Study Area. Pollutants may also pose a threat to false killer whales (Ylitalo et al. 2009). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.17 Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale is often confused with the false killer whale and melon-headed whale, which are similar in overall appearance to this species.

3.4.2.17.1 Status and Management

The pygmy killer whale is protected under the MMPA and is not listed pursuant to the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including animals found within the U.S. EEZ of the Hawaiian Islands and adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of pygmy killer whales in the MITT Study Area.

3.4.2.17.2 Geographic Range and Distribution

The pygmy killer whale has a worldwide distribution in deep tropical and subtropical oceans (Davis et al. 2000; Würsig et al. 2000). Pygmy killer whales generally do not range north of 40°N or south of 35°S (Jefferson et al. 1993), and their distribution is continuous across the Pacific (Donahue and Perryman 2008; Jefferson et al. 2008). Reported sightings suggest that this species primarily occurs in equatorial waters, at least in the eastern tropical Pacific (Perryman et al. 1994). This species has been sighted in the western Pacific (Wang and Yang 2006; Brownell et al. 2009). Most of the records outside the tropics are associated with strong, warm western boundary currents that effectively extend tropical conditions into higher latitudes (Ross and Leatherwood 1994; Baird et al. 2011; Jeyabaskaran et al. 2011).

There was only one pygmy killer whale sighting of a group of six animals during the 2007 survey of the Study Area (Fulling et al. 2011). The sighting was made 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. During small boat surveys of Guam and CNMI waters in August and early September of 2011, there was a single pygmy killer whale sighting of six animals in the Marpi Reef area, northeast of Saipan, in waters with a bottom depth of 1,847 ft. (563 m) (Hill et al. 2011).

3.4.2.17.3 Population and Abundance

Although the pygmy killer whale has an extensive global distribution, it is not known to occur in high densities in any region and thus is probably one of the least abundant of the pantropical delphinids. The current best available abundance estimate for the Pacific management stock of pygmy killer whale based on a 2010 line-transect survey of the Hawaiian Islands EEZ is 3,433 individuals (CV = 0.52) (Carretta et al. 2014). Based on the single sighting during the 2007 Study Area survey, the best estimate of abundance was 78 individuals (CV = 0.88) (Fulling et al. 2011).

3.4.2.17.4 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. 2008; Perryman and Foster 1980; Ross and Leatherwood 1994). The pygmy killer whale has no documented predators (Weller 2008), although it may be subject to predation by killer whales.

3.4.2.17.5 Species-Specific Threats

Pygmy killer whales may be particularly susceptible to fishery interactions and entanglements (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.18 Short-Finned Pilot Whale (*Globicephala macrorhynchus*)

3.4.2.18.1 Status and Management

The short-finned pilot whale is protected under the MMPA and is not listed pursuant to the ESA. For MMPA stock assessment reports, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete, non-contiguous areas: (1) waters off California, Oregon, and Washington; and (2) Hawaiian waters (Carretta et al. 2013). In Japanese waters, two stocks (northern and southern) have been identified based on pigmentation patterns and head shape differences of adult males (Kasuya et al. 1988). The southern stock of short-finned pilot whales is probably the stock associated with the Mariana Islands area (Kasuya et al. 1988).

3.4.2.18.2 Geographic Range and Distribution

The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world. A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Bernard and Reilly 1999; Hui 1985; Payne and Heinemann 1993). The short-finned pilot whale occurs mainly in deep offshore areas; thus, the species occupies waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Olson 2009; Sakai et al. 2011). While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in waters off the northeastern United States (Payne and Heinemann 1993) and close to shore at oceanic islands, where the shelf is narrow and deeper waters are found nearby (Mignucci-Giannoni 1998; Gannier 2000).

Miyashita et al. (1996) reported sightings in the vicinity of the Northern Mariana Islands during February–March 1994, but did not provide the actual sighting coordinates. A group of more than 30 individuals was sighted in late April 1977 near Urunao Point, off the northwest coast of Guam (Birkeland 1977). A stranding occurred on Guam in July 1980 (Donaldson 1983; Kami and Hosmer 1982).

During the 2007 survey of the Study Area, there were a total of five sightings of short-finned pilot whales in waters with bottom depth ranging from 3,041 to 14,731 ft. (922 to 4,464 m), and group size ranging from 5 to 43 individuals (Fulling et al. 2011). Three sightings were over the West Mariana Ridge (an area of seamounts), and another sighting was 7 nm off the northeast corner of Guam, just inshore of the 9,900 ft. (3,000 m) isobath. There was also an off-effort sighting of a group of 6–10 pilot whales near the mouth of Apra Harbor (Fulling et al. 2011). No calves were seen, although there was a mixed-species aggregation involving bottlenose dolphins and rough-toothed dolphins. On 30 March 2010, during an oceanographic survey of waters in Micronesia and the CNMI, there was a single short-finned pilot whale sighting of an estimated 23 individuals, at approximately 17°N, more than 60 nm north of FDM (Oleson and Hill 2010). A mixed-species group of short-finned pilot whales and bottlenose dolphins were sighted during small boat surveys around Guam in February 2011 (HDR 2011). A group of 14 short-finned pilot whales were seen off Guam later that year (August; Hill et al. 2011). During small boat surveys in waters of the CNMI in August and September 2011, there were a total of 4 short-finned pilot whale sightings: (1) off the west coast of Guam north of Tumon Bay, (2) north of Saipan, (3) west of Tinian, and (4) off the northwest coast of Rota (Hill et al. 2011). The sighting off Rota was just inshore from the 656 ft. (200 m) isobath, while the other 3 sightings were in waters with bottom depths ranging from 1,640 to 3,281 ft. (500 to 1,000 m) (Hill et al. 2011). During small boat surveys in March 2012, a group of 23 short-finned pilot whales was sighted off the western coast of Guam (HDR EOC 2012), and several groups of 20–30 were sighted in the summer of 2012 off Guam and CNMI (Hill et al. 2013).

3.4.2.18.3 Population and Abundance

The Japanese southern stock of short-finned pilot whales has been estimated to number about 18,700 whales in the waters south of 30˚N (Miyashita 1993). There were an estimated 909 (CV = 0.68) short-finned pilot whales in the Study Area based on the 2007 survey (Fulling et al. 2011). Between 22 February 2011 and 10 June 2012, as part of an ongoing photo-identification project, a total of 5,636 photos were analyzed from 10 sightings of short-finned pilot whales in the Study Area (Hill et al. 2013). Across all locations and years, 129 individual pilot whales were identified (Hill et al. 2013).

3.4.2.18.4 Predator-Prey Interactions

Pilot whales feed primarily on squid but also take fish (Bernard and Reilly 1999). They are generally well adapted to feeding on squid (Jefferson et al. 2008; Werth 2006a). Pilot whales are not generally known to prey on other marine mammals, but records from the eastern tropical Pacific suggest that short-finned pilot whales do occasionally chase and attack, and may eat, dolphins during fishery operations (Perryman and Foster 1980; Olson 2009). They have also been observed harassing sperm whales in the Gulf of Mexico (Weller et al. 1996).

This species is not known to have any predators (Weller 2008), although it may be subject to predation by killer whales.

3.4.2.18.5 Species-Specific Threats

Short finned pilot whales are particularly susceptible to fisheries interactions and entanglement (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. This species has been a target in the drive fishery off the coast of Japan (Kasuya and Marsh 1984). Pollutants may also pose a threat to short-finned pilot whales (Tanabe et al. 1987). Pilot whales are frequently observed to strand for reasons unclear (Hohn et al. 2006). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.19 Melon-Headed Whale (*Peponocephala electra*)

3.4.2.19.1 Status and Management

The melon-headed whale is protected under the MMPA and is not listed pursuant to the ESA. For the MMPA stock assessment reports, there are two Pacific management stocks: (1) the Kohala resident stock, including melon-headed whales off the Kohala Peninsula and west coast of the island of Hawaii in less than 2,500 meters of water, and (2) the Hawaiian Islands stock, including animals found within the U.S. EEZ of the Hawaiian Islands as well as adjacent international waters (Carretta et al. 2014). Little is known about the stock structure of melon-headed whales in the MITT Study Area.

3.4.2.19.2 Geographic Range and Distribution

Melon-headed whales are found worldwide in tropical and subtropical oceanic waters. They have occasionally been reported at higher latitudes, but these movements are considered to be beyond their normal range, because records indicate these movements occurred during incursions of warm water currents (Perryman et al. 1994). Melon-headed whales are most often found in offshore deep waters but sometimes move close to shore over the continental shelf. Brownell et al. (2009) found that melon-headed whales near oceanic islands rest near shore during the day, and feed in deeper waters at night (Gannier 2002; Woodworth et al. 2012). The melon-headed whale is not known to migrate.

There was a live stranding of a melon-headed whale on the beach at Inarajan Bay, Guam in April 1980 (Donaldson 1983; Kami and Hosmer 1982), and there have been some sightings at Rota and Guam (Fulling et al. 2011; Jefferson et al. 2006). Based on sighting records, melon-headed whales are expected to occur from the shelf break (660 ft. [200 m] isobath) to seaward of the Mariana Islands area and vicinity. There is also a low or unknown occurrence from the coastline to the shelf break, since deep water is very close to shore at these islands. In July 2004, there was a sighting of an estimated 500–700 melon-headed whales and an undetermined smaller number of rough-toothed dolphins at Sasanhayan Bay (Rota) (Jefferson et al. 2006). 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). Melon-headed whales were sighted in waters with a bottom depth, ranging from 10,577 to 12,910 ft. (3,205 to 3,912 m). One of the two sightings was in the vicinity of the West Mariana Ridge. There was one sighting of approximately 53 animals on 5 February 2010, southeast of Guam during the large vessel Pacific Islands Fisheries Science Center survey (Oleson and Hill 2010). During small boat surveys in March 2012, a group of 100 melon-headed whales was sighted off the western coast of Guam in waters approximately 8,530 ft. (2,600 m) deep (HDR EOC 2012).

3.4.2.19.3 Population and Abundance

Based on sighting data from the 2007 survey, there were an estimated 2,455 (CV = 0.70) melon-headed whales in the Study Area (Fulling et al. 2011).

3.4.2.19.4 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 4,920 ft. (1,500 m) deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros 1997).

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. 2006).

3.4.2.19.5 Species-Specific Threats

Melon-headed whales are particularly susceptible to fisheries interactions and entanglement (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. Melon-headed whales have been observed to strand for reasons that are unclear (Fromm et al. 2006; Southall et al. 2006). See 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.20 Bottlenose Dolphin (*Tursiops truncatus*)

The classification of the genus *Tursiops* continues to be in question; while two species are generally recognized, the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice 1998), the specific affinities of these animals remains controversial. Recent morphological analyses suggest a new species be recognized, *Tursiops australis* (Charlton-Robb et al. 2011).

3.4.2.20.1 Status and Management

The common bottlenose dolphin is protected under the MMPA and is not listed pursuant to the ESA. For the MMPA stock assessment reports, bottlenose dolphins within the Pacific U.S. EEZ are divided into seven stocks: (1) California coastal; (2) California, Oregon, and Washington Offshore; (3) Kauai and Niihau; (4) Oahu; (5) the 4-Islands Region; (6) Hawaii Island; and (7) the Hawaii Pelagic, including animals found within the U.S. EEZ of the Hawaiian Islands as well as adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of bottlenose dolphins in the MITT Study Area.

3.4.2.20.2 Geographic Range and Distribution

Common bottlenose dolphins are generally found in coastal and continental shelf waters of tropical and temperate regions of the world. They are known to occur in most enclosed or semi-enclosed seas. The species is known to inhabit shallow, murky, estuarine waters as well as deep, clear offshore waters in oceanic regions (Wells et al. 2009; Martien et al. 2012). Although in most areas bottlenose dolphins do not migrate (especially where they occur in bays, sounds, and estuaries), seasonal shifts in abundance do occur in many areas (Griffin and Griffin 2004).

Miyashita (1993) reported multiple sightings of bottlenose dolphins in the western Pacific. However, there are no stranding records available for this species in the Mariana Islands area and vicinity, and only a mention by Trianni and Kessler (2002) that bottlenose dolphins are seen in coastal waters of Guam. It is possible that bottlenose dolphins do not occur in great numbers in this island chain, but they are frequently seen. In the main Hawaiian Islands, data suggest that bottlenose dolphins exhibit site fidelity (Baird et al. 2009; 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. A similar situation could be occurring in the Study Area and vicinity.

There were three on-effort sightings of bottlenose dolphins during the 2007 survey of the Study Area. Two of the sightings were in the vicinity of Challenger Deep, while the other sighting was east of Saipan near the Mariana Trench in deep waters ranging from 13,995 to 16,536 ft. (4,241 to 5,011 m) (Fulling et al. 2011). The Challenger Deep sighting was a mixed-species aggregation that included sperm whales (with calves) logging at the surface. Another mixed-species aggregation involved short-finned pilot whales and rough-toothed dolphins. A mixed-species group of bottlenose dolphins and short-finned pilot whales were also sighted during small boat surveys around Guam in February 2011 (HDR 2011). During small boat surveys in waters of Guam and the CNMI in August and September 2011, there were a total of 3 bottlenose dolphin sightings: (1) off Rota Bank north of Guam (14 animals including 2 calves); (2) in inshore waters off the southeast coast of Saipan (10 animals); and (3) in inshore waters off the northwest tip of Tinian (10 animals) (Hill et al. 2011). During small boat surveys in March 2012, a group of 11 bottlenose dolphins was sighted off the northwestern coast of Saipan in waters approximately 328 ft. (100 m) deep (HDR EOC 2012), and several groups observed in the summer of 2012 (Hill et al. 2013).

3.4.2.20.3 Population and Abundance

As mentioned above, little is known of the stock structure of bottlenose dolphins around the Mariana Islands. A bottlenose dolphin abundance estimate of 31,700 animals was made for the area north of the Marianas (Miyashita 1993), which may possibly represent a stock of offshore bottlenose dolphins that occurs around the Mariana Islands. In some regions "inshore" and "offshore" species differ genetically and morphologically (Tezanos-Pinto et al. 2009). Between 22 February 2011 and 29 June 2012, as part of an ongoing photo-identification project, a total of 1,793 photos were analyzed from nine sightings of bottlenose dolphins in the Study Area (Hill et al. 2013). Across all locations and years, 34 individual bottlenose dolphins were identified (Hill et al. 2013).

3.4.2.20.4 Predator-Prey Interactions

Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimps (Wells and Scott 1999), and using a variety of feeding strategies (Shane 1990). In addition to using echolocation, a process for locating prey by emitting sound waves that reflect back, bottlenose dolphins detect and orient fish prey by listening for the sounds their prey produce, so-called 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 and Potter 1995). Pacific coast bottlenose dolphins feed primarily on surf perches (family Embiotocidae) and croakers (family Sciaenidae) (Wells and Scott 1999).

Throughout its range bottlenose dolphins are known to be preyed on by killer whales and sharks (Wells and Scott 1999; Heithaus 2001; Ferguson et al. 2012).

3.4.2.20.5 Species-Specific Threats

Common bottlenose dolphins are particularly susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.21 Pantropical Spotted Dolphin (*Stenella attenuata*)

3.4.2.21.1 Status and Management

The species is protected under the MMPA and is not listed pursuant to the ESA. Pantropical spotted dolphins may have several stocks in the western Pacific (Miyashita 1993), although this is not confirmed at present. For the MMPA stock assessment reports, four stocks of pantropical spotted dolphins are identified within waters of the Hawaiian Islands EEZ (Carretta et al. 2014). In the eastern tropical Pacific, Deoxyribonucleic acid (DNA) analyses suggest genetic isolation between inshore and offshore populations of spotted dolphins (Escorza-Treviño et al. 2005). Little is known about the stock structure of pantropical spotted dolphins in the MITT Study Area.

3.4.2.21.2 Geographic Range and Distribution

The pantropical spotted dolphin is distributed in offshore tropical and subtropical waters of the Pacific, Atlantic, and Indian Oceans between about 40°N and 40°S (Baldwin et al. 1999; Perrin 2008a), although this species is much more abundant in the lower latitudes of its range. It is found mostly in deeper offshore waters but does approach the coast in some areas (Jefferson et al. 2008; Perrin 2001). Pantropical spotted dolphins are extremely gregarious, forming groups of hundreds or even thousands of individuals. Their range in the central Pacific is from the Hawaiian Islands in the north to at least the Marquesas Islands in the south (Perrin and Hohn 1994). Based on the known habitat preferences of the pantropical spotted dolphin, this species is expected to occur seaward of the shelf break (660 ft. [200 m] isobath). Low or unknown occurrence of the pantropical spotted dolphin from the coastline to the shelf break (except in harbors and lagoons) is based on sightings of pantropical spotted dolphins being reported in coastal waters of Guam (Trianni and Kessler 2002). Although pantropical spotted dolphins do not migrate, extensive movements are known in the eastern tropical Pacific (Scott and Chivers 2009). Mixed species groups of pantropical spotted dolphins and spinner dolphins have been observed off the Waianae (western) coast of Oahu (Psarakos et al. 2003).

Pantropical spotted dolphins were sighted throughout the Study Area during the 2007 ship survey in waters with a variable bottom depth, ranging from 374 to 18,609 ft. (113 to 5,639 m) (Fulling et al. 2011). The vast majority of the sightings (65 percent; 11 of 17 sightings) were in deep waters greater than 10,000 ft. (3,030 m); these findings match the known preference of this species for oceanic waters. There was only one shallow-water sighting 1.4 nm north of Tinian, in waters with a bottom depth of 374 ft. (113 m). Pantropical spotted dolphin group size ranged from 1 to 115 individuals. There were multiple sightings that included young calves, one mixed species aggregation with melon-headed whales, and another with an unidentified *Balaenoptera* species. These pantropical spotted dolphins were identified as the offshore morphotype.

During marine mammal monitoring for Valiant Shield 07, a group of 30 pantropical spotted dolphins was observed about 140 nm southeast of Guam (Mobley 2007). A group of 17 pantropical spotted dolphins was sighted during small boat surveys around Guam in February and early March of 2010 (Ligon et al. 2011). This species was also sighted during small boat surveys in August and September of 2011, with two sightings off the northwest coast of Guam and one sighting off the northwest coast of Saipan (Hill et al. 2011). All three of these sightings were in waters with bottom depth ranging from 1,640 to 3,281 ft. (500 to 1,000 m). There were two sightings of pantropical spotted dolphins during small boat surveys in March 2012, both on 19 March off the western coast of Guam (HDR EOC 2012). The first was a group of 6 animals in waters approximately 3,940 ft. (1,200 m) deep and the second was a group of 30 animals in waters approximately 4,593 ft. (1,400 m) deep (HDR EOC 2012). Several groups of pantropical spotted dolphins were observed off Guam and the CNMI in the summer of 2012 (Hill et al. 2013).

3.4.2.21.3 Population and Abundance

There are estimated to be about 127,800 spotted dolphins in the waters surrounding the Mariana Islands (Miyashita 1993). There were an estimated 12,981 (CV = 0.70) pantropical spotted dolphins in the Study Area based on the 2007 survey data (Fulling et al. 2011). Pantropical spotted dolphins are one of the focus species of an ongoing photo-identification project in the Study Area; however, data collected to date still need to be processed for creation of photo-identification catalogs (Hill et al. 2013).

3.4.2.21.4 Predator-Prey Interactions

Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans and on some mid-water species (Perrin and Hohn 1994). Results from various tracking and food habit 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; Robertson and Chivers 1997).

Pantropical spotted dolphins may be preyed on by killer whales and sharks, and have been observed fleeing killer whales in Hawaiian waters (Maldini Feinholz 2003; Baird et al. 2006). Other predators may include the pygmy killer whale, false killer whale, and occasionally the short-finned pilot whale (Perrin 2008a).

3.4.2.21.5 Species-Specific Threats

Pantropical spotted dolphins located in the eastern tropical Pacific have been taken as bycatch by the tuna purse seine fishery (Wade 1994; Archer et al. 2004), and are susceptible to entanglement in fishing gear in other areas (Carretta et al. 2011). Even though direct bycatch has been reduced for these fisheries, interactions may have negative effects on species survival and reproduction (Archer et al. 2010b). There are no specific fisheries interactions or other threat data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.22 Striped Dolphin (*Stenella coeruleoalba*)

3.4.2.22.1 Status and Management

This species is protected under the MMPA and is not listed pursuant to the ESA. In the eastern Pacific, NMFS divides striped dolphin management stocks within the U.S. Pacific EEZ into two separate areas: (1) waters off California, Oregon, and Washington; and (2) waters around Hawaii, including animals found within the U.S. EEZ of the Hawaiian Islands as well as adjacent international waters (Carretta et al. 2013). In the western north Pacific, three migratory stocks are provisionally recognized (Kishiro and Kasuya 1993).

3.4.2.22.2 Geographic Range and Distribution

Striped dolphins have a cosmopolitan distribution in tropical to warm temperate waters (Perrin et al. 1994b). Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus *Stenella* (spotted and spinner dolphins) (Baird et al. 1993). Striped dolphins are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman 1985; Reilly 1990). This species is well documented in both the western and eastern Pacific off the coasts of Japan and North America (Perrin et al. 1994b); the northern limits are the Sea of Japan, Hokkaido, Washington state, and along roughly 40°N across the western and central Pacific (Reeves et al. 2002). In some areas, this species appears to avoid waters with sea temperatures less than 68°F (20°C) (Van Waerebeek et al. 1998).

Prior to the 2007 survey of the Study Area (Fulling et al. 2011), striped dolphins were only known from two strandings; one recorded in July 1985 (Eldredge 1991, 2003) and a second in 1993 off Saipan (Trianni and Tenorio 2012). However, striped dolphins were sighted throughout the Study Area during the 2007 survey in waters with variable bottom depth, ranging from 7,749 to 24,835 ft. (2,348 to 7,526 m) (Fulling et al. 2011). There was at least one sighting over the Mariana Trench, southeast of Saipan. Group size ranged from 7 to 44 individuals, and several sightings included calves. There were no sightings south of Guam (approximately 13°N). In early April 2010, during an oceanographic survey of waters in Micronesia and the CNMI, there were two striped dolphin sightings south of Guam, both on the 143.8 longitude line (Oleson and Hill 2010). The first sighting was of an estimated 6 animals at 11.384°N, and the second was a sighting of an estimated 12 animals at 10.286°N (Oleson and Hill 2010).

3.4.2.22.3 Population and Abundance

The population of striped dolphins south of 30˚N in the western Pacific was estimated to be around 52,600 dolphins (Miyashita 1993). Based on the 2007 survey data, there were an estimated 3,531 (CV = 0.54) striped dolphins in the Study Area (Fulling et al. 2011).

3.4.2.22.4 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, suggesting that striped dolphins may be feeding at great depths, possibly diving to 655–2,295 ft. (200–700 m) (Archer and Perrin 1999). Striped dolphins may feed at night in order to take advantage of the deep scattering layer’s diurnal vertical movements. Small mid-water fishes (in particular lanternfishes) and squids are the predominant prey (Perrin et al. 1994b; Santos et al. 2008).

This species has been documented to be preyed upon by sharks (Ross 1971; Morey et al. 2003). It may also be subject to predation by killer whales.

3.4.2.22.5 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. 2011). There are no specific fisheries interactions or other threat data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.23 Spinner Dolphin (*Stenella longirostris*)

Four well-differentiated geographical forms of spinner dolphins have been described as separate subspecies: *Stenella longirostris* (Gray’s spinner dolphin), *Stenella longirostris orientalis* (eastern spinner dolphin), *Stenella longirostris centroamericana* (Central American spinner dolphin), and *Stenella longirostris roseiventris* (dwarf spinner dolphin). The latter three subspecies have restricted distributions and are unlikely to occur in the Study Area; hence, *Stenella longirostris* is probably the one that occurs there (Trianni and Kessler 2002; Bearzi et al. 2012; Carretta et al. 2012).

3.4.2.23.1 Status and Management

The spinner dolphin is protected under the MMPA and is not listed pursuant to the ESA. The eastern spinner dolphin (*Stenella longirostris orientalis*) is listed as depleted under the MMPA. Under the

MMPA, there are seven Pacific management stocks for Gray's spinner dolphin (*Stenella longirostris longirostris*): (1) American Samoa, (2) Hawaii Island, (3) Oahu/4-islands, (4) Kauai/Niihau, (5) Pearl and Hermes Reef, (6) Midway Atoll/Kure, and (7) Hawaii Pelagic, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Hill et al. 2010; Carretta et al. 2013). Little is known about the stock structure of spinner dolphins in the MITT Study Area. However, based on recent sighting data (summarized in Section 3.4.2.22.2, Geographic Range and Distribution) and what is known of the Hawaiian Islands stocks, it is likely that there are both island-associated and pelagic populations of spinner dolphins in the MITT Study Area.

3.4.2.23.2 Geographic Range and Distribution

The spinner dolphin is found in tropical and subtropical waters worldwide, generally between 40°N and 40°S (Norris and Dohl 1980; Perrin and Gilpatrick 1994; Jefferson et al. 2008). Spinner dolphins occur in both oceanic and coastal environments. Most sightings of this species have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick 1994). Open ocean populations, such as those in the eastern tropical Pacific, often are found in waters with a shallow thermocline (rapid temperature difference with depth) (Au and Perryman 1985; Reilly 1990; Perrin 2008b). The thermocline concentrates open sea organisms in and above it, which spinner dolphins feed on. Coastal populations are usually found in island archipelagos, where they are tied to trophic and habitat resources associated with the coast (Norris and Dohl 1980; Lammers 2004; Thorne et al. 2012).

Spinner dolphins at islands and atolls rest during daytime hours in shallow, wind-sheltered nearshore waters and forage over deep waters at night (Norris et al. 1994; Östman 1994; Gannier 2000, 2002; Benoit-Bird and Au 2003; Lammers 2004; Östman-Lind et al. 2004; Oremus et al. 2007; Benoit-Bird and Au 2009; Andrews et al. 2010;). Spinner dolphins are expected to occur in shallow water (about 164 ft. [50 m] or less) resting areas throughout the middle of the day, moving into deep waters offshore during the night to feed. Preferred resting habitat is usually more sheltered from prevailing trade winds than adjacent areas and the bottom substrate is generally dominated by large stretches of white sand bottom rather than reef and rock bottom (Norris et al. 1994; Lammers 2004). These clear, calm waters and light bottom substrates provide a less cryptic backdrop for predators like tiger sharks (Norris et al. 1994; Lammers 2004).

Spinner dolphins travel among the Mariana Islands chain (Trianni and Kessler 2002), and are expected to occur throughout the Marianas, except there have been no documented sightings within Apra Harbor. High-use areas 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). Spinner dolphins have also been seen at FDM (Trianni and Kessler 2002; Vogt 2008) and Rota (Jefferson et al. 2006). Spinner dolphins have been reported in the Saipan Lagoon at Saipan nearly every year; typically, sightings are from the northern part of the lagoon, referred to as Tanapag Lagoon (Trianni and Kessler 2002).

During the 2007 survey of the Study Area, there was one sighting of spinner dolphins northeast of Saipan in waters with a bottom depth of 1,398 ft. (424 m) (Fulling et al. 2011). Spinner dolphins have been sighted during the Navy's routine aerial surveys of FDM on several occasions, including one sighting in March of 2006, approximately 1,312 ft. (400 m) east of the island, and another sighting in July of 2007, approximately 31 mi. (50 km) north of Saipan (Vogt 2008). There were a total of 14 spinner dolphin sightings during small boat surveys around Guam (8 sightings) and Saipan (6 sightings) in February and early March of 2010 (Oleson and Hill 2010; Ligon et al. 2011). Of the eight total sightings off Guam, seven were in Agat Bay and there was a single sighting just south of Facpi Point, all inshore of the 328 ft. (100 m) isobath (Ligon et al. 2011). An additional four sightings were made in shallow (less than 328 ft. [100 m]) waters off Saipan, and another two sightings in shallow waters near Marpi Reef, northeast of Saipan (Ligon et al. 2011). During small boat surveys around the western and northern side of Guam in February 2011, there were a total of seven sightings of spinner dolphins on five different days, with group sizes ranging from 3 to 35 animals (HDR 2011). There were a total of 22 spinner dolphin sightings during small boat surveys around Guam and the CNMI in August and early September 2011 (Hill et al. 2011). All of the sightings were in waters less than 656 ft. (200 m) deep, either directly off the coasts of Guam, Saipan, Tinian, Aguijan, and Rota, or in shallow waters off Marpi Reef and Rota Bank north of Guam (Hill et al. 2011). There were five sightings of spinner dolphins during small boat surveys in March 2012, one sighting off the western coast of Guam and four sightings off Saipan (HDR EOC 2012). There were also several sightings of spinner dolphins off Guam and the CNMI during summer surveys in 2012 (Hill et al. 2013).

Given what is known of spinner dolphin resting areas in other island areas as described above, and based on both recent survey efforts and local knowledge, primary resting areas in the Study Area likely include multiple bays and inlets around Guam and the CNMI (Oleson and Hill 2010; Ligon et al. 2011; HDR EOC 2012; Hill et al. 2013). As sighting data, photographs, and biopsy samples collected during recent surveys continue to be analyzed, and as additional data are collected, it is anticipated that the identification and understanding of spinner dolphin resting areas in the Study Area will be further refined.

3.4.2.23.3 Population and Abundance

Although there are multiple sighting records of spinner dolphins around the Mariana Islands, no abundance estimate is available for the region. The only systematic line-transect survey of the Study Area was the 2007 survey for which there was only one sighting of this species (Fulling et al. 2011). Between 22 February 2011 and 16 June 2012, as part of an ongoing photo-identification project, a total of 8,047 photos were analyzed from 29 sightings of spinner dolphins in the Study Area (Hill et al. 2013). Across all locations and years, 89 individual spinner dolphins were identified (Hill et al. 2013).

3.4.2.23.4 Predator-Prey Interactions

Spinner dolphins feed primarily on small mid-water fish, squid, and shrimp, and they dive to at least 655–985 ft. (200–300 m) (Perrin and Gilpatrick 1994). Foraging can begin in the late afternoon (Lammers 2004), but takes place primarily at night when the mesopelagic prey migrates vertically towards the surface and also horizontally towards the shore (Benoit-Bird and Au 2003; Benoit-Bird 2004). Spinner dolphins track the horizontal migrations of their prey (Benoit-Bird and Au 2003), allowing for foraging efficiencies (Benoit-Bird and Au 2003; Benoit-Bird 2004). Foraging behavior has also been linked to lunar phases in scattering layers off Hawaii (Benoit-Bird and Au 2004).

Spinner dolphins may be preyed on by sharks, killer whales, pygmy killer whales, and short-finned pilot whales (Perrin 2008b).

3.4.2.23.5 Species-Specific Threats

Spinner dolphins are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011; Gerrodette and Forcada 2005; Wade et al. 2007), although there are no specific data available for this species in the Study Area. Due to their coastal distribution, spinner dolphins are also subject to potential effects from tourism (Danil et al. 2005; Timmel et al.2008). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.24 Rough-Toothed Dolphin (*Steno bredanensis*)

3.4.2.24.1 Status and Management

This species is protected under the MMPA and is not listed pursuant to the ESA. Rough-toothed dolphins are among the most widely distributed species of tropical dolphins, but little information is available regarding population status (Jefferson 2009; Jefferson et al. 2008). There are two Pacific management stocks recognized by NMFS for stock assessment purposes: (1) an American Samoa stock, and (2) a Hawaiian Islands stock including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of rough-toothed dolphins in the MITT Study Area.

3.4.2.24.2 Geographic Range and Distribution

Rough-toothed dolphins are typically found in tropical and warm temperate waters, rarely ranging north of 40°N or south of 35°S (Miyazaki and Perrin 1994). The rough-toothed dolphin is regarded as an offshore species that prefers deep water, but it can occur in waters of variable bottom depth as observed at the Windward Islands (French Polynesia) (Gannier and West 2005; Baird et al. 2008; Oremus et al. 2012). It rarely occurs close to land, except around islands with steep drop-offs nearshore (Gannier and West 2005), similar to the Study Area. In some areas, this species may be found in coastal waters and areas with shallow bottom depths (Davis et al. 1998; Fulling et al. 2011; Lodi and Hetzel 1999; Mignucci-Giannoni 1998; Ritter 2002). Rough-toothed dolphins can often be found in mixed species groups with other species such as pilot whales, bottlenose dolphins, or melon-headed whales (e.g., Fulling et al. 2011). At the Society Islands, rough-toothed dolphins were sighted in waters with bottom depths ranging from less than 330 ft. (100 m) to more than 9,845 ft. (more than 3,000 m), although they apparently favored the 1,640–4,920 ft. (500–1,500 m) range (Gannier 2000).

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 at Sasanhayan Bay (Rota) in waters with a bottom depth of 249 ft. (75.9 m) (Jefferson et al. 2006). During marine mammal monitoring for Valiant Shield 07, a group of 8 rough-toothed dolphins was observed about 102 nm east of Guam (Mobley 2007). During the 2007 survey of the Study Area, there were two sightings of rough-toothed dolphins, both in groups of nine individuals with calves present in one sighting (Fulling et al. 2011). Both sightings were in deep waters, ranging from 3,343 to 14,731 ft. (1,013 to 4,464 m). One sighting was off the island of Guguan, while the other was at the southern edge of the Study Area (Fulling et al. 2011).

3.4.2.24.3 Population and Abundance

There are no abundance estimates for the rough-toothed dolphin in the western Pacific. Rough-toothed dolphins are common in tropical areas, but not nearly as abundant as some other dolphin species (Reeves et al. 2002). During the only systematic line-transect survey of the Study Area in 2007, there was only one on-effort sighting of this species (Fulling et al. 2011).

3.4.2.24.4 Predator-Prey Interactions

Prey of rough-toothed dolphins includes fish and cephalopods. They are known to feed on large fish species, such as mahi (Miyazaki and Perrin 1994; Pitman and Stinchcomb 2002). Perkins and Miller (1983) noted that parts of reef fish had been found in the stomachs of stranded rough-toothed dolphins in Hawaii. Gannier and West (2005) observed rough-toothed dolphins feeding during the day on near-surface fishes, including flying fishes.

Rough-toothed dolphins have not been documented to be preyed on by any other species, although they may be subject to predation by killer whales.

3.4.2.24.5 Species-Specific Threats

Rough-toothed dolphins are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.25 Fraser's Dolphin (*Lagenodelphis hosei*)

Since its discovery in 1956, Fraser's dolphin was known only from skeletal specimens until it was once again identified in the early 1970s (Perrin et al. 1973). Fraser's dolphin has become much better described as a species in recent years, although it is still one of the least-known species of cetaceans.

3.4.2.25.1 Status and Management

Fraser's dolphin is protected under the MMPA and is not listed pursuant to the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of Fraser's dolphin in the MITT Study Area.

3.4.2.25.2 Geographic Range and Distribution

Fraser's dolphin is a tropical oceanic species, except where deep water approaches the coast (Dolar 2008). Species found outside 30°N and 30°S are probably there due to temporary oceanographic events (Dolar 2008). In the Gulf of Mexico, this species has been seen in waters over the abyssal plain (Leatherwood et al. 1993). In the offshore eastern tropical Pacific, this species is distributed mainly in upwelling-modified waters (Au and Perryman 1985). 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, and little is known about its potential migrations. No specific information regarding routes, seasons, or resighting rates in specific areas is available. As noted above, data on Fraser's dolphin are lacking, and there are only a few scattered reports of stranding (Hersh and Odell 1986). They are often found with other species of cetaceans; they have been observed with melon-headed whales, sperm whales, short-finned pilot whales, false killer whales, Risso's dolphins, pantropical spotted dolphins, spinner dolphins, and striped dolphins (Jefferson and Leatherwood 1994).

3.4.2.25.3 Population and Abundance

Fraser's dolphin is not considered to be extremely abundant in any region in the world, although there is little concern regarding its global conservation status (Dolar 2008; Jefferson et al. 2008). There are no abundance estimates for Fraser's dolphin in the Study Area.

3.4.2.25.4 Predator-Prey Interactions

Fraser's dolphin feeds on mid-water fish, squid, and shrimp (Jefferson and Leatherwood 1994; Perrin et al. 1994a; Watkins et al. 1994; Mignucci-Giannoni et al. 1999).

Fraser's dolphin has been subjected to predation by killer whales (Dunn et al. 2007).

3.4.2.25.5 Species-Specific Threats

Although data on fishery-related mortality are limited, Fraser's dolphins are likely susceptible to fishery interactions (Carretta et al. 2011). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.26 Risso's Dolphin (*Grampus griseus*)

3.4.2.26.1 Status and Management

Risso's dolphin is protected under the MMPA and is not listed pursuant to the ESA. For the MMPA stock assessment reports, Risso's dolphins within the Pacific U.S. EEZ are divided into two separate areas: (1) waters off California, Oregon, and Washington; and (2) Hawaiian waters, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of Risso's dolphins in the MITT Study Area.

3.4.2.26.2 Geographic Range and Distribution

Occurrence of this species is well known in deep open ocean waters off Hawaii, and in other locations in the Pacific (Au and Perryman 1985; Carretta et al. 2010; Leatherwood et al. 1980; Miyashita 1993; Miyashita et al. 1996; Wang et al. 2001). Several studies have documented that Risso's dolphins are found offshore, along the continental slope, and over the outer continental shelf (Green et al. 1992; Baumgartner 1997; Davis et al. 1998; Mignucci-Giannoni 1998; Kruse et al. 1999; Cañadas et al. 2002). Risso's dolphins are also found over submarine canyons (Mussi et al. 2004). Shane (1994) reported sightings of Risso's dolphins in shallow waters in the northeastern Pacific, including near oceanic islands. These sites are in areas where the continental shelf is narrow and deep water is closer to the shore (Gannier 2000, 2002).

On 30 March 2010, during an oceanographic survey of waters in Micronesia and the CNMI, there was a single Risso's dolphin sighting of three individuals, at approximately 17°N, more than 60 nm north of FDM (Oleson and Hill 2010).

3.4.2.26.3 Population and Abundance

This is a widely distributed species that occurs in all major oceans, and although no global population estimates exist, it is generally considered to be one of the most abundant of the large dolphins (Bearzi et al. 2011). Miyashita (1993) used Japanese survey data to estimate that about 7,000 Risso's dolphins occur in the area north of the Mariana Islands.

3.4.2.26.4 Predator-Prey Interactions

Cephalopods and crustaceans are the primary prey for Risso's dolphins (Clarke 1996), which feed mainly at night (Baird 2008; Jefferson et al. 2008).

This dolphin may be preyed on by both killer whales and sharks, although there are no documented reports of predation by either species (Weller 2008).

3.4.2.26.5 Species-Specific Threats

Risso's dolphins are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.27 Cuvier's Beaked Whale (*Ziphius cavirostris*)

3.4.2.27.1 Status and Management

Cuvier's beaked whale is protected under the MMPA and is not listed pursuant to the ESA. Cuvier's beaked whale stocks are defined for three separate areas within Pacific U.S. EEZ waters: (1) Alaska; (2) California, Oregon, and Washington; and (3) Hawaii, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of Cuvier's beaked whale in the MITT Study Area (Allen et al. 2012).

3.4.2.27.2 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. 2006; Ferguson et al. 2005; 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 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). Little is known about potential migration. 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 marine mammal monitoring for Valiant Shield 07, 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 was observed in deep water during the 2007 survey of the Study Area, but was not identified to the species level (Fulling et al. 2011). In August 2011, two stranded Cuvier's beaked whales were found on and near Micro Beach, Saipan (one alive and one dead); a necropsy conducted on the live stranded animal after euthanization revealed abnormalities in the animal's kidneys and intestines but further investigation is needed in order to determine if the stranding or morbidity should be categorized as natural or human-related (Saipan Tribune 2011; Hawaii Pacific University 2012). There were no Navy activities during the time of the stranding.

3.4.2.27.3 Population and Abundance

No abundance estimates for Cuvier's beaked whale are available for the Study Area.

3.4.2.27.4 Predator-Prey Interactions

Cuvier's beaked whales, similar to other beaked whale species, are apparently deepwater feeders. Stomach content analyses show that they feed mostly on deep-sea squid, fish, and crustaceans (Hickmott 2005; Baird et al. 2006; Santos et al. 2007). They apparently use suction to swallow prey (Werth 2006a, b; Jefferson et al. 2008).

Cuvier's beaked whales may be preyed upon by killer whales (Heyning and Mead 2008; Jefferson et al. 2008).

3.4.2.27.5 Species-Specific Threats

Cuvier's beaked whales commonly strand, which results in some of the occurrence data on this species, and they seem to be vulnerable to acoustic impacts (Frantzis et al. 2002; Podesta et al. 2006; Hooker et al. 2009; Southall et al. 2012a). Additionally, Cuvier's beaked whales are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.28 Blainville's Beaked Whale (*Mesoplodon densirostris*)

3.4.2.28.1 Status and Management

Blainville's beaked whale is protected under the MMPA and is not listed pursuant to the ESA. Although little is known about the stock structure of this species, based on resightings and genetic analysis of individuals around the Hawaiian Islands, NMFS recognizes a Hawaiian stock of Blainville's beaked whale, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). However, little is known about the stock structure of Blainville's beaked whale in the MITT Study Area.

3.4.2.28.2 Geographic Range and Distribution

Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales within the *Mesoplodon* genus (MacLeod et al. 2006; Jefferson et al. 2008), and occur in temperate and tropical waters of all oceans (Jefferson et al. 1993; Jefferson et al. 2008). Blainville's beaked whales are found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific and in the eastern south Pacific (Mead 1989; Pastene et al. 1990; Leslie et al. 2005; MacLeod and Mitchell 2006;). In the eastern Pacific, where there are about a half-dozen *Mesoplodon* species known, Blainville's beaked whale is second only to the pygmy beaked whale (*Mesoplodon peruvianus*) in abundance in tropical waters (Wade and Gerrodette 1993). In waters of the western Pacific, Blainville's beaked whale is probably the most common and abundant tropical species of *Mesoplodon* (Jefferson et al. 2008). Studies suggest that some beaked whale species (Blainville's beaked whales, Cuvier's beaked whales, and northern bottlenose whales) may show long-term site fidelity in certain areas (Hooker et al. 2002; McSweeney et al. 2007).

There were two *Mesopolodon* 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 small boat surveys off Rota on 3 June 2012, two to three unidentified *Mesoplodon* whales were seen off the southwest tip of the island in 3,385 ft. (1,032 m) deep water (Hill et al. 2013).

3.4.2.28.3 Population and Abundance

There are no abundance estimates for Blainville's beaked whales in the Study Area.

3.4.2.28.4 Predator-Prey Interactions

This species preys on squid and possibly deepwater fish. Like other *Mesoplodon* species, Blainville's beaked whales apparently use suction for feeding (Werth 2006a,b; Jefferson et al. 2008; Arranz et al. 2011).

This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation like other whale species.

3.4.2.28.5 Species-Specific Threats

Blainville's beaked whales have been shown to react to anthropogenic noise by avoidance (Tyack et al. 2011). In response to a simulated sonar signal and pseudorandom noise (a signal of pulsed sounds that are generated in a random pattern), a tagged whale ceased foraging at depth and slowly moved away from the source while gradually ascending toward the surface (Tyack et al. 2011). Additionally, Blainville's beaked whales are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.29 Longman's Beaked Whale (*Indopacetus pacificus*)

3.4.2.29.1 Status and Management

Longman's beaked whale is protected under the MMPA and is not listed pursuant to the ESA. Longman's beaked whale is a rare beaked whale species and, until recently, was considered to be the world's rarest cetacean; the spade-toothed whale now holds that position (Dalebout et al. 2003; Pitman 2008; Thompson et al. 2012). NMFS identifies only one Pacific stock, the Hawaiian stock, which includes animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2013). Little is known about the stock structure of Longman's beaked whale in the MITT Study Area.

3.4.2.29.2 Geographic Range and Distribution

Longman's beaked whale generally is found in warm tropical waters, with most sightings occurring in waters with sea surface temperatures warmer than 79°F (26°C) (Anderson et al. 2006; MacLeod et al. 2006). Longman's beaked whale is not as rare as previously thought but is not as common as the Cuvier's and *Mesoplodon* beaked whales (Ferguson and Barlow 2001). 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. 2002; Dalebout et al. 2003; Moore 1972). Ferguson and Barlow (2001) reported that all Longman's beaked whale sightings were south of 25°N.

Records of this species indicate presence in the eastern, central, and western Pacific, including waters off the coast of Mexico. Worldwide, Longman's beaked whales normally inhabit continental slope and deep oceanic waters (greater than 655 ft. [200 m]), and are only occasionally reported in waters over the continental shelf (Waring et al. 2001; Cañadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006; Pitman 2008). There were no sightings of Longman's beaked whale during the 2007 survey of the Study Area (Fulling et al. 2011).

3.4.2.29.3 Population and Abundance

There are no abundance estimates available for Longman's beaked whales in the Study Area.

3.4.2.29.4 Predator-Prey Interactions

Based on recent tagging data from Cuvier's and Blainville's beaked whales, Baird et al. (2005) suggested that Longman's beaked whale might feed at mid-water rather than only at or near the bottom (Heyning 1989; MacLeod et al. 2003).

This species has not been documented to be prey to any other species, although it is likely subject to occasional killer whale predation like other whale species.

3.4.2.29.5 Species-Specific Threats

In general, beaked whales may be more vulnerable to acoustic impacts (Frantzis et al. 2002; Southall et al. 2012a). Additionally, Longman's beaked whales are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. Debris ingestion could be a concern, although the volume of plastic debris found in the stomachs of two stranded Longman's beaked whales was not sufficient to be the cause of death (Yamada et al. 2012). Morbillivirus infection in a subadult male stranded in Hawaii has been confirmed (West et al. 2012). See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.2.30 Ginkgo-Toothed Beaked Whale (*Mesoplodon ginkgodens*)

Due to the similarities between the species, the ginkgo-toothed beaked whale may be virtually indistinguishable at sea from other *Mesoplodon* species. Species identification is generally restricted to strandings as a result of a lack of obvious morphological differences between beaked whale species. Adult males can be identified by their distinctively ginkgo leaf-shaped teeth, but females and juveniles are almost impossible to identify by species (MacLeod et al. 2006; Dalebout et al. 2012; Moore and Barlow 2013). Passive acoustic monitoring has been used to distinguish beaked whale species by their echolocation calls (Baumann-Pickering et al. 2012). Visual sightings combined with the acoustic data enable researchers to characterize the whale’s call (e.g., by frequency, amplitude, and duration) for subsequent use in identifying the presence of the species solely by acoustic monitoring.

3.4.2.30.1 Status and Management

The ginkgo-toothed beaked whale is protected under the MMPA and is not listed pursuant to the ESA. Due to the difficulty in distinguishing the different *Mesoplodon* species from one another, the ginkgo-toothed beaked whale has been combined with other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al. 2013). The ginkgo-toothed whale is known only from strandings in tropical waters of the Pacific and Indian Oceans (Mead 1989; Palacios and Mate 1996), and there are no occurrence records for this species in the Study Area. However, this area is within the known distribution range for this species (Taylor et al. 2008).

3.4.2.30.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep ocean waters (greater than 655 ft. [200 m]) and are only occasionally reported in waters over the continental shelf (Waring et al. 2001; Cañadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006; Pitman 2008). Based on stranding records in the eastern Pacific Ocean, Palacios and Mate (1996) suggested that ginkgo-toothed beaked whales may select relatively cool, upwelling-modified habitats, such as those found in the California and Peru Currents and along the equatorial front. This species probably occurs only in the temperate and tropical waters of the Indo-Pacific; however, no specific information regarding migration is available (Jefferson et al. 2008; MacLeod and D'Amico 2006). Analysis of passive acoustic monitoring data collected off of Saipan identified calls that most likely come from ginkgo-toothed beaked whales, which are known to occur in the region from visual sightings (Baumann-Pickering et al. 2012). A species of beaked whale previously grouped with ginkgo-toothed beaked whales, *M. hotaula*, has been identified through visual observation and passive acoustic monitoring near Palmyra Atoll; however, there is no indication that this species occurs in the Study Area (Baumann-Pickering et al. 2012; Dalebout et al. 2014).

3.4.2.30.3 Population and Abundance

There are no abundance estimates available for ginkgo-toothed beaked whales in the Study Area.

3.4.2.30.4 Predator-Prey Interactions

Studies indicate that 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 1989; Heyning and Mead 1996; MacLeod et al. 2003). They can dive up to 6,562 ft. (2,000 m) and spend as much as 90 minutes submerged while vocalizing underwater for navigation, prey detection, and potentially communication (Klinck et al. 2012). However feeding may also occur at mid-water rather than only at or near the bottom as shown from tagging data on Cuvier's and Blainville's beaked whales (Baird et al. 2004). This may also be the case with this species. Although no published stomach content analysis is available, ginkgo-toothed beaked whales presumably prey on squid and possibly fish, similar to other *Mesoplodon* species. These species occupy an ecological niche distinct from Cuvier's beaked whales by feeding on smaller squids, allowing the different beaked whale species to coexist (MacLeod et al. 2003; MacLeod 2005).

Ginkgo-toothed beaked whales have not been documented to be prey to any other species, although they are likely subject to occasional killer whale predation like other whale species.

3.4.2.30.5 Species-Specific Threats

In general, beaked whales may be more vulnerable to acoustic impacts (Frantzis et al. 2002; Southall et al. 2012a). Additionally, ginkgo-toothed beaked whales are susceptible to entanglement and other interactions with fishery operations (Carretta et al. 2011), although there are no specific data available for this species in the Study Area. See Section 3.4.2.4 (General Threats) for a general discussion of threats to marine mammals.

3.4.3 ENVIRONMENTAL CONSEQUENCES

This section evaluates how and to what degree the activities described in Chapter 2 (Description of Proposed Action and Alternatives), potentially impact marine mammals known to occur within the Study Area. Tables 2.8-1 to 2.8-4 present the baseline and proposed typical training and testing activity locations for each alternative (including number of events and ordnance expended). The stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors applicable to marine mammals in the Study Area that are analyzed below include the following:

- Acoustic (sonar and other active acoustic sources; explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise)
- Energy (electromagnetic devices)
- Physical Disturbance and Strike (vessels, in-water devices, military expended materials, and seafloor devices)
- Entanglement (fiber optic cables and guidance wires, and decelerators/parachutes)
- Ingestion (munitions and military expended materials other than munitions)
- Secondary (impacts associated with sediments and water quality).

In this analysis, marine mammal species are grouped together based on similar biology (such as hearing) or behaviors (such as feeding or expected reaction to stressors) when most appropriate for the discussion. In addition, for some stressors, species are grouped based on their taxonomic relationship with discussion first of mysticetes (baleen whales), followed by odontocetes (toothed whales).

When impacts are expected to be similar to all species or when it is determined there is no impact to any species, the discussion will be general and not species-specific. However, when impacts are not the same to certain species or groups of species, the discussion will be as specific as the best available data allow. In addition, if activities only occur in or will be concentrated in certain areas, the discussion will be geographically specific. Based on acoustic thresholds and criteria developed with NMFS, impacts from sound sources as stressors will be quantified at the species or stock level as is required pursuant to authorization of the proposed actions under the MMPA.

In cases where potential impacts rise to the level that warrants mitigation, mitigation measures designed to minimize the potential impacts are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). In addition to the measures presented, additional and/or different mitigations may subsequently be implemented in coordination with NMFS resulting from the MMPA authorization and ESA consultation processes.

3.4.3.1 Acoustic Stressors

3.4.3.1.1 Non-Impulse and Impulse Sound Sources

Long recognized by the scientific community (Payne and Web 1971), and summarized by the National Academies of Science, anthropogenic sound could possibly harm marine mammals or significantly interfere with their normal activities (National Research Council 2005). 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 sound, 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, defense, 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). Furthermore, many other factors besides just the received level of sound may affect an animal's reaction, such as the animal's physical condition, prior experience with the sound, and proximity to the source of the sound.

As discussed in Section 3.0.4 (Acoustic and Explosives Primer) sounds may be broadly categorized as impulse or non-impulse. Impulse sounds feature a very rapid increase to high pressures, followed by a rapid return to the static pressure. Explosives and airgun detonations are examples of impulse sound sources analyzed in this document. Non-impulse sounds lack the rapid rise time and can have longer durations than impulse sounds. Non-impulse sound can be continuous or intermittent. Sonar pings, vessel noise, and underwater transponders are all examples of non-impulse sound sources analyzed in this document.

The methods used to predict acoustic effects to marine mammals build on Appendix H (Biological Resource Methods). Additional research specific to marine mammals is presented where available.

3.4.3.1.2 Analysis Background and Framework

3.4.3.1.2.1 Direct Injury

The potential for direct injury in marine mammals has been inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973; Ketten et al. 1993). Additionally, non-injurious effects on marine mammals (e.g., temporary threshold shift [TTS]) are extrapolated to injurious effects (e.g., permanent threshold shift [PTS]) based on data from terrestrial mammals to derive the criteria serving as the potential for injury (Southall et al. 2007). Actual effects on marine mammals may differ from terrestrial animals due to anatomical and physiological adaptations to the marine environment, for example, some characteristics such as a reinforced trachea and flexible thoracic cavity (Ridgway and Dailey 1972) may or may not decrease the risk of lung injury.

Potential direct injury from non-impulse sound sources, such as sonar, is unlikely due to relatively lower peak pressures and slower rise times than potentially injurious impulse sources such as explosives. Although there have been strandings associated with use of sonar, as Ketten (2012) has observed, "to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result anthropogenic sound exposures, including sonar." Non-impulse sources also lack the strong shock wave such as that associated with an explosion. Therefore, primary blast injury and barotraumas (i.e., injuries caused by large pressure changes; discussed below) would not occur due to exposure to non-impulse sources such as sonar. The theories of sonar-induced acoustic resonance and bubble formation are discussed below, although these phenomena are difficult to recreate in the natural environment under real-world conditions and are therefore unlikely to occur. The Navy has prepared a technical report presenting specific information on marine mammal stranding events that may have been associated with U.S. Navy activities (U.S. Department of the Navy 2012). The report discusses both natural and anthropogenic stimuli that may contribute to marine mammal strandings. Stranding is also discussed in Section 3.4.3.1.2.8 (Stranding) in this EIS/OEIS.

Primary Blast Injury and Barotraumas

The greatest potential for direct, non-auditory tissue effects is primary blast injury and barotraumas after exposure to high amplitude impulse sources, such as explosives. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to a blast wave. Primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the auditory system (Phillips and Richmond 1990; Craig and Hearn 1998; Craig Jr. 2001). Barotraumas refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of pulmonary contusions, pneumothorax, pneumomediastinum, traumatic lung cysts, or interstitial or subcutaneous emphysema (Phillips and Richmond 1990). These injuries may be fatal depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air emboli that can cause a cerebral infarct or heart attack by restricting oxygen delivery to these organs. Though often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer contusions and lacerations from blast exposure, particularly in air-containing regions of the tract. Potential traumas include hematoma, bowel perforation, mesenteric tears, and ruptures of the hollow abdominal viscera. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered.

The only known occurrence of mortality or injury to a marine mammal due to a Navy training or testing event involving impulse sources (use of underwater explosives) occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex (SSTC). This area has been used for underwater demolitions training for at least three decades without incident. On this occasion, however, a group of long-beaked common dolphins entered the mitigation zone and approximately 1 minute after detonation, three animals were observed dead at the surface; a fourth animal was discovered stranded dead approximately 42 mi. (68 km) to the north of the detonation site 3 days later. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Leger 2011). See Section 3.4.3.1.2.8 (Stranding), and U.S. Department of the Navy (2012) for more information on this topic.

Auditory Trauma

Relatively little is known about auditory system trauma in marine mammals resulting from a known sound exposure. A single study spatially and temporally correlated the occurrence of auditory system trauma in humpback whales with the detonation of a 5,000 kg (11,023-pound [lb.]) explosive (Ketten et al. 1993). The exact magnitude of the exposure in this study cannot be determined, but it is likely the trauma was caused by the shock wave produced by the explosion. There are no known occurrences of direct auditory trauma in marine mammals exposed to tactical sonar or other non-impulse sound sources (Ketten 2012). The potential for auditory trauma in marine mammals exposed to impulse sources (e.g., explosives) is inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973; Ketten et al. 1993).

Acoustic Resonance

Acoustic resonance has been proposed as a hypothesis suggesting that acoustically induced vibrations (sound) from sonar or sources with similar operating characteristics could be damaging tissues of marine mammals. In 2002, NMFS convened a panel of government and private scientists to consider the hypothesis of mid-frequency sonar-induced resonance of gas-containing structures (i.e., lungs) (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 (U.S. Department of Defense 2001; U.S. Department of the Navy 2012). The conclusions of that group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding (National Oceanic and Atmospheric Administration 2002). The frequencies at which resonance was predicted to occur in uncollapsed lungs were below 50 Hz—well below the frequencies utilized 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 worst-case scenario in which air volumes would be undamped by surrounding tissues and the amplitude of the resonant response would be maximal. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance is not likely under realistic conditions during training and testing activities, and this type of impact is not considered further in this analysis.

Bubble Formation (Acoustically Induced)

A suggested cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a 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, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs, (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. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based upon what is known about the specific process involved. Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard 1979). The dive patterns of some marine mammals (e.g., beaked whales) are theoretically predicted to induce greater supersaturation (Houser et al. 2001a, b). If surface intervals between dives are short, there is insufficient time to clear nitrogen in tissues accumulated due to pressures experienced while diving. Subsequent dives can increase tissue nitrogen accumulation, leading to greater levels of nitrogen saturation at each ascent. 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 (e.g., nausea, disorientation, localized pain, breathing problems).

It is unlikely that the short duration of sonar or explosive sounds 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 the tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough period of time for bubbles to become a problematic size. Recent research with *ex vivo* supersaturated bovine tissues suggested that for a 37 kHz signal, a sound exposure level of approximately 215 dB re 1 µPa would be required before microbubbles became destabilized and grew (Crum et al. 2005). Assuming spherical spreading loss and a nominal sonar source level of 235 dB re 1 µPa, a whale would need to be within 10 yards (yd.) (10 m) of the sonar dome to be exposed to such sound levels. Furthermore, tissues in the study were supersaturated by exposing them to pressures of 400–700 kilopascals for periods of hours and then releasing them to ambient pressures. Assuming the equilibration of gases with the tissues occurred when the tissues were exposed to the high pressures, levels of supersaturation in the tissues could have been as high as 400–700 percent. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al. 2001a, b; Saunders et al. 2008). It is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings. Both the degree of supersaturation and exposure levels observed to cause microbubble destabilization are unlikely to occur, either alone or in concert (Kvadsheim et al. 2012).

There is considerable disagreement among scientists as to the likelihood of this phenomenon (Piantadosi and Thalmann 2004; Evans and Miller 2003). Although it has been argued that traumas from recent 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 (Moore et al. 2009; Dennison et al. 2011; Bernaldo de Quiros et al. 2012). Prior experimental work has also demonstrated the post-mortem presence of bubbles following decompression in laboratory animals can occur as a result of invasive investigative procedures (Stock et al. 1980). Additional discussion on stranding is also provided in Section 3.4.3.1.2.8 (Stranding) in this EIS/OEIS and in U.S. Department of the Navy (2012).

3.4.3.1.2.2 Nitrogen Decompression

Although not a direct injury, variations in marine mammal diving behavior or avoidance responses could possibly result in nitrogen tissue supersaturation and nitrogen off-gassing, possibly to the point of deleterious vascular and tissue bubble formation (Jepson et al. 2003; Saunders et al. 2008; Hooker et al. 2012); nitrogen off-gassing occurring in human divers is called decompression sickness. The mechanism for bubble formation from saturated tissues would be indirect and also different from rectified diffusion, but the effects would be similar. Although hypothetical, the potential process is under debate in the scientific community (Saunders et al. 2008; Hooker et al. 2012). The hypothesis speculates 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 (Jepson et al. 2003; Fernández et al. 2005; Hooker et al. 2012). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation.

Previous 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 and Tyack 2007). Tyack et al. (2006) suggested that emboli observed in animals exposed to mid-frequency active (MFA) sonar (Jepson et al. 2003; Fernández 2005) could stem instead from a behavioral response that involves repeated dives, shallower than the depth of lung collapse. A bottlenose dolphin was trained to repetitively dive to specific depths to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser et al. 2010).

More recently, 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 (e.g., fat, bone lipid) to the point that they are supersaturated when the animals are at the surface (Hooker et al. 2009). 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 has been demonstrated in by-catch animals drowned at depth and brought to the surface (Moore et al. 2009). Since bubble formation is facilitated by compromised blood flow, it has been suggested that rapid stranding may lead to bubble formation in animals with supersaturated, long-halftime tissues because of the stress of stranding and the cardiovascular collapse that can accompany it (Houser et al. 2009). Additional discussion on stranding is also provided in Section 3.4.3.1.2.8 (Stranding) in this EIS/OEIS and in U.S. Department of the Navy (2012).

A fat embolic syndrome 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. Recently, Dennison et al. (2011) reported on investigations of dolphins stranded in 2009–2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of 22 live-stranded dolphins and in the livers of 2 of the 22 animals. The authors postulated that stranded animals are unable to recompress by diving, and thus may retain bubbles that are otherwise re-absorbed in animals that can continue to dive. The researchers concluded that the minor bubble formation observed can be tolerated since the majority of stranded dolphins released did not re-strand (Dennison et al. 2011). Recent modeling by Kvadsheim et al. (2012) determined that while behavioral and physiological responses to sonar have the potential to result in bubble formation, the actually observed behavioral responses of cetaceans to sonar did not imply any significantly increased risk over what may otherwise occur normally in individual marine mammals. As a result of these recent findings and for purposes of this analysis, the potential for acoustically mediated bubble growth and the potential for bubble formation as a result of behavioral-altered-dive profiles are not addressed further.

3.4.3.1.2.3 Hearing Loss

The most familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. The meaning of the term “hearing loss” does not equate to “deafness.” The phenomenon associated with hearing loss is called a noise-induced threshold shift, or simply a threshold shift (Miller 1994). If high-intensity sound over stimulates tissues in the ear, causing a threshold shift, the impacted area of the ear (associated with and limited by the sound’s frequency band) no longer provides the same auditory impulses to the brain as before the exposure (Ketten 2012). The distinction between PTS and TTS is based on whether there is a complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (the threshold returns to the pre-exposure value), the threshold shift is a TTS.

For temporary threshold shift, full recovery of the hearing loss (to the pre-exposure threshold) has been determined from studies of marine mammals, and this recovery occurs within minutes to hours for the small amounts of TTS that have been experimentally induced (Nachtigall et al. 2004; Finneran et al. 2010a). The recovery time is related to the exposure duration, sound exposure level, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005; Mooney et al. 2009a, b; Finneran et al. 2010a). In some cases, threshold shifts as large as 50 dB (loss in sensitivity) have been temporary, although recovery sometimes required as much as 30 days (Ketten 2012). 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. Again, for clarity, PTS, as discussed in this document, is not the loss of hearing, but instead is the loss of hearing sensitivity over a particular range of frequencies. Figure 3.4-1 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. The actual amount of threshold shift depends on the amplitude, duration, frequency, temporal pattern of the sound exposure, and on the susceptibility of the individual animal.

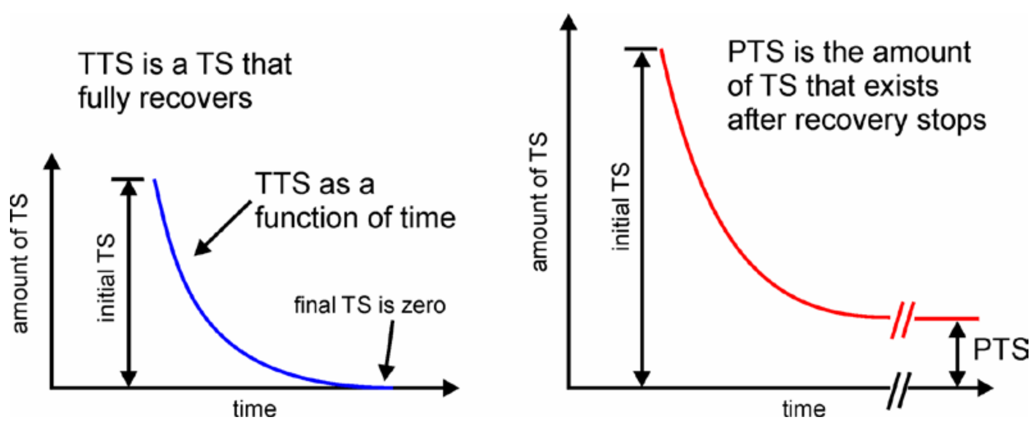

Figure 3.4-1: Two Hypothetical Threshold Shifts, Temporary and Permanent

Both auditory trauma and auditory fatigue may result in hearing loss. Many are familiar with hearing protection devices (e.g., ear plugs) required in many occupational settings where pervasive noise could otherwise cause auditory fatigue and possibly result in hearing loss. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic fatigue and exhaustion of the hair cells and cochlear tissues. Note that the term “auditory fatigue” is often used to mean “temporary threshold shift”; however, in this EIS/OEIS, a more general meaning is used to differentiate fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) from trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure).

Hearing loss, or auditory fatigue, in marine mammals has been studied extensively for many years by a number of investigators (Schlundt et al. 2000; Finneran et al. 2000, 2002, 2005, 2007, 2010a, 2010b; Nachtigall et al. 2003, 2004; Mooney et al. 2009a, 2009b; Kastak et al. 2007; Lucke et al. 2009; Ketten 2012; Kastelein et al. 2012a, 2012b, 2014a, 2014b; Finneran and Schlundt 2013; Popov et al. 2011, 2013). The studies of marine mammal auditory fatigue were all designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency. In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicated the amount of TTS. Species studied include the bottlenose dolphin (total of nine individuals), beluga (two), harbor porpoise (one), finless porpoise (two), California sea lion (three), harbor seal (one), and Northern elephant seal (one). Some of the more important data obtained from these studies are onset-TTS levels—exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (for example, Schlundt et al. 2000).

The primary findings of the marine mammal TTS studies are:

- The growth and recovery of TTS are analogous to those in terrestrial mammals. This means that, as in terrestrial mammals, threshold shifts primarily depend on the amplitude, duration, frequency content, and temporal pattern of the sound exposure.
- The amount of TTS increases with sound pressure level and the exposure duration.
- For continuous sounds, exposures of equal energy lead to approximately equal effects (Ward 1997). For intermittent sounds, less hearing loss occurs than from a continuous exposure with the same energy (some recovery will occur during the quiet period between exposures) (Kryter et al. 1965, Ward 1997; Kastelein et al. 2014a). Ward (1997) studied the effects of noise on humans, and Kryter et al. (1965) analyzed research conducted on the hearing sensitivity of humans.
- Sound exposure level is correlated with the amount of TTS and is a good predictor for onset-TTS from single, continuous exposures with similar durations. This agrees with human TTS data presented by Ward et al. (1958, 1959). However, for longer duration sounds—beyond 16–32 seconds—the relationship between TTS and sound exposure level breaks down and duration becomes a more important contributor to TTS (Finneran et al. 2010a). Ward et al. (1958, 1959) conducted studies using human subjects. Finneran et al. (2010a) studied the hearing sensitivity of marine mammals (Finneran and Schlundt 2010). Still, for a wide range of exposure durations, sound exposure level correlates reasonably well to TTS growth (Popov et al. 2014).
- The maximum TTS after tonal exposures occurs one-half–one octave above the exposure frequency (Finneran et al. 2007; Schlundt et al. 2000). TTS from tonal exposures can thus extend over a large (greater than one octave) frequency range. Finneran et al. (2007) and Schlundt et al. (2000) conducted studies on marine mammals.
- For bottlenose dolphins, non-impulse sounds with frequencies above 10 kHz have a greater potential for impact than those at lower frequencies (i.e., hearing is affected at lower sound exposure levels for frequencies above 10 kHz) (Finneran et al. 2010b, Finneran and Schlundt 2013).

- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic. The amount of 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., 40 dB) require several days for recovery.
- TTS can accumulate across multiple intermittent exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same sound exposure level. This means that predictions based on total, cumulative sound exposure level (such as the predictions made in this analysis) will overestimate the amount of TTS from intermittent exposures.

Although there have been no marine mammal studies designed to measure PTS, the potential for PTS in marine mammals can be estimated based on known similarities between the inner ears of marine and terrestrial mammals. Experiments with marine mammals have revealed their similarities with terrestrial mammals with respect to features such as TTS, age-related hearing loss (called Presbycusis), ototoxic drug-induced hearing loss, masking, and frequency selectivity (Southall et al. 2007). Therefore, in the absence of marine mammal PTS data, onset-PTS exposure levels may be estimated by assuming some upper limit of TTS that equates the onset of PTS, then using TTS growth relationships from marine and terrestrial mammals to determine the exposure levels capable of producing this amount of TTS (Southall et al. 2007).

Hearing loss resulting from auditory fatigue could effectively reduce the distance over which animals can communicate, detect biologically relevant sounds such as predators, and echolocate (for odontocetes). The costs to marine mammals with TTS, or even some degree of PTS, have not been studied; however, it is likely that a relationship between the duration, magnitude, and frequency range of hearing loss could have consequences to biologically important activities (e.g., intraspecific communication, foraging, and predator detection) that affect survivability and reproduction.

3.4.3.1.2.4 Auditory Masking

As with hearing loss, auditory masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may or may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone.

Detections of signals under varying masking conditions have been determined for active echolocation and passive listening tasks in odontocetes (Johnson 1971; Au and Pawloski 1989; Erbe 2000; Branstetter et al 2013). These studies provide baseline information from which the probability of masking can be estimated.

Clark et al. (2009) developed a methodology for estimating masking effects on communication signals for low-frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that in Stellwagen Bank National Marine Sanctuary, when two commercial vessels pass through a North Atlantic right whale's optimal communication space (estimated as a sphere of water with a diameter of 12 mi. [20 km]), that space is decreased by 84 percent. This methodology relies on empirical data on source levels of calls (which is unknown for many species), and requires many assumptions about ancient ambient noise conditions and simplifications of animal behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Subsequent research on North Atlantic right whales at Stellwagen Bank National Marine

Sanctuary estimated that an average of 63–67 percent of their communication space has been reduced by an increase in ambient noise levels, and that noise associated with transiting vessels is a major contributor to the increase (Hatch et al. 2012).

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. Changes to vocal behavior and call structure may result from a need to compensate for an increase in background noise. In cetaceans, vocalization changes have been reported from exposure to anthropogenic sources such as sonar, vessel noise, and seismic surveying (Gordon et al. 2003; Rolland et al. 2012) as well as changes in the natural acoustic environment (Dunlop et al. 2014).

In the presence of low-frequency active sonar, humpback whales have been observed to increase the length of their “songs” (Miller et al. 2000; Fristrup et al. 2003), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar. North Atlantic right whales have been 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; Rolland et al. 2012) as well as increasing the amplitude (intensity) of their calls (Parks 2009; Parks et al. 2010). In contrast, both sperm and pilot whales possibly ceased sound production during the Heard Island feasibility test (Bowles et al. 1994), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Differential vocal responding in marine mammals has been documented in the presence of seismic survey sound. An overall decrease in vocalization during active surveying has been noted in large marine mammal groups (Potter et al. 2007), while detection of blue whale feeding/social calls increased when seismic exploration was underway (Di Iorio and Clark 2010), indicative of a potentially compensatory response to the increased sound level. Melcón et al. (2012) recently documented that blue whales decreased the proportion of time spent producing certain types of calls when mid-frequency sonar was present.

Evidence suggests that some marine mammals have the ability to acoustically identify potential predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for attending to and responding to all killer whale calls. The occurrence of masking or hearing impairment provides a means by which marine mammals may be prevented from responding to the acoustic cues produced by their predators. Whether or not this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

3.4.3.1.2.5 Physiological Stress

Marine mammals 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, and interactions with predators all contribute to the stress a marine mammal experiences. In some cases, naturally occurring stressors can have profound impacts on marine mammals, resulting in physiological or behavioral responses (see next section for discussion on behavioral responses). For example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), has been demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006).

Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. Marine mammals may exhibit a physiological or behavioral response (or a combination of responses) upon exposure to an anthropogenic stressor (e.g., sound). If a sound is detected by a marine mammal, a stress response (e.g., startle or annoyance) or a cueing response based on a past stressful experience can occur. Although preliminary because of the small number of samples collected, different types of sounds have been shown to produce variable stress responses in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of acute stress) response to the playback of oil drilling sounds (Thomas et al. 1990) but showed an increase in catecholamines following exposure to impulse 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 an elevation in aldosterone, a hormone that has been suggested as being a significant indicator of stress in odontocetes (St. Aubin and Geraci 1989; St. Aubin and Dierauf 2001). Increases in heart rate were observed in bottlenose dolphins to which conspecific calls were played, although no increase in heart rate was observed when tank noise was played back (Miksis et al. 2001). Collectively, these results suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal.

Other types of stressors include the presence of vessels, fishery interactions, acts of pursuit and capture, the act of stranding, and pollution. In contrast to the limited amount of work performed on stress responses resulting from sound exposure, a considerably larger body of work exists on stress responses associated with pursuit, capture, handling and stranding. Many cetaceans exhibit an apparent vulnerability in the face of these particular situations when taken to the extreme. One study compared pathological changes in organs/tissues of odontocetes stranded on beaches or captured in nets over a 40-year period (Cowan and Curry 2008). The type of changes observed indicate multisystemic harm caused in part by an overload of catecholamines into the system, as well as a restriction in blood supply capable of causing tissue damage and tissue death. This extreme response to a major stressor (or multiple stressors) is thought to be mediated by the overactivation of the animal's normal physiological adaptations to diving or escape.

Pursuit, capture and short-term holding of belugas have been observed to result in a decrease in thyroid hormones (St. Aubin and Geraci 1988) and increases in epinephrine (a catecholamine) (St. Aubin and Dierauf 2001). In dolphins, the duration of handling time potentially contributes to the magnitude of the stress response (St. Aubin et al. 1996; Ortiz and Worthy 2000; St. Aubin 2002). Male grey seals subjected to capture and short-term restraint showed an increase in cortisol levels accompanied by an increase in testosterone (Lidgard et al. 2008). This result may be indicative of a compensatory response that enables the seal to maintain reproduction capability in spite of stress. Elephant seals demonstrate an acute cortisol response to handling, but do not demonstrate a chronic response; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al. 2002). Similarly, no correlation between cortisol levels and heart/respiration rate changes were seen in harbor porpoises during handling for satellite tagging (Eskesen et al. 2009). These studies illustrate the wide variations in the level of response that can occur when animals are faced with these stressors, and strongly suggest that marine mammals can acclimate to handling and perhaps other stressors.

Factors to consider when trying to predict a stress or cueing response include the mammal's life history stage and whether they are naïve or experienced with the sound. Prior experience with a stressor may be of particular importance, because repeated experience with a stressor may reduce the stress response via habituation (St. Aubin and Dierauf 2001; Bejder et al. 2009).

The sound characteristics that correlate with specific stress responses in marine mammals are poorly understood. Therefore, in practice, a stress response is assumed if a physiological reaction such as a hearing loss or trauma is predicted; or if a significant behavioral response is predicted.

3.4.3.1.2.6 Behavioral Responses

The response of a marine mammal to an anthropogenic sound will depend on the frequency, duration, and temporal pattern and amplitude of the sound, as well as the animal's prior experience with the sound. The context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure) and the animal's internal physiological state and repertoire of species-typical responses also determine the type of behavioral response that may be exhibited by the animal.

The distance from the sound source and whether it is perceived as approaching or moving away can 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 and others (Richardson 1995). More recent reviews (Nowacek et al. 2007; Southall et al. 2007) address studies conducted since 1995 and focus on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated.

Except for some vocalization changes that may be compensating for auditory masking, all behavioral reactions are assumed to occur due to a preceding stress or cueing response; however, stress responses cannot be predicted directly due to a lack of scientific data (see preceding section on Physiological Stress). Responses can overlap; for example, an increased respiration rate is likely to be coupled to a flight response. Differential responses between and within species are expected since hearing ranges vary across species and the behavioral ecology of individual species is unlikely to completely overlap.

Southall et al. (2007) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. While 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). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response. Nonetheless, in some conditions consistent avoidance reactions were noted at higher sound levels dependent on the marine mammal species or group, allowing conclusions to be drawn. Most low-frequency cetaceans (mysticetes) observed in studies usually avoided sound sources at levels of less than or equal to 160 dB re 1 µPa (Southall et al. 2007). Published studies of mid-frequency cetaceans analyzed include sperm whales, belugas, bottlenose dolphins, and river dolphins. These groups showed no clear tendency, but for non-impulse sounds, captive animals tolerated levels in excess of 170 dB re 1 µPa before showing behavioral reactions, such as avoidance, erratic swimming, and attacking the test apparatus. High-frequency cetaceans (observed from studies with harbor porpoises) exhibited changes in respiration and avoidance behavior at levels between 90 and 140 dB re 1 µPa, with profound avoidance behavior noted for levels exceeding this. Recent studies with beaked whales have shown them to be particularly sensitive to noise, with animals during three playbacks of sound breaking off foraging dives at levels below 142 dB re 1 µPa, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at levels up to 157 dB re 1 µPa (Tyack et al. 2011). Passive acoustic monitoring of beaked whales, classified as Blainville's beaked whales and Cross-seamount type beaked whales, at the Pacific Missile Rage Facility (PMRF) showed statistically significant differences in dive rates, diel occurrence patterns, and spatial distribution of dives after the initiation of a training event. However, for the beaked whale dives that continued to occur during mid-frequency active sonar (MFAS) activity, differences from normal dive profiles and click rates were not detected with estimated received levels up to 137 decibels references to 1 micropascal (dB re 1 µPa) while the animals were at depth during their dives (Manzano-Roth et al. 2013).

Behavioral Responses to Impulse Sound Sources

Mysticetes

Baleen whales have shown a variety of responses to impulse sound sources (e.g., explosives), including avoidance, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Southall et al. 2007; Richardson 1995; Gordon et al. 2003). While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson 1995), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 µPa root mean square (rms). Additionally, Malme et al. (1988) observed clear changes in diving and respiration patterns in bowheads at ranges up to 39 nm from seismic vessels, with received levels as low as 125 dB re 1 µPa. Behavioral responses in bowheads in the presence of seismic surveys has been shown to be varied and dependent on a number of other factors influencing behavior, including the activity the whale is engaged in at the time (e.g., foraging, traveling, socializing), season, and whether or not calves are present during the exposure (Robertson et al. 2013).

Humpback whales showed avoidance behavior at ranges of 3–5 nm from a seismic array during observational studies and controlled exposure experiments in western Australia (McCauley 1998). 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 and a shift to a higher incidence of net entanglement closer to the noise source. Seismic airgun surveys conducted off of the Angolan coast over a 10-month period did not significantly reduce sightings of humpback whales in the area. Furthermore, the distance from the ship to observed humpbacks was not significantly different when the airgun was in use compared to when it was not in use (Weir 2008). Some humpbacks were observed approaching the survey vessel while the airgun was in use. This suggests that the low-frequency, impulse sounds may be mistaken by male humpbacks for breaches, tail flips, and other similar sounds produced by competitors during the breeding season.

Gray whales migrating along the U.S. west coast showed avoidance responses to seismic vessels by 10 percent of animals at 164 dB re 1 µPa, and by 90 percent of animals at 190 dB re 1 µPa, with similar results for whales in the Bering Sea (Malme et al. 1986, 1988). In contrast, sound from seismic surveys was not found to impact feeding behavior or exhalation rates while resting or diving in western gray whales off the coast of Russia (Yazvenko et al. 2007; Gailey et al. 2007).

Seismic pulses at average received levels of 131 dB re 1 micropascal squared second (μPa^2-s) caused blue whales to increase call production (Di Iorio and Clark 2010). In contrast, 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 5 nm from the seismic vessel (estimated received level 143 dB re 1 µPa peak-to-peak). These studies demonstrate that even low levels of sound received far from the sound source can induce behavioral responses.

Odontocetes

Madsen et al. (2006) and Miller et al. (2009a) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys in a controlled experiment. Sound sources were from approximately 2–7 nm away from the whales, and based on multipath propagation; received levels were as high as 162 dB SPL re 1 µPa with energy content greatest between 0.3 and 3.0 kHz (Madsen et al. 2006). The whales showed no horizontal avoidance, although the whale that was approached most closely had an extended resting period and did not resume foraging until the airguns had ceased firing (Miller et al. 2009). The remaining whales continued to execute foraging dives throughout exposure; however, swimming movements during foraging dives were 6 percent lower during exposure than control periods, suggesting subtle effects of sound on foraging behavior (Miller et al. 2009).

Weir (2008) observed that seismic airgun surveys along the Angolan coast did not significantly reduce the encounter rate of sperm whales during the 10-month survey period. Neither were avoidance behaviors to airgun impulse sounds observed in sperm whales. Thompson et al. (2013) showed that seismic surveys conducted over a 10 day period in the North Sea did not result in the broad-scale displacement of harbor porpoises away from preferred habitat. The harbor porpoises were observed to leave the area at the onset of survey, but returned within a few hours, and the overall response of the porpoises decreased over the 10 day period. However, Atlantic spotted dolphins did show a significant, short-term avoidance response to airgun impulses. The dolphins were observed at greater distances from the vessel when the airgun was in use, and when the airgun was not in use they readily approached the vessel to bow ride.

Captive bottlenose dolphins sometimes vocalized after an exposure to impulse sound from a seismic water gun (Finneran et al. 2002, Finneran and Schlundt 2010).

Behavioral Responses to Sonar and other Active Acoustic Sources

Mysticetes

Mysticetes have shown a variety of behavioral reactions to non-impulse sound sources (e.g., sonar). Specific to U.S. Navy systems using low-frequency sound, studies were undertaken in 1997–98 pursuant to the Navy's Low-frequency Sound Scientific Research Program. These studies found only short-term responses to low-frequency sound by mysticetes (fin, blue, and humpback) including changes in vocal activity and avoidance of the source vessel (Clark and Fristrup 2001; Miller et al. 2000; Croll et al. 2001; Fristrup et al. 2003; Nowacek et al. 2007). Baleen whales exposed to moderate low-frequency signals demonstrated no variation in foraging activity (Clark and Fristrup 2001; Croll et al. 2001). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives. The alarm signal was long, lasting several minutes, and was designed to elicit a reaction from the animals as part of a prospective tool that could be used to protect the whales from ship strikes (Nowacek et al. 2004a). Although the animal's received sound pressure level was similar in the latter two studies (133–150 dB re 1 µPa), the frequency, duration, and temporal pattern of signal presentation were different. Additionally, the right whales did not respond to playbacks of either right whale social sounds or vessel noise, highlighting the importance of the sound characteristics, species differences, and individual sensitivity in producing a behavioral reaction.

As part of the Acoustic Thermometry of Ocean Climate program, two low-frequency, underwater sound sources were deployed in phases in deepwater locations off California and Hawaii to study large-scale changes in ocean temperature and the effects of low-frequency transmissions on marine mammals. The acoustic transmissions were detected at multiple locations in the Pacific Ocean, often thousands of kilometers from the sound source. The low-frequency signals from the sound sources were not found to affect dive times of humpback whales in Hawaiian waters, (Frankel and Clark 2000). Frankel and Clark (2000) reported that while no overt behavioral responses were noted, the distance and time between successive surfacings of humpbacks increased slightly with an increase in estimated received sound level. Although the change in surfacing behavior was minor, multiple years of data from different locations and using a similar sound source show that the behavior is repeatable. Subtle effects were also observed in elephant seal dives that varied in direction and degree among the individual seals, again illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

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 (Melcón et al. 2012). It is not known whether the lower rates of calling actually indicated a reduction in feeding behavior or social contact since the study used data from remotely deployed, passive acoustic monitoring buoys. In contrast, blue whales increased their likelihood of calling when ship noise was present, and decreased their likelihood of calling in the presence of explosive noise, although this last result was not statistically significant, possibly due to the low sample size (Melcón et al. 2012). Additionally, the likelihood of an animal calling decreased with the increased received level of mid-frequency sonar, beginning at a sound pressure level of approximately 110–120 dB re 1 µPa (Melcón et al. 2012). Blue whales responded to a simulated mid-frequency sound source at received sound levels up to 160 dB re 1 µPa, by exhibiting generalized avoidance responses and changes to dive behavior during controlled exposure experiments (CCEs) (Goldbogen et al. 2013). However, reactions were not consistent across individuals based on received sound levels alone, and likely were the result of a complex interaction between sound exposure factors such as proximity to sound source and sound type (mid-frequency sonar simulation vs. pseudo-random noise), environmental conditions, and behavioral state. Surface feeding whales did not show a change in behavior during CCEs, but deep feeding and non-feeding whales showed temporary reactions that quickly abated after sound exposure. Whales were sometimes less than a mile from the sound source during the controlled exposure experiments. Furthermore, the more dramatic reactions reported by Goldbogen et al. (2013) were from non-sonar like signals, a pseudorandom noise that could likely have been a novel signal to blue whales.

In a behavioral response study conducted in Australian waters, humpback whales responded to an artificial tone by moving away from the stimulus and surfacing more often, presumably to avoid the stimulus (Dunlop et al. 2013b). The response to the tone was consistent and was dependent on received level and distance from the source. When a conspecific social sound was used as the stimulus, the response of the whales was inconsistent and depended on the social makeup of the group at the time of the stimulus. In some cases the whales approached the vessel (sound source), and, as with the tone stimulus, changes in diving and surfacing behavior were noted.

Preliminary results from the 2010 to 2011 field season of an ongoing behavioral response study in Southern California waters indicated that in some cases and at low RLs, tagged blue whales responded to mid-frequency sonar but that those responses were mild and there was a quick return to their baseline activity (Southall et al. 2012b). These preliminary findings from Melcón et al. (2012) and Goldbogen et al. 2013 are consistent with the Navy's criteria and thresholds for predicting behavioral effects to mysticetes from sonar and other active acoustic sources used in the quantitative acoustic effects analysis (see Section 3.4.3.1.2.6, Behavioral Responses). The behavioral response function predicts a probability of a substantive behavioral reaction for individuals exposed to a received sound pressure level of 120 dB re 1 µPa or greater, with an increasing probability of reaction with increased received level as demonstrated in Melcón et al. (2012). Although the long-term implications of disruption in call production to blue whale foraging and other behaviors are currently not well understood, vessel noise is much more pervasive in both time and space compared to the intermittent use of various types of sonar, including fathometers, fish-finders, research sonar, and Navy mid-frequency sonar. Understanding the impacts of vessel noise on blue whale call production is likely more of a concern given its broader implications. Further discussion of impacts from vessel noise is presented in the section “Behavioral Responses to Vessels.”

Odontocetes

From 2007 to the present, behavioral response studies were conducted through the collaboration of various research organizations in the Bahamas, Southern California, the Mediterranean, Cape Hatteras, and Norwegian waters (DeRuiter et al. 2013b; Miller et al. 2011). These studies attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to better understand their potential impacts. Results from the 2007 to 2008 study conducted near the Bahamas showed a change in diving behavior of an adult Blainville's beaked whale to playback of mid-frequency source and predator sounds (Boyd et al. 2008; Tyack et al. 2011). Reaction to mid-frequency sounds included premature cessation of clicking and termination of a foraging dive, and a slower ascent rate to the surface.

Preliminary results from the behavioral response studies in Southern California waters have been presented for multiple field seasons (Southall et al. 2011, 2012a, 2013, 2014). Stimpert et al. (2014) tagged a Baird’s beaked whale, which was subsequently exposed to simulated mid-frequency sonar. Changes in the animal’s dive behavior and locomotion were observed when received level reached 127 dB re 1µPa. DeRuiter et al. (2013a) presented results from two Cuvier’s beaked whales that were tagged and exposed to simulated MFA sonar during the 2010 and 2011 field seasons of the Southern California behavioral response study. The 2011 whale was also incidentally exposed to MFA sonar from a distant naval exercise. Received levels from the MFA sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa rms, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Cuvier's beaked whale responses suggested particular sensitivity to sound exposure as consistent with results for Blainville’s beaked whale. Passive acoustic monitoring of a British major exercise in 2006 on an instrumented range reported that beaked whale vocalizations occurred less frequently in the vicinity of the exercise and as the exercise progressed, and that vocalizations were ultimately not detected at all in the vicinity of the training activity. However, higher concentrations of vocalizations were detected at the range boundaries, suggesting that the beaked whales may have moved to the periphery of the range to forage (Defence Science and Technology Laboratory 2007). It is possible, however, that the whales may have remained at the center of the range near the exercise and simply stopped vocalizing.

Controlled exposure experiments in 2007 and 2008 in the Bahamas recorded responses of false killer whales, short-finned pilot whales, and melon-headed whales to simulated MFA sonar (DeRuiter et al. 2013b). The responses to exposures between species were variable and are indicative of variability in species sensitivity. After hearing each MFA signal, false killer whales were found to have “increase[d] their whistle production rate and made more-MFA-like whistles” (DeRuiter et al. 2013b). In contrast, melon-headed whales had “minor transient silencing” after each MFA signal, while pilot whales had no apparent response. Consistent with the findings of other previous research (see Southall et al. 2007 for review), DeRuiter et al. (2013b) found the responses were variable by species and with the context of the sound exposure. In the 2007–2008 Bahamas study, playback sounds of a potential predator—a killer whale—resulted in a similar but more pronounced reaction, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area. The authors noted, however, that the magnified reaction to the predator sounds could represent a cumulative effect of exposure to the two sound types since killer whale playback began approximately 2 hours after playback of the mid-frequency source. In contrast, preliminary analyses suggest that none of the pilot whales or false killer whales in the Bahamas showed an avoidance response to controlled exposure playbacks (Southall et al. 2009b).

Miller et al. (2011) reported on behavioral responses of pilot whales, killer whales, and sperm whales off Norway to a Norwegian Navy sonar (Sea Mammals, Sonar, and Safety Project [hereafter referred to as the 3S study]) (see also Miller et al. 2012, Sivle et al. 2012, Kuningas et al. 2013, Antunes et al. 2014, Miller et al. 2014). The sonar outputs included 1 to 2 kHz up- and down-sweeps and 6-7 kHz upsweeps; source levels were ramped-up from 152to 158 dB re 1 µPa @ 1m to a maximum of 195-214 dB re 1 µPa @ 1m. Reactions at different distances and received levels were variable, and types of responses observed included cessation of feeding, avoidance, changes in vocalizations, and changes in dive behavior. Some exposures elicited no observable reactions, and others resulted in brief or minor reactions, such as minor changes in vocalizations or locomotion. The experimental exposures occurred across different behavioral and environmental contexts, which may have played a role in the type of response observed, at least for killer whales (see Miller et al. 2014).

Many aspects of the experiment differ from typical Navy actions and may have exacerbated observed reactions; for example, animals were directly approached by the source vessel, researchers conducted multiple approaches toward the same animal groups, some exposures were conducted in bathymetrically restricted areas, and, in some cases, researchers “leapfrogged” the groups to move ahead of the animals on their travel path. Many of the observed behavioral responses were of a prolonged duration, as the animals continued moving to avoid the oncoming vessel as it corrected course toward the animals. At the onset of each sonar exposure session, the signal amplitude was ramped-up over several pings while the vessel approached the animals. This rapid increase in received levels of subsequent sonar pings during ramp-up could have been perceived by the animals as a rapidly approaching source. In contrast, U.S. Navy vessels avoid approaching marine mammals head-on, and vessels will maneuver to maintain a distance of at least 500 yd. (457 m) from observed animals. Furthermore, Navy mitigation measures would dictate power-down of hull-mounted ASW sonars within 1,000 yd. (914 m) of marine mammals and ultimately shutdown if an animal is within 200 yd. (183 m).

Two of the four exposed killer whale groups were foraging prior to the initial sonar exposure; they ceased to feed and began avoiding the vessel during the first exposure session. Received sound pressure levels corresponding to avoidance reactions or changes in behavioral state varied from approximately 94 dB re 1 µPa at 8.9 km to 164 dB re 1 µPa at 3,500 yd. (3.2 km). One killer whale group that was not foraging was in a shallow part of the fjord and could only be approached to within about 1,750 yd. (1.6 km) by the vessel towing the sonar source. Received sound pressure levels in that case were as high as 166 dB re 1 µPa with no observed reactions. This group did not respond to any of the exposures until the final approach, when the group had moved out of the shallow part of the fjord and a young calf became separated from the rest of the group.

Pilot whale behavioral responses occurred at received sound pressure levels between approximately 152 to 175 dB re 1 µPa corresponding to distances of 3,400 yd. (3.1 km) to 98 yd. (90 m), respectively;

although during exposures as high as approximately 172 dB re 1 µPa corresponding to a distance of 380 yd. (350 m), no more than minor and brief reactions were observed.

Sperm whales responded at received levels between 116 to 156 dB re 1 µPa, corresponding to distances of around 2,000 yd. (1.8 km) to 9,800 yd. (9.0 km), respectively. However, sperm whales exposed to higher levels (up to 166 dB re 1 µPa at 980 yd. [0.9 km]) showed no response, or no more than a brief and minor response. These counterintuitive results with respect to received sound pressure level demonstrate some of the issues that must be addressed when interpreting behavioral response data for marine mammals in different contextual conditions.

The 3S study included some control passes of ships with the sonar off to discern the behavioral responses of the animals to vessel presence alone versus active sonar. A single control pass was conducted on killer whales, which was insufficient to rule out vessel presence as a factor in behavioral response. During four control passes on pilot whales, Miller et al. (2011) described similar responses for two of the groups to those observed when the vessels approached with active sonar. In some cases, it is difficult to ascertain if the received sound pressure level alone caused the reactions, or whether the repeated, close passes of the research vessel contributed to the observed behavioral reactions.

Through analysis of the behavioral response studies, a preliminary overarching effect of greater sensitivity to all anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al. 2009a). Therefore, more recent studies have focused specifically on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge 2006; Defence Science and Technology Laboratory 2007; Claridge and Durban 2009; Moretti et al. 2009; McCarthy et al. 2011; Tyack et al. 2011). In the Bahamas, Blainville's beaked whales located on the range will move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge and Durban 2009; Moretti et al. 2009; McCarthy et al. 2011; Tyack et al. 2011). Moretti et al. (2014) used recordings from seafloor-mounted hydrophones at the Atlantic Undersea Test and Evaluation Center (AUTEC) to analyze the probability of Blainsville's beaked whale dives before, during, and after Navy sonar exercises.

In May 2003, killer whales in Haro Strait, Washington, were observed exhibiting what were believed by some observers to be abnormal behaviors while *USS SHOUP* (DDG-86) was in the vicinity and engaged in MFA sonar operations. Observed behaviors included bunching nearshore and other behaviors consistent with avoidance (National Marine Fisheries Service 2005). However, other experienced scientists interpreted the behaviors as within the normal range of behaviors for killer whales. Sound fields modeled for the *USS SHOUP* transmissions (National Marine Fisheries Service 2005; U.S. Department of the Navy 2003; Fromm 2004a, 2004b) estimated a mean received sound pressure level of approximately 169.3 dB re 1 µPa at the location of the killer whales during the closest point of approach between the animals and the vessel (estimated sound pressure levels ranged from 150 to 180 dB re 1 µPa). Response behaviors including avoidance behaviors were also observed from Dall's porpoise and a minke whale in the area.

In the Caribbean, research on sperm whales near the Grenadines in 1983 coincided with the U.S. intervention in Grenada, where sperm whales were observed to interrupt their activities by stopping echolocation and leaving the area in the presence of underwater sounds surmised to have originated from submarine sonar signals since the source was not visible (Watkins and Schevill 1975; Watkins et al. 1985). The authors did not provide any sound levels associated with these observations, although they did note getting a similar reaction from banging on their boat hull. It was unclear if the sperm whales were reacting to the “sonar” signal itself or to a potentially new unknown sound in general, as had been demonstrated previously on another occasion in which sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins and Schevill 1975).

Researchers at the Navy’s Marine Mammal Program facility in San Diego, California, have conducted a series of controlled experiments on bottlenose dolphins and beluga whales to study TTS (Schlundt et al. 2000; Finneran et al. 2001; Finneran et al. 2003; Finneran and Schlundt 2004; Finneran et al. 2005). Ancillary to the TTS studies, scientists evaluated whether the marine mammals performed their trained tasks when prompted, during and after exposure to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site 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 (Schlundt et al. 2000; Finneran et al. 2002). Bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178–193 dB re 1 μPa rms, and 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 these studies were generally not designed to test avoidance behavior and animals were commonly reinforced with food, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to sound sources. More recently, a controlled-exposure study was conducted with U.S. Navy bottlenose dolphins at the Navy Marine Mammal Program facility specifically to study behavioral reactions to simulated mid-frequency sonar (Houser et al. 2013). Animals were trained to swim across a pen, touch a panel, and return to the starting location. During transit, a simulated mid-frequency sonar signal was played. Behavioral reactions were more likely with increasing received level and included increased respiration rates, fluke or pectoral fin slapping, and refusal to participate, among others. From these data, it was determined that bottlenose dolphins were more likely to respond to the initial trials, but habituated to the sound over the course of 10 trials except at the highest received levels. All dolphins responded at the highest received level (185 dB re 1 μPa).

These observations are particularly relevant to situations where animals are motivated to remain in an area where they are being exposed to sound.

Studies with captive harbor porpoises showed increased respiration rates upon introduction of acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al. 2001; Kastelein et al. 2006) and emissions for underwater data transmission (Kastelein et al. 2005). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006; Lucke et al. 2009), again highlighting the importance in understanding species differences in the tolerance of underwater noise (Southall et al. 2007, Henderson et al. 2014).

Behavioral Responses to Vessels

Sound emitted from large vessels, such as shipping and cruise 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 (Richardson et al. 1995; Foote et al. 2004; Hildebrand 2005; Hatch and Wright 2007; Holt et al. 2008; Melcón et al. 2012).

In short-term studies, researchers have noted changes in resting and surface behavior states of cetaceans to whale watching vessels. A number of studies investigating the potential effects of whale watching and vessel traffic on cetaceans have been conducted (Acevedo 1991; Aguilar de Soto et al. 2006; Arcangeli and Crosti 2009; Au and Green 2000; Erbe 2002; Williams et al. 2009; Noren et al. 2009; Stensland and Berggren 2007; Stockin et al. 2008, Christiansen et al. 2010).

A brief summary is presented in this EIS/OEIS; however the topic is too extensive to be covered adequately in this EIS/OEIS. Most studies associated with whale watching are opportunistic and have only ascertained the short-term response to vessel sound and vessel traffic (May-Collado and Quiñones-Lebrón 2014, Lusseau 2006; Magalhães et al. 2002; Richardson et al. 1995; Watkins 1981); however, recent research has attempted to quantify the effects of whale watching using focused experiments (Pirotta et al. 2015, Meissner et al. 2015). The long-term and cumulative implications of ship sound on marine mammals is largely unknown (National Marine Fisheries Service 2007). Clark et al. (2009) provided a discussion on calculating the cumulative impacts of anthropogenic noise on baleen whales and estimated that in one Atlantic setting and with the noise from the passage of two vessels, the optimal communication space for North Atlantic right whales could be decreased by 84 percent.

Christensen et al. (2013) observed minke whales on feeding grounds frequented by whale watching vessels and compared behavior (e.g., breathing interval), in the presence and absence of the vessels. The authors observed that the presence of whale watching vessels disturbed the feeding behavior of the minke whales, which they hypothesize could have long-term consequences for the population by reducing the energy needed for fetal development and the survival of calves.

Ellison et al. (2012) outlined an approach to assessing the effects of sound on marine mammals that incorporates contextual-based factors. They recommend considering not just the received level of sound, but also the activity the animal is engaged in at the time the sound is received, the nature and novelty of the sound (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.

Bassett et al. (2012) recorded vessel traffic over a period of approximately 1 year (short by 11 percent) as large vessels passed within 11 nm of a hydrophone site located at Admiralty Inlet in Puget Sound, Washington. Although not specifically relevant to the Study Area, the research provides insight into noise generated by transiting vessels, including military vessels. During this period there were 1,363 unique Automatic Identification System transmitting vessels recorded. Given they are much fewer in number, Navy vessels were a small component of overall vessel traffic and vessel noise in most areas where they operated. Mintz and Filadelfo (2011) provide a general summary and comparison of the effects of military and non-military vessel noise in the U.S. EEZ. In addition, Navy and U.S. Coast Guard combatant vessels have been designed to generate minimal noise and use ship-quieting technology to elude detection by enemy passive acoustic devices (Southall et al. 2005; Mintz and Filadelfo 2011).

Mysticetes

Fin whales may alter their swimming patterns by increasing speed and heading away from the vessel, as well as changing their breathing patterns in response to a vessel approach (Jahoda et al. 2003). Vessels that remained 328 ft. (100 m) or farther from fin and humpback whales were largely ignored in one study in an area where whale watching activities are common (Watkins 1981). Only when vessels approached more closely did the fin whales in this study alter their behavior by increasing time at the surface and exhibiting avoidance behaviors. Other studies have shown when vessels are near, some but not all fin whales change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au and Green 2000; Richter et al. 2003; Williams et al. 2002).

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. At present it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors.

In the Watkins (1981) study, humpback whales did not exhibit any avoidance behavior but did react to vessel presence. In a study of regional vessel traffic, Baker et al. (1983) found that when vessels were in the area, the respiration patterns of the humpback whales changed. The whales also exhibited two forms of behavioral avoidance: horizontal avoidance (changing direction or speed) when vessels were between 1.24 and 2.48 mi. (2,000 and 4,000 m) away, and vertical avoidance (increased dive times and change in diving pattern) when vessels were between 0 and 1.24 mi. (2,000 m) away (Baker et al. 1983). Similar findings were documented for humpback whales when approached by whale-watch vessels in Hawaii, with responses including increased speed, changed direction to avoid, and staying submerged for longer periods of time (Au and Green 2000).

Gende et al. (2011) reported on observations of humpback whale in inland waters of southeast Alaska subjected to frequent cruise ship transits (i.e., in excess of 400 transits in a 4-month season in 2009). The study was focused on determining if close encounter distance was a function of vessel speed. The reported observations, however, seem in conflict with other reports of avoidance at much greater distance so it may be that humpback whales in those waters are more tolerant of vessels (given their frequency) or are engaged in behaviors, such as feeding, that they are less willing to abandon. This example again highlights that context is critical for predicting and understanding behavioral reactions as concluded by Southall et al. (2007). Navy vessels avoid approaching large whales head on and maneuver to maintain a mitigation zone of 500 yd. (460 m) around observed marine mammals.

Sei whales have been observed ignoring the presence of vessels and passing close to the vessel (National Marine Fisheries Service 1998). 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. 2009a). Minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots [6.2 m/second]) at a distance of 5.5 nm; however, when the vessel drifted or moved at very slow speeds (about 1 knot [0.51 m/second]), many whales approached it (Leatherwood et al. 1982).

Although not expected to be in the Study Area, North Atlantic right whales tend not to respond to the sounds of oncoming vessels (Nowacek et al. 2004a). North Atlantic right whales continue to use habitats in high vessel traffic areas (Nowacek et al. 2004a). Studies show that North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves (Nowacek et al. 2004a, Terhune and Verboom 1999). Although this may minimize potential disturbance from passing ships, it does increase the whales' vulnerability to potential ship strike. The regulated approach distance for right whales is 500 yd. (460 m) (National Marine Fisheries Service 2001).

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 toward the boat or research equipment to investigate, to more "uninterested" reactions toward the end of the study. Finback [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 (ignoring) reactions, allowing boats to approach within 98.4 ft. (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).

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. An increase in feeding call rates and repetition by humpback whales in Alaskan waters is associated with vessel noise (Doyle et al. 2008). Melcón et al. (2012) also recently documented that blue whales increased the proportion of time spent producing certain types of calls when vessels were present. Conversely, decreases in singing activity by humpback whales have been noted near Brazil due to boat traffic (Sousa-Lima and Clark 2008). The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place in Hawaii and Alaska; however, with whale watching and other tourist-related activities (e.g., use of jet skis) growing, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Allen and Angliss 2010).

Bernasconi et al. (2012) observed the reactions of six individual baleen whales in the presence of a fishing vessel conducting an acoustic survey of pelagic fisheries. The vessel was also equipped with a system for measuring the acoustic target strength of observed whales, which was the main purpose of the experiment. During the target strength measurements, the whales were free to interact with the vessel and were sighted at distances from 50 to 400 m while behavioral observations were made. During the fisheries survey, the vessel attempted to encircle the whale at a distance of approximately 200 m while acoustically surveying for fish. The results showed that breathing intervals of feeding whales did not increase during the fisheries survey, contrary to the anticipated result, and no increase in swimming speed was observed either. The authors did note a change in the swimming direction of the whales during the fisheries survey.

Odontocetes

In one study conducted by Würsig et al. (1998) in the Gulf of Mexico, sperm whales only reacted to vessels that approached within several hundred meters; otherwise, no reactions to the survey vessel were observed. Seventy-three percent of the sperm whales observed in the study had no reaction, and the remaining 27 percent were observed to dive abruptly as the vessel approached; however, all of these reactions occurred within 656 ft. (200 m) of the vessel. Another study suggested that the presence of vessels and aircraft associated with whale watching caused a decrease in blow intervals and a corresponding increase in the time whales spent at the surface (Richter et al. 2003). The presence of vessels seemed to cause the time from the first click to any subsequent clicks to decrease. Differences between the reactions of transient and resident sperm whales were also observed. Transient whales tended to react more frequently and strongly to the presence of vessels than resident whales, which encounter whale-watching vessels and aircraft more frequently (Richter et al. 2003). The 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 the individual whale. Reactions to military vessels are not well documented, but smaller whale-watching and research boats have been shown to cause these species to alter their breathing intervals and echolocation patterns (Richter et al. 2003; Richter et al. 2006).

Würsig et al. (1998) reported most *Kogia* species and beaked whales react negatively to vessels by quick diving and other avoidance maneuvers. Cox et al. (2006) noted very little information is available on the behavioral impacts of vessels or vessel noise on beaked whales. A single observation of vocal disruption of a foraging dive by a tagged Cuvier's beaked whale documented when a large noisy vessel was opportunistically present suggests that vessel noise may disturb foraging beaked whales (Aguilar de Soto et al. 2006). Tyack et al. (2011) note the result of a controlled exposure to pseudorandom noise suggests that beaked whales would respond to vessel noise and at similar received levels to those noted previously and for mid-frequency sonar.

Most delphinids have been observed reacting neutrally to vessels, although both avoidance and attraction behavior is known, particularly to instances of repeated disturbance by vessels (Hewitt 1985; Würsig et al. 1998; Lemon et al. 2006; Lusseau et al. 2006). Avoidance reactions include a decrease in resting behavior or change in travel direction (Bejder et al. 2006). Incidence of attraction includes harbor porpoises approaching a vessel and common, rough-toothed, and bottlenose dolphins bow riding and jumping in the wake of a vessel (Norris and 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. 2010a; Archer et al. 2010b). The presence of vessels has also been shown to interrupt feeding behavior in delphinids (Pirotta et al. 2015, Meissner et al. 2015).

Killer whales, the largest of the delphinids, are targeted by numerous small whale-watching vessels in the Pacific Northwest, and research suggests that whale-watching guideline distances may be insufficient to prevent behavioral disturbances (Noren et al. 2009). These vessels have measured source levels that ranged from 145 to 169 dB re 1 µPa at 1 m, and the sound they produce underwater has the potential to result in behavioral disturbance, interfere with communication, and affect the killer whales' hearing (Erbe 2002). Killer whales foraged significantly less and traveled significantly more when boats were within 328 ft. (100 m) of the whales (Kruse 1991; Lusseau et al. 2009; Trites and Bain 2000; Williams et al. 2002; 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). 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. For inland waters of Washington State, regulations were promulgated in 2011, restricting approach to within 200 yd. (183 m) of "whales." The approach regulations do not apply to "government vessels," which includes U.S. military vessels. Although these regulations were specifically developed to protect the endangered southern resident killer whales, the regulation reads "whales" and does not specify if it applies to only killer whales, all cetaceans, or marine mammals with a common name including the word "whale" (National Marine Fisheries Service 2011a). Navy standard practice is to avoid approaching marine mammals head on and to maneuver to maintain a mitigation zone of 500 yd. around detected whales, which is therefore more protective than the distance provided by the regulation.

Similar behavioral changes (increases in traveling and other stress-related behaviors) have been documented in Indo-Pacific bottlenose dolphins in Zanzibar (Christiansen et al. 2010; Englund and Berggren 2002; Stensland and Berggren 2007). Short-term displacement of dolphins due to tourist boat presence has been documented (Carrera et al. 2008), while longer term or repetitive/sustained displacement for some dolphin groups due to chronic vessel noise has been noted (Haviland-Howell et al. 2007; Miksis-Olds et al. 2007). 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 in most cases (Acevedo 1991; Arcangeli and Crosti 2009; Berrow and Holmes 1999; Janik and Thompson 1996; Lusseau 2004; Mattson et al. 2005; Scarpaci et al. 2000). 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 they also found the dolphins' reactions varied depending on whether the observing research vessel was approaching or moving away from the animals being observed.

Odontocetes have been shown to make short-term changes to vocal parameters such as intensity (Holt et al. 2008) as an immediate response to vessel noise, as well as increase the pitch, frequency modulation, and length of whistling (May-Collado and Wartzok 2008). Likewise, modification of multiple vocalization parameters has been 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. 2008). 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 from 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 has been suggested as a long-term response to increased masking noise produced by the vessels (Foote et al. 2004). Conversely, long-term modifications to vocalizations may be indicative of a learned response to sustained noise, or of a genetic or physiological shift in the populations. For example, the source level of killer whale vocalizations has been shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect). 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. 2008).

Behavioral Responses to Aircraft and Missile Overflights

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, helicopters, and missiles. Thorough reviews of the subject and available information are presented in Richardson et al. (1995), Efroymson et al. (2001), Luksenburg and Parsons (2009), and Holst et al. (2011), including that the transmission of airborne sound into the water is generally limited to a narrow approximately 26 degree cone described by Snell's law. 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). Richardson et al. (1995) 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 overflight (Richardson et al. 1995). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (centered on the animal, off to one side, circling, level and slow), environmental factors such as wind speed, sea state, cloud cover, and locations where native subsistence hunting continues.

Mysticetes

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Koski et al. 1998; Efroymson et al. 2001). Richardson et al. (1995) reported that while data on the reactions of mysticetes are meager and largely anecdotal, there is no evidence that single or occasional aircraft flying above mysticetes causes long-term displacement of these mammals. In general, overflights above 1,000 ft. (305 m) do not cause a reaction and the NOAA has promulgated a regulation for Hawaiian Waters and the Hawaii Humpback Whale National Marine Sanctuary adopting this stand-off distance. For right whales, the stand-off distance for aircraft is 500 yd. (457 m) (National Marine Fisheries Service 2001).

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. (305 m) above sea level, infrequently observed at 1,500 ft. (457 m), and not observed at 2,000 ft. (610 m) above sea level (Richardson et al. 1995). 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 492 ft. (150 m) or higher. It should be noted that bowhead whales may have more acute responses to anthropogenic activity than many other marine mammals, because bowheads are often presented with limited egress due to limited open water between ice floes.

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. 1995).

Results from studies of reactions by sperm whales to aircraft overflights provide some insight into possible behavioral responses that could occur from military aircraft activity in the Study Area. One conclusion that can be drawn from these and other studies is that behavioral responses to aircraft in sperm whales are variable. During standard marine mammal surveys at an altitude of 750 ft. (229 m), 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; Magalhaes et al. 2002; Richter et al. 2006; Richter et al. 2003; Smultea et al. 2008; Würsig et al. 1998). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors (Richardson et al. 1995). In another study, a group of sperm whales responded to a circling aircraft (altitude of 800–1,100 ft. [244–335 m]) 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). Richter et al. (2003) reported that whale-watching aircraft apparently caused sperm whales to turn or change direction more sharply than would normally be expected. However, the presence of the aircraft did not affect the blow interval, amount of time at the surface, length of time to first click, or the frequency of aerial behavior (Richter et al. 2003). An important distinction between these studies, which focused on aircraft and vessels engaged in whale watching and the proposed military activities, is that military aircraft would not fly at low altitudes, hover over, or follow whales and, therefore, would not be expected to evoke similar types of responses.

Smaller delphinids generally react to overflights either neutrally or with a startle response (Würsig et al. 1998). The same species that show strong avoidance behavior to vessel traffic (*Kogia* species and beaked whales) also react to aircraft (Würsig et al. 1998). Beluga whales and bowhead whales reacted differently to aircraft overflights, exhibiting responses including diving, breaching, changing direction or behavior, and altering breathing patterns. Belugas reacted more frequently to a hovering or passing helicopter than bowheads. These reactions increased in frequency as the altitude of the helicopter dropped below 492 ft. (150 m). Belugas also reacted to the helicopter when it was sitting on the ice with its engines running, whereas bowheads showed almost no reaction (Patenaude et al. 2002). Both species showed similar reactions to a low flying (600 ft. [182 m]) fixed-wing aircraft at a distance of 820 ft. (250 m). Nevertheless, there is no evidence that single or occasional aircraft flying above odontocetes causes long-term displacement of these mammals (Richardson et al. 1995).

3.4.3.1.2.7 Repeated Exposures

Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with costs that can accumulate over time to cause long-term consequences for the individual. Animals repeatedly exposed to a stressor can become sensitized to the stressor if it is followed by a consequence (negative or positive), resulting in an escalating behavioral reaction over time (Bejder et al. 2009). Conversely, some animals may habituate to a stressor over time. If there is no consequence associated with a stressor, then the animal's response to repeated exposures to the stressor gradually wanes, and the animal becomes habituated. An animal's tolerance of a stressor (or disturbance) is an instantaneous measure of the animal's ability to "tolerate" the disturbance without responding (Bedjer et al. 2009). Increasing tolerance of a stressor indicates habituation whereas decreasing tolerance of a stressor indicates sensitization.

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 (*Delphinus* sp.) 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. (2006) 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.

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. Marine mammals that are more tolerant may stay in a disturbed area, whereas individuals that are more sensitive may leave for areas with less human disturbance. However, animals that remain in the area throughout the disturbance may be unable to leave the area for a variety of physiological or environmental reasons. Terrestrial examples of this abound as human disturbance and development displace more sensitive species, and tolerant animals move in to exploit the freed resources and fringe habitat (Barber et al. 2011; Francis et al. 2009). Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region if they do not become acclimated to the presence of the sound (Blackwell et al. 2004; Bejder et al. 2006; Teilmann et al. 2006). Gray whales in Baja California abandoned an historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. Whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al. 1984).

Over a shorter time scale, studies on the AUTEC instrumented range in the Bahamas have shown that some Blaineville's beaked whales may be resident during all or part of the year in the area, and that individuals may move to the periphery or off of the range during a sonar event. However, the whales would typically return to the range within 2–3 days following the sonar event (Tyack et al. 2011). Observed behavioral responses to the mid-frequency sonar included stopping echolocation and ascending from dives over longer time periods. Similar behaviors were recorded during the Navy sonar event and a controlled experiment using sonar playback and playback of killer whale calls. Even though the animals left the range during the sonar event, they are thought to have continued feeding at short distances (approximately 10 km) from the center of the range and the sound source. The results indicate that the whales may cease feeding behavior (halting echolocation) when the sound pressure level reaches 140 dB re 1 μPa (McCarthy et al. 2011; Tyack et al. 2011). Tyack et al. (2011) acknowledge that a beaked whale exposed to killer whale sounds may exhibit a heightened sensitivity and prolonged response influencing subsequent responses to sonar. Similarly, a whale exposed to sonar only a few hours after an initial exposure may also influence the behavioral response to the second exposure. Furthermore, the whales showed a greater sensitivity (reacting at a lower sound pressure level) to killer whale sounds than to the sonar, possibly because they associate the killer whale sounds with the presence of a predator.

Moore and Barlow (2013) noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. Moore and Barlow (2013) suggest that one reason for the decline in beaked whales from Canada to Mexico may be as a result of anthropogenic sound, including the use of sonar by the U.S. Navy in the fraction of the U.S. Pacific coast overlapped by the Southern California (SOCAL) Range Complex. The Navy trains and tests in the small fraction of that area in Southern California off San Diego. Although Moore and Barlow (2013) have noted a decline in the overall beaked whale population along the Pacific coast, in the small fraction of that area where the Navy has been training and testing with sonar and other systems for decades (the Navy's SOCAL Range Complex), higher densities and long-term residency by individual Cuvier's beaked whales suggest that the decline noted elsewhere is not apparent where Navy sonar use is most intense. Navy sonar training and testing is not conducted along a large part of the US West Coast from which Moore and Barlow (2013) drew their survey data. In Southern California, based on a series of surveys from 2006 to 2008 and a high number encounter rate, Falcone et al. (2009) suggested the ocean basin west of San Clemente Island may be an important region for Cuvier's beaked whales given the number of animals encountered there. Follow-up research (Falcone and Schorr 2012) in this same location suggests that Cuvier's beaked whales may have population sub-units with higher than expected residency, particularly in the Navy's instrumented Southern California Anti-Submarine Warfare Range. Photo identification studies in the SOCAL Range Complex have identified approximately 100 individual Cuvier's beaked whale individuals, with 15 percent having been seen in more than 1 year, and sightings spanning up to 4 years (Falcone and Schorr 2012). This finding is also consistent with concurrent results from passive acoustic monitoring that estimated regional Cuvier's beaked whale densities were higher than indicated by NMFS' broad scale visual surveys for the U.S. west coast (Hildebrand and McDonald 2009).

Moore and Barlow (2013) recognized the inconsistency between their hypothesis and the abundance trends in the region of SOCAL Range Complex, stating: "High densities are not obviously consistent with a hypothesis that declines are due to military sonar, but they do not refute the possibility that declines have occurred in these areas (i.e., that densities were previously even higher).” While it is possible that the high densities of beaked whale currently inhabiting the Navy’s range were even higher before the Navy began training with sonar, there are no data available to test that hypothesis. Furthermore, the decline of beaked whales Moore and Barlow (2013) assert for other areas of the U.S. West Coast where the Navy does not conduct sonar training or testing limits the validity of their speculation about the effects of sonar on beaked whale populations. 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. Nevertheless, the long-term consequences of these habitat utilization changes are unknown, and likely vary depending on the species, geographic areas, and the degree of acoustic or other human disturbance.

3.4.3.1.2.8 Stranding

When a live or dead marine mammal 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 and Lounsbury 2005). Animals outside of their “normal” habitat are also sometimes considered “stranded” even though they may not have beached themselves. Under the U.S. Law, a stranding is an event in the wild that: “(A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance” (16 United States Code 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 on land or die at-sea (Geraci et al. 1999; Geraci and Lounsbury 2005). Even for the fractions of more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for the majority of strandings remain undetermined. Natural factors related to strandings include, for example, the availability of food, predation, disease, parasitism, climatic influences, and aging (Bradshaw et al. 2006; Culik 2004; Geraci et al. 1999; Geraci and Lounsbury 2005; Hoelzel 2003; National Research Council 2006; Perrin and Geraci 2002; Walker et al. 2005). Anthropogenic factors may include, for example, pollution (Marine Mammal Commission 2010; Elfes et al. 2010; Hall et al. 2006a; Hall et al. 2006b; Jepson et al. 2005; Tabuchi et al. 2006), vessel strike (Berman-Kowalewski et al. 2010; de Stephanis and Urquiola 2006; Geraci and Lounsbury 2005; Jensen and Silber 2003; Laist et al. 2001), fisheries interactions (Look 2011; Read et al. 2006; Geijer and Read 2013), entanglement (Baird and Gorgone 2005; Johnson and Allen 2005; Saez et al. 2012), and noise (Richardson 1995; National Research Council 2003; Cox et al. 2006).

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 1,400 cetacean strandings and 4,300 pinniped strandings (5,700 total) per year (National Marine Fisheries Service 2011a, b, c). Several “mass stranding” events—strandings that involve two or more individuals of the same species (excluding a single cow-calf pair)—that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. An in-depth discussion of strandings is presented in the technical report, *Marine Mammal Strandings Associated With U.S. Navy Sonar Activities* (U.S. Department of the Navy 2012).

Sonar use during exercises involving the U.S. Navy (most often in association with other nations' defense forces) 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 (Marine Mammal Commission 2006). These five mass stranding events resulted in about 40 known stranding deaths among cetaceans consisting mostly of beaked whales with a potential causal link to sonar (International Council for the Exploration of the Sea 2005). Although these events have served to focus attention on the issue of impacts resulting from the use of sonar, as Ketten (2012) recently pointed out, "ironically, to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result anthropogenic noise exposures, including sonar." In these previous strandings, exposure to non-impulse acoustic energy has been considered a potential indirect cause of the death of marine mammals (Cox et al. 2006). One hypothesis regarding a potential cause of the strandings is tissue damage resulting from "gas and fat embolic syndrome" (Fernandez et al. 2005; Jepson et al. 2003; Jepson et al. 2005). Models of nitrogen saturation in diving marine mammals have been used to suggest that altered dive behavior might result in the accumulation of nitrogen gas such that the potential for nitrogen bubble formation is increased (Houser et al. 2001a; Houser et al. 2001b; Zimmer and Tyack 2007). If so, this mechanism might explain the findings of gas and bubble emboli in stranded beaked whales. It is also possible that stranding is a behavioral response to a sound under certain contextual conditions and that the subsequently observed physiological effects (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding rather than direct physical impact from exposure to sonar (Cox et al. 2006).

As the International Council for the Exploration of the Sea (2005) noted, taken in context of marine mammal populations in general, sonar is not a major threat or significant portion of the overall ocean noise budget. This has also been demonstrated by monitoring in areas where the Navy operates (Bassett et al. 2010; Baumann-Pickering et al. 2010; Hildebrand et al. 2011; McDonald et al. 2006; Tyack et al. 2011). Regardless of the direct cause, the Navy considers potential sonar related strandings important and continues to fund research and work with scientists to better understand circumstances that may result in strandings.

The Navy prepared a technical report as a supporting document to the EIS/OEIS that presents specific information regarding marine mammal stranding events that may have been associated with U.S. Navy activities (U.S. Department of the Navy 2012). Additionally, this report provides general information on other threats to marine mammals (natural and anthropogenic) that may cause or contribute to strandings.

During a Navy training event on 4 March 2011 at the SSTC (San Diego, California), three

Criteria for Estimating Mortality Reflects a Conservative Overestimate:

Navy's modeling uses onset mortality criteria for estimating effects that provides a conservative overestimate of likely mortalities. These mortality criteria are based on receipt of impulse energy where 1 percent of the animals exposed would not survive the injuries received. All animals within the range to onset mortality are quantified as mortalities, although many animals would actually recover from or otherwise survive the injury that is the basis of the criteria. The Navy's modeling also assumes that all animals are calf-sized, resulting in additional over-prediction of effects since the likelihood of mortality decreases as an animal's mass increases, and most marine mammals are adult-sized not calf-sized (see Section 3.4.3.1.4.1, Mortality and Injury from Explosives) long-beaked common dolphins were found dead immediately after an underwater detonation associated with the event.[3] In addition to the three dolphin mortalities at the detonation site, a fourth dolphin was discovered dead 3 days later (on 7 March near Oceanside, California) approximately 37 nm north of the training event location. It is not known when this fourth dolphin died, but it is assumed to be between the time of the training event and the discovery at the stranding location. Details, such as individual dolphins' depth and distance from the explosive source at the time of detonation, could not be estimated; however, the stranding was assessed as having been related to the training event at the SSTC (Danil and St. Ledger 2011).

These dolphin mortalities are the only known occurrence of a U.S. Navy training event involving impulse energy (underwater detonation) that has resulted in injury to a marine mammal. Despite this being a rare occurrence, Navy has reviewed training requirements, safety procedures, and potential mitigation measures and, along with NMFS, is determining appropriate changes to implement to reduce the potential for this to occur in the future. Discussions of procedures associated with these and other training and testing events are presented in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), which details all mitigations.

The potential for marine mammals to die as a result of military activities is very low, and the numbers resulting from Navy modeling reflect a very conservative approach.[4] In comparison to strandings, serious injury, and death from non-military human activities affecting the oceans, major causes include commercial shipping vessels strike (e.g., Berman-Kowalewski et al. 2010; Silber et al. 2010), impacts from urban pollution (e.g., O'Shea & Brownell 1994; Hooker et al. 2007), and annual fishery-related entanglement, bycatch, injury, and mortality (e.g., Baird and Gorgone 2005, Forney and Kobayashi 2007; Saez et al. 2012; Geijer and Read 2013), which have been estimated worldwide to be orders of magnitude greater (hundreds of thousands of animals versus tens of animals) than the few potential injurious impacts that could be possible as a result of military activities (Culik 2004; International Council for the Exploration of the Sea 2005; Read et al. 2006). This does not negate the potential influence of mortality or additional stress to small, regionalized sub-populations which may be at greater risk from human related mortalities (fishing, vessel strike, sound) than populations with larger oceanic level distributions, but overall the military's impact in the oceans and inland water areas where training and testing occurs is small by comparison to other human activities.

3.4.3.1.3 Long-Term Consequences to the Individual and the Population

Long-term consequences to a population are determined by examining changes in the population growth rate. Individual effects that could lead to a reduction in the population growth rate include mortality or injury (that removes animals from the reproductive pool), loss in hearing sensitivity (which depending on severity could impact navigation, foraging, predator avoidance, or communication),

[3] During this underwater detonation training event, a pod of 100 to 150 dolphins were observed moving towards the explosive event's 700 yd. (640 m) exclusion zone monitored by a personnel in a safety boat and participants in a dive boat. Within the exclusion zone, approximately 5 minutes remained on a timed fuse connected to a single 8.76 lb. (3.97 kg) explosive charge weight (C-4 and detonation cord) set at a depth of 48 ft. (14.6 m), approximately 0.5–0.75 nm from shore. Although the dive boat was placed between the pod and the explosive in an effort to guide the dolphins away from the area, that effort was unsuccessful. The Navy informed NMFS, recovered the three animals, and transferred them to the local stranding network for necropsy.

[4] Navy's metric for modeling and quantifying "mortality" provides a conservative overestimate of the mortalities likely to occur. The mortality criteria are based on an injury from impulse energy for which only 1 percent of the animals receiving that injury would die. All animals within the range to onset mortality are modeled as mortalities, although many would actually survive. With the exception of rare Navy vessel strikes to large whales, marine mammals are not expected to die as a result of future Navy training and testing activities.

chronic stress (which could make individuals more susceptible to disease), displacement of individuals (especially from preferred foraging or mating grounds), and disruption of social bonds (due to masking of conspecific signals or displacement) (see Appendix H, Biological Resource Methods, and U.S. Department of the Navy 2012). However, the long-term consequences of any of these effects are difficult to predict because individual experience and time can create complex contingencies, especially for intelligent, long-lived animals like marine mammals. While a lost reproductive opportunity could be a measureable cost to the individual, the outcome for the animal, and ultimately the population, can range from insignificant to significant. Any number of factors, such as maternal inexperience, years of poor food supply, or predator pressure, could result in a lost reproductive opportunity, but these events may be "made up" during the life of a normal healthy individual. The same holds true for exposure to human-generated sound sources. These biological realities must be taken into consideration when assessing risk, uncertainties about that risk, and the feasibility of preventing or recouping such risks. All too often, the long-term consequence of relatively trivial events like short-term masking of a conspecific's social sounds, or a single lost feeding opportunity, is exaggerated beyond its actual importance by focusing on the single event and not the important variable, which is the individual and its lifetime parameters of growth, reproduction, and survival.

A causal link between anthropogenic noise, animal communication, and individual impacts, as well as population viability over the long term, is difficult to quantify and assess (McGregor et al. 2013, Read et al. 2014). For instance, Read et al. (2014) reviewed select terrestrial literature on individual and population response to sound and described a necessary framework to assess future direct and indirect fitness impacts. The difficulty with assessing behavioral effects associated with anthropogenic noise, individually and cumulatively, is the confounding nature of the issue. Depending on the situation, there may or may not be indirect effects resulting from a complex interactive dependence based on age class, prior experience, and behavioral state at the time of exposure, as well as influences by other non-sound related factors (Knight and Swaddle 2011, Ellison et al. 2012, Goldbogen et al. 2013, McGregor et al. 2013, Read et al. 2014, Williams et al. 2014). McGregor et al. (2013) summarized some studies on sound impacts and described two types of possible effects based on the studies they reviewed: (1) an apparent effect of noise on communication, but with a link between demonstrated proximate cost and ultimate cost in survival or reproductive success being inferred rather than demonstrated; and (2) studies showing a decrease in population density or diversity in relation to noise, but with a relationship that is usually a correlation, so that factors other than noise or its effect on communication might account for the relationship (McGregor et al. 2013). Within the ocean environment, there is a complex interaction of considerations needed in terms of defining cumulative anthropogenic impacts that has to also be considered in context of natural variation and climate change (Boyd and Hutchins 2012). These considerations can include environmental enhancers that improve fitness, additive effects from two or more factors, multiplicity where response from two or more factors is greater than the sum of individual effects, synergism between factors and response, antagonism as a negative feedback between factors, acclimation as a short-term individual response, and adaptation as a long-term population change (Boyd and Hutchins 2012). To address determination of cumulative effects and response changes due to processes such as habituation, tolerance, and sensitization, future experiments over an extended period of time require further research (Bejder et al. 2009, Blickley et al. 2012, Read et al 2014).

The linkage between a stressor such as sound and its immediate behavioral or physiological consequences for the individual, and then the subsequent effects on that individual's vital rates (growth, survival, and reproduction), and the consequences, in turn, for the population have been reviewed in National Research Council (2005). The Population Consequences of Acoustic Disturbance model (see National Research Council 2005) proposed a quantitative methodology for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translate into biologically significant consequences to the population. 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. The time-scale of the inputs in a population model for long-lived animals such as marine mammals is on the order of seasons, years, or life stages (e.g., neonate, juvenile, reproductive adult), and are often concerned only with the success of individuals from one time period or stage to the next. Unfortunately, for acoustic and explosive impacts to marine mammal populations, many of the inputs required by population models are not known.

The best assessment of long-term consequences from training and testing activities will be to monitor the populations over time within the Study Area. A recent 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 monitoring plans for protected marine mammals and sea turtles 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 current mitigation practices. Although there are limited data available for the MITT Study Area (Mobley 2007), results of intensive monitoring from 2009 to 2012 by independent scientists and Navy observers in SOCAL Range Complex and Hawaii Range Complex have recorded an estimated 256,000 marine mammals with no evidence of distress or unusual behavior observed during Navy activities (see Section 3.4.5.2, Summary of Observations During Previous Navy Activities, for a broader discussion on this topic). Continued monitoring efforts over time will be necessary to completely evaluate the long-term consequences of exposure to sound sources.

3.4.3.1.4 Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals

If proposed military activities introduce sound or explosive energy into the marine environment, an analysis of potential impacts to marine mammals is conducted. To do this, quantifiable information about the sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed.

3.4.3.1.4.1 Mortality and Injury from Explosives

There is a considerable body of laboratory data on actual injury from impulse sound, usually from explosive pulses, obtained from tests with a variety of lab animals (mice, rats, dogs, pigs, sheep, and other species). Onset Mortality, Onset Slight Lung Injury, and Onset Slight Gastrointestinal (GI) Tract Injury represent a series of effects with decreasing likelihood of serious injury or lethality. Primary impulse injuries from explosive blasts are the result of differential compression and rapid re-expansion of adjacent tissues of different acoustic properties (e.g., between gas-filled and fluid-filled tissues or between bone and soft tissues). These injuries usually manifest themselves in the gas-containing organs (lung and gut) and auditory structures (e.g., rupture of the eardrum across the gas-filled spaces of the outer and inner ear) (Craig and Hearn 1998; Craig Jr. 2001).

Criteria and thresholds for predicting mortality and injury to marine mammals from impulse sources were initially developed for the U.S. Navy shock trials of the SEAWOLF submarine (Craig and Hearn 1998) and *USS WINSTON S. CHURCHILL* (DDG-81) surface ship (Craig Jr. 2001). These criteria and thresholds were also adopted by NMFS in several Final Rules issued under the MMPA (63 Federal

Register [FR] 230; 66 FR 87; 73 FR 121; 73 FR 199). These criteria and thresholds were revised as necessary based on new science, used for the shock trial of the U.S. Navy amphibious transport dock ship *USS MESA VERDE* (LPD-19) (Finneran and Jenkins 2012), and were subsequently adopted by NMFS in their MMPA Final Rule authorizing the *USS MESA VERDE* shock trial (73 FR 143). Upper and lower frequency limits of hearing are not applied for lethal and injurious exposures. These criteria and their origins are explained in greater detail in Finneran and Jenkins (2012) covering the development of the thresholds and criteria for assessment of impacts.

Mortality and Slight Lung Injury

In air or submerged, the most commonly reported internal bodily injury was hemorrhaging in the fine structure of the lungs (Richmond et al. 1973). Biological damage is governed by the impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973; Yelverton et al. 1973; Yelverton et al. 1975; Yelverton and Richmond 1981). Therefore, impulse was used as a metric upon which internal organ injury could be predicted. A review of the predicted effects from impulse sources on marine mammals up to 1995 is provided by Ketten (1998). The research estimates impact zones for marine mammals ranging from TTS to mortality for two hypothetical underwater explosions based on extrapolated data from fish, submerged terrestrial animals, and humans.

Species-specific masses are used for determining impulse-based thresholds because it most closely represents effects to individual species. The Navy's Thresholds and Criteria Technical Report (Finneran and Jenkins 2012) provides a nominal conservative body mass for each species based on newborn weights. In some cases, body masses were extrapolated from similar species rather than the listed species. The scaling of lung volume to depth is conducted for all species since data are from experiments with terrestrial animals held near the water's surface.

Because the thresholds for onset of mortality and onset of slight lung injury are proportional to the cube root of body mass, the use of all newborn, or calf, weights rather than representative adult weights results in an over-estimate of effects to animals near an explosion. The range to onset mortality for a newborn compared to an adult animal of the same species can range from less than twice to over four times as far from an explosion, depending on the differences in calf versus adult sizes for a given species and the size of the explosion. Considering that injurious high pressures due to explosions propagate away from detonations in a roughly spherical manner, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.

The use of onset mortality and onset slight lung injury is a conservative method to estimate potential mortality and recoverable (non-mortal, non-PTS) injuries. When analyzing impulse-based effects, all animals within the range to these thresholds are assumed to experience the effect. The onset mortality and onset slight lung injury criteria are based on the impulse at which these effects are predicted for 1 percent of animals; the portion of animals affected would increase closer to the explosion. As discussed above, according to the Navy's analysis all animals receive the effect vice a percentage; therefore, these criteria conservatively over-estimate the number of animals that could be killed or injured.

Impulse thresholds for onset mortality and slight injury are indexed to 75 and 93 lb. (34 and 42 kg) for mammals, respectively (Richmond et al. 1973). The regression curves based on these experiments were plotted, such that a prediction of mortality to larger animals could be determined as a function of positive impulse and mass (Craig Jr. 2001). After correction for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass, as used in the Goertner injury model (Goertner 1982), the minimum impulse for predicting onset of extensive (i.e., 50 percent) lung injury for "1 percent

Mortality" (defined as most survivors had moderate blast injuries and should survive on their own) and slight lung injury for "0 percent Mortality" (defined as no mortality, slight blast injuries) (Yelverton and Richmond 1981) were derived for each species. As the mortality threshold, the Navy chose to use the minimum impulse level predictive of 50 percent lung injury, even though this injury is likely to result in mortality to only 1 percent of exposed animals. Because the mortality criteria represents a threshold at which 99 percent of exposed animals would be expected to recover, this analysis overestimates the impact on individuals and populations from exposure to impulse sources.

Onset of Gastrointestinal Tract Injury

Evidence indicates that gas-containing internal organs, such as lungs and intestines, are the principle damage sites from shock waves in submerged terrestrial mammals (Clark and Ward 1943; Greaves et al. 1943; Richmond et al. 1973; Yelverton et al. 1973). Furthermore, slight injury to the gastrointestinal tract may be related to the magnitude of the peak shock wave pressure over the hydrostatic pressure and would be independent of the animal's size and mass (Goertner 1982). Slight contusions to the gastrointestinal tract were reported during small charge tests (Richmond et al. 1973), when the peak was 237 dB re 1 µPa.

There are instances where injury to the gastrointestinal tract could occur at a greater distance from the source than slight lung injury, especially for animals near the surface. Gastrointestinal tract injury from small test charges (described as "slight contusions") was observed at peak pressure levels as low as 104 pounds per square inch (known as psi), equivalent to a sound pressure level of 237 dB re 1 µPa (Richmond et al. 1973). This criterion was previously used by Navy and NMFS for ship shock trials (Finneran and Jenkins 2012; 63 FR 230, 66 FR 87, 73 FR 143).

3.4.3.1.4.2 Frequency Weighting

Frequency-weighting functions are used to adjust the received sound level based on the sensitivity of the animal to the frequency of the sound. The weighting functions de-emphasize sound exposures at frequencies to which marine mammals are not particularly sensitive. This effectively makes the acoustic thresholds frequency-dependent, which means they are applicable over a wide range of frequencies and therefore applicable for a wide range of sound sources. Frequency-weighting functions, deemed "M-weighting" functions by the authors, were proposed by Southall et al. (2007) to account for the frequency bandwidth of hearing in marine mammals. These M-weighting functions were derived for each marine mammal hearing group based on an algorithm using the range of frequencies that are within 80 dB of an animal or group's best hearing sensitivity at any frequency (Southall et al. 2007). The Southall et al. (2007) M-weighting functions are nearly flat between the lower and upper cutoff frequencies, and thus were believed to represent a conservative approach to assessing the effects of sound (Figure 3.4-2). For the purposes of this analysis, the Navy will refer to these as Type I auditory weighting functions.

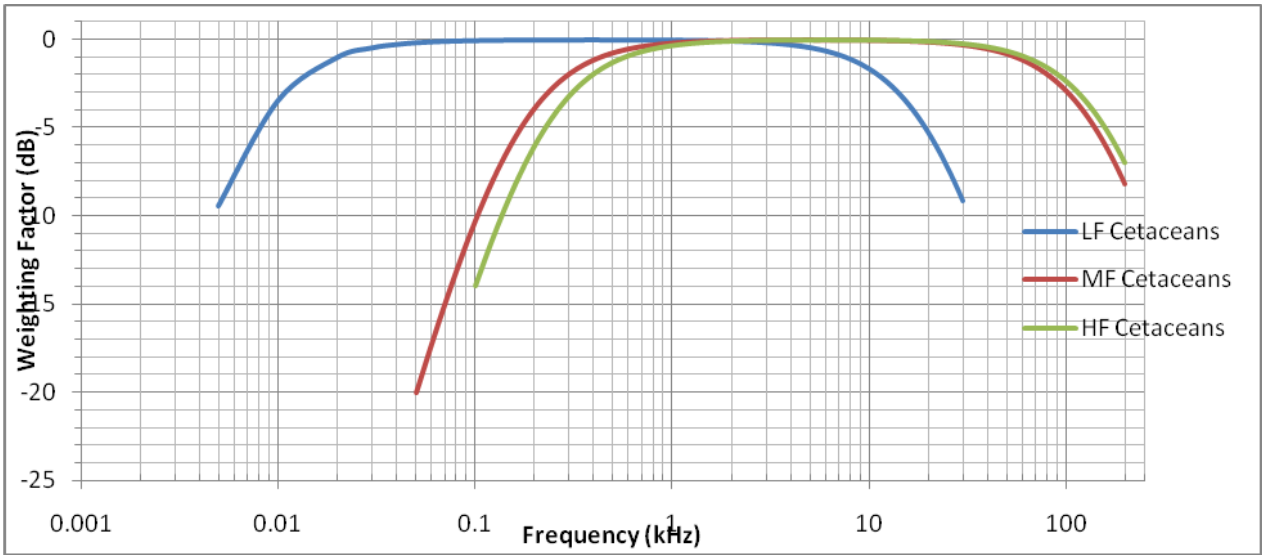

Figure 3.4-2: Type I Auditory Weighting Functions Modified from the Southall et al. (2007) M-Weighting Functions

Finneran and Jenkins (2012) considered data since Southall et al (2007) to determine if any adjustments to the weighting functions were appropriate. Only two published experiments suggested that modification of the mid-frequency cetacean auditory weighting function was necessary (see Finneran and Jenkins [2012] for more details on that modification not otherwise provided below). The first experiment measured TTS in a bottlenose dolphin after exposure to pure tones with frequencies from 3 to 28 kHz (Finneran et al. 2010b). These data were used to derive onset-TTS values as a function of exposure frequency, and demonstrate that the use of a single numeric threshold for onset-TTS, regardless of frequency, is not correct. The second experiment examined how subjects perceived the loudness of sounds at different frequencies to derive equal loudness contours (Finneran and Schlundt 2011). These data are important because human auditory weighting functions are based on equal loudness contours. The dolphin equal loudness contours provide a means to generate auditory weighting functions in a manner directly analogous to the approach used to develop safe exposure guidelines for people working in noisy environments (National Institute for Occupational Safety and Health 1998).

Taken together, the recent higher-frequency TTS data and equal loudness contours provide the underlying data necessary to develop new weighting functions, referred to as Type II auditory weighting functions, to improve accuracy and avoid underestimating the impacts on animals at higher frequencies, as shown on Figure 3.4-3. To generate the new Type II weighting functions, Finneran and Schlundt (2011) substituted lower and upper frequency values which differ from the values used by Southall et al. (2007). The new Type II weighting curve predicts appreciably higher susceptibility for frequencies above 3 kHz. Since data below 3 kHz are not available, the original Type I weighting functions from Southall et al. (2007) were substituted below this frequency. Low- and high-frequency cetacean weighting functions were extrapolated from the dolphin data as well, because of the suspected similarities of greatest susceptibility at best frequencies of hearing. Similar Type II weighting curves were not developed for pinnipeds since their hearing is markedly different from cetaceans, and because they do not hear as well at higher frequencies and so their weighting curves did not require the same adjustment (see Finneran and Jenkins 2012 for additional details).

The Type II auditory cetacean weighting functions (Figure 3.4-3) are applied to the received sound level before comparing it to the appropriate sound exposure level thresholds for TTS or PTS, or the impulse behavioral response threshold. For some criteria, received levels are not weighted before being compared to the thresholds to predict effects. These include the peak pressure criteria for predicting impulse TTS and PTS, the acoustic impulse metrics used to predict onset-mortality and slight lung injury, and the thresholds used to predict behavioral responses from beaked whales from non-impulse sound. Beaked whales have unique behavioral criteria based on data that show these animals to be especially sensitive to sound. To account for their sensitivity to sound, beaked whale non-impulse behavioral criteria are unweighted (i.e., the received level is not weighted before comparing it to the threshold) (Finneran and Jenkins 2012).

Frequency Weighting Example:

A spinner dolphin, a mid-frequency cetacean (see 3.4.2.3.2, Mid-Frequency Cetaceans), receives a 10 kHz ping from a sonar with a sound exposure level (SEL) of 180 dB re 1 μPa^2-s. To discern if this animal may suffer a TTS, the received level must first be adjusted using the appropriate Type II auditory weighting function for mid-frequency cetaceans (see 3.4.2.3.2, Mid-Frequency Cetaceans). At 10 kHz, the weighting factor for mid-frequency cetaceans is -3 dB, which is then added to the received level (180 dB re 1 μPa^2-s + (-3 dB) = 177 dB re 1 μPa^2-s) to yield the weighted received level. This is compared to the Non-Impulse Mid-Frequency Cetacean TTS threshold (178 dB re 1 μPa^2-s; see Table 3.4-3). Since the adjusted received level is less than the threshold, TTS is not likely for this animal from this exposure.

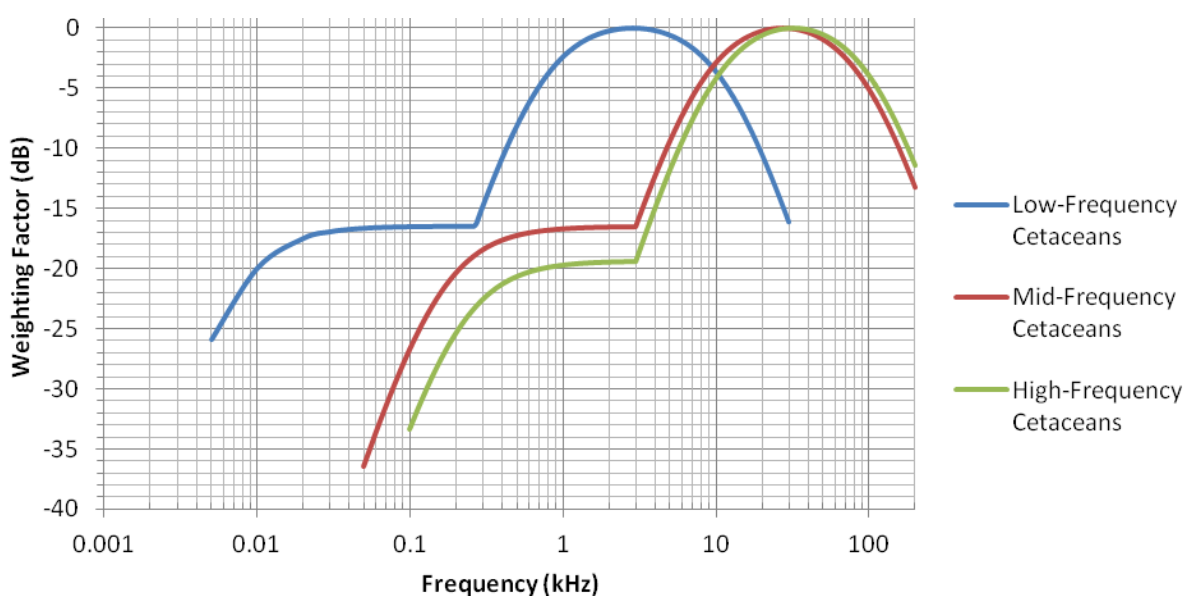

Figure 3.4-3: Type II Weighting Functions for Low-, Mid-, and High-Frequency Cetaceans

Summation of Energy From Multiple Sources

In most cases, an animal's received level will be the result of exposure to a single sound source. In some scenarios, however, multiple sources will be operating simultaneously, or nearly so, creating the potential for accumulation of energy from multiple sources. Energy is summed for multiple exposures of similar source types. For sonars, including use of multiple systems within any scenario, energy will be summed for all exposures within a frequency band, with the cumulative frequency exposure bands defined as 0–1.0 kHz (low-frequency sources), 1.1–10.0 kHz (mid-frequency sources), 10.1–100.0 kHz (high-frequency sources), and 100.1–200.0 kHz (very high-frequency sources). Sources operated at frequencies above 200 kHz are considered to be inaudible to all groups of marine mammals and are not analyzed in the quantitative modeling of exposure levels. After the energy has been summed within each frequency band, the band with the greatest amount of energy is used to evaluate the onset of PTS or TTS. For explosives, including use of multiple explosives in a single scenario, energy is summed across the entire frequency band.

Hearing Loss – Temporary and Permanent Threshold Shift

Criteria for physiological effects from non-impulse sources are based on TTS and PTS with thresholds based on cumulative sound exposure levels. The onset of TTS or PTS from exposure to impulse sources is predicted using a sound exposure level-based threshold in conjunction with a peak pressure threshold. The horizontal ranges are then compared, with the threshold producing the longest range being the one used to predict effects. For multiple exposures within any 24-hour period, the received sound exposure level (SEL) for individual events are accumulated for each animal.

Since no studies have been designed to intentionally induce PTS in marine mammals due to moral and ethical issues inherent in such a study, onset-PTS levels have been estimated using empirical TTS data obtained from marine mammals and relationships between TTS and PTS established in terrestrial mammals.

Temporary and permanent threshold shift thresholds are based on TTS onset values for impulse and non-impulse sounds obtained from representative species of mid- and high-frequency cetaceans. The Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis technical report (Finneran and Jenkins 2012) provides a detailed explanation of the selection of criteria and derivation of thresholds for temporary and permanent hearing loss for marine mammals. Section 3.4.3.1.2.3 (Hearing Loss) provided the specific meanings of temporary and permanent threshold shift as used in this EIS/OEIS. Table 3.4-3 provides a summary of acoustic thresholds for TTS and PTS for marine mammals from sonar and other active acoustic sources (non-impulse sources), and Table 3.4-4 provides a summary of acoustic thresholds for TTS, PTS, injury, and mortality from explosives (impulse sources).

Temporary Threshold Shift from Sonar and Other Active Acoustic Sources

Temporary threshold shift involves no tissue damage, is by definition temporary, and therefore is not considered injury. TTS values for mid-frequency cetaceans exposed to non-impulse sound are derived from multiple studies (Finneran et al. 2005; Schlundt et al. 2000; Mooney et al. 2009a; Finneran et al. 2010a; Finneran and Schlundt 2010) from two species, bottlenose dolphins and beluga whales. Especially notable are data for frequencies above 3 kHz, where bottlenose dolphins have exhibited lower TTS onset thresholds than at 3 kHz (Finneran and Schlundt 2010; Finneran and Schlundt 2011). This difference in TTS onset at higher frequencies is incorporated into the weighting functions (Table 3.4-3).

Table 3.4-3: Acoustic Criteria and Thresholds for Predicting Physiological Effects on Marine Mammals from Sonar and Other Active Acoustic Sources

Hearing Group	Species	Physiological	
		Onset TTS	Onset PTS
Low-Frequency Cetaceans	All mysticetes	178 dB re 1 μPa^2-s SEL (Type II Weighting)	198 dB re 1 μPa^2-s SEL (Type II Weighting)
Mid-Frequency Cetaceans	Dolphins, beaked whales, and medium and large toothed whales	178 dB re 1 μPa^2-s SEL (Type II Weighting)	198 dB re 1 μPa^2-s SEL (Type II Weighting)
High-Frequency Cetaceans	Porpoises and *Kogia* spp.	152 dB re 1 μPa^2-s SEL (Type II Weighting)	172 dB re 1 μPa^2-s SEL (Type II Weighting)

Notes: dB = decibels, SEL = sound exposure level, TTS = temporary threshold shift, PTS = permanent threshold shift, μPa^2-s = micropascal squared second

Previously, there had been no direct measurements of TTS from non-impulse sound in high-frequency cetaceans. Lucke et al. (2009) measured TTS in a harbor porpoise exposed to a small seismic airgun and those results are reflected in the current impulse sound TTS thresholds described below. The beluga whale, which had been the only species for which both impulse and non-impulse TTS data existed, has a non-impulse TTS onset value about 6 dB above the (weighted) impulse threshold (Finneran et al. 2002; Schlundt et al. 2000). Therefore, 6 dB was added to the harbor porpoise's impulse TTS threshold demonstrated by Lucke et al. (2009) to derive the non-impulse TTS threshold used in the current Navy modeling for high-frequency cetaceans. A report on the first direct measurements of TTS from non-impulse sound was recently presented by Kastelein et al. (2012) for harbor porpoise. These new data are consistent with the current harbor porpoise thresholds used in the modeling of effects from sonar and other active acoustic sources.

There are no direct measurements of TTS or hearing abilities for low-frequency cetaceans. The Navy has applied mid-frequency cetacean thresholds to the low-frequency cetacean group as described in Finneran and Jenkins (2012) on the development of the thresholds and criteria. The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict TTS.

Temporary Threshold Shift from Explosives

The TTS sound exposure level thresholds for cetaceans are consistent with the thresholds approved by NMFS for the *USS MESA VERDE* ship shock trial (73 FR 143: 43130–43138, 24 July 2008) and are more representative of TTS induced from impulses (Finneran et al. 2002; Finneran and Jenkins 2012) rather than pure tones (Schlundt et al. 2000). In most cases, a total weighted sound exposure level is more conservative than greatest sound exposure level in one-third-octave bands, which was used prior to the *USS MESA VERDE* ship shock trials. Impulse threshold criteria for mid-frequency cetaceans from Finneran et al. (2002) are used for low-frequency cetaceans, because there are no data on TTS obtained directly from low-frequency cetaceans. High-frequency cetacean TTS thresholds are based on research by Lucke et al. (2009), who exposed harbor porpoises to pulses from a single airgun. The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict TTS (Table 3.4-4).

Table 3.4-4: Criteria and Thresholds for Predicting Physiological Effects on Marine Mammals[1]

Group	Species	Onset TTS	Onset PTS	Onset Slight GI Tract Injury	Onset Slight Lung Injury[2]	Onset Mortality[1]
Low Frequency Cetaceans	All mysticetes	172 dB re 1 μPa^2-s SEL (Type II weighting) or 224 dB re 1 µPa Peak SPL (unweighted)	187 dB re 1 μPa^2-s SEL (Type II weighting) or 230 dB re 1 µPa Peak SPL (unweighted)			
Mid-Frequency Cetaceans	Most delphinids, medium and large toothed whales	172 dB re 1 μPa^2-s SEL (Type II weighting) or 224 dB re 1 µPa Peak SPL (unweighted)	187 dB re 1 μPa^2-s SEL (Type II weighting) or 230 dB re 1 µPa Peak SPL (unweighted)	237 dB re 1 µPa (unweighted)	Note 1	Note 2
High Frequency Cetaceans	Porpoises and *Kogia* spp.	146 dB re 1 μPa^2-s SEL (Type II weighting) or 195 dB re 1 µPa Peak SPL (unweighted)	161 dB re 1 μPa^2-s SEL (Type II weighting) or 201 dB re 1 µPa Peak SPL (unweighted)			

Note 1 $= 39.1M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec$

Note 2 $= 91.4M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec$

[1]Additional information on the derivation and use of criteria thresholds is presented in the technical report, *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis* (Finneran and Jenkins 2012).
[2] Impulse calculated over a delivery time that is the lesser of the initial positive pressure duration or 20 percent of the natural period of the assumed-spherical lung adjusted for animal size and depth.
Notes: GI = gastrointestinal, M = mass of animals in kg, D_{Rm} = depth of receiver (animal) in meters,
SEL = sound exposure level (in units of dB re μPa^2-s)
SPL = sound pressure level (in units of dB re 1 µPa),
dB re 1 µPa = decibels referenced to 1 micropascal,
dB re μPa^2-s = decibels referenced to 1 micropascal squared second

Permanent Threshold Shift from Sonar and Other Acoustic Sources

There are no direct measurements of PTS onset in marine mammals. Well-understood relationships between terrestrial mammalian TTS and PTS have been applied to marine mammals. Threshold shifts up to 40–50 dB have been induced in terrestrial mammals without resultant PTS (Miller et al. 1963; Ward et al. 1958; Ward et al. 1959). These data would suggest that 40 dB of TTS would be a reasonable limit for approximating the beginning of PTS for marine mammals exposed to continuous sound. Data from terrestrial mammal testing (Ward et al. 1958; Ward et al. 1959b) show growth of TTS by 1.5–1.6 dB for every 1 dB increase in exposure level. The difference between measurable TTS onset (6 dB) and the selected 40 dB upper safe limit of TTS yields a difference in TTS of 34 dB which, when divided by a TTS growth function of 1.6, indicates that an increase in exposure of 21 dB would result in 40 dB of TTS. For simplicity and additional conservatism, the number was rounded down to 20 dB (Southall et al. 2007).

Therefore, exposures to sonar and other active acoustic sources with levels 20 dB above those producing TTS are used to predict the threshold at which a PTS exposure would result (Table 3.4-3). For example, an onset-TTS criterion of 195 dB re 1 µPa^2-s would have a corresponding onset-PTS criterion of 215 dB re 1 µPa^2-s. This extrapolation process is identical to that recently proposed by Southall et al. (2007). The method overestimates effects (i.e., predicts greater effects) beyond those actually observed in tests on a bottlenose dolphin (Schlundt et al. 2006; Finneran et al. 2010a) indicating that this is a conservative approach to predicting onset-PTS.

The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict PTS.

Permanent Threshold Shift from Explosives

Since marine mammal PTS data from impulse exposures do not exist, onset-PTS levels for these animals are estimated by adding 15 dB re 1 µPa^2-s to the sound exposure level-based TTS threshold and by adding 6 dB re 1 µPa to the peak pressure based thresholds. These relationships were derived by Southall et al. (2007) from impulse noise TTS growth rates in chinchillas. The appropriate frequency weighting function for each species group is applied using the resulting sound exposure level-based thresholds, as shown on Table 3.4-4, to predict PTS.

3.4.3.1.4.3 Behavioral Responses

Behavioral response criteria are used to estimate the number of animals that may exhibit a behavioral response. In this analysis, animals may be behaviorally harassed in each modeled scenario (using the Navy Acoustic Effects Model) or within each 24-hour period, whichever is shorter. Therefore, the same animal could have a behavioral reaction multiple times over the course of a year.

Sound from Sonar and Other Active Sources

Potential behavioral effects to marine mammals from sonar and other active acoustic sources underwater were predicted using a behavioral response function for most animals. The received sound level is weighted with Type I auditory weighting functions (Southall et al. 2007; see Figure 3.4-2) before the behavioral response function is applied. There are exceptions made for beaked whales, which have unique behavioral criteria based on specific data that show these animals to be especially sensitive to sound. Beaked whale non-impulse behavioral criteria are unweighted; without weighting the received level before comparing it to the threshold (Finneran and Jenkins 2012).

Behavioral Response Functions

The Navy worked with NMFS to define a mathematical function used to predict potential behavioral effects to mysticetes (Figure 3.4-4) and odontocetes (Figure 3.4-5) from mid-frequency sonar (National Marine Fisheries Service 2008a). This effects analysis assumes that the potential consequences of exposure to sonar and other active acoustic sources on individual animals would be a function of the received sound pressure level (dB re 1 µPa). Although the response functions differ, the intercepts on each figure highlight that each function has a 50 percent probability of harassment at a received level of 165 dB SPL.

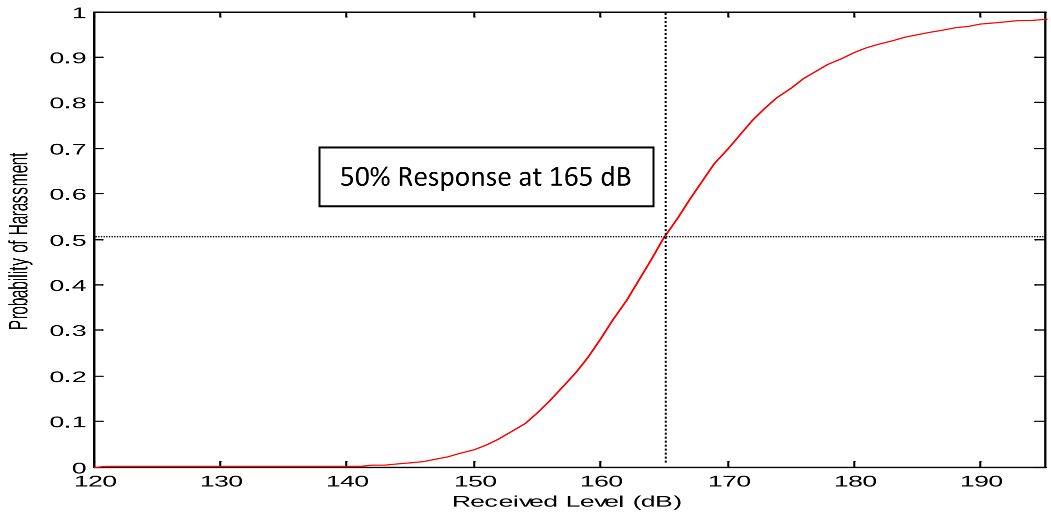

Figure 3.4-4: Behavioral Response Function Applied to Mysticetes

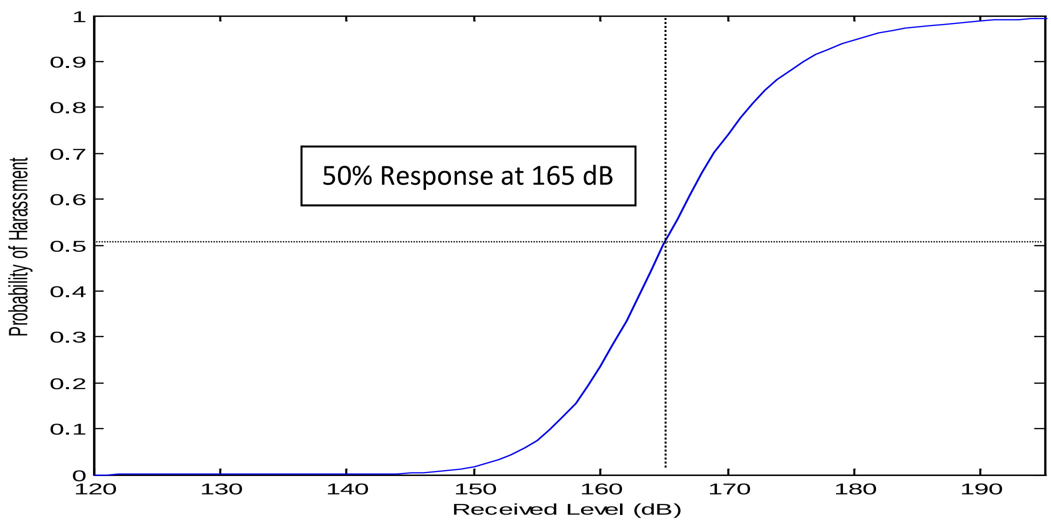

Figure 3.4-5: Behavioral Response Function Applied to Odontocetes

The behavioral response function applied to mysticetes differs from that used for odontocetes in having a shallower slope, which results in the inclusion of more behavioral events at lower amplitudes, consistent with observational data from North Atlantic right whales (Nowacek et al. 2007). These analyses assume that sound poses a negligible risk to marine mammals if they are exposed to sound pressure levels below a certain basement value. The values used in this analysis are based on three sources of data: behavioral observations during TTS experiments conducted at the Navy Marine Mammal Program and documented in Finneran et al. (2001, 2003, and 2005, Finneran and Schlundt 2004); reconstruction of sound fields produced by *USS SHOUP* associated with the behavioral responses of killer whales observed in Haro Strait (Fromm 2004a, b; National Marine Fisheries Service 2005; U.S. Department of the Navy 2004); and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components documented in Nowacek et al. (2004a).

In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al. 1995; Wartzok et al. 2003; Southall et al. 2007). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict. Therefore, the behavioral response functions represent a relationship that is deemed to be generally accurate, but may not be true in specific circumstances.

Specifically, the behavioral response function treats the received level as the only variable that is relevant to a marine mammal's behavioral response. However, many other variables, such as the marine mammal's gender, age, and prior experience; the activity it is engaged in during a sound exposure; its distance from a sound source; the number of sound sources; and whether the sound sources are approaching or moving away from the animal can be critically important in determining whether and how a marine mammal will respond to a sound source (Southall et al. 2007; Ellison et al. 2012). Currently available data do not allow for incorporation of these other variables in the current behavioral response functions; however, the response function represents the best use of the data that are available. Furthermore, the behavioral response functions do not differentiate between different types of behavioral reactions (e.g., area avoidance, diving avoidance, or alteration of natural behavior) or provide information regarding the predicted consequences of the reaction.

The behavioral response function is used to estimate the percentage of an exposed population that is likely to exhibit behaviors that would qualify as harassment (as that term is defined by the MMPA applicable to military readiness activities, such as the Navy's testing and training with MFA sonar) at a given received level of sound (Table 3.4-5). For example, at 165 dB SPL (dB re 1 µPa rms), the risk (or probability) of harassment is defined according to this function as 50 percent. This means that 50 percent of the individuals exposed at that received level would be predicted to exhibit a significant behavioral response.

Table 3.4-5: Summary of Behavioral Thresholds for Marine Mammals

Group	Behavioral Thresholds for Sonar and Other Active Acoustic Sources	Behavioral Thresholds for Explosions (SEL)
Low-Frequency Cetaceans	SPL: BRF_1 (Type I weighting)	167 dB re 1 µPa^2-s (Type II Weighting)
Mid-Frequency Cetaceans	SPL: BRF_2 (Type I weighting)	167 dB re 1 µPa^2-s (Type II Weighting)
High-Frequency Cetaceans	SPL: BRF_2 (Type I weighting)	141 dB re 1 µPa^2-s (Type II Weighting)
Beaked Whales	140 dB re 1 µPa (Unweighted)	167 dB re 1 µPa^2-s (Type II Weighting)

Notes: dB re 1 µPa = decibels referenced to 1 micropascal, dB re 1 µPa^2-s = decibels referenced to 1 micropascal squared second, BRF = Behavioral Response Function, SPL = sound pressure level, SEL = sound exposure level

Beaked Whales

The inclusion of a special behavioral response criterion for beaked whales of the family Ziphiidae is new to these Phase II criteria and is based on Southall et al. (2012a). It has been speculated for some time that beaked whales might have unusual sensitivities to sound due strandings which occurred in conjunction with mid-frequency sonar use, even in areas where other species were more abundant (D'Amico et al. 2009; U.S. Department of the Navy 2012), but there were not sufficient data to support a separate treatment for beaked whales until recently. With the recent publication of results from beaked whale monitoring and experimental exposure studies on the Navy's instrumented range in the Bahamas (McCarthy et al. 2011; Tyack et al. 2011), there are now statistically strong data demonstrating that beaked whales tend to avoid actual naval mid-frequency sonar in real anti-submarine training scenarios, playbacks of sonar, and playbacks of killer whale vocalizations, as well as other anthropogenic sounds. Tyack et al. (2011) report that, in reaction to sonar playbacks, most beaked whales stopped echolocating, made long slow ascent, and moved away from the sound. During an exercise using mid-frequency sonar, beaked whales avoided the area at a distance from the sonar where the received level was "around 140 dB" (SPL) and once the exercise ended, beaked whales re-inhabited the center of exercise area within 2–3 days (Tyack et al. 2011). The Navy has therefore adopted a 140 dB re 1 µPa sound pressure level threshold for behavioral effects for all beaked whales (see Table 3.4-5).

Since the development of the criterion, analysis of the data from the 2010 and 2011 field seasons of the Southern California Behavioral Responses Study have been published. The study, DeRuiter et al. (2013a), provides similar evidence of Cuvier's beaked whale sensitivities to sound based on two controlled exposures. Two whales, one in each season, were tagged and exposed to simulated MFA sonar at distances of 3.4–9.5 km. The 2011 whale was also incidentally exposed to MFA sonar from a distant naval exercise (~ 118 km away). Received levels from the MFA sonar signals during the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa rms, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Because the sample size was limited (controlled exposures during a single dive in both 2010 and 2011) and baseline behavioral data were obtained from different stocks and geographic areas (i.e., Hawaii and Mediterranean Sea), the Navy relied on the studies at AUTEC that analyzed beaked whale responses to actual naval exercises using MFA sonar to evaluate potential behavioral responses by beaked whales to proposed training and testing activities using sonar and other active acoustic sources.

Impulse Sound from Explosives

If more than one impulse 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 behavioral reaction. For multiple impulse events (with the exception of pile driving) the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold (in sound exposure level) (see Table 3.4-5). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulse TTS testing (Schlundt et al. 2000).

Some multiple impulse events, such as certain gunnery exercises, may be treated as a single impulse event because a few explosions occur closely spaced within a very short time (a few seconds). For single impulses 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 impulse, significant behavioral reactions would not be expected to occur. This reasoning was applied to ship shock trials (63 FR 230; 66 FR 87; 73 FR 143) and is extended to the criteria used in this analysis.

Since impulse events can be quite short, it may be possible to accumulate multiple received impulses at sound pressure levels above the energy-based criterion and still not be considered a behavioral take. The Navy treats all individual received impulses as if they were 1 second long for the purposes of calculating cumulative sound exposure level for multiple impulse events. For example, five impulses, each 0.1 second long, received at a Type II weighted SPL of 167 dB SPL would equal a 164 dB sound pressure level, and would not be predicted as leading to a significant behavioral response in MF or HF cetaceans. However, if the five 0.1-second pulses are treated as a 5-second exposure, it would yield an adjusted value of approximately 169 dB, exceeding the threshold of 167 dB sound exposure level. For impulses associated with explosions that have durations of a few microseconds, this assumption greatly overestimates effects based on sound exposure level metrics such as TTS and PTS and behavioral responses.

Appropriate weighting values will be applied to the received impulse in one-third octave bands and the energy summed to produce a total weighted sound exposure level value. For impulsive behavioral criteria, the new weighting functions (Figure 3.4-5) are applied to the received sound level before being compared to the threshold.

Impulse Sound from Airguns

Existing NMFS risk criteria are applied to the unique impulse sounds generated by airguns (Table 3.4-6) Weir (2008) reported minimal (or no) behavioral responses from humpback whales and sperm whales to airguns used during seismic surveys. Atlantic spotted dolphins did show overt avoidance behavior during airgun use, but readily approached the vessel to bow ride when the airgun was not in use. All observed responses occurred within 200 m of the vessel conducting the surveys.

Table 3.4-6: Airgun Thresholds Used in this Analysis to Predict Effects on Marine Mammals

Species Groups	Underwater Airgun Criteria (sound pressure level, dB re 1 μPa)	
	Level A Injury Threshold	Level B Disturbance Threshold
Cetaceans (whales, dolphins, porpoises)	180 dB rms	160 dB rms

Notes: (1) rms = root mean square, dB re 1 μPa = decibels referenced to 1 micropascal; (2) Root mean square calculation is based on the duration defined by 90 percent of the cumulative energy in the impulse.

3.4.3.1.5 Quantitative Analysis

The Navy performed a quantitative analysis to estimate the number of marine mammals that could be affected by acoustic sources or explosives used during military training and testing activities. Inputs to the quantitative analysis included marine mammal density estimates, marine mammal depth occurrence distributions, oceanographic and environmental data, marine mammal hearing data, and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer-modeled estimates from the Navy Acoustic Effects Model and a post-model analysis to determine the number of potential mortalities and harassments. The model calculates sound energy propagation from sonar, other active acoustic sources, and explosives during naval activities; the sound or impulse received by animat dosimeters representing marine mammals distributed in the area around the modeled activity; and whether the sound or impulse received by a marine mammal exceeds the thresholds for effects. The model estimates are then further analyzed to consider animal avoidance and implementation of mitigation measures, resulting in final estimates of potential effects due to military training and testing.

A number of computer models and mathematical equations can be used to predict how energy spreads from a sound source (e.g., sonar or underwater detonation) to a receiver (e.g., dolphin or sea turtle). See the Acoustic and Explosives Primer (Section 3.0.4) and a more detailed discussion in Appendix I (Acoustic and Effects Primer) for background information about how sound travels through the water. Basic underwater sound models calculate the overlap of energy and marine life using assumptions that account for the many, variable, and often unknown factors that can influence the result. Assumptions in previous and current Navy models have intentionally erred on the side of overestimation when there are unknowns or when the addition of other variables was not likely to substantively change the final analysis. For example, because the ocean environment is extremely dynamic and information is often limited to a synthesis of data gathered over wide areas and requiring many years of research, known information tends to be an average of a seasonal or annual variation. El Niño Southern Oscillation events of the ocean-atmosphere system are an example of dynamic change where unusually warm or cold ocean temperatures are likely to redistribute marine life and alter the propagation of underwater sound energy. Previous Navy modeling therefore made some assumptions indicative of a maximum theoretical propagation for sound energy (such as a perfectly reflective ocean surface and a flat seafloor). More complex computer models build upon basic modeling by factoring in additional variables in an effort to be more accurate by accounting for such things as bathymetry and an animal's likely presence at various depths.

The Navy has developed a set of data and new software tools for quantification of estimated marine mammal impacts from military activities. This new approach is the resulting evolution of the basic model previously used by Navy and reflects a more complex modeling approach as described below. Although this more complex computer modeling approach (i.e., the Navy Acoustic Effects Model) accounts for various environmental factors affecting acoustic propagation in more detail than previously considered, the current modeling (like all previous modeling) and resulting preliminary exposure numbers do not factor in: (1) the likelihood that a marine mammal would attempt to avoid repeated exposures to a sounds or explosions underwater, (2) that a marine mammal would avoid an area of intense activity where a training or testing event may be focused, and (3) implementation of Navy mitigation (e.g., stopping sonar transmissions when a detected marine mammal is within a certain distance of a ship; see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring, for details). In short, naval activities are modeled as though an activity would occur regardless of proximity to detected marine mammals and without any horizontal movement by the animal away from the sound source or human activities (e.g., without accounting for likely animal avoidance) because the science necessary to support that level of modeling complexity is beyond what is currently available. Therefore, the final step in the assessment of acoustic effects is to consider the implementation of mitigation and the possibility that marine mammals would avoid continued or repeated sound exposures to complete the analysis of potential impacts from the proposed action under the various alternatives.

The additional post-model quantification has been undertaken to further refine the numerical analysis of acoustic effects to include animal behavior such as avoidance of sound sources and avoidance of areas of activity before use of a sound source or explosive or during use of repeated explosives, and to account for protections afforded by implementation of standard Navy mitigations (see Marine Species Modeling Team 2013). The sections below describe the steps of the quantitative analysis of acoustic effects.

3.4.3.1.5.1 Marine Species Density Data

A quantitative analysis of impacts on a species requires data on the abundance and distribution of the species population in the potentially impacted area. The most appropriate unit of metric for this type of analysis is density, which is defined as the number of animals present per unit area.

There is no single source of density data for every area, species, and season because of the fiscal costs, resources, and effort involved in providing enough survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the MITT Study Area, the Navy needed to compile data from multiple sources. To develop a database of marine species density estimates, the Navy, in consultation with NMFS experts at the two science centers (Southwest Fisheries Science Center and Pacific Islands Fisheries Science Center) overlapping the MITT, adopted a protocol to select the best available data sources based on species, area, and season (see Navy's Pacific Marine Species Density Database Technical Report; U.S. Department of the Navy 2013c). The resulting Geographic Information System database includes one single spatial and seasonal density value for every marine mammal and sea turtle species present within the MITT Study Area.

The Navy Marine Species Density Database includes a compilation of the best available density data from several primary sources and published works including survey data from NMFS within the U.S. Economic Exclusion Zone and a Navy sponsored survey in waters of the MITT Study Area (Fulling et al. 2011). NMFS is the primary agency responsible for estimating marine mammal and sea turtle density within the United States exclusive economic zone. NMFS publishes annual Stock Assessment Reports for various regions of U.S. waters and covers all stocks of marine mammals within those waters. The majority of species that occur in the MITT Study Area are covered by the Pacific Region Stock Assessment Report (Carretta et al. 2013). Other independent researchers often publish density data or research covering a particular marine mammal species, which is integrated into the NMFS Stock Assessment Reports.

For most cetacean species, abundance is estimated using line-transect methods that employ a standard equation to derive densities based on sighting data collected from systematic ship or aerial surveys. More recently, habitat-based density models have been used effectively to model cetacean density as a function of environmental variables (e.g., Barlow et al. 2009). Habitat-based density models allow predictions of cetacean densities on a finer spatial scale than traditional line-transect analyses because cetacean densities are estimated as a continuous function of habitat variables (e.g., sea surface temperature, water depth, etc.). Within most of the world's oceans, however, there have not been enough systematic surveys to allow for line-transect density estimation or the development of habitat models. To get an approximation of the cetacean species distribution and abundance for unsurveyed areas, in some cases it is appropriate to extrapolate data from areas with similar oceanic conditions where extensive survey data exist. Habitat Suitability Index or Relative Environmental Suitability have also been used in data-limited areas to estimate occurrence based on existing observations about a given species' presence and relationships between basic environmental conditions (Kaschner et al. 2006).

3.4.3.1.5.2 Upper and Lower Frequency Limits

The Navy adopted a single frequency cutoff at each end of a functional hearing group's frequency range, based on the most liberal interpretations of their composite hearing abilities (see Finneran and Jenkins 2012) for details involving derivation of these values). These are not the same as the values used to calculate weighting curves, but instead exceed the demonstrated or anatomy-based hypothetical upper and lower limits of hearing within each group. Table 3.4-7 provides the lower and upper frequency limits for each species group. Sounds with frequencies below the lower frequency limit, or above the upper frequency limit, are not analyzed with respect to auditory effects for a particular group.

Table 3.4-7: Lower and Upper Cutoff Frequencies for Marine Mammal Functional Hearing Groups Used in this Acoustic Analysis

Functional Hearing Group	Limit (Hertz)	
	Lower	Upper
Low-Frequency Cetaceans	5	30,000
Mid-Frequency Cetaceans	50	200,000
High-Frequency Cetaceans	100	200,000

3.4.3.1.5.3 Navy Acoustic Effects Model

For this analysis of military training and testing activities at sea, the Navy developed a set of software tools and compiled data for the quantification of predicted acoustic impacts to marine mammals. These databases and tools collectively form the Navy Acoustic Effects Model. Details of this model's processes and the description and derivation of the inputs are presented in the Navy's Determination of Acoustic Effects Technical Report (Marine Species Modeling Team 2013).

The Navy Acoustic Effects Model improves upon previous modeling efforts in several ways (e.g., U.S. Department of the Navy 2008a, 2008b; Schecklman et al. 2011). First, unlike earlier methods that modeled sources individually, the Navy Acoustic Effects Model has the capability to run all sources within a scenario simultaneously, providing a more realistic depiction of the potential effects of an activity. Second, previous models calculated sound received levels within set volumes of water and spread animals uniformly across the volumes; in the Navy Acoustic Effects Model, animats (virtual animals) are distributed nonuniformly based on higher resolution species-specific density, depth distribution, and group size information, and animats serve as dosimeters, recording energy received at their location in the water column. Third, a fully three-dimensional environment is used for calculating sound propagation and animat exposure in the Navy Acoustic Effects Model, rather than a two-dimensional environment where the worst case sound pressure level across the water column is always encountered. Finally, current efforts incorporate site-specific bathymetry, sound speed profiles, wind speed, and bottom properties into the propagation modeling process rather than the flat-bottomed provinces used during earlier modeling (Marine Species Monitoring Team 2012). The following paragraphs provide an overview of the Navy Acoustic Effects Model process and its more critical data inputs.

Using information on the likely density of marine mammals in the area being modeled, Navy Acoustic Effects Model derives an abundance (total number of individuals) and distributes the resulting number of animats into an area bounded by the maximum distance that energy propagates out to a criterion threshold value (energy footprint). For example, for non-impulsive sources, all animats that are predicted to occur within a range that could receive sound pressure levels greater than or equal to 120 dB re 1 µPa are distributed. These animats are distributed based on density differences across the area, the group (pod) size, and known depth distributions (dive profiles). Animats change depths every 4 minutes but do not otherwise mimic actual animal behaviors, such as avoidance or attraction to a stimulus (horizontal movement), or foraging, social, or traveling behaviors.

Schecklman et al. (2011) argue that static distributions underestimate acoustic exposure compared to a model with fully three-dimensionally moving animals. However, their static method is different from the Navy Acoustic Effects Model in several ways. First, they distribute the entire population at depth with respect to the species-typical depth distribution histogram, and those animats remain static at that position throughout the entire simulation. In the Navy Acoustic Effects Model, animats are placed horizontally dependent on nonuniform density information, and then move up and down over time within the water column by integrating species-typical depth distribution information. Second, for the static method, they calculate acoustic received level for designated volumes of the ocean and then sum the animats that occur within that volume, rather than using the animats themselves as dosimeters, as in the Navy Acoustic Effects Model. Third, Schecklman et al. (2011) ran 50 iterations of the moving distribution to arrive at an average number of exposures, but because they rely on uniform horizontal density (and static depth density), only a single iteration of the static distribution is realized. In addition to moving the animats vertically, the Navy Acoustic Effects Model overpopulates the animats over a nonuniform density and then resamples the population a number of times to arrive at an average number of exposures as well. Tests comparing fully moving distributions and static distributions with vertical position changes at varying rates were compared during development of the Navy Acoustic Effects Model. For position updates occurring more frequently than every 5 minutes, the number of estimated exposures was similar between the Navy Acoustic Effects Model and the fully moving distribution; however, computational time was much longer for the fully moving distribution.

The Navy Acoustic Effects Model calculates the likely propagation for various levels of energy (sound or pressure) resulting from sonar and other active acoustic sources or impulse sources (e.g., explosives) used during a training or testing event. This is done taking into account the actual bathymetric relief and bottom types (e.g., reflective), and estimated sound speeds and sea surface roughness at an event's location. Platforms (such as a ship using one or more sound sources) are modeled as moving across an area whose size is representative of what would normally occur during a training or testing scenario. The model uses typical platform speeds and event durations. Moving source platforms either travel along a predefined track or move along straight-line tracks from a random initial course, reflecting at the edges of a predefined boundary. Static sound sources are stationary in a fixed location for the duration of a scenario. Modeling locations were chosen based on historical data where activities have been ongoing and in an effort to include all the environmental variation within the Study Area where similar events might occur in the future.

The Navy Acoustic Effects Model then tracks the energy received by each animat within the energy footprint of the event and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects to the animats are then converted using actual marine mammal densities, and the highest order effect predicted for a given animal is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine mammal could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the Study Area, sound may propagate beyond the boundary of the Study Area. Any exposures occurring outside the boundary of the Study Area are included in the model-estimated impacts for each alternative. The Navy Acoustic Effects Model provides the initial predicted impacts to marine species (based on application of multiple conservative assumptions which are assumed to overestimate impacts), which are then further analyzed to produce final estimates used in the Navy's MMPA take requests and ESA risk analyses (see Section 3.4.3.2, Marine Mammal Avoidance of Sound Exposures, for further information on additional analyses).

3.4.3.1.5.4 Model Assumptions and Limitations

There are limitations to the data used in the Navy Acoustic Effects Model, and the results must be interpreted with consideration for these known limitations. Output from the Navy Acoustic Effects Model relies heavily on the quality of both the input parameters and impact thresholds and criteria. When there was a lack of definitive data to support an aspect of the modeling (such as lack of well-described diving behavior for all marine species), conservative assumptions believed to overestimate the number of exposures were chosen:

- Marine mammals (animats in the model) are modeled as being underwater and facing the source and therefore are always predicted to receive the maximum sound level (e.g., the model does not account for conditions such as body shading, porpoising out of the water, or an animal raising its head above water). Some odontocetes have been shown to have directional hearing, with best hearing sensitivity facing a sound source and higher hearing thresholds for sounds propagating toward the rear or side of an animal (Kastelein et al. 2005; Mooney et al. 2008; Popov and Supin 2009).
- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological effects such as hearing loss, especially for slow moving or stationary sound sources in the model.
- Animats are stationary horizontally and therefore do not avoid the sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels, especially those exposures that may result in PTS.
- Animats are assumed to receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury) assume an impulse delivery time adjusted for animal size and depth. Therefore, these impacts are overestimated at farther distances and increased depths.
- Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the temporary or permanent hearing loss, because there are not sufficient data to estimate a hearing recovery function for the time between exposures.
- Mitigation measures implemented during many training and testing activities were not considered in the model (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). In reality, sound-producing activities would be reduced, stopped, or delayed if marine mammals are detected within the mitigation zones around sound sources.

Because of these inherent model limitations and simplifications, initial predicted model results must be further analyzed, considering such factors as the range to specific effects and the likelihood of successfully implementing mitigation measures. This analysis uses a number of factors in addition to the acoustic model results to predict acoustic effects to marine mammals as presented in the following section.

3.4.3.2 Marine Mammal Avoidance of Sound Exposures

Marine mammals may avoid underwater sound exposures by either avoiding areas with high levels of anthropogenic activity or moving away from a sound source. Because the Navy Acoustic Effects Model does not consider horizontal movement of animats, including avoidance of human activity or sounds, it overestimates the number of marine mammals that would be exposed to sound sources that could cause injury. Therefore, the potential for avoidance is considered in the post-model analysis. The consideration of avoidance during use of sonar and other active acoustic sources and during use of explosives is described below and discussed in more detail in Section 3.4.3.1.2 (Analysis Background and Framework).

3.4.3.2.1 Avoidance of Human Activity

Cues preceding the commencement of an event (e.g., multiple vessel presence and movement, aircraft overflight) may result in some animals departing the immediate area, even before active sound sources begin transmitting. Beaked whales have been observed to be especially sensitive to human activity (Tyack et al. 2011; Pirotta et al. 2012), which is accounted for by using a low threshold for behavioral disturbance due to exposure to sonar and other active acoustic sources (see Section 3.4.3.1.2, Analysis Background and Framework).

Therefore, for certain military activities preceded by high levels of vessel activity (multiple vessels) or hovering aircraft, beaked whales are assumed to avoid the activity area prior to the start of a sound-producing activity. Model-estimated effects during these types of activities are adjusted so that high level sound impacts to beaked whales (those causing PTS during use of sonar and other active acoustic sources and those causing mortality due to explosives) are considered to be TTS and injury, respectively, due to animals moving away from the activity and into a lower effect range.

3.4.3.2.2 Avoidance of Repeated Exposures

Marine mammals would likely avoid repeated high level exposures to a sound source that could result in injuries (e.g., PTS). Therefore, the model-estimated effects are adjusted to account for marine mammals swimming away from a sonar or other active source and away from multiple explosions to avoid repeated high level sound exposures. Avoidance of repeated sonar exposures is discussed further in Section 3.4.4.1.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources), and avoidance of repeated explosive exposures is discussed further in Section 3.4.4.2.2 (Avoidance Behavior and Mitigation Measures as Applied to Explosions).

3.4.3.3 Implementing Mitigation to Reduce Sound Exposures

The Navy implements mitigation measures (described in Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) during sound-producing activities, including halting or delaying use of a sound source or explosives when marine mammals are observed in the mitigation zone. The Navy Acoustic Effects Model estimates acoustic effects without taking into account any shutdown or delay of the activity when marine mammals are detected; therefore, the model over-estimates impacts to marine mammals within mitigation zones. The post-model adjustment considers and quantifies the potential for highly effective mitigation to reduce the likelihood or risk of PTS due to exposure to sonar and other active acoustic sources and to reduce the likelihood of PTS, injuries, and mortalities due to explosives.

Two factors are considered when quantifying the effectiveness of mitigation: (1) the sightability of each species that may be present in the mitigation zone, which is affected by species-specific characteristics; and (2) 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. The mitigation zones proposed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) encompass the estimated ranges to injury (including the range to mortality for explosives) for a given source.

Mitigation is considered in the quantified reduction of model-predicted effects when the mitigation zone can be fully or mostly observed prior to and during a sound-producing activity. Mitigation for each training or testing event is considered in its entirety, taking into account the different ways an event's activities may take place as part of that event (some scenarios involve different mitigation zones, platforms, or number of Lookouts). The ability to observe the range to mortality (for explosive activities only) and the range to potential injury (for all sound-producing activities) were estimated for each training or testing event. Mitigation was considered in the acoustic analysis as follows:

- If the entire mitigation zone can be continuously visually observed based on the platform(s), number of Lookouts, and size of the range to effects zone, the mitigation is considered fully effective (Effectiveness = 1).
- If over half of the mitigation zone can be continuously visually observed or if there is one or more of the scenarios within the activity for which the mitigation zone cannot be continuously visually observed (but for the majority of the scenarios the range to effects zone can be continuously visually observed), the mitigation is considered mostly effective (Effectiveness = 0.5).
- If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, the mitigation is not considered as an adjustment factor in the acoustic effects analysis.

Integral to the ability of Lookouts to detect marine mammals in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability. The Navy considered what applicable data were available to numerically approximate the sightability of marine mammals and determined that the standard "detection probability" referred to as g(0) was most appropriate. The abundance of marine mammals is typically estimated using line-transect analyses (Buckland et al. 2001), in which g(0) is the probability of detecting an animal or group of animals on the transect line (the straight-line course of the survey ship or aircraft). This detection probability is derived from systematic line-transect marine mammal surveys based on species-specific estimates for vessel and aerial platforms. Estimates of g(0) are available from peer-reviewed marine mammal line-transect survey reports, generally provided through research conducted by the NMFS Science Centers.

There are two separate components of g(0): perception bias and availability bias (Marsh and Sinclair 1989). Perception bias accounts for marine mammals that are on the transect line and detectable, but were simply missed by the observer. Various factors influence the perception bias component of g(0), including species-specific characteristics (e.g., behavior and appearance, group size, and blow characteristics), viewing conditions during the survey (e.g., sea state, wind speed, wind direction, wave height, and glare), observer characteristics (e.g., experience, fatigue, and concentration), and platform characteristics (e.g., pitch, roll, speed, and height above water). To derive estimates of perception bias, typically an independent observer is present who looks for marine mammals missed by the primary observers. Mark-recapture methods are then used to estimate the probability that animals are missed by the primary observers. Availability bias accounts for animals that are missed because they are not at the surface at the time the survey platform passes by, which generally occurs more often with deep diving whales (e.g., sperm whale and beaked whale). The availability bias portion of g(0) is independent of prior marine mammal detection experience since it only reflects the probability of an animal being at the surface within the survey track and therefore available for detection.

Some g(0) values are estimates of perception bias only, some are estimates of availability bias only, and some reflect both, depending on the species and data that are currently available. The Navy used g(0) values with both perception and availability bias components, if those data were available. If both components were not available for a particular species, the Navy determined that g(0) values reflecting perception bias or availability bias, but not both, still represent the best statistically-derived factor for assessing the likelihood of marine mammal detection by Navy Lookouts.

As noted above, line-transect surveys and subsequent analyses are typically used to estimate cetacean abundance. To systematically sample portions of an ocean area (such as the coastal waters off California or the east coast), marine mammal surveys are designed to uniformly cover the survey area and are conducted at a constant speed (generally 10 knots for ships and 100 knots for aircraft). Survey transect lines typically follow a pattern of straight lines or grids. Generally there are two primary observers searching for marine mammals. Each primary observer looks for marine mammals in the forward 90-degree quadrant on their side of the survey platform. Based on data collected during the survey, scientists determine the factors that affected the detection of an animal or group of animals directly along the transect line.

Visual marine mammal surveys (used to derive g(0)) are conducted during daylight.[5] Marine mammal surveys are typically scheduled for a season when weather at sea is more likely to be good, however, observers on marine mammal surveys will generally collect data in sea state conditions up to Beaufort 6 and do encounter rain and fog at sea which may also reduce marine mammal detections (see Barlow 2006). For most species, g(0) values are based on the detection probability in conditions from Beaufort 0 to Beaufort 5, which reflects the fact that marine mammal surveys are often conducted in less than ideal conditions (see Barlow 2003; Barlow and Forney 2007). The ability to detect some species (e.g., beaked whales, *Kogia* spp., and Dall's porpoise) decreases dramatically with increasing sea states, so g(0) estimates for these species are usually restricted to observations in sea state conditions of Beaufort 0 to 2 (Barlow 2003).

Military training and testing events differ from systematic line-transect marine mammal surveys in several respects. These differences suggest the use of g(0), as a sightability factor to quantitatively adjust model-predicted effects based on mitigation, is likely to result in an underestimate of the protection afforded by the implementation of mitigation as follows:

- Mitigation zones for military training and testing events are significantly smaller (typically less than 1,000 yd. radius) than the area typically searched during line-transect surveys, which includes the maximum viewable distance out to the horizon.
- In some cases, training and testing events can involve more than one vessel or aircraft (or both) operating in proximity to each other or otherwise covering the same general area. Additional vessels and aircraft can result in additional watch personnel observing the mitigation zone (e.g., ship shock trials). This would result in more observation platforms and observers looking at the mitigation zone than the two primary observers used in marine mammal surveys upon which g(0) is based.
- A systematic marine mammal line-transect survey is designed to sample broad areas of the ocean, and generally does not retrace the same area during a given survey. Therefore, in terms of g(0), the two primary observers have only a limited opportunity to detect marine mammals that may be present during a single pass along the trackline (i.e., deep diving species may not be present at the surface as the survey transits the area). In contrast, many military training and

[5] At night, passive acoustic data may still be collected during a marine mammal survey.

testing activities involve area-focused events (e.g., anti-submarine warfare tracking exercise), where participants are likely to remain in the same general area during an event. In other cases military training or testing activities are stationary (i.e., pierside sonar testing or use of dipping sonar), which allow Lookouts to focus on the same area throughout the activity. Both of these circumstances result in a longer observation period of a focused area with more opportunities for detecting marine mammals, than are offered by a systematic marine mammal line-transect survey that only passes through an area once.

Although Navy Lookouts on ships have hand-held binoculars and on some ships, pedestal mounted binoculars very similar to those used in marine mammal surveys, there are differences between the scope and purpose of marine mammal detections during research surveys along a trackline and Navy Lookouts observing the water proximate to a military training or testing activity to facilitate implementation of mitigation. The distinctions required careful consideration when comparing the Navy Lookouts to marine mammal surveys.[6]

- A marine mammal observer is responsible for detecting marine mammals in their quadrant of the trackline out to the limit of the available optics. Although Navy Lookouts are responsible for observing the water for safety of ships and aircraft, during specific training and testing activities, they need only detect marine mammals in the relatively small area that surrounds the mitigation zone (in most cases less than 1,000 yd. from the ship) for mitigation to be implemented.
- Navy Lookouts, personnel aboard aircraft and on watch onboard vessels at the surface will have less experience detecting marine mammals than marine mammal observers used for line-transit survey. However, Navy personnel responsible for observing the water for safety of ships and aircraft do have significant experience looking for objects (including marine mammals) on the water's surface and Lookouts are trained using the NMFS-approved Marine Species Awareness Training.

[6] Barlow and Gisiner (2006) provide a description of typical marine mammal survey methods from ship and aircraft and then provide "a crude estimate" of the difference in detection of beaked whales between trained marine mammal observers and seismic survey mitigation, which is not informative with regard to Navy mitigation procedures for the following reasons. The authors note that seismic survey differs from marine mammal surveys in that, "(1) seismic surveys are also conducted at night; (2) seismic surveys are not limited to calm sea conditions; (3) mitigation observers are primarily searching with unaided eyes and 7x binoculars; and (4) typically only one or possibly two observers are searching." When Navy implements mitigation for which adjustments to modeling output were made, the four conditions Barlow and Gisiner (2006) note are not representative of Navy procedures nor necessarily a difference in marine mammal line-transect survey procedures. Navy accounts for reduced visibility (i.e., activities which occur at night, etc.) by assigning a lower value to the mitigation effectiveness factor. On Navy ships, hand-held binoculars are always available and pedestal mounted binoculars very similar to those used in marine mammal surveys, are generally available to Navy Lookouts on board vessels over 60 ft. Also like marine mammal observers, Navy Lookouts are trained to use a methodical combination of unaided eye and optics as they search the surface around a vessel. The implication that marine mammal surveys only occur in "calm sea conditions" is not accurate since the vast majority of marine mammal surveys occur and data is collected in conditions up to sea states of Beaufort 5. The specific g(0) values analyzed by Barlow and Gisiner (2006) were derived from survey data for Cuvier's and *Mesoplondon* beaked whales conducted that were detected in sea states of Beaufort 0–2 during daylight hours which, as noted above, is common for marine mammal surveys conducted for these particular species. However, marine mammal surveys for most species are not similarly restricted to sea states of Beaufort 0–2, many species g(0) values are based on conditions up to and including Beaufort 5 and, therefore, the conclusions reached by Barlow and Gisiner (2006) regarding the effect of sea state conditions on sightability do not apply to other species. Finally, when Lookouts are present, there are always more than the "one or two personnel" described by Barlow and Gisiner (2006) observing the area ahead of a Navy vessel (additional bridge watch personnel are also observing the water around the vessel).

Although there are distinct differences between marine mammal surveys and military training and testing, the use of g(0) as an approximate sightability factor for quantitatively adjusting model-predicted impacts due to mitigation [mitigation effectiveness x g(0)] is an appropriate use of the best available science based on the way it has been applied. I'Conservative application of g(0) includes:

- In addition to a sightability factor (based on g(0)), the Navy also applied a mitigation effectiveness factor to acknowledge the uncertainty associated with applying the g(0) values derived from marine mammal surveys to specific military training and testing activities where the ability to observe the whole mitigation zone is less than optimal (generally due to the size of the mitigation zone).
- For activities that can be conducted at night, the Navy assigned a lower value to the mitigation effectiveness factor. For example, if an activity can take place at night half the time, then the mitigation effectiveness factor was only given a value of 0.5.
- The Navy did not quantitatively adjust model-predicted effects for activities that were given a mitigation effectiveness factor of zero. A mitigation effectiveness factor of zero was given to activities where less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone. In reality, however, some protection from applied mitigation measures would be afforded even during these activities, even though it is not accounted for in the quantitative reduction of model-predicted impacts.
- The Navy did not quantitatively adjust model-predicted effects based on detections made by other personnel that may be involved with an event (such as range support personnel aboard a torpedo retrieval boat or support aircraft), even though in reality information about marine mammal sightings are shared amongst the units participating in the training or testing activity. In other words, the Navy only quantitatively adjusted the model-predicted effects based on the required number of Lookouts.
- The Navy only quantitatively adjusted model-predicted effects within the range to mortality (explosives only) and injury (all sound-producing activities), and not for the range to TTS or other behavioral effects (see Table 5.3-2 for a comparison of the range to effects for PTS, TTS, and the recommended mitigation zone). Despite employing the required mitigation measures during an activity that will also reduce some TTS exposures, Navy did not quantitatively adjust the model-predicted TTS effects as a result of implemented mitigation.
- The total model-predicted number of animals affected is not reduced by the post-model mitigation analysis, since all reductions in mortality and injury effects are then added to and counted as TTS effects.
- Mitigation involving a power-down or cessation of sonar, or delay in use of explosives, as a result of a marine mammal detection, protects the observed animal and all unobserved (below the surface) animals in the vicinity. The quantitative adjustments of model-predicted impacts, however, assumes that only animals on the water surface, approximated by considering the species-specific g(0) and activity-specific mitigation effectiveness factor, would be protected by the applied mitigation (i.e., a power down or cessation of sonar or delaying the event). The quantitative post-model mitigation analysis, therefore, does not capture the protection afforded to all marine mammals that may be near or within the mitigation zone.

The Navy recognizes that g(0) values are estimated specifically for line-transect analyses; however, g(0) is still the best statistically-derived factor for assessing the likely marine mammal detection abilities of Navy Lookouts. Based on the points summarized above, as a factor used in accounting for the implementation of mitigation, g(0) is therefore considered to be the best available scientific basis for Navy's representation of the sightability of a marine mammal as used in this analysis.

The g(0) value used in the mitigation analysis is based on the platform(s) with Lookouts utilized in the activity. In the case of multiple platforms, the higher g(0) value for either the aerial or vessel platform is selected. For species for which there is only a single published value for each platform, that individual value is used. For species for which there is a range of published g(0) values, an average of the values, calculated separately for each platform, is used. A g(0) of zero is assigned to species for which there are no data available, unless a g(0) estimate can be extrapolated from similar species/guilds based on the published g(0) values. The g(0) values used in this analysis are provided in Table 3.4-8. The post-model acoustic effects quantification process is summarized in Table 3.4-9.

Table 3.4-8: Sightability Based on g(0) Values for Marine Mammal Species in the Study Area

Species/Stocks	Family	Vessel Sightability	Aircraft Sightability
Blainville's Beaked Whale	Ziphidae	0.395	0.074
Blue Whale, Fin Whale; Omura's Whale; Sei Whale	Balaenopteridae	0.921	0.407
Bottlenose Dolphin, Fraser's Dolphin	Delphinidae	0.808	0.96
Bryde's Whale	Balaenopteridae	0.91	0.407
Cuvier's Beaked Whale; Ginkgo-toothed Beaked Whale	Ziphidae	0.23	0.074
Dwarf Sperm Whale, Pygmy Sperm Whale, *Kogia* spp.	Kogiidae	0.35	0.074
False Killer Whale, Melon-headed Whale	Delphinidae	0.76	0.96
Humpback Whale	Balaenopteridae	0.921	0.495
Killer Whale	Delphinidae	0.91	0.96
Longman's Beaked Whale, Pygmy Killer Whale	Ziphidae, Delphinidae	0.76	0.074
Mesoplodon spp.	Ziphiidae	0.34	0.11
Minke Whale	Balaenopteridae	0.856	0.386
Pantropical Spotted/Risso's/Rough-toothed/ Spinner/Striped Dolphin	Delphinidae	0.76	0.96
Short-finned Pilot Whale	Delphinidae	0.76	0.96
Sperm Whale	Physeteridae	0.87	0.495

Note: For species having no data, the g(0) for Cuvier's aircraft value (where g(0) = 0.074) was used; or in cases where there was no value for vessels, the g(0) for aircraft was used as a conservative underestimate of sightability following the assumption that the availability bias from a slower moving vessel should result in a higher g(0).

Sources: Barlow 2010; Barlow and Forney 2007; Carretta et al. 2000.

Table 3.4-9: Post-Model Acoustic Impact Analysis Process

What is the Sound Source? Sonar (or Other Active Sources) OR Explosives?	
Sonar and Other Active Acoustic Sources (i.e., Non-impulse Sources)	**Explosives (i.e., Impulse Sources)**
S-1. Is the activity preceded by multiple vessel activity or hovering helicopter?	**E-1. Is the activity preceded by multiple vessel activity or hovering helicopter?**
Species sensitive to human activity (e.g., beaked whales) are assumed to avoid the activity area, putting them out of the range to Level A harassment. Model-estimated permanent threshold shift (PTS) exposures to these species during these activities are unlikely to actually occur and, therefore, are considered to be temporary threshold shift (TTS) exposures (animal is assumed to move into the range of TTS). The training and testing activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 3.4-14 and Table 3.4-15 in Section 3.4.4.1.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources).	Species sensitive to human activity (e.g., beaked whales) are assumed to avoid the activity area, putting them out of the range to mortality. Model-estimated mortalities to these species during these activities are unlikely to actually occur and, therefore, are considered to be injuries (animal is assumed to move into the range of potential injury). The training and testing activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 3.4-20 in Section 3.4.4.2.2 (Avoidance Behavior and Mitigation Measures as Applied to Explosions).
S-2. Can Lookouts observe the activity-specific mitigation zone (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) up to and during the sound-producing activity?	**E-2. Can Lookouts observe the activity-specific mitigation zone (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) up to and during the sound-producing activity?**
If Lookouts are able to observe the mitigation zone up to and during a sound-producing activity, the sound-producing activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone (per the mitigation procedures in Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). Therefore, model-estimated PTS exposures are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated PTS exposures are instead assumed to be TTS (animal is assumed to move into the range of TTS). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated Lookout(s). For activities with Lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 3.4-8. The Mitigation Effectiveness values are provided in Table 3.4-16.	If Lookouts are able to observe the mitigation zone up to and during an explosion, the explosive activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone. Therefore, model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated mortalities or injuries are instead assumed to be injuries or behavioral disturbances, respectively (animals are assumed to move into the range of a lower effect). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated Lookout(s). For activities with Lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 3.4-8. The Mitigation Effectiveness values for explosive activities are provided in Table 3.4-21.

Table 3.4-9: Post-Model Acoustic Impact Analysis Process (continued)

S-3. Does the activity cause repeated sound exposures which an animal would likely avoid?	E-3. Does the activity cause repeated sound exposures which an animal would likely avoid?
The Navy Acoustic Effects Model assumes that animals do not move away from a sound source and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the sound source. Therefore, only the initial exposures resulting in model-estimated PTS exposures to high-frequency cetaceans, low-frequency cetaceans, and phocids are expected to actually occur (after accounting for mitigation in step S-3). Model estimates of PTS exposures beyond the initial pings are considered to actually be behavioral disturbances, as the animal is assumed to move out of the range to PTS and into the range of TTS. Marine mammals in the mid-frequency hearing group would have to be close to the most powerful moving source (less than 10.9 yards [10 meters]) to experience PTS. These model-estimated PTS exposures of mid-frequency cetaceans are unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to move into the range of TTS).	The Navy Acoustic Effects Model assumes that animals do not move away from multiple explosions and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the site of multiple explosions. Therefore, only the initial exposures resulting in model-estimated PTS exposures are expected to actually occur (after accounting for mitigation in step E-2). Model estimates of PTS are reduced to account for animals moving away from an area with multiple explosions, out of the range to PTS, and into the range of TTS. Activities with multiple explosions are listed in Section 3.4.4.2.2 (Avoidance Behavior and Mitigation Measures as Applied to Explosions) Table 3.4-22.

Note: For additional information on post-modeling analysis refer to the Navy's Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for the Mariana Islands Training and Testing technical report (U.S. Department of the Navy 2013d).

3.4.3.4 Marine Mammal Monitoring During Training and Testing

The current behavioral exposure criteria under the response function also assumes there will be a range of reactions from minor or inconsequential to severe. Section 3.0.2.2 (Navy Integrated Comprehensive Monitoring Program) summarizes the monitoring data that have been collected thus far within the Study Area. For further discussion, also see Section 3.4.5.2 (Summary of Observations During Previous Navy Activities). Results of monitoring may provide indications that the severity of reactions suggested by the current modeling and thresholds has been overestimated.

3.4.3.5 Application of the Marine Mammal Protection Act to Potential Acoustic and Explosive Effects

The MMPA prohibits the unauthorized harassment of marine mammals and provides the regulatory processes for authorization for any such incidental harassment that might occur during an otherwise lawful activity. Harassment that may result from military training and testing activities described in this EIS/OEIS is unintentional and incidental to those activities.

For military readiness activities, MMPA Level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Injury, as defined in this EIS/OEIS, is the destruction or loss of biological tissue from a marine mammal. The destruction or loss of biological tissue will result in an alteration of physiological function that exceeds the normal daily physiological variation of the intact tissue. For example, increased localized histamine production, edema, production of scar tissue, activation of clotting factors, white blood cell response, etc., may be expected following injury. Therefore, this EIS/OEIS assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings (National Marine Fisheries Service 2001, 2009 a, b), all injuries (except those serious enough to be expected to result in mortality) are considered MMPA Level A harassment.

PTS is non-recoverable and, by definition, results from the irreversible impacts to auditory sensory cells, supporting tissues, or neural structures within the auditory system. PTS therefore qualifies as an injury and is classified as Level A harassment under the wording of the MMPA. The smallest amount of PTS (onset-PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset-PTS is used to define the outer limit of the MMPA Level A exposure zone. Model-predicted slight lung injury, gastrointestinal tract injuries, and mortalities are also considered MMPA Level A harassment in this analysis.

Public Law 108-136 (2004) amended the MMPA definitions of Level B harassment for military readiness activities to be "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered." Unlike MMPA Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may cause MMPA Level B harassment.

TTS is recoverable and is considered to result from the temporary, non-injurious fatigue of hearing-related tissues. The smallest measurable amount of TTS (onset-TTS) is taken as the best indicator for slight temporary sensory impairment. Because it is considered non-injurious, the acoustic exposure associated with onset-TTS is used to define the outer limit of the portion of the MMPA Level B exposure zone attributable to physiological effects. Short-term reduction in hearing acuity could be considered a temporary decrement similar in scope to a period of hearing masking or behavioral disturbance. As such, it is considered by the Navy and NMFS as a Level B effect overlapping the range of sounds producing behavioral effects.

The harassment status of slight behavior disruption has been addressed in workshops, previous actions, and rulings (National Marine Fisheries Service 2001, 2008b, 2009a, 2009b; U.S. Department of Defense 2001). The conclusion is that a momentary behavioral reaction of an animal to a brief, time-isolated acoustic event does not qualify as MMPA Level B harassment. This analysis uses behavioral criteria to predict the number of animals likely to experience a significant behavioral reaction, and therefore a MMPA Level B harassment.

NMFS also includes mortality, or serious injury likely to result in mortality, as a possible outcome to consider in addition to MMPA Level A and MMPA Level B harassment. An individual animal predicted to experience simultaneous multiple injuries, multiple disruptions, or both, is typically counted as a single take (National Marine Fisheries Service 2001, 2006). There are many possible temporal and spatial combinations of activities, stressors, and responses, for which multiple reasonable methods can be used to quantify take by Level B harassment on a case-specific basis. NMFS generally considers it appropriate for applicants to consider multiple modeled exposures of an individual animal to levels above the behavioral harassment threshold within one 24-hour period as a single MMPA take. Behavioral harassment, under the response function presented in this request, uses received sound pressure level over a 24-hour period as the metric for determining the probability of harassment (see Section 3.4.4.1.2, Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources).

3.4.3.6 Application of the Endangered Species Act to Marine Mammals

Generalized information on definitions and the application of the ESA are presented in Section 3.0.4 (Acoustic and Explosives Primer) along with the acoustic conceptual framework used in this analysis. Consistent with NMFS analysis for Section 7 consultation under the ESA (e.g., National Marine Fisheries Service 2013), the spatial and temporal overlap of activities with the presence of listed species is assessed in this EIS/OEIS. The definitions used by the Navy in making the determination of effect under Section 7 of the ESA are based on the U.S. Fish and Wildlife Service and NMFS *Endangered Species Consultation Handbook* (United States Fish and Wildlife Service and National Marine Fisheries Service 1998) and recent NMFS Biological Opinions involving many of the same activities and species.

- "No effect" is the appropriate conclusion when a listed species or its designated critical habitat will not be affected, either because the species will not be present or because the project does not have any elements with the potential to affect the species or modify designated critical habitat. "No effect" does not include a small effect or an effect that is unlikely to occur.
- If effects are insignificant (in size) or discountable (extremely unlikely), a "may affect" determination is still appropriate. "May affect" is appropriate when animals are within a range where they could potentially detect or otherwise be affected by the sound (e.g., the sound is above background ambient levels). If effects are insignificant (in size) or discountable (extremely unlikely), a "may affect" determination is appropriate.
  - Insignificant effects relate to the size of the impact and should never reach the scale where take occurs.
  - Discountable effects are those extremely unlikely to occur; based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.
- If a stressor and species presence overlap, and a predicted effect is not insignificant, discountable, or beneficial, a "may affect, likely to adversely affect" determination is appropriate.

There are no harassment or injury criteria established for marine mammals under the ESA because the ESA requires an assessment starting with mere exposure potential. Acoustic modeling is used to predict the number of ESA-listed marine mammals exposed to sound resulting from military training and testing activities, without any behavioral or physiological criteria applied.

There is no designated critical habitat in the MITT Study Area.

3.4.4 Analysis of Effects on Marine Mammals

3.4.4.1 Impacts from Sonar and Other Active Acoustic Sources

Sonar and other active acoustic sources proposed for use are transient in most locations as active sonar activities move throughout the MITT Study Area. Sonar and other active acoustic sound sources emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of sonar systems are described in Section 3.0.4.1.6 (Classification of Acoustic and Explosive Sources).

Exposure of marine mammals to sonar and other active acoustic sources is not likely to result in primary blast injuries or barotraumas given the power output of the sources and the proximity to the source that would be required. Sonar induced acoustic resonance and bubble formation phenomena are also unlikely to occur under realistic conditions in the ocean environment, as discussed in Section 3.4.3.1.2.1 (Direct Injury). Direct injury from sonar and other active acoustic sources would not occur under conditions present in the natural environment, and therefore is not considered further in this analysis. Research and observations of auditory masking in marine mammals is discussed in Section 3.4.3.1.2.4 (Auditory Masking).

Anti-submarine warfare sonar can produce intense underwater sounds in the Study Area associated with the Proposed Action. These sounds are likely within the audible range of most cetaceans but are normally very limited in the temporal, frequency, and spatial domains. The duration of individual sounds is short; sonar pulses can last up to a few seconds each, but most are shorter than 1 second. The duty cycle is low, with most tactical anti-submarine warfare sonar typically transmitting about once per minute. Furthermore, events are geographically and temporally dispersed, and most events are limited to a few hours. Tactical sonar has a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant auditory masking in marine mammals.

Some object-detecting sonar (i.e., mine warfare sonar) has a high duty cycle producing up to a few pings per second. Such sonar typically employs high frequencies (above 10 kHz) that attenuate rapidly in the water, thus producing only a small area of potential auditory masking. Higher-frequency mine warfare sonar systems are typically outside the hearing and vocalization ranges of mysticetes (Section 3.4.2.3, Vocalization and Hearing of Marine Mammals); therefore, mysticetes are unlikely to be able to detect the higher frequency mine warfare sonar, and these systems would not interfere with their communication or detection of biologically relevant sounds. Odontocetes may experience some limited masking at closer ranges as the frequency band of many mine warfare sonar overlaps the hearing and vocalization abilities of some odontocetes; however, the frequency band of the sonar is narrow, limiting the likelihood of auditory masking. With any of these activities, the limited duration and dispersion of the activities in space and time reduce the potential for auditory masking effects from proposed activities on marine mammals.

The most probable effects from exposure to sonar and other active acoustic sources are PTS, TTS, and behavioral harassment (Section 3.4.4.1.3, Predicted Impacts from Sonar and Other Active Acoustic Sources, and Section 3.4.3.1.2.6, Behavioral Responses). The Navy Acoustic Effects Model is used to produce initial estimates of the number of animals that may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation. These are discussed below in the following sections.

Another concern is the number of times an individual marine mammal is exposed and potentially reacts to a sonar or other active acoustic source over the course of a year or within a specific geographic area. Animals that are resident during all or part of the year near Navy ports or on fixed Navy ranges are the most likely to experience multiple exposures. Repeated and chronic noise exposures to marine mammals and their observed reactions are discussed in this analysis where applicable.

3.4.4.1.1 Range to Effects

The following section provides the predicted range (distance) over which specific physiological or behavioral effects are expected to occur based on the acoustic criteria (Finneran and Jenkins 2012) and the acoustic propagation calculations from the Navy Acoustic Effects Model (Section 3.4.3.1.5.3, Navy Acoustic Effects Model).

The range to specific effects are used to assess model results and determine adequate mitigation ranges to avoid higher level effects, especially physiological effects (e.g., PTS). Additionally, these data can be used to analyze the likelihood of an animal being able to avoid the effects of an oncoming sound source by simply moving a short distance away (e.g., a few hundred meters). Figure 3.4-6 shows a representation of effects with distance from a hypothetical sonar source; notice the proportion of animals that are likely to have a behavioral response (yellow block; "response-function") decreases with increasing distance from the source.

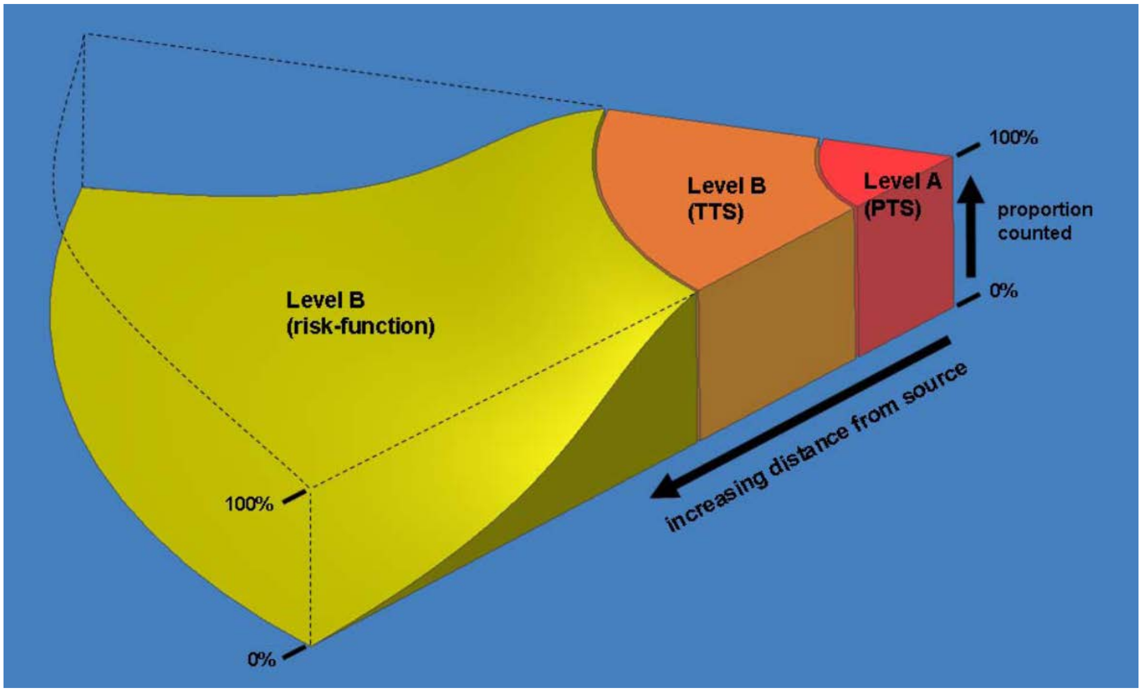

Figure 3.4-6: Hypothetical Range to Specified Effects for a Non-Impulse Source

Although the Navy uses a number of sonar and active acoustic sources, the three sonar bins provided below (MF1, MF4, and MF5) represent three of the most powerful sources (see 3.0.4.1.5, Categories of Sound, for a discussion of sonar and other active acoustic source bins included in this analysis). These three sonar bins are often the dominant source in the activity in which they are included, especially for smaller unit level training exercises and many testing activities. Therefore, these ranges provide realistic maximum distances over which the specific effects would be possible.

PTS: The ranges to the PTS threshold (i.e., ranges to onset of PTS: the maximum distance to which PTS would be expected) are shown in Table 3.4-10 relative to the marine mammal's functional hearing group (Navy's high-frequency sources have a lower source level and more energy loss over distance than these mid-frequency examples and therefore have a shorter range to effects). For SQS-53C sonar transmitting for 1 second at 3 kHz and a source level of 235 dB re 1 μPa^2-s at 1 m, the range to PTS for the most sensitive species (the high-frequency cetaceans) extends from the source to a range approximately 100 m (109 yd.).

Since any surface vessel using hull-mounted anti-submarine warfare sonar, such as the SQS-53, engaged in anti-submarine warfare training and testing would be moving at between 10 and 15 knots (5.1 and 7.7 m/second) and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 280 yd. (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). It is unlikely that any animal would receive overlapping PTS level exposures from a second ship, as Navy sonar exercises do not involve ships within such close proximity to each other while using their active sonar. For all other functional hearing groups (low-frequency cetaceans and mid-frequency cetaceans) single-ping PTS zones are within 77 yd. (70 m) of the sound source. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship; however, as indicated in Table 3.4-10, the distances required make a second 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 result in PTS. For all sources except hull-mounted sonar (e.g., SQS-53) ranges to PTS are well within 27 yd. (25 m), even for multiple pings (up to 10 pings examined) and the most sensitive functional hearing group (high-frequency cetaceans).

Table 3.4-10: Approximate Ranges to Permanent Threshold Shift Criteria for Each Functional Hearing Group for a Single Ping from Three of the Most Powerful Sonar Systems within Representative Ocean Acoustic Environments

Functional Hearing Group	Ranges to Onset PTS for One Ping (meters)[1]		
	Source Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)	Source Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)	Source Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)
Low-Frequency Cetaceans	70	10	< 2
Mid-Frequency Cetaceans	10	< 2	< 2
High-Frequency Cetaceans	100	20	10

[1] Ranges to TTS represent the sound energy loss due to spherical spreading to reach the furthest distance to the PTS effect criteria.

Notes: ASW = anti-submarine warfare, TTS = temporary threshold shift, PTS = permanent threshold shift

TTS: Table 3.4-11 illustrates the ranges to the onset of TTS (i.e., the maximum distances to which TTS would be expected) for 1, 5, and 10 pings from four representative sonar systems. Due to the lower acoustic thresholds for TTS versus PTS, ranges to onset TTS are longer; this can also be thought of as a larger volume acoustic footprint for TTS effects. Because the effects threshold is total summed sound energy and because of the greater range to effects, successive pings can add together, further increasing the range to onset-TTS.[7]

For hull-mounted sonar (e.g., the SQS-53), mid-frequency cetaceans have TTS ranges of up to 200 yd. (180 m) for 1 ping; up to 480 yd. (440 m) for 5 pings; and up to 1,910 yd. (1,750 m) for 10 pings. For all other sonar and other active acoustic sources, the range to TTS for up to 10 pings is within 55 yd. (50 m) for mid-frequency cetaceans, making any temporary hearing loss in these species from these sources very unlikely.

[7] This discussion is presenting a simple case for an omni-directional stationary sources and stationary animals. With a moving source such as all hull mounted anti-submarine warfare sonar, the additional volume of energy above the TTS threshold is only present where there is overlap of sufficient acoustic energy from subsequent pings. When a source is moving, the time between pings and the vessel's forward motion can exceed the distance required for sufficient overlap of acoustic energy from the summation of subsequent pings and therefore never exceed the TTS (total energy) threshold. The nominal speed and time between pings for a ship engaged in anti-submarine warfare events will result in the source having traveled approximately 281–393 yd. (257–359 m) between pings. Additional factors such as animals avoiding the source, porpoising behavior, etc. are additional complexities.

Low-frequency cetaceans (mysticetes) have TTS ranges for 10 pings from anti-submarine warfare hull mounted sonar (e.g., SQS-53) of approximately 9,690 yd. (8,860 m). Ten pings from anti-submarine warfare dipping sonar (e.g., AQS-22) would produce a TTS zone of approximately 2,950 yd. (2,700 m). Ten pings from a SSQ-62 sonobuoy would have a range to onset TTS of up to 1,760 yd. (1,560 m), and 10 pings from the SSQ-32 sonar system would produce a TTS zone extending up to 900 yd. (820 m) from the source.

Ranges to TTS for high-frequency cetaceans are the most extensive of the three groups based on a low acoustic effects threshold for these apparently sensitive species. For a hull-mounted sonar (e.g., SQS-53), ranges to TTS for high-frequency cetaceans are up to 8,280 yd. (7,570 m) for 1 ping, up to 16,790 yd. (15,350 m) for 5 pings, and up to 21,325 yd. (19,500 m) for 10 pings. Ranges to onset TTS for high-frequency cetaceans are much shorter for all other systems. The range for anti-submarine warfare dipping sonar is approximately 100 yd. (90 m) for 1 ping and up to 1,040 yd. (950 m) for 10 pings. Range to onset TTS for sonobuoys and mine warfare sonar, which have lower source levels than hull-mounted and dipping sonar systems, is less than 55 yd. (50 m) for 1, 5, and 10 pings.

Behavioral: The distances at which a significant behavioral response from an animal may occur, and the percentage of animals that may exhibit a response, are estimated for four representative sonar sources using the mysticete (low-frequency cetacean) and odontocete (mid-frequency cetacean) behavioral response functions (Table 3.4-12 and Table 3.4-13, respectively).

The distance from the source and the percentage of animals that would exhibit a behavioral response at that distance are calculated for SPLs ranging from 120 dB to 198 dB re 1 μPa, with SPLs grouped into 6 dB increments. The distance from the source to a specific sound pressure level varies by sonar system. For the most powerful hull-mounted sonar systems (e.g., SQS-53) the distance from the sound source to 120 dB re 1 μPa is approximately 184 km. However, at that distance, the analysis predicts that less than 1 percent of animals would respond to the received sound level (SPLs from 120 dB to 126 dB re 1 μPa). For the AQS-22 dipping sonar, approximately 42 percent of animals located between 8,970 and 65,620 yd. (8,200 and 60,000 m) from the sound source may exhibit a behavioral response to sonar transmissions (Table 3.4-12 and Table 3.4-13). Beaked whales are predicted to have behavioral reactions at distances out to approximately 184 km (Table 3.4-13).

See Section 3.4.3.1.2 (Analysis Background and Framework) for details on the derivation and use of the behavioral response function as well as the step function threshold used for beaked whales of 140 dB re 1 μPa.

Table 3.4-11: Approximate Ranges to Onset of Temporary Threshold Shift for Four Representative Sonar Over a Representative Range of Ocean Environments

Functional Hearing Group	Approximate Ranges to the Onset of TTS (meters)[1]											
	Source Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)			Source Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)			Source Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)			Sonar Bin HF4 (e.g., SQQ-32; MIW Sonar)		
	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings
Low-Frequency Cetaceans	560–2,280	1,230–6,250	1,620–8,860	220–240	490–1,910	750–2,700	110–120	240–310	340–1,560	100–160	150–730	150–820
Mid-Frequency Cetaceans	150–180	340–440	510–1,750	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
High-Frequency Cetaceans	2,170–7,570	4,050–15,350	5,430–19,500	90	180–190	260–950	< 50	< 50	< 50	< 50	< 50	< 50

[1] Ranges to TTS represent the model-predicted zones in which animals are expected to receive TTS and extends from onset-PTS to the distance indicated.

Notes: ASW = anti-submarine warfare, MIW = mine warfare, TTS = temporary threshold shift

Table 3.4-12: Range to Received Sound Pressure Level in 6-Decibel Increments and Percentage of Behavioral Harassments for Low-Frequency Cetaceans under the Mysticete Behavioral Response Function for Four Representative Source Bins (Nominal Values; Not Specific to the Study Area)

Received Level in 6dB Increments	Source Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)		Source Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)		Source Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		Source Bin HF4 (e.g., SQQ-32; MIW Sonar)	
	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment
120 <= SPL < 126	183,000–133,000	< 1%	71,000–65,000	< 1%	18,000–13,000	< 1%	2,300–1,700	< 1%
126 <= SPL < 132	133,000–126,000	<1%	65,000–60,000	< 1%	13,000–7,600	< 1%	1,700–1,200	< 1%
132 <= SPL < 138	126,000–73,000	< 1%	60,000–8,200	42%	7,600–2,800	12%	1,200–750	< 1%
138 <= SPL < 144	73,000–67,000	< 1%	8,200–3,500	10%	2,800–900	26%	750–500	5%
144 <= SPL < 150	67,000–61,000	3%	3,500–1,800	12%	900–500	15%	500–300	17%
150 <= SPL < 156	61,000–17,000	68%	1,800–950	15%	500–250	21%	300–150	34%
156 <= SPL < 162	17,000–10,200	12%	950–450	13%	250–100	20%	150–100	20%
162 <= SPL < 168	10,200–5,600	9%	450–200	6%	100–<50	6%	100–< 50	24%
168 <= SPL < 174	5,600–1,600	6%	200–100	2%	< 50	< 1%	< 50	< 1%
174 <= SPL < 180	1,600–800	< 1%	100–< 50	< 1%	< 50	< 1%	< 50	< 1%
180 <= SPL < 186	800–400	< 1%	<50	< 1%	< 50	< 1%	< 50	< 1%
186 <= SPL < 192	400–200	< 1%	<50	< 1%	< 50	< 1%	< 50	< 1%
192 <= SPL < 198	200–100	< 1%	<50	< 1%	< 50	< 1%	< 50	< 1%

Notes: ASW = anti-submarine warfare, MIW = mine warfare, m = meters, SPL = sound pressure level

Table 3.4-13: Range to Received Sound Pressure Level in 6-Decibel Increments and Percentage of Behavioral Harassments for Mid-Frequency Cetaceans under the Odontocete Behavioral Response Function for Four Representative Source Bins (Nominal Values for Deep Water Offshore Areas; Not Specific to the Study Area)

Received Level in 6dB Increments	Source Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)		Source Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)		Source Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		Source Bin HF4 (e.g., SQQ-32; MIW Sonar)	
	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment
120 <= SPL < 126	184,000–133,000	< 1%	72,000–66,000	< 1%	19,000–15,000	< 1%	3,600–2,800	< 1%
126 <= SPL < 132	133,000–126,000	< 1%	66,000–60,000	< 1%	15,000–8,500	< 1%	2,800–2,100	< 1%
132 <= SPL < 138	126,000–73,000	< 1%	60,00–8,300	41%	8,500–3,300	3%	2,100–1,500	< 1%
138 <= SPL < 144	73,000–67,000	< 1%	8,300–3,600	10%	3,300–1,000	12%	1,500–1,000	3%
144 <= SPL < 150	67,000–61,000	3%	3,600–1,900	12%	1,000–500	10%	1,000–700	10%
150 <= SPL < 156	61,000–18,000	68%	1,900–950	15%	500–300	22%	700–450	21%
156 <= SPL < 162	18,000–10,300	13%	950–480	12%	300–150	27%	450–250	32%
162 <= SPL < 168	10,300–5,700	9%	480–200	7%	150–< 50	25%	250–150	19%
168 <= SPL < 174	5,700–1,700	6%	200–100	2%	< 50	< 1%	150–100	9%
174 <= SPL < 180	1,700–900	< 1%	100–< 50	< 1%	< 50	< 1%	100–< 50	6%
180 <= SPL < 186	900–400	< 1%	< 50	< 1%	< 50	< 1%	< 50	< 1%
186 <= SPL < 192	400–200	< 1%	< 50	< 1%	< 50	< 1%	< 50	< 1%
192 <= SPL < 198	200–100	< 1%	< 50	< 1%	< 50	< 1%	< 50	< 1%

Notes: (1) ASW = anti-submarine warfare, MIW = mine warfare, m = meters, SPL = sound pressure level; (2) Odontocete behavioral response function is also used for high-frequency cetaceans.

3.4.4.1.2 Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources

As previously discussed, within the Navy Acoustic Effects Model, animats (representing individual marine mammals) do not move horizontally or react in any way to avoid sound or any other disturbance. A number of researchers have demonstrated that cetaceans can perceive the movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Palka and Hammond 2001; Richardson et al. 1995; Tyack et al. 2011; Watkins 1986; Würsig et al. 1998; Tyack 2009). See Section 3.4.3.1.2.6 (Behavioral Responses), for a review of research and observations of marine mammals' reactions to vessels and active sound sources. The behavioral criteria used as a part of this analysis acknowledges that a behavioral reaction is likely to occur at levels below those required to cause hearing loss (TTS or PTS) or higher order physiological impacts. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area immediately around intense activity associated with a sound source (such as a low hovering helicopter) or a sound source is assumed in most cases. However, it is possible that an animal could be surprised prior to the implementation of mitigation measures (e.g., the animal is at depth and not visible at the surface). Under this scenario, the animal could receive enough acoustic energy to be exposed at the PTS level. In most cases, avoidance of the area as described above is the more likely scenario. Table 3.4-14 and Table 3.4-15 present a list of activities using sonar and other active acoustic sources that are preceded by intense activity, resulting in likely avoidance of the local area. Additionally, the Navy Acoustic Effects Model does not account for the implementation of mitigation, which would prevent many of the model-estimated PTS effects. Therefore, the model-estimated PTS effects due to sonar and other active acoustic sources are further analyzed considering avoidance and implementation of mitigation measures described in Section 3.4.3.1.5 (Quantitative Analysis) and in greater detail in the Navy's *Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for the Atlantic Fleet Training and Testing* technical report (U.S. Department of the Navy 2013d).

For example, if sound-producing activities are preceded by multiple vessel traffic or hovering aircraft, beaked whales are assumed to move beyond the range to PTS before sound transmission begins, as discussed above in Section 3.4.3.2.1 (Avoidance of Human Activity). Table 3.4-10 shows the ranges to PTS for four of the most common and three of the most powerful sound sources proposed for use when training and testing in the Study Area. The source class Bin MF1 includes the most powerful anti-submarine warfare system for a surface combatant, the SQS-53. The range to PTS for all systems is much less than 110 yd. (100 m), with the exception of high-frequency cetaceans exposed to bin MF1 with a PTS range of approximately 110 yd. (100 m). Because the Navy Acoustic Effects Model does not include avoidance behavior, the preliminary model-estimated effects are based on unlikely behavior for these species: that they would tolerate staying in an area of high human activity.

Table 3.4-14: Training Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

Training
Fleet Strike Group Exercise
Integrated Anti-Submarine Warfare Exercise
Joint Expeditionary Exercise
Joint Multi-Strike Group Exercise
Marine Air Ground Task Force Exercise (Amphibious)
Civilian Port Defense
Mine Countermeasure – Towed Mine Detection
Mine Countermeasure Exercise – Ship Sonar
Mine Countermeasure Exercise (MCM) – Towed Sonar
Ship Squadron Anti-Submarine Warfare Exercise
TRACKEX/TORPEX – Helo

Notes: Helo = helicopter, MCM = mine countermeasure, TORPEX = torpedo exercise, TRACKEX = tracking exercise

Table 3.4-15: Testing Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

Testing
Countermeasure Testing
ASW Mission Package Testing
MCM Mission Package Testing
Torpedo Testing

Notes: ASW = anti-submarine warfare, MCM = mine countermeasure

Animal avoidance of the area immediately around the sonar or other active acoustic system, coupled with mitigation measures designed to avoid exposing animals to high energy levels, would make the majority of model-estimated PTS to mid-frequency cetaceans unlikely. The maximum ranges to onset PTS for mid-frequency cetaceans (Table 3.4-10) do not exceed 10 yd. (10 m) in any environment modeled for the most powerful non-impulse acoustic sources, hull-mounted sonar (e.g., Bin MF1; SQS-53C). Ranges to PTS for low-frequency cetaceans and high-frequency cetaceans (Table 3.4-10) do not exceed 77 and 110 yd. (70 m and 100 m), respectively. Considering vessel speed during anti-submarine warfare activities normally exceeds 10 knots, and sonar pings occur about every 50 seconds, even for the MF1 an animal would have to maintain a position within a 22 yd. (20 m) radius in front of, or alongside the moving the ship for over 3 minutes (the time between five pings) to experience PTS. In addition, the animal(s) or pod would have to remain unobserved, otherwise implemented mitigation would result in the sonar transmissions being shut down and thus ending any further exposure. Finally, the majority of marine mammals (odontocetes) have been demonstrated to have directional hearing, with best hearing sensitivity when facing a sound source (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005). An odontocete avoiding a source would receive sounds along a less sensitive hearing orientation (its tail pointed toward the source), potentially reducing impacts. All model-estimated PTS exposures of mid-frequency cetaceans, therefore, are considered to actually be TTS due to the likelihood that an animal would be observed if it is present within the very short range to PTS effects.

As part of the modeling adjustments, beaked whales that were model-estimated to experience PTS due to sonar and other active acoustic sources are assumed to move away, but conservatively considered to remain within the range of TTS prior to the start of the sound-producing activity for the activities using the sources listed in Table 3.4-14. Given the proximity to the source required for model-estimated PTS to mid-frequency cetaceans and likely avoidance of the source's vicinity, all model-estimated PTS to mid-frequency cetaceans are adjusted to TTS due to the likelihood that an animal would avoid the very short range to PTS effects (while remaining undetected). Marine mammals in other functional hearing groups, if present but not observed by Lookouts, are assumed to leave the area near the sound source after the first 3–4 pings, thereby reducing sound exposure levels and the potential for PTS. The range to the onset of PTS for low-frequency cetaceans does not exceed 77 yd. (70 m) and for high-frequency cetaceans does not exceed 110 yd. (100 m) in any environment for the most powerful active acoustic sources, hull-mounted sonar (e.g., AN/SQS-53C). As stated above, odontocetes, including high-frequency cetaceans, may also minimize sound exposure during avoidance due to directional hearing. During the first few pings of an event, or after a pause in sonar operations, if animals are caught unaware and mitigation measures are not yet implemented (e.g., animals are at depth and not visible at the surface) it is possible that they could receive enough acoustic energy resulting in PTS. Only these initial exposures resulting in model-estimated PTS are expected to actually occur. The remaining model-estimated PTS are considered to be TTS due to avoidance.

The Navy Acoustic Effects Model does not consider implemented standard mitigation measures (as presented in detail in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). To account for the implementation of mitigation measures, the acoustic effects analysis assumes a model-estimated PTS would not occur if an animal at the water surface would likely be observed during those activities with dedicated Lookouts up to and during use of the sound source, considering the sightability of a species based on g(0) (Table 3.4-8), the range to PTS for each hearing group and source (see examples on Table 3.4-10), and mitigation effectiveness (Table 3.4-16). The preliminary model-estimated PTS numbers are reduced by the portion of animals that are likely to be seen (Mitigation Adjustment Factor x Sightability). Model-predicted PTS effects are adjusted based on these factors and added to the model-predicted TTS exposures. This is a conservative approach that will still result in an overestimation of PTS effects, because the range to PTS is generally much less than 55 yd. (55 m), Lookouts need only detect animals before they are within this very close range to implement mitigation to prevent PTS, and the g(0) detection probabilities used as a sightability factor are based on having to detect animals at much greater distance (many kilometers; as presented previously in Section 3.4.3.3, Implementing Mitigation to Reduce Sound Exposures).

Table 3.4-16: Non-Impulse Activities Adjustment Factors Integrating Implementation of Mitigation into Modeling Analyses

Activity[1]	Factor for Adjustment of Preliminary Modeling Estimates[2]	Mitigation Platform Used for Assessment
Training		
Fleet Strike Group Exercise	1	Vessel
Integrated Anti-Submarine Warfare Exercise	1	Vessel
Joint Expeditionary Exercise	1	Vessel
Joint Multi-Strike Group Exercise	1	Vessel
Marine Air Ground Task Force Exercise (Amphibious)	1	Aircraft
Civilian Port Defense	1	Aircraft
Mine Countermeasure Exercise – Surface (SMCMEX) Sonar	1	Vessel
Mine Countermeasure Exercise – Towed Sonar	1	Aircraft
Mine Neutralization – Remotely Operated Vehicle Sonar	1	Vessel or Aircraft
Submarine Navigation	1	Vessel
Ship Squadron Anti-Submarine Warfare Exercise	1	Vessel
Submarine Sonar Maintenance	0.5	Vessel
Surface Ship Sonar Maintenance	1	Vessel
TRACKEX/TORPEX – MPA	0.5	Aircraft
Tracking Exercise – Maritime Patrol Advanced Extended Echo Ranging Sonobuoys	0.5	Aircraft
TRACKEX/TORPEX – Surface	0.5	Vessel
TRACKEX/TORPEX – Helo	0.5	Aircraft
Testing		
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoys)	1	Aircraft
ASW Mission Package Testing	1	Vessel
At Sea Sonar Testing	0.5	Vessel
Countermeasure Testing	1	Vessel
MCM Mission Package Testing	1	Vessel or Aircraft
Pierside Integrated Swimmer Defense	1	Vessel
Ship Signature Testing	1	Vessel
Torpedo Testing	0.5	Vessel

[1] The adjustment factor for all other activities (not listed) is zero; there is no adjustment of the preliminary modeling estimates as a result of implemented mitigation.

[2] If less than half of the mitigation zone cannot be continuously visually observed due to the type of mitigation platform used for this assessment, number of Lookouts, and size of the mitigation zone, mitigation is not used as a factor adjusting the acoustic effects analysis of that activity and the activity is not listed in this table.

Notes: MCM = mine countermeasure, MPA = maritime patrol aircraft, TORPEX = Torpedo Exercise, TRACKEX = Tracking Exercise

3.4.4.1.3 Predicted Impacts from Sonar and Other Active Acoustic Sources

Predicted impacts to marine mammals from sonar and other active acoustic sources for training and testing activities are presented for the No Action Alternative, Alternative 1, and Alternative 2 (Table 3.4-17 and Table 3.4-18). The totals presented in these tables are the summation of all proposed events occurring annually.

The Navy Acoustic Effects Model does not account for several factors (see Sections 3.0.5, Overall Approach to Analysis, and 3.4.3.2, Marine Mammal Avoidance of Sound Exposures) that must be considered in the overall acoustic analysis. The results in the following tables are the predicted exposures from the Navy Acoustic Effects Model adjusted by the animal avoidance and mitigation factors discussed in the section above (Section 3.4.4.1.2, Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources). Mitigation measures are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). These measures provide additional protections, which are not considered in the numerical results below since reductions as a result of implemented mitigation were only applied to those events having a very high likelihood of detecting marine mammals. It is important to note that there are additional protections offered by mitigation procedures that are implemented for all activities using sonar and other active acoustic sources (not just those with a high likelihood of detecting marine mammals) which will further reduce exposures to marine mammals, but they are not considered in the quantitative adjustment of the model-predicted effects.

These predicted effects are the result of the acoustic analysis, including acoustic effects modeling followed by consideration of animal avoidance of multiple exposures, avoidance by sensitive species of areas with a high level of activity, and Navy mitigation measures. It is important to note that exposures presented in Table 3.4-17 and Table 3.4-18 are the total number of exposures and not necessarily the number of individuals exposed. As discussed in Section 3.4.3.1.2.6 (Behavioral Responses), an animal could be predicted to receive more than one acoustic impact over the course of a year.

Table 3.4-17: Predicted Impacts from Annual Training Use of Sonar and Other Active Acoustic Sources

Species	No Action Alternative			Alternative 1			Alternative 2		
	Non-TTS	TTS	PTS	Non-TTS	TTS	PTS	Non-TTS	TTS	PTS
Humpback whale	223	501	0	163	609	0	218	906	0
Blue whale	4	18	0	3	22	0	5	39	0
Fin whale	5	17	0	4	22	0	6	38	0
Sei whale	73	174	0	54	229	0	71	330	0
Bryde's whale	100	212	0	71	283	0	100	439	0
Minke whale	23	67	0	18	66	0	22	94	0
Omura's whale	24	60	0	17	70	0	21	92	0
Sperm whale	503	4	0	413	23	0	610	30	0
Pygmy sperm whale	111	3,825	6	98	4,708	12	116	7,076	16
Dwarf sperm whale	298	10,167	18	276	12,034	34	326	18,166	43
Killer whale	78	5	0	62	11	0	93	15	0
False killer whale	538	29	0	421	75	0	640	97	0
Pygmy killer whale	89	6	0	79	14	0	111	17	0
Short-finned pilot whale	1,713	102	0	1,367	256	0	2,065	320	0
Melon-headed whale	2,107	153	0	1,524	365	0	2,398	462	0
Bottlenose dolphin	684	58	0	548	122	0	819	149	0
Pantropical spotted dolphin	12,468	804	0	9,612	2,128	0	13,911	2,610	0
Striped dolphin	3,328	192	0	2,482	495	0	3,668	651	0
Spinner dolphin	502	32	0	419	84	0	579	103	0
Rough-toothed dolphin	1,702	129	0	1,333	307	0	2,048	389	0
Fraser's dolphin	2,472	139	0	1,895	353	0	3,372	462	0
Risso's dolphin	462	25	0	390	65	0	577	84	0
Cuvier's beaked whale	21,968	48	0	18,563	180	0	26,394	240	0
Blainville's beaked whale	4,233	15	0	3,662	49	0	5,135	63	0
Longman's beaked whale	1,719	5	0	1,649	19	0	2,050	23	0
Ginkgo-toothed beaked whale	3,981	11	0	3,208	41	0	4,315	51	0
Total Exposures	**59,408**	**16,798**	**24**	**48,331**	**22,630**	**46**	**69,670**	**32,946**	**59**

Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table 3.4-18: Predicted Impacts from Annual Testing Use of Sonar and Other Active Acoustic Sources

Species	No Action Alternative			Alternative 1			Alternative 2		
	Non-TTS	TTS	PTS	Non-TTS	TTS	PTS	Non-TTS	TTS	PTS
Humpback whale	0	0	0	18	70	0	21	86	0
Blue whale	0	0	0	0	3	0	1	4	0
Fin whale	0	0	0	0	2	0	1	3	0
Sei whale	0	0	0	7	29	0	8	35	0
Bryde's whale	0	0	0	8	36	0	10	44	0
Minke whale	0	0	0	2	15	0	2	18	0
Omura's whale	0	0	0	2	14	0	2	18	0
Sperm whale	0	0	0	39	31	0	45	46	0
Pygmy sperm whale	0	0	0	11	758	3	13	917	4
Dwarf sperm whale	0	0	0	28	1,864	7	32	2,254	10
Killer whale	0	0	0	7	4	0	8	6	0
False killer whale	0	0	0	33	26	0	38	38	0
Pygmy killer whale	0	0	0	7	5	0	8	7	0
Short-finned pilot whale	0	0	0	114	78	0	130	113	0
Melon-headed whale	0	0	0	113	83	0	129	122	0
Bottlenose dolphin	0	0	0	43	28	0	49	41	0
Pantropical spotted dolphin	0	0	0	614	456	0	705	672	0
Striped dolphin	0	0	0	204	117	0	232	173	0
Spinner dolphin	0	0	0	51	35	0	58	50	0
Rough-toothed dolphin	0	0	0	109	70	0	124	103	0
Fraser's dolphin	0	0	0	183	140	0	210	205	0
Risso's dolphin	0	0	0	31	19	0	35	28	0
Cuvier's beaked whale	0	0	0	3,670	128	0	4,171	187	0
Blainville's beaked whale	0	0	0	691	24	0	786	36	0
Longman's beaked whale	0	0	0	246	10	0	280	15	0
Ginkgo-toothed beaked whale	0	0	0	627	21	0	715	31	0
Total Exposures	**0**	**0**	**0**	**6,858**	**4,066**	**10**	**7,813**	**5,252**	**14**

Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

3.4.4.1.3.1 No Action Alternative

Training

As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1) and Section 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources), training activities under the No Action Alternative include activities that produce in-water sound from the use of sonar and other active acoustic sources. Activities could occur throughout the Study Area but would be concentrated within 200 nm of the Mariana Islands.

In excess of 61 percent of predicted effects to marine mammals from training activities under the No Action Alterative are from sonar and other active acoustic sources used during anti-submarine warfare events involving surface ships with hull-mounted sonar (i.e., tracking and torpedo exercises for surface ships), which take place more than 3 nm from shore. As discussed in Section 3.4.4.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for hull mounted sonar (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of several kilometers, whereas a small percentage of behavioral effects could take place at distances exceeding 184 km, more meaningful behavioral effects are much more likely at higher received levels within a few kilometers of the sound source.

Under the No Action Alternative, about 38 percent of predicted behavioral effects to marine mammals from sonar and other active acoustic sources are associated with major training exercises (i.e., Joint Expeditionary Exercise, Joint Multi-Strike Group Exercise, Marine Air Ground Task Force Exercise [Amphibious]; see Table 2.8-1). These major training exercises are multi-day events composed of multiple, dispersed activities involving multiple platforms (ships, aircraft, submarines) that often require movement across or use of large areas of a range complex. Potential acoustic impacts from major training exercises, especially behavioral impacts, could be more pronounced given the duration and scale of the activity. Some animals may be exposed to this activity multiple times over the course of a few days and leave the area temporarily; although, these activities do not use the same training locations day-after-day during multi-day activities. Therefore, displaced animals could return after the major training exercise moves away, allowing the animal to recover from any energy expenditure or missed resources.

For shorter term exposures or those from distant sources, animals may stop vocalizing, break off feeding dives, or alternatively, ignore the acoustic stimulus, especially if it is located more than a few kilometers away (see Section 3.4.3.1.2.6, Behavioral Responses, for discussion of research and observations on the behavioral reactions of marine mammals to sonar and other active acoustic sources).

In the ocean, the use of sonar and other active acoustic sources is transient and is unlikely to repeatedly expose the same population of animals over a short period. A few behavioral reactions per year, even from a single individual, are unlikely to produce long-term consequences for that individual or the population. Furthermore, mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Mysticetes

Under the No Action Alternative, predicted acoustic effects to mysticetes from training activities using sonar and other active acoustic sources all occur during anti-submarine warfare activities as part of Major Training Exercises and tracking and torpedo exercises for surface ships. Predicted effects only include TTS level effects and behavioral responses. As discussed in Section 3.4.4.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for hull mounted sonar (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of several kilometers for up to 10 pings, whereas some behavioral effects could take place at distances up to 184 km, although meaningful behavioral effects are much more likely at higher received levels within a few kilometers of the sound source.

Regarding long-term impacts on blue whales, Goldbogen et al. (2013) reported on the results of an ongoing Navy-funded behavioral response study in the waters of Southern California (see Southall et al. 2012a for additional details on the behavioral response study). Goldbogen et al. (2013) suggested that "frequent exposure to mid-frequency anthropogenic sounds may pose significant risks to the recovery rates of endangered blue whale populations." While there are no data indicating any trend in the entire Eastern North Pacific population toward recovery since the end of whaling (e.g., Barlow and Forney 2007), research along the U.S. west coast and Baja California reported by Calambokidis et al. (2009b) and based on mark-recapture estimates "indicated a significant upward trend in abundance of blue whales" at a rate of increase just under 3 percent per year for the portion of the blue whale population in the Pacific that includes Southern California as part of its range. The Eastern North Pacific stock (population), which is occasionally present in Southern California, is known to migrate from the northern Gulf of Alaska to the eastern tropical Pacific at least as far south as the Costa Rica Dome (Carretta et al. 2013). Given this population's vast range and absent discussion of any other documented impacts, such as commercial ship strikes (Berman-Kowalewski et al. 2010), the suggestion by Goldbogen et al. (2013) that since the end of commercial whaling, sonar use (in the fraction of time and area represented by Navy's training and testing in the SOCAL Range Complex) may be of significant risk to the blue whale's recovery in the Pacific is speculative at this stage. Furthermore, the suggestion is contradicted by the upward trend in abundance and counts (Calambokidis et al. 2009b; Berman-Kowalewski et al. 2010) of blue whales in the area where sonar use has been occurring for decades.

Research and observations show that if mysticetes are exposed to sonar and other active acoustic sources such as sonar 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). Reactions may include alerting, breaking off feeding dives and surfacing, diving or swimming away, or no response at all. Additionally, migrating mysticetes (such as humpback whales moving through the MITT Study Area) may divert around sound sources that are located within their path or may ignore a sound source depending on the context of the exposure.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

As shown in Table 3.4-17, there are no model-predicted PTS effects to mysticetes for training under the No Action Alternative.

Blue Whales (Endangered Species Act-Listed)

Blue whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that in the Study Area blue whales could be exposed to sound that may result in 18 TTS and 4 behavioral reactions per year. Long-term consequences for individuals or populations would not be expected.

Humpback Whales (Endangered Species Act-Listed)

Humpback whales may be exposed to sonar or other acoustic stressors associated with training activities throughout the year. In the Study Area, acoustic modeling predicts exposure to sound that may result in 501 TTS and 223 behavioral reactions per year. Long-term consequences for individuals or populations would not be expected.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sonar or other acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that sei whales in the Study Area could be exposed to sound that may result in 174 TTS and 73 behavioral reactions per year. Long-term consequences for individuals or populations would not be expected.

Fin Whales (Endangered Species Act-Listed)

Fin whales may be exposed to sonar or other acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that fin whales in the Study Area could be exposed to sound that may result in 17 TTS and 5 behavioral reactions per year. Long-term consequences for individuals or populations would not be expected.

Bryde's, Omura's, and Minke Whales (Not Endangered Species Act-Listed)

Bryde's, Omura's, and minke whales may be exposed to sonar or other active acoustic stressors associated with training activities. For Bryde's whales in the Study Area, acoustic modeling predicts exposure to sound that may result in 212 TTS and 100 behavioral reactions per year. For Omura's whales in the Study Area, acoustic modeling predicts exposure to sound that may result in 60 TTS and 24 behavioral reactions per year. For minke whales in the MITT Study Area, acoustic modeling predicts exposure to sound that may result in 67 TTS and 23 behavioral reactions per year. For all three species, long-term consequences would not be expected.

Odontocetes

Predicted impacts to odontocetes from training activities under the No Action Alterative from sonar and other active acoustic sources are all from anti-submarine warfare activities during Major Exercises and tracking and torpedo exercises for surface ships. As discussed in Section 3.4.4.1.1 (Range to Effects), ranges to TTS for hull mounted sonar (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of a few hundred meters for mid-frequency cetaceans. However, for high-frequency cetaceans (i.e., dwarf and pygmy sperm whales; genus *Kogia*) ranges to TTS for multiple pings can, under certain conditions, reach over (3 km) from a source. Some behavioral effects could take place at distances exceeding approximately 184 km for more sensitive species (high-frequency cetaceans and beaked whales), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Modeling predicts behavioral effects at long distance and low received levels but does not take into account background ambient noise levels or other competing biological sounds, which may mask sound from distant Navy sources. D'Spain and Batchelor (2006) conducted research on ambient sound levels off the coast of Southern California. The researchers measured a source spectral density of 105–120 dB re 1 $\mu Pa^2/Hz$ at 1 m (in the mid-frequency range) and calculated an estimated source level of 135–150 dB re 1 µPa at 1 m from various biologics (fish and marine mammals) contributing to underwater ambient sound levels recorded to the southeast of San Clemente Island, California.

Activities involving anti-submarine warfare training often involve multiple participants and activities associated with the event. More sensitive species of odontocetes such as beaked whales and dwarf and pygmy sperm whales may avoid the area for the duration of the event (see Section 3.4.3.1.2.6, Behavioral Responses, for a discussion of these species observed reactions sonar and other active acoustic sources). After the event ends, displaced animals would likely return to the area within a few days as seen in the Bahamas study with Blainville's beaked whales (Tyack et al. 2011). This would allow the animal to recover from any energy expenditure or missed resources, reducing the likelihood of long-term consequences for the individual or population.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

An annual total of 24 PTS exposures is predicted by the modeling, but because these only involve species of pygmy and dwarf sperm whale; discussion of those exposures is presented in detail below (see Pygmy and Dwarf Sperm Whales [*Kogia* spp.]).

Sperm Whales (Endangered Species Act-Listed)

Sperm whales (classified as mid-frequency cetaceans (see Section 3.4.2.3.2, Mid-Frequency Cetaceans) may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. For sperm whale in the Study Area, acoustic modeling predicts exposure to sound that may result in 4 TTS and 503 behavioral reactions per year.

Research and observations (see Section 3.4.3.1.2.6, Behavioral Responses) show that if sperm whales are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Sperm whales have shown resilience to acoustic and human disturbance, although they may react to sound sources and activities within a few kilometers. Sperm whales that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, avoid the area by swimming away or diving, or display aggressive behavior. As presented above for odontocetes in general, long-term consequences for sperm whale individuals or populations would not be expected.

False Killer Whale

False killer whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year in the Study Area.

Acoustic modeling for the false killer whale, predicts exposure to sound that may result in 29 TTS and 538 behavioral reactions per year. As presented above for odontocetes in general, long-term consequences for false killer whale individuals or populations would not be expected.

Beaked Whales

Beaked whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that the several species of beaked whales (i.e., Cuvier's, Blainville's, Longman's, and ginkgo-toothed beaked whales) could be exposed to sound that may result in 79 TTS and 31,901 behavioral reactions. As discussed below, it is important to consider that there are behavioral responses that cannot be accounted for by the model, and as a result, the number of predicted behavioral reactions for beaked whales is considered a conservative estimate. For a more detailed description of the model and the assumptions made in predicting effects, see U.S. Department of the Navy (2013d; Marine Species Modeling Team 2013).

Research and observations (see 3.4.3.1.2.6, Behavioral Responses) show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source to levels of 157 dB re 1 µPa, or below (McCarthy et al. 2011). In research done at the Navy's instrumented tracking range in the Bahamas, animals leave the immediate area of the anti-submarine warfare training exercise, but return within a few days after the event ends (Claridge and Durban 2009, McCarthy et al. 2011, Moretti et al. 2009, Tyack et al. 2011). Passive acoustic monitoring of a training event at the Navy's instrumented range in Hawaii was undertaken during a Submarine Commander Course involving three surface ships and a submarine using mid-frequency sonar over the span of the multiple-day event. Manzano-Roth et al. (2013) determined that beaked whales (tentatively identified as Blainville's beaked whales) continued to make foraging dives at estimated distances of 13 to 52 km from active mid-frequency sonar, but that the animals shifted to the southern edge of the range with differences in the dive vocal period duration, and dive rate. De Ruiter et al. (2013a) presented results from two Cuvier's beaked whales that were tagged and exposed to simulated MFA sonar during the 2010 and 2011 field seasons of the Southern California behavioral response study (note that preliminary results from a similar behavioral response study in Southern California waters have been presented for the 2010–2011 field season [Southall 2011]). The 2011 tagged whales were also incidentally exposed to MFA sonar from a distant naval exercise. Received levels from the MFA sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa root mean square, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure from distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Cuvier's beaked whale responses suggested particular sensitivity to sound exposure as consistent with results for Blainville's beaked whale.

Based on these findings, significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers (see Section 3.4.4.1, Impacts from Sonar and Other Active Acoustic Sources), especially for prolonged periods (a few hours or more) since research indicates beaked whales will leave an area where anthropogenic sound is present (Tyack et al. 2011; De Ruiter et al. 2013; Manzano-Roth et al. 2013).

The concern with beaked whales and an avoidance response is whether that displacement is likely to have long-term consequences for an animal or populations. Research involving tagged Cuvier's beaked whales in the SOCAL Range Complex reported on by Falcone and Schorr (2012, 2014) has documented movements in excess of hundreds of kilometers by some those animals. Schorr et al. (2014) reported the results for eight tagged Cuvier's beaked whales from the same area. Four of these eight whales made journeys of approximately 250 km from their tag deployment location, and one of the four 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, temporarily leaving an area to avoid sonar or other anthropogenic activity may have little if any cost to such an animal. Photo identification studies in the SOCAL Range Complex have identified approximately 100 individual Cuvier's beaked whales with 40 percent having been seen in more than 1 year and with time spans between sightings of up to 7 years (Falcone and Schorr 2014). These results indicate long-term residency by beaked whales in an intensively used Navy training and testing area where sonar use is common and has been occurring for decades. These results suggest inconsequential effects or a lack of long-term consequences resulting from exposure to Navy training activities.

Moore and Barlow (2013) noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico, which is extremely more area than the Navy uses during training and testing. Interestingly, however, in the small portion of that area overlapping the Navy's Southern California Range Complex, long-term residency by individual Cuvier's beaked whales and higher densities suggest that the proposed decline noted elsewhere is not apparent where the Navy has been intensively training and testing with sonar and other systems for decades. Navy sonar training and testing is not conducted along a large part of the U.S. west coast from which Moore and Barlow (2013) drew their survey data. In Southern California, based on a series of surveys from 2006 to 2008 and a high number encounter rate, Falcone et al. (2009) suggested the ocean basin west of San Clemente Island may be an important region for Cuvier's beaked whales given the number of animals encountered there. Follow-up research (Falcone and Schorr 2012, 2014) in this same location suggests that Cuvier's beaked whales may have population sub units with higher than expected residency, particularly in Navy's instrumented Southern California Anti Submarine Warfare Range. Encounters with multiple groups of Cuvier's and Baird's beaked whales indicated not only that they were prevalent on the range where Navy routinely trains and tests, but also that they were potentially present in much higher densities than had been reported for anywhere along the U.S. west coast (Falcone et al. 2009, Falcone and Schorr 2012). This finding is also consistent with concurrent results from passive acoustic monitoring that estimated regional Cuvier's beaked whale densities were higher than indicated by NMFS's broad scale visual surveys for the U.S. west coast (Hildebrand and McDonald 2009).

Moore and Barlow (2013) suggest that one reason for the decline in beaked whales from Canada to Mexico may be as a result of anthropogenic sound, including the use of sonar by the U.S. Navy in the fraction of the U.S. Pacific coast overlapped by the Southern California Range Complex. Moore and Barlow (2013) recognized the inconsistencies between hypothesis and the abundance trends in the region of SOCAL Range Complex, stating: "High densities are not obviously consistent with a hypothesis that declines are due to military sonar, but they do not refute the possibility that declines have occurred in these areas (i.e., that densities were previously even higher)." While it is possible that the high densities of beaked whale currently inhabiting the Navy's range were even higher before the Navy began training with sonar, there are no data available to test that hypothesis. Furthermore, the decline of beaked whales Moore and Barlow (2013) assert for other areas of the U.S. west coast where the Navy does not conduct sonar training or testing limits the validity of their speculation about the effects of sonar on beaked whale populations.

Claridge (2013) used photo-recapture methods to estimate population abundance and demographics of Blainville's beaked whale (*Mesoplodon densirostris*) at two study sites in the Bahamas, one of which is regularly used for MFA sonar exercises. Claridge hypothesized that the reason a lower abundance was found at the site located within the bounds of the Navy's AUTEC range than at the site off Abaco Island is due either to reduced prey availability at AUTEC or to population-level effects from the exposure to MFA sonar at AUTEC. However, Claridge sampled half as frequently at AUTEC as at Abaco over the 5-year study period (102 versus 235 surveys), with only 20 encounter days at AUTEC from March to October versus 34 at Abaco. The estimated annual abundances at each location (31 [22–42] at AUTEC, 49 [38–62] at Abaco) was almost identical to the number of distinct (and therefore identifiable by photographic identification) individuals observed annually at each site (30 including 1 calf at AUTEC, 48 including 4 calves at Abaco). In fact, in the full 15-year study at Abaco (1997–2011), the estimated annual density was 42, and this population was considered to be part of a larger "parent" population in the area of approximately 135 whales.

All of the resighted whales at both sites were female. This leads to heterogeneity in the capture probability due to an age/sex bias, which can compromise the model fit and lead to negative bias in the estimation of abundances (Claridge 2013). The two study sites were each 300 km^2, an area that is small for known Blainville's beaked whale home ranges, based on tag data (e.g., Schorr et al. 2009). In addition, the population models for both sites were best described as an open population with re-immigration. At Abaco, over the 15-year study, many of the resighted females had sighting gaps of 5–10 years, but most of the animals were only observed in one year. This gap in resights is equal to or longer than the duration of the study at AUTEC.

These results indicate that there is both temporary and permanent emigration from the population at both sites, and that even over 15 years of research, the entire population (either the "parent" population or the smaller one at Abaco) was not entirely sampled (as indicated by the lack of an asymptote in the discovery curve of individuals from Abaco). In addition, beaked whales at AUTEC are known to leave the area for a few days following sonar activity (McCarthy et al. 2011, Tyack et al. 2011) so, depending on the timing of the photo-identification surveys, many animals may not have even been present to be sampled. Therefore, while Claridge did find a lower abundance at AUTEC than at Abaco, the results are biased by reduced effort and a study period that was not long enough to capture some of the emigration/immigration trends discovered at Abaco. In addition, while Claridge makes no mention of the "parent" population in comparing the study sites, she easily attributes the low site fidelity and small population size at Abaco to the larger movement patterns of these whales throughout the area, which could just as easily be done for the population at AUTEC.

Finally, when comparing only the 5-year study period between AUTEC and Abaco, the estimated abundance at Abaco appears to be almost double that of the AUTEC population; however, when the full 15-year dataset at Abaco is presented, the estimated annual abundance is approximately seven animals fewer (42 compared to 49), which is then only about 11 animals greater than the estimated annual abundance at AUTEC (31). Therefore the presentation of these population abundances as markedly different is questionable, and to attribute the difference largely to the presence of Navy sonar without considering ecological factors is poorly supported.

In an effort to understand beaked whale responses to stressors, New et al. (2013) developed a mathematical model simulating a functional link between foraging energetics and requirements for survival and reproduction for 21 species of beaked whale. New et al. (2013) report "reasonable confidence" in their model although approximately 29 percent (6 of 21 beaked whale species modeled) failed to survive or reproduce, which the authors attribute to possible inaccuracies in the underlying parameter values. Based on the model simulation, New et al. (2013) determined that if habitat quality and "accessible energy" (derived from the availability of either plentiful prey or prey with high energy content) are both high, then survival rates are high as well. If these variables are low, then adults may survive, but calves will not. The simulations suggested that adults will survive but not reproduce if anthropogenic disturbances resulted in them being displaced to areas of "impaired foraging."

Ecological modeling provides an important tool for exploring the properties of an animal's use of the environment and the factors that drive or contribute to survivorship and reproduction. The ability of any model to accurately predict real ecological processes is partly dictated by the ability of the modeler to correctly parameterize the model and incorporate assumptions that do not violate real-world conditions. Assumptions and parameters identified by New et al. (2013) that likely have a large effect on the model output include the period of reproduction (i.e., inter-calf interval) and prey selection (i.e., energy acquisition). Although New et al. (2013) concluded that anthropogenic disturbances might impair foraging through animal displacement and ultimately impact reproduction, the parameter values need to be revisited, as do assumptions that habitat capable of sustaining a beaked whale is limited in proximity to where any disturbance has occurred (i.e. beaked whales are likely not always in the most optimal foraging location).

While the New et al. (2013) model provides a test case for future research, the model has little of the critical data necessary to form conclusions applicable to current management decisions. There remains significant scientific uncertainty from which to infer modeled impacts to any marine species, especially reclusive beaked whales. For each population and sub-population, critical demographic data gaps still exist (adult survival, calf survival, juvenile survival, annual probability of calving, age at first calving, longevity, and an indication of likely levels of variation between years).The authors note the need for more data on prey species and reproductive parameters, including gestation and lactation duration, as the model results are particularly affected by these assumptions. Therefore, any suggestion of biological sensitivity to the simulation's input parameters is uncertain. Given this level of uncertainty, the Navy will continue to follow developments in the mathematical modeling of energetics to estimate specific sensitivity to disturbance. The Navy continues to fund the research and monitoring (such as the Behavioral Response Studies in the Bahamas and Southern California) specifically to better understand, via direct field observations, the potential for anthropogenic activities to disturb marine mammals. In cooperation with NMFS, the Navy will continue to develop the most effective management and conservation actions needed to protect marine mammals while accomplishing the Navy's mission to train and test safely and effectively.

The Navy has continued to review emerging science and fund research to better assess the potential impacts that may result from the continuation of ongoing training and testing in the historically used range complexes worldwide, as summarized in Section 3.4.5.2 (Summary of Observations During Previous Navy Activities). The Navy's assessment based on that compendium of data is that it is unlikely there would be impacts to populations of marine mammals having any long-term consequences as a result of the proposed continuation of training and testing in the ocean areas historically used by the Navy. This assessment of likelihood is based on four indicators from areas 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) 6 years of comprehensive monitoring data indicating a lack of any observable effects to marine mammal populations as a result of Navy training and testing activities.

At the Bahamas range and at Navy instrumented ranges that have been operating for decades (in Hawaii north of Kauai and in Southern California west of San Clemente Island), populations of beaked whales appear to be stable (see Section 3.4.3.4, Marine Mammal Monitoring During Navy Training). Photographic evidence indicating re-sightings of individual beaked whales (from two species, Cuvier's and Blainville's beaked whales), suggesting long-term site fidelity to the area west of the Island of Hawaii (McSweeney et al. 2007), which is a channel used for years to conduct anti-submarine warfare training during Rim of the Pacific and Undersea Warfare Exercise (Major Exercises involving multiple vessels and aircraft). In Southern California to the west of San Clemente Island, surveys encountered a high number of Cuvier's beaked whales, leading Falcone et al. (2009) to suggest the area may be an important region for this species. For over three decades, this ocean area has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific, given the proximity to the naval installations in San Diego.

Based on the best available science (McCarthy et al. 2011; Tyack et al. 2011; Southall et al. 2012b), the Navy believes that beaked whales that exhibit a significant behavioral reaction due to sonar and other active acoustic training activities would generally not have long-term consequences for individuals or populations. However, because of a lack of scientific consensus regarding the causal link between sonar and stranding events, NMFS has stated in a letter to the Navy dated October 2006 that it "cannot conclude with certainty the degree to which mitigation measures would eliminate or reduce the potential for serious injury or mortality." For over three decades, the ocean west of San Clemente Island has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific. Research has documented the presence and long-term residence of Cuvier's beaked whales for the ocean basin west of San Clemente Island (Falcone et al. 2009, Falcone and Schorr 2012, 2014), and results from passive acoustic monitoring estimated regional Cuvier's beaked whale densities were higher than indicated by the NMFS's broad scale visual surveys for the U.S. west coast (Hildebrand and McDonald 2009).

Therefore, the Navy is requesting two serious injury or mortality takes for beaked whale species per year. This approach overestimates the potential effects to marine mammals associated with sonar training in the Study Area, as no mortality or serious injury of any species is anticipated. This request will be made even though Navy has conducted similar exercises in the Study Area without observed incident, which indicates that injury, strandings, and mortality are not expected to occur as a result of military activities. Neither NMFS nor the Navy anticipates that marine mammal strandings or mortality will result from the operation of sonar or other acoustic sources during military exercises within the Study Area. 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 military activities and a future stranding involving beaked whale or other marine mammal species.

Costs and long-term consequences to the individual and population as a result of a beaked whale receiving a TTS is the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy and dwarf sperm whales (genus: *Kogia*) (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that dwarf sperm whale in the Study Area could be exposed to sound that may result in 18 PTS; 10,167 TTS; and 298 behavioral reactions. Acoustic modeling predicts that pygmy sperm whale in the Study Area could be exposed to sound that may result in 6 PTS; 3,825 TTS; and 111 behavioral reactions.

Research and observations (see Section 3.4.3.1.2.5, Behavioral Responses) on *Kogia* species are limited. However, these species tend to avoid human activity and presumably anthropogenic sounds. Pygmy and dwarf sperm whales may startle and leave the immediate area of the anti-submarine warfare training exercise. Significant behavioral reactions seem more likely than with most other odontocetes, however it is unlikely that animals would receive multiple exposures over a short time period allowing animals time to recover lost resources (e.g., food) or opportunities (e.g., mating). Therefore, long-term consequences for individual *Kogia* or their respective populations are not expected.

Costs and long-term consequences to the individual and population as a result of a *Kogia* receiving a PTS or TTS exposure is the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

For PTS, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Kloepper et al. 2010; Ketten 2012). Furthermore, likely avoidance of intense activity and sound coupled with mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the potential for PTS exposures to occur. Considering these factors, long-term consequences for individuals or populations would not be expected.

Dolphins, Porpoise, and Small Toothed Whales (Delphinids)

Delphinids (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Species included as delphinids for purposes of this discussion include the following: common bottlenose dolphin, Fraser's dolphin, killer whale, melon-headed whale, pantropical spotted dolphin, pygmy killer whale, Risso's dolphin, rough toothed dolphin, short-finned pilot whale, spinner dolphin, and striped dolphin. Acoustic modeling predicts that delphinids could be exposed to sound that may result in 1,649 TTS and 25,610 behavioral reactions.

Research and observations (see Section 3.4.3.1.2.5, Behavioral Responses) show that if delphinids are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Delphinids may not react at all until the sound source is approaching within a few hundred meters to within a few kilometers depending on the environmental conditions and species. Delphinids that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, change their behaviors or vocalizations, avoid the sound source by swimming away or diving, or be attracted to the sound source. Long-term consequences to individual delphinids or populations are not likely due to exposure to sonar or other active acoustic sources.

Costs and long-term consequences to the individual and population as a result of delphinids receiving an exposure resulting in TTS are the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Training activities under the No Action Alternative include the use of sonar and other active acoustic sources as described in Table 2.8-1 and Section 3.0.5.2.1 (Acoustic Stressors). Table 3.4-17 provides a summary of the annual estimated sound exposures resulting from the use of sonar and other active acoustic sources during military training under the No Action Alternative. Exposures at the behavioral (non-TTS), TTS, and PTS levels are presented. The acoustic modeling and post-modeling analyses indicate that 76,206 marine mammal exposures to sonar and other active acoustic sources may occur, resulting in Level B harassment as defined under the MMPA. Of these, 16,798 exposures would exceed the TTS threshold, and 59,408 behavioral exposures are predicted. Based on modeled estimates, 24 annual exposures would exceed the PTS threshold (Level A harassment).

Pursuant to the MMPA, sonar and other active acoustic sources used during training activities under the No Action Alternative:

- *May expose marine mammals up to 76,206 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 24 times annually to sound levels that would be considered Level A harassment*
- *May expose up to 2 beaked whales annually to sound levels that may elicit stranding and subsequent serious injury or mortality*

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities as described in the No Action Alternative:

- *May affect, and is likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing

As described in Chapter 2 (Description of Proposed Action and Alternatives, Tables 2.8-2, 2.8-3, 2.8-4), and Section 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources), no testing activities using sonar or other active acoustic sources are proposed under the No Action Alternative.

3.4.4.1.3.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1) and Section 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources), training activities under Alternative 1 that produce in-water sound from the use of sonar and other active acoustic sources would increase over those proposed under the No Action Alternative. Activities would occur in the same locations throughout the Study Area for all alternatives and would be concentrated within 200 nm of the Mariana Islands. New training activities proposed under Alternative 1 using sonar and other active acoustic sources that impact the modeling results include:

- Civilian Port Defense
- Mine Countermeasure – Towed Mine Detection
- Mine Countermeasure Exercise – Ship Sonar
- Mine Neutralization – Remotely Operated Vehicle
- Submarine Mine Exercise
- Submarine Navigation Exercise
- Submarine Sonar Maintenance
- Surface Ship Sonar Maintenance

Adjustments to the tempo of surface ship tracking exercises and torpedo exercises (TRACKEX/TORPEX Surface) under Alternative 1 result in a decrease of 317 sonar hours from sources in the MF1 bin, which includes a decrease in the number of annual sonar hours for the SQS-53 anti-submarine warfare hull-mounted sonar (see Section 3.0.5, Overall Approach to Analysis, Table 3.0-6). This adjustment to the tempo of training activities results in nearly a 15 percent decrease in the use of sources in the MF1 bin, which as discussed previously (see Section 3.4.4.1.1, Range to Effects), are the most powerful sonar sources and have the greatest probability of affecting marine mammals.

The inclusion of the new activities under Alternative 1 and adjustments to the location, type, and tempo of activities included under the No Action Alternative, result in a predicted increase in PTS and TTS exposures and a decrease in behavioral (non-TTS) exposures (Table 3.4-17). The acoustic modeling and post-modeling analyses indicate that 46 annual exposures to sonar and other active acoustic sources would exceed the PTS threshold (Level A harassment as defined under the MMPA) and 70,961 marine mammal exposures may result in Level B harassment. Of these, 22,630 exposures would exceed the TTS threshold, and 48,331 behavioral responses are predicted.

Under Alternative 1, TTS exposures to all marine mammals would increase by approximately 35 percent over the number of exposures predicted under the No Action Alternative. The number of PTS exposures would increase by 88 percent (from 24 to 45) under Alternative 1; however the number of non-TTS (behavioral) exposures would decrease by 23 percent compared to the number or behavioral exposures predicted under the No Action Alternative. Total predicted acoustic impacts (behavioral responses, TTS, and PTS) would decrease by approximately 7 percent under Alternative 1, because of the decrease in behavioral exposures.

Some training activities that use sonar and other active acoustic sources have the potential to occur, at least partially, in nearshore or littoral waters of the Study Area (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-1). It is possible, although unlikely, that these activities may occur in proximity to spinner dolphin resting areas identified in Section 3.4.2.23.2 (Spinner Dolphin, Geographic Range and Distribution). Several of these training activities occur infrequently (1–4 times per year). Other training activities would occur in nearshore areas where non-military activities also occur (e.g., Apra Harbor), which are unlikely to be spinner dolphin resting areas. To date, there have been no sightings of spinner dolphins in Apra Harbor.

The total number of exposures to spinner dolphins from all sonar and other active acoustic sources used in both the offshore and nearshore areas of the Study Area, not just from nearshore activities, is 84 TTS exposures and 419 behavioral responses. These predicted exposures are included in the estimated number of behavioral responses and TTS exposures presented in this section.

Mitigation, as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), for activities occurring in offshore and nearshore areas of the Study Area would include surveying for marine mammals, including resting spinner dolphins, prior to conducting the activity. Given that nearshore activities occur infrequently, it would be unlikely that they would occur in the vicinity of spinner dolphin resting areas, and mitigation to avoid potential effects would be conducted. Therefore, no long-term consequences to spinner dolphins, such as habitat abandonment, are anticipated.

Notable results for Alternative 1 in comparison to results for the No Action Alternative are as follows:

- Predicted acoustic impacts (behavioral and TTS) on mysticetes overall would increase by less than 10 percent. TTS exposures for all mysticetes would increase between 0 percent (for minke whale) and 33 percent (for Bryde's whale). No PTS exposures on mysticetes are predicted under Alternative 1.
- Predicted TTS exposures on ESA-listed species would increase by about 27 percent for Alternative 1 as compared to the No Action Alternative. Predicted non-TTS (behavioral) exposures would decrease by about 27 percent.
- Combined TTS and PTS exposures predicted for dolphins and small-toothed whales would increase by about 34 percent. Predicted non-TTS (behavioral) exposures would decrease by about 23 percent.
- Predicted TTS exposures on beaked whales would increase from 81 under the No Action Alternative to 180 under Alternative 1. Approximately 60 percent of the TTS exposures predicted for beaked whales are on Cuvier's beaked whale and are associated with an increase in sonar use during the Joint Multi-Strike Group Exercise.

Increases in the number of predicted TTS and PTS exposures could mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some individual animals are exposed, although the types and severity of individual responses to sonar and other active acoustic sources are not expected to change between Alternative 1 and the No Action Alternative.

Pursuant to the MMPA, sonar and other active acoustic sources used during training activities under Alternative 1:

- *May expose marine mammals up to 70,961 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 45 times annually to sound levels that would be considered Level A harassment*
- *May expose up to 2 beaked whales annually to sound levels that may elicit stranding and subsequent serious injury or mortality*

Pursuant to the ESA, the use of sonar and other acoustic sources during training activities as described in Alternative 1:

- *May affect, and is likely to adversely affect the humpback whale, sei whale, fin whale, blue whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As described in Chapter 2 (Description of Proposed Action and Alternatives, Tables 2.8-2, 2.8-3, 2.8-4) and Section 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources), testing activities under Alternative 1 that produce in-water sound from the use of sonar and other active acoustic sources would occur within the Study Area. Activities would be concentrated within 200 nm of the Mariana Islands. New testing activities proposed under Alternative 1 resulting in potential effects to marine mammals from sonar and other active acoustic sources include:

- Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft
- At-Sea Sonar Testing
- Countermeasure Testing
- Anti-Submarine Warfare Mission Package Testing
- Mine Countermeasures Mission Package Testing
- Pierside Integrated Swimmer Defense
- Ship Signature Testing
- Torpedo Testing

There are no testing activities using sonar and other active acoustic sources proposed under the No Action Alternative. The inclusion of new testing activities under Alternative 1 would increase predicted exposures to marine mammals (e.g., non-TTS behavioral responses, TTS, and PTS). As shown in Table 3.4-18, the acoustic modeling and post-modeling analyses indicate that 10 annual exposures to sonar and other active acoustic sources would exceed the PTS threshold (Level A harassment as defined under the MMPA), and 10,924 marine mammal exposures may result in Level B harassment. Of these, 4,066 exposures would exceed the TTS threshold, and the remaining 6,858 would be classified as behavioral responses.

Notable results for testing activities under Alternative 1 are as follows:

- The 10 predicted PTS exposures are to dwarf sperm whale (7) and pygmy sperm whale (3).
- Predicted acoustic impacts on ESA-listed species would total 135 TTS exposures and 64 non-TTS (behavioral) responses.
- Approximately 50 percent of all non-TTS (behavioral) responses are on Cuvier's beaked whales, and 64 percent of those responses are associated with Anti-Submarine Warfare Mission Package Testing.

No testing activities involving the use of sonar or other active acoustic sources are included as part of the No Action Alternative. Therefore, all predicted acoustic impacts (e.g., non-TTS, TTS, and PTS exposures) from testing activities would mean an increase in the number of animals exposed per year or an increase in the number of times per year some individual animals are exposed. The types and severity of individual responses to sonar and other active acoustic sources are not expected to be different than similar training activities described under Alternative 1 (Training) in this section.

Pursuant to the MMPA, sonar and other active acoustic sources used during testing activities under Alternative 1:

- *May expose marine mammals up to 10,924 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 10 times annually to sound levels that would be considered Level A harassment*

Pursuant to the ESA, the use of sonar and other acoustic sources during testing activities as described in Alternative 1:

- *May affect, and is likely to adversely affect the humpback whale, sei whale, fin whale, blue whale, sperm whale*

3.4.4.1.3.3 Alternative 2

Training

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1) and Section 3.0.5.2.1.1 (Sonar and Active Acoustic Sources), training activities under Alternative 2 that produce underwater sound from the use of sonar and other active acoustic sources would increase over those proposed under the No Action Alternative. Activities would occur in the same locations throughout the Study Area as presented for the No-Action Alternative and would be concentrated within 200 nm of the Mariana Islands. New training activities proposed under Alternative 2 using sonar and other active acoustic sources that impact the modeling results include:

- Fleet Strike Group Exercise
- Integrated Anti-Submarine Warfare Exercise
- Ship Squadron Anti-Submarine Warfare Exercise

The inclusion of these activities under Alternative 2 and adjustments to the location, type, and tempo of activities included under the No Action Alternative result in a predicted increase in PTS and TTS exposures and a decrease in behavioral (non-TTS) exposures. As is shown in Table 3.4-17, the acoustic modeling and post-modeling analyses indicate that 59 annual exposures to sound from sonar and other active acoustic sources would exceed the PTS threshold (Level A harassment as defined under the MMPA), and 102,616 marine mammal exposures may result in Level B harassment. Of these, 32,946 exposures would exceed the TTS threshold, and 69,670 behavioral responses are predicted.

Under Alternative 2, TTS exposures to all marine mammals would increase by approximately 145 percent over the number of exposures predicted under the No Action Alternative. The number of PTS exposures would increase by 96 percent (from 24 to 59) under Alternative 2, and the number of non-TTS (behavioral) exposures would increase by 17 percent compared to the number of behavioral exposures predicted under the No Action Alternative. Total predicted acoustic impacts (behavioral responses, TTS, and PTS) would increase by approximately 35 percent under Alternative 2.

Some training activities that use sonar or other active acoustic sources have the potential to occur, at least partially, in nearshore or littoral waters of the Study Area (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-1). It is possible, although unlikely, that these activities may occur in proximity to spinner dolphin resting areas identified in Section 3.4.2.23.2 (Spinner Dolphin, Geographic Range and Distribution). Several of these training activities occur infrequently (1–4 times per year). Other training activities would occur in nearshore areas where non-military activities also occur (e.g., Apra Harbor), which are unlikely to be spinner dolphin resting areas. To date, there have been no sightings of spinner dolphins in Apra Harbor.

The total number of exposures to spinner dolphins from all sonar and other active acoustic sources used in both the offshore and nearshore areas of the Study Area, not just from nearshore activities, is 103 TTS exposures and 579 behavioral responses. These predicted exposures are included in the estimated number of behavioral responses and TTS exposures presented in this section.

Mitigation, as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), for activities occurring in offshore and nearshore areas of the Study Area would include surveying for marine mammals, including resting spinner dolphins, prior to conducting the activity. Given that nearshore activities occur infrequently, would be unlikely to occur in the vicinity of spinner dolphin resting areas, and mitigation to avoid potential effects would be conducted, no long-term consequences to spinner dolphins, such as habitat abandonment, are anticipated.

Notable results for Alternative 2 in comparison to results for the No Action Alternative and Alternative 1 are as follows:

- Predicted acoustic impacts (behavioral and TTS) on mysticetes overall would increase by about 60 percent over the No Action Alternative and 45 percent over Alternative 1. Predicted TTS exposures for all mysticetes would increase by 85 percent over the No Action Alternative and by about 50 percent over Alternative 1. No PTS exposures on mysticetes are predicted under Alternative 2.
- Predicted TTS exposures on ESA-listed species would increase by about 48 percent over the No Action Alternative and by about 46 percent over Alternative 1. No PTS exposures are predicted on ESA-listed species.
- Combined TTS and PTS exposures predicted for dolphins and small-toothed whales would increase by about 35 percent over the No Action Alternative and 23 percent over Alternative 1. Predicted non-TTS (behavioral) exposures would increase by about 17 percent over the No Action Alternative and 44 percent over Alternative 1.
- Predicted TTS exposures on beaked whales would increase from 79 under the No Action Alternative to 377 under Alternative 2. Predicted TTS exposures under Alternative 2 would increase by 30 percent over Alternative 1.
- Approximately 60 percent of the predicted TTS exposures on beaked whales under all three alternatives are on Cuvier’s beaked whale, and 60–79 percent of TTS exposures on Cuvier’s beaked whale are associated with sonar use during the Joint Multi-Strike Group Exercise.

Increases in the number of predicted acoustic impacts could mean an increase in the number of animals exposed per year or an increase in the number of times per year some individual animals are exposed, although the types and severity of individual responses to sonar and other active acoustic sources are not expected to change between Alternative 2 and the No Action Alternative.

Pursuant to the MMPA, sonar and other active acoustic sources used during training activities under Alternative 2:

- *May expose marine mammals up to 102,616 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 59 times annually to sound levels that would be considered Level A harassment*
- *May expose up to 2 beaked whales annually to sound levels that may elicit stranding and subsequent serious injury or mortality*

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities as described in Alternative 2:

- *May affect, and is likely to adversely affect the humpback whale, sei whale, fin whale, blue whale, and sperm whale*

Testing

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-2, 2.8-3, 2.8-4) and Section 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources), proposed testing activities involving sonar and other active acoustic sources under Alternative 2 would all be new, given none of these activities were proposed for the No Action Alternative. This section describes predicted impacts on marine mammals from testing activities under Alternative 2. These activities would occur throughout the Study Area and would be concentrated within 200 nm of the Mariana Islands.

Under Alternative 2, the number of annual testing activities would increase, including increases in the number of anti-submarine warfare events, mission package testing events, and at-sea sonar testing events (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-2, 2.8-3, 2.8-4). No new testing activities using sonar and other active acoustic sources are proposed under Alternative 2. The increase in proposed testing activities under Alternative 2 would result in an increase in predicted impacts to marine mammals (i.e., behavioral responses, TTS, and PTS) over the No Action Alternative (no sonar and other active acoustic activities; therefore no exposures) and Alternative 1.

As shown in Table 3.4-18, the acoustic modeling and post-modeling analyses indicate that 14 annual exposures to sound from sonar and other active acoustic sources would exceed the PTS threshold (Level A harassment as defined under the MMPA), and 13,065 marine mammal exposures may result in Level B harassment. Of these, 5,252 exposures would exceed the TTS threshold, and, the remaining 7,813 would be classified as behavioral responses.

Notable results for testing activities under Alternative 2 in comparison to Alternative 1 are as follows:

- The 14 predicted PTS exposures are on dwarf sperm whale (10) and pygmy sperm whale (4) and represent a 40 percent increase in total PTS exposures over Alternative 1.
- Predicted acoustic impacts on ESA-listed species total 76 non-TTS (behavioral) and 174 TTS exposures, an increase of about 20 percent and 10 percent over Alternative 1, respectively.

- Combined TTS and PTS exposures predicted for dolphins and small-toothed whales would increase by about 30 percent over Alternative 1. Predicted non-TTS (behavioral) exposures would increase by about 14 percent over Alternative 1.
- Approximately 50 percent of all non-TTS (behavioral) exposures on all marine mammals are on Cuvier's beaked whale, and 60 percent of all non-TTS (behavioral) exposures on Cuvier's beaked whale are associated with Anti-Submarine Warfare Mission Package Testing.

Increases in the number of acoustic impacts (non-TTS, TTS, and PTS) from testing activities would mean an increase in the number of animals exposed per year or an increase in the number of times per year some individual animals are exposed compared to predicted exposures under Alternative 1. The types and severity of individual responses to sonar and other active acoustic sources are not expected to change between Alternative 2 and Alternative 1.

Pursuant to the MMPA, sonar and other active acoustic sources used during testing activities under Alternative 2:

- *May expose marine mammals up to 13,065 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 14 times annually to sound levels that would be considered Level A harassment*

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities as described in Alternative 2:

- *May affect, and is likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2 Impacts from Explosives

Marine mammals could be exposed to energy and sound from underwater explosions associated with proposed activities as described in Chapter 2 (Description of Proposed Action and Alternatives). Explosives used during proposed military training and testing activities could occur throughout the Study Area. These activities include amphibious warfare, strike warfare, anti-surface warfare, anti-submarine warfare, and mine warfare. Activities that involve explosions are described in Chapter 2 (Description of Proposed Action and Alternatives).

The Navy Acoustic Effects Model (Marine Species Modeling Team 2013), in conjunction with the explosive thresholds and criteria are used to predict impacts on marine mammals from underwater explosions. Predicted impacts on marine mammals from at-sea explosions are based on a modeling approach that considers many factors. The equations for the models consider the net explosive weight (NEW), the properties of detonations underwater, and environmental factors such as depth of the explosion, overall water depth, water temperature, and bottom type. The NEW accounts for the mass and type of explosive material. Energy from explosions is capable of causing mortality, injury to the lungs or gastrointestinal tract, permanent or TTS, or a behavioral response depending on the level of exposure.

Section 3.4.3.1.2 (Analysis Background and Framework) presents the framework for the analysis of potential impacts. The death of an animal will, of course, eliminate future reproductive potential and cause a long-term consequence for the individual that must then be considered for potential long-term consequences for the population. Exposures that result in long-term injuries such as PTS may limit an animal's ability to find food, communicate with other animals, or interpret the environment around them. Impairment of these abilities can decrease an individual's chance of survival or impact its ability to successfully reproduce. TTS can also impair animal's abilities, but the TTS effect and the individual may recover quickly with little significant overall effect. 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). However, it is not clear how these responses relate to long-term consequences for the individual or population (National Research Council 2005).

Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds are likely within the audible range of most cetaceans, but the duration of individual sounds is very short. The direct sound from impulse sources such as explosions used during military training and testing activities last less than a second, and most events involve the use of only one or a few explosions. Furthermore, events are dispersed in time and throughout the Study Area. These factors reduce the likelihood of these sources causing substantial auditory masking in marine mammals.

Section 3.4.3.1.2.1 (Direct Injury) presents a review of observations and experiments involving marine mammals and reactions to impulse sounds and underwater explosions. Energy from explosions is capable of causing mortality, direct injury, hearing loss, or a behavioral response depending on the level of exposure. The death of an animal will, of course, eliminate future reproductive potential and must then be considered for potential long-term consequences for the population. Exposures that result in long-term injuries such as 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 may recover quickly with little significant effect. 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). However, it is not clear how these responses relate to long-term consequences for the individual or population (National Research Council 2005).

3.4.4.2.1 Range to Effects

This section describes the ranges (distances) to effects from an explosion as defined by specific criteria and explosive propagation calculations used in the Navy Acoustic Effects Model (Section 3.4.3.1.5.3). Marine mammals within these ranges are predicted to receive the associated effect. The range to effects is important information in estimating the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher-level effects, especially physiological effects such as injury and mortality. The ranges to effects are described below for explosive bins E2 (up to 0.5 lb. NEW)–E12 (up to 1,000 lb. NEW).

Figure 3.4-7 through Figure 3.4-10 show the range to slight lung injury and mortality for five representative animals of different masses for 0.5–1,000 lb. NEW detonations. Ranges for onset slight lung injury and onset mortality are based on the smallest calf weight in each category and therefore represents a conservative estimate (i.e., longer ranges) since populations contain many animals larger than calves and are therefore less susceptible to injurious effects. 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.

Note that the modeling of proposed activities used species-specific masses and not the representative animal masses presented in Figure 3.4-7 through Figure 3.4-10.

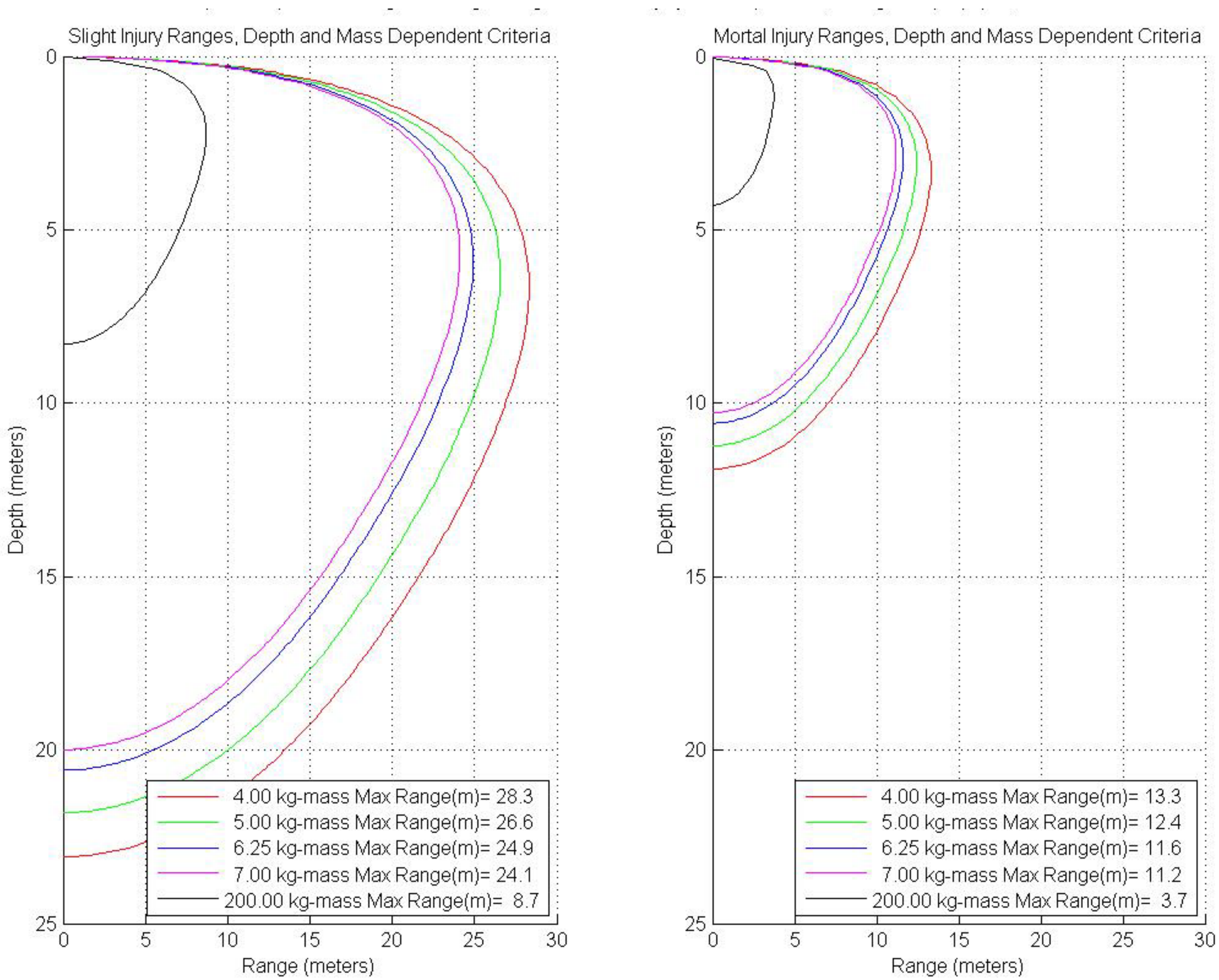

Figure 3.4-7: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 0.5-Pound Net Explosive Weight Charge (Bin E2) Detonated at 1-Meter Depth

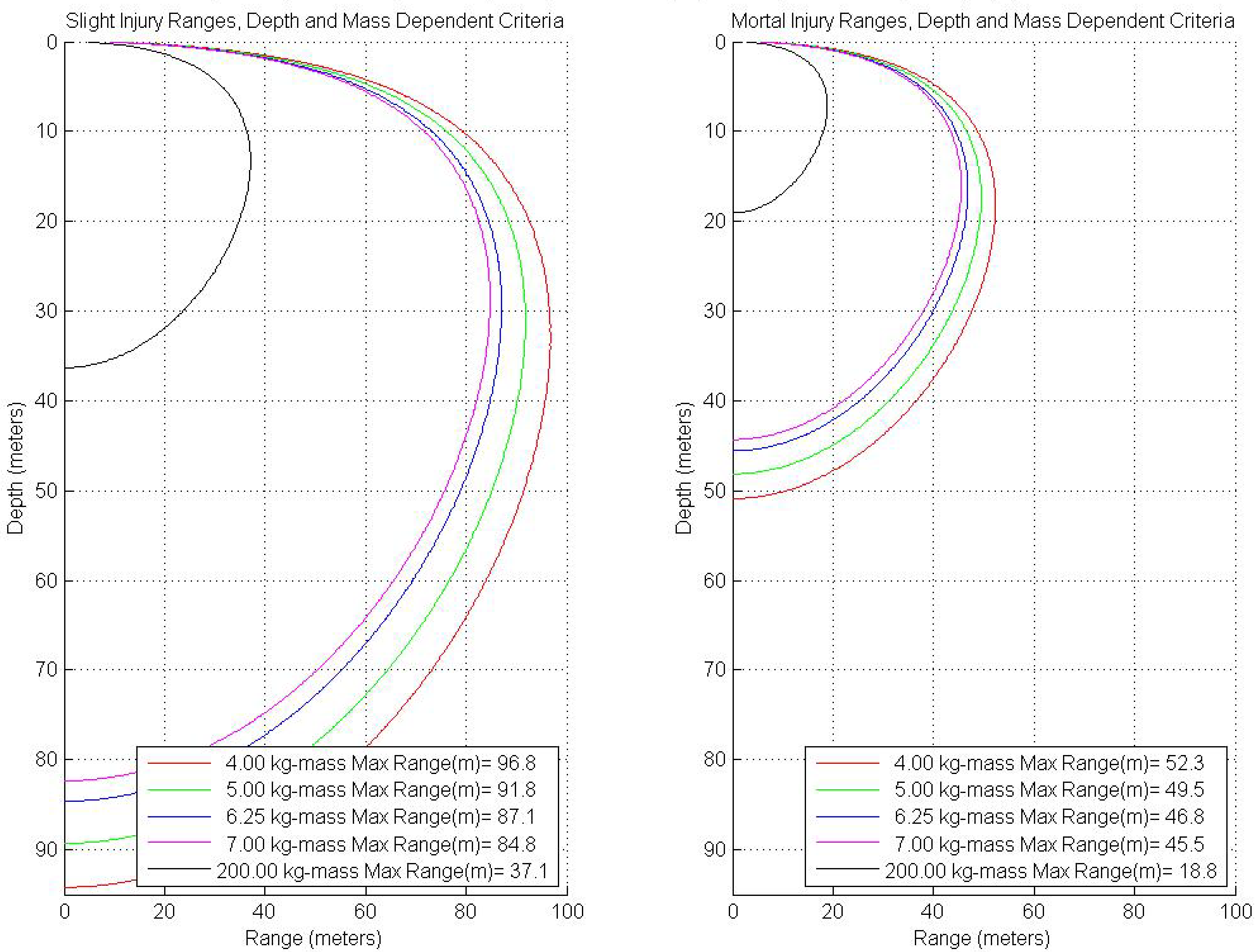

Figure 3.4-8: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 10-Pound Net Explosive Weight Charge (Bin E5) Detonated at 1-Meter Depth

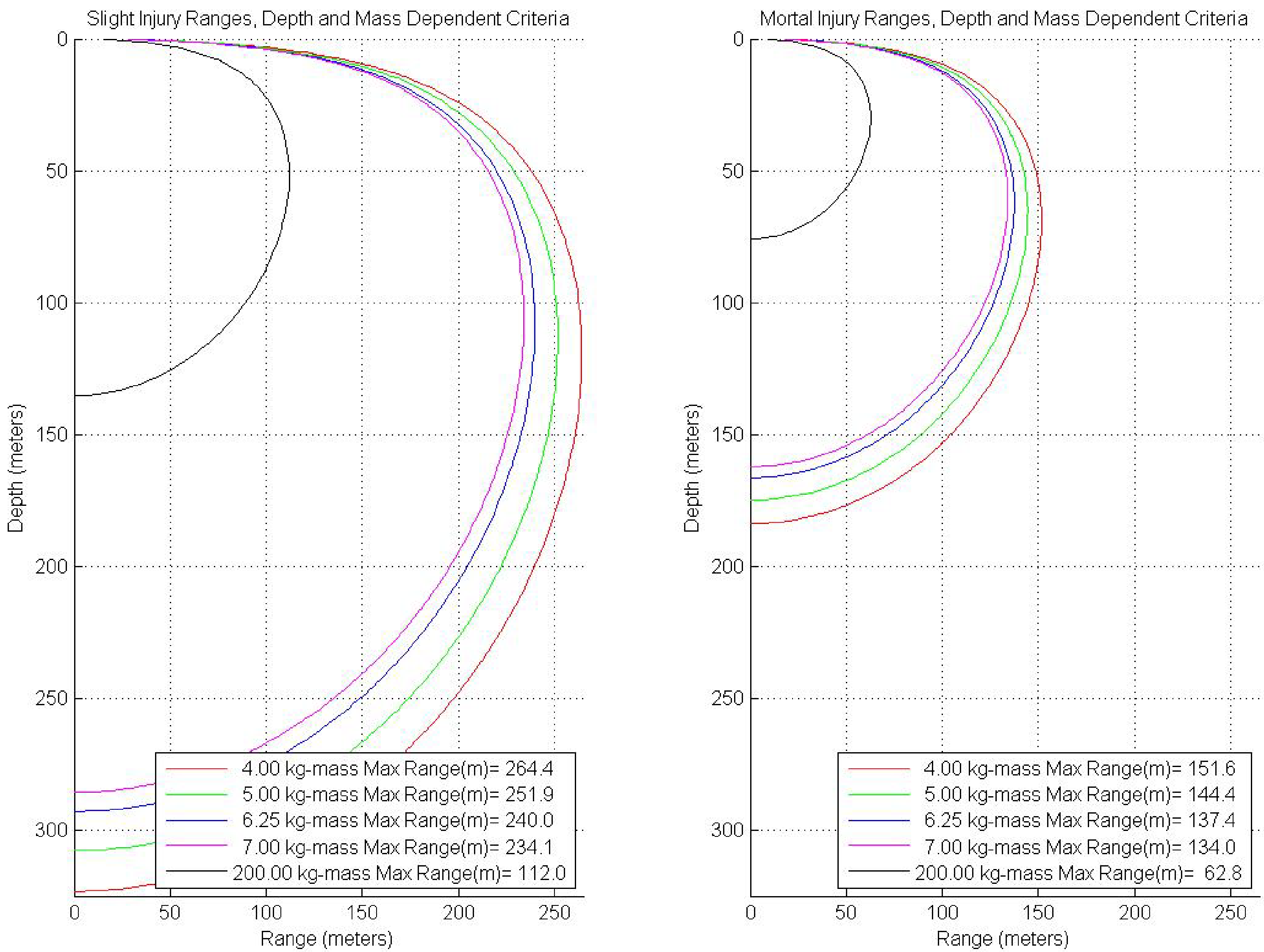

Figure 3.4-9: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 250-Pound Net Explosive Weight Charge (Bin E9) Detonated at 1-Meter Depth

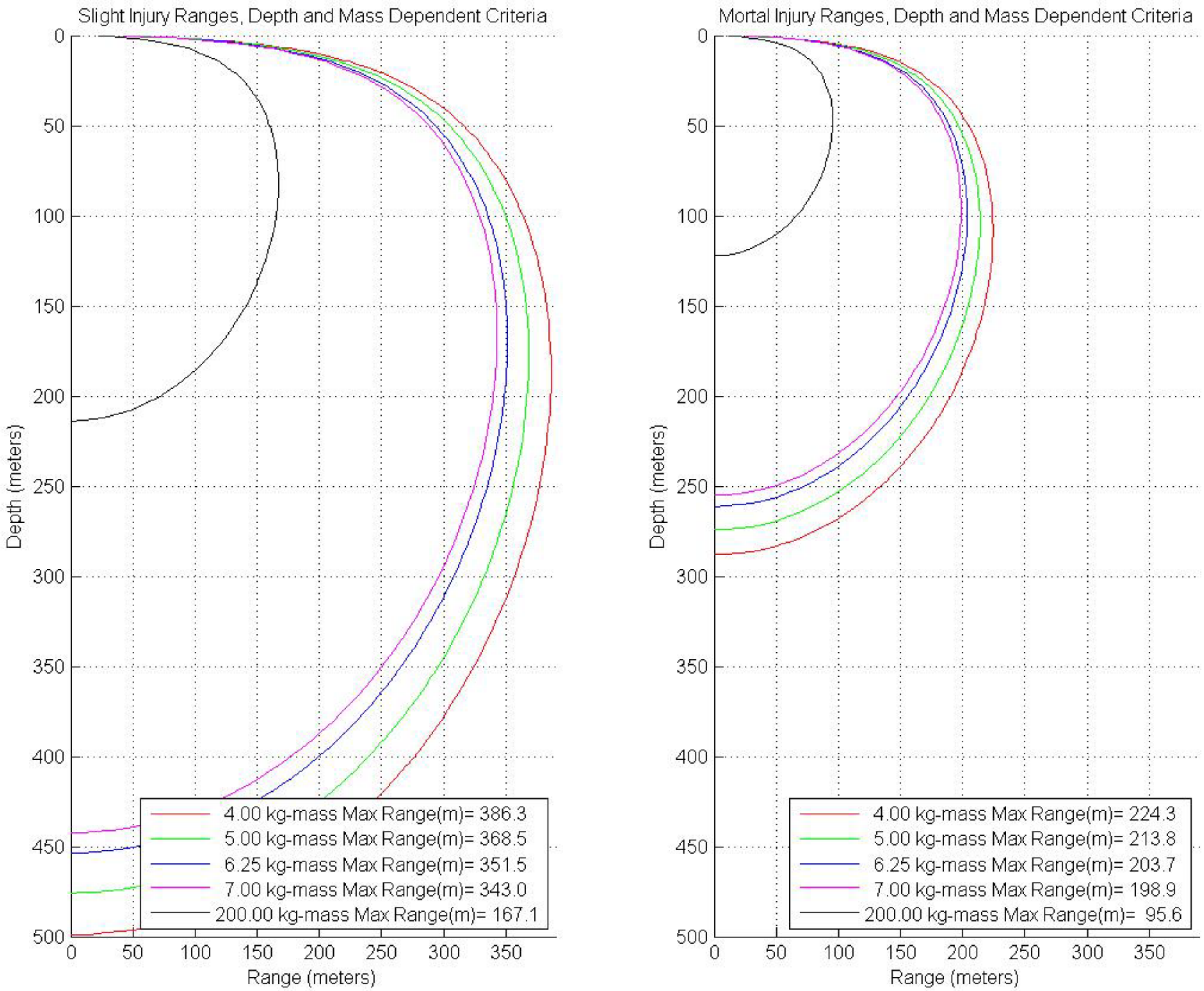

Figure 3.4-10: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 1,000-Pound Net Explosive Weight Charge (Bin E12) Detonated at 1-Meter Depth

Table 3.4-19 shows the average approximate ranges to the potential effect based on the thresholds described in Section 3.4.3.1.4 (Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). Similar to slight lung injury and mortality ranges discussed above, behavioral, TTS, and PTS ranges also represent conservative estimates (i.e., longer ranges) based on assuming all impulses are 1 second in duration. In fact, most impulses are much less than 1 second and therefore contain less energy than what is being used to produce the estimated ranges.

Explosions were modeled at the depths at which the explosive sources would typically be detonated during a training or testing activity. The depths at which explosives are detonated are not the same for all bins. The propagation of the energy generated by an explosion varies with depth and can lead to results that are contrary to the expected increase in distance with an increase in NEW (e.g., compare ranges for bin E7–bin E9).

Table 3.4-19: Average Approximate Range to Effects from a Single Explosion for Marine Mammals Across Representative Acoustic Environments (Nominal Values for Deep Water Offshore Areas; Not Specific to the Study Area)

Hearing Group Criteria/Predicted Impact	Average Approximate Range (meters) to Effects for Sample Explosive Bins					
	Bin E3 (>0.5–2.5 lb. NEW)	Bin E5 (>5–10 lb. NEW)	Bin E7 (>20–60 lb. NEW)	Bin E9 (>100–250 lb. NEW)	Bin E10 (>250–500 lb. NEW)	Bin E12 (>650–1,000 lb. NEW)
Low-frequency Cetaceans (calf weight 200 kg)						
Onset Mortality	10	20	80	65	80	95
Onset Slight Lung Injury	20	40	165	110	135	165
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	85	170	370	255	305	485
TTS	215	445	860	515	690	1,760
Behavioral Response	320	525	1,290	710	905	2,655
Mid-frequency Cetaceans (calf weight 5 kg)						
Onset Mortality	25	45	205	135	165	200
Onset Slight Lung Injury	50	85	390	235	285	345
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	35	70	160	170	205	265
TTS	100	215	480	355	435	720
Behavioral Response	135	285	640	455	555	970
High-frequency Cetaceans (calf weight 4 kg)						
Onset Mortality	30	50	225	145	175	215
Onset Slight Lung Injury	55	90	425	250	305	370
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	140	375	710	470	570	855
TTS	500	705	4,125	810	945	2,415
Behavioral Response	570	930	5,030	2,010	4,965	5,705

Notes: GI = gastrointestinal, kg = kilograms, lb. = pounds, NEW = net explosive weight, PTS = permanent threshold shift, TTS = temporary threshold shift

3.4.4.2.2 Avoidance Behavior and Mitigation Measures as Applied to Explosions

As previously discussed, within the Navy Acoustic Effects Model, animats do not move horizontally or react in any way to avoid sound at any level. In reality, researchers have demonstrated that cetaceans can perceive the location and movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Watkins 1986; Würsig et al. 1998; Richardson et al. 1995; Jansen et al. 2010; Tyack et al. 2011). Section 3.4.3.1.2 (Analysis Background and Framework) reviews research and observations of marine mammals' reactions to sound sources including seismic surveys and explosives. The Navy Acoustic Effects Model also does not account for the implementation of mitigation, which would prevent many of the model-predicted injurious and mortal exposures to explosives. Therefore, the model-estimated mortality and Level A effects are further analyzed and adjusted to account for animal movement (avoidance) and implementation of mitigation measures.

If explosive activities are preceded by multiple vessel traffic or hovering aircraft, beaked whales are assumed to move beyond the range to onset mortality before detonations occur. Table 3.4-19 shows the ranges to onset mortality for mid-frequency and high-frequency cetaceans for a representative range of charge sizes. The range to onset mortality for all NEWs is less than 280 yd. (260 m), which is conservatively based on range to onset mortality for a calf. Because the Navy Acoustic Effects Model does not include avoidance behavior, the model-estimated mortalities are based on unlikely behavior for these species—that they would tolerate staying in an area of high human activity. Therefore, beaked whales that were model-estimated to be within range of a mortality criterion exposure are assumed to avoid the activity and analyzed as being in the range of potential injury prior to the start of the explosive activity for the activities listed in Table 3.4-20.

Table 3.4-20: Activities Using Impulse Sources Preceded by Multiple Vessel Movements or Hovering Helicopters for the Mariana Islands Training and Testing Study Area

Training
Civilian Port Defense
Gunnery Exercise (Surface-to-Surface) Ship/Boat – Medium-caliber
Maritime Security Operations
Missile Exercise (Air-to-Surface)
Missile Exercise (Air-to-Surface)– Rocket
Mine Neutralization – Explosive Ordnance Disposal
Mine Neutralization – Remotely Operated Vehicle
Sinking Exercise
Underwater Demolition Qualification/Certification
Testing
Mine Countermeasure Mission Package Testing
Pierside Integrated Swimmer Defense
Torpedo Testing

The Navy Acoustic Effects Model does not consider mitigation, discussed in detail in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), Section 5.3 (Mitigation Assessment). As explained in Section 3.4.3.3 (Implementing Mitigation to Reduce Sound Exposures), to account for the implementation of mitigation measures, the acoustic analysis assumes a model-predicted mortality or injury would not occur if an animal at the water surface would likely be observed during those activities with dedicated Lookouts up to and during the use of explosives, considering the mitigation effectiveness (Table 3.4-21) and sightability of a species based on g(0) (see Table 3.4-8). The mitigation effectiveness is considered over two regions of an activity's mitigation zone: (1) the range to onset mortality closer to the explosion and (2) range to onset PTS. The model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen (Mitigation Effectiveness x Sightability, g(0)); these animals are instead assumed to be present within the range to injury and range to TTS, respectively.

Table 3.4-21: Adjustment Factors for Activities Using Explosives Integrating Implementation of Mitigation into Modeling Analyses for the Mariana Islands Training and Testing Study Area

Activity[1]	Factor for Adjustment of Preliminary Modeling Estimates[2]		Mitigation Platform Used for Assessment
	Injury Zone	Mortality Zone	
Training			
BOMBEX [A-S] (HF/LF)	0	1	Aircraft
BOMBEX [A-S] (MF)	0.5	1	Aircraft
Civilian Port Defense	1	1	Vessel
Maritime Security Operations	1	1	Both[3]
Mine Neutralization – EOD	0.5	1	Vessel
Mine Neutralization – ROV	1	1	Vessel
Fleet Strike Group Exercise	0.5	0.5	Both[3]
GUNEX [A-S] – Medium-Caliber (BW/HF)	0.5	0.5	Aircraft
GUNEX [A-S] – Medium-Caliber (LF/MF)	1	1	Aircraft
GUNEX [S-S] – Boat – Medium-Caliber (BW/HF)	0.5	0.5	Vessel
GUNEX [S-S] – Boat – Medium-Caliber (MF/LF)	1	1	Vessel
GUNEX [S-S] – Ship – Medium-Caliber (BW/HF)	0.5	0.5	Vessel
GUNEX [S-S] – Ship – Medium-Caliber (MF/LF)	1	1	Vessel
Joint Expeditionary Exercise	0.5	0.5	Both[3]
Joint Multi-CSG Exercise	0.5	0.5	Both[3]
SINKEX (HF/LF)	0.5	1	Aircraft
SINKEX (MF)	0.5	1	Aircraft
TRACKEX/TORPEX – MPA AEER/IEER	0.5	0.5	Aircraft
Underwater Demolition Qualification/Certification	1	1	Vessel
Testing			
MCM Mission Package Testing	1	1	Vessel
Torpedo Testing	0.5	1	Aircraft

[1] Ranges to effect differ for functional hearing groups based on weighted threshold values. HF: high-frequency cetaceans; MF: mid-frequency cetaceans; LF: low-frequency cetaceans. The adjustment factor for all other activities (not listed) is zero and there is no adjustment of the preliminary modeling estimates as a result of implemented mitigation for those activities.
[2] A zero value is provided if the predicted maximum zone for the criteria is large and exceeds what mitigation procedures are likely to affect; a zero value indicates mitigation did not adjust or reduce the predicted exposures under that criteria.
[3] Activity employs both vessel and aircraft based Lookouts. The larger g(0) value (aerial or vessel) is used to estimate sightability.
Notes: A-S = air-to-surface, AEER = Advanced Extended Echo Ranging, BOMBEX = Bombing Exercise, BW = beaked whale, CSG = Carrier Strike Group, EOD = Explosive Ordnance Disposal, GUNEX = Gun Exercise, HF = high-frequency, IEER = Improved Extended Echo Ranging, LF = low-frequency, MCM = mine countermeasure, MF = mid-frequency, MISSILEX = Missile Exercise, MPA = Maritime Patrol Aircraft, S-S = surface-to-surface, SINKEX = Sinking Exercise, TORPEX = Torpedo Exercise, TRACKEX = Tracking Exercise

During an activity with a series of explosions (not concurrent multiple explosions [Table 3.4-22]), an animal is expected to exhibit an initial startle reaction to the first detonation, followed by a behavioral response after multiple detonations. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area around the explosions is the assumed behavioral response for most cases. The ranges to PTS for each functional hearing group for a range of explosive sizes (single detonation) are shown in Table 3.4-19. Animals not observed by Lookouts within the ranges to PTS at the time of the initial couple of explosions are assumed to experience PTS; however, animals that exhibit avoidance reactions beyond the initial range to PTS are assumed to move away from the expanding range to PTS effects with each additional explosion.

Additionally, odontocetes have been demonstrated to have directional hearing, with best hearing sensitivity facing a sound source (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005). An odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts. Because the Navy Acoustic Effects Model does not account for avoidance behavior, the model-estimated effects are based on unlikely behavior that animals would remain in the vicinity of potentially injurious sound sources. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur. The remaining model-estimated PTS are considered to be TTS due to avoidance. The remaining model-estimated PTS exposures (resulting from accumulated energy) are considered to be TTS due to avoidance. Activities involving multiple non-concurrent explosive or other impulsive sources are listed in Table 3.4-22.

Table 3.4-22: Activities with Multiple Non-Concurrent Explosions

Training
BOMBEX (A-S)
Civilian Port Defense
GUNEX (A-S)
GUNEX (S-S) – Medium-caliber
GUNEX (S-S) – Large caliber
Mine Neutralization – EOD
Mine Neutralization – ROV
SINKEX
Testing
MCM Mission Package Testing
ASUW Mission Package Testing

Notes: A-S = air-to-surface, ASUW = Anti-Surface Warfare, BOMBEX = Bombing Exercise, EOD = Explosive Ordnance Disposal, GUNEX = Gunnery Exercise, MCM = mine countermeasure, ROV = remotely operated vehicle, S-S = surface-to-surface, SINKEX = Sinking Exercise

3.4.4.2.3 Predicted Impacts from Explosives

Predicted impacts to marine mammals from impulse sources for training activities (Table 3.4-23) and testing activities (Table 3.4-24) are presented for Alternative 1 and Alternative 2 (the predicted impacts for the two alternatives are the same). There are no modeling predicted effects to marine mammals as a result of the No Action Alternative for testing or training activities using impulse sources. The totals presented in these tables are the summation of all proposed events occurring annually.

It is also important to note that impacts from impulse sources presented in Table 3.4-23 and Table 3.4-24: are the total number of exposures and not necessarily the number of individuals exposed. As discussed in Section 3.4.3.1.4.3 (Behavioral Responses) an animal could be predicted to receive more than one acoustic impact over the course of a year. Species presented in the tables had species density values (i.e., theoretically present to some degree) within the areas modeled for the given alternative and activities, although modeling may still indicate no exposures after summing all annual impacts.

The analysis of acoustic effects from explosives uses the Navy Acoustic Effects Model followed by post-model consideration of avoidance and implementation of mitigation to predict effects using the explosive criteria and thresholds.

As presented previously, the Navy Acoustic Effects Model accounts for several limitations in the data needed for the model by making assumptions that are believed to overestimate the number of animal exposures to impulse and non-impulse sound sources (Section 3.4.3.1.5.4, Model Assumptions and Limitations). When there is uncertainty in model input values, a conservative approach has been adopted to assure that potential effects are not under predicted. As a result, the Navy Acoustic Effects Model provides predictions that are conservative (in that it over predicts the likely impacts). The following is a list of additional factors that cause the model to overestimate potential injury effects from impulse sound sources (e.g., explosions):

- The onset mortality criterion is based on the impulse at which 1 percent of the animals receiving an injury would not recover. Therefore, many predicted mortalities in this analysis may actually represent animals that recover from their injuries.
- Slight lung injury criteria are based on the impulse at which 1 percent of the animals exposed would incur a slight lung injury from which full recovery would be expected. Therefore, many predicted slight lung injury exposures in this analysis may not actually result in injuries to animals.
- The metrics used for the threshold for slight lung injury and mortality (i.e., acoustic impulse) are based on the animal's mass. The smaller an animal, the more susceptible that individual is to these effects. In this analysis, all individuals of a given species are assigned the weight of that species newborn. Since many individuals in a population are obviously larger than a newborn calf of that species, this assumption causes the acoustic model to overestimate the number of animals that may incur slight lung injury or mortality. As discussed in the explanation of onset mortality and onset slight lung injury criteria, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.
- Many explosions from munitions such as bombs and missiles will actually occur upon impact with above-water targets. However, for this analysis, sources such as these were modeled as exploding at 1 m depth. This overestimates the amount of explosive and acoustic energy entering the water and therefore overestimates effects on marine mammals.
- The Navy Acoustic Effects Model does not account for animal avoidance behavior that would most likely occur during activities that involve multiple explosives. Animal avoidance would decrease the effects predicted in this analysis.

Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) provide additional protections, many of which are not considered in the following exposure summary tables since reductions as a result of implemented mitigation were only applied to those events having a very high likelihood of detecting marine mammals.

3.4.4.2.3.1 No Action Alternative, Alternative 1, and Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1) and Section 3.0.5.2.1.2 (Explosives) training activities would use underwater detonations and explosive ordnance under all three alternatives. Training activities involving explosions could be conducted throughout the Study Area and typically occur more than 3 nm from shore. Exceptions to this are events that have historically occurred in Apra Harbor and other nearshore shallow water locations designated for military use.

Under the No Action Alternative, there are no model-predicted effects to marine mammals from training activities using impulse sources. New training activities proposed under Alternative 1 using sonar and other active acoustic sources that impact the modeling results include:

- Gunnery (Air-to-Surface) Medium-Caliber
- Gunnery (Surface-to-Surface) Boat – Medium-Caliber
- Gunnery (Surface-to-Surface) Ship – Medium-Caliber
- Joint Expeditionary Exercise
- Joint Multi-Carrier Strike Group Exercise
- Civilian Port Defense
- Maritime Security Operations
- Missile Exercise (Surface-to-Surface)

One new training activity that uses sonar and other active acoustic sources, the Fleet Strike Group Exercise, is proposed under Alternative 2. This activity occurs one time per year.

As presented in Table 3.4-23, modeling predicts the identical number of effects for Alternative 1 and Alternative 2. No exposures are predicted from impulse sound or underwater detonations during training events that would result in slight lung injury or mortality. One MMPA Level A exposure at the PTS level is predicted, and six exposures to marine mammals are predicted at the TTS level. The modeling results and a historical record of conducting the same or similar events for decades in the Pacific indicates Level A exposures are unlikely.

Mysticetes

There are no predicted impacts on mysticetes from impulse sources (explosions and detonations) associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Blue Whales (Endangered Species Act-Listed)

There are no predicted impacts on blue whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Fin Whales (Endangered Species Act-Listed)

There are no predicted impacts on fin whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Table 3.4-23: Alternative 1 and Alternative 2 Annual Training Exposure Summary for Impulse Sound Sources[1]

Species	Level B		Level A			
	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Blainville's Beaked Whale	0	0	0	0	0	0
Blue Whale	0	0	0	0	0	0
Bottlenose Dolphin	0	0	0	0	0	0
Bryde's Whale	0	0	0	0	0	0
Minke Whale	0	0	0	0	0	0
Cuvier's Beaked Whale	0	0	0	0	0	0
Dwarf Sperm Whale	0	3	1	0	0	0
False Killer Whale	0	0	0	0	0	0
Fin Whale	0	0	0	0	0	0
Fraser's Dolphin	0	1	0	0	0	0
Ginkgo-toothed Beaked Whale	0	0	0	0	0	0
Humpback Whale	0	0	0	0	0	0
Killer Whale	0	0	0	0	0	0
Longman's Beaked Whale	0	0	0	0	0	0
Melon-headed Whale	0	0	0	0	0	0
Omura's Whale	0	0	0	0	0	0
Pantropical Spotted Dolphin	0	1	0	0	0	0
Pygmy Killer Whale	0	0	0	0	0	0
Pygmy Sperm Whale	0	1	0	0	0	0
Risso's Dolphin	0	0	0	0	0	0
Rough Toothed Dolphin	0	0	0	0	0	0
Sei Whale	0	0	0	0	0	0
Short-finned Pilot Whale	0	0	0	0	0	0
Sperm Whale	0	0	0	0	0	0
Spinner Dolphin	0	0	0	0	0	0
Striped Dolphin	0	0	0	0	0	0
Total Predicted Exposures	**0**	**6**	**1**	**0**	**0**	**0**

[1] There are no predicted exposures from impulse sound sources under the No Action Alternative.
Notes: GI = gastrointestinal, PTS = permanent threshold shift, TTS = temporary threshold shift

Humpback Whales (Endangered Species Act-Listed)

There are no predicted impacts on humpback whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Sei Whales (Endangered Species Act-Listed)

There are no predicted impacts on sei whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Odontocetes

Predicted impacts to odontocetes under all three alternatives are from sound or energy caused by explosions, and all are associated with the Bombing Exercise (air-to-surface) training activity.

Sperm Whales (Endangered Species Act-Listed)

There are no predicted impacts on sperm whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Beaked Whales

There are no predicted impacts on beaked whales from explosive sources associated with training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy and dwarf sperm whales (genus: *Kogia*) (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) may be exposed to sound or energy from explosions associated with training activities throughout the year. Acoustic modeling predicts that dwarf sperm whales could be exposed to sound or energy from explosions that may result in three TTS level exposures and one PTS level exposure per year. Pygmy sperm whales could be exposed to sound or energy from explosions that may result in one TTS level exposure per year. For reasons described in Section 3.4.4.2.3 (Predicted Impacts from Impulse Sources) no long-term consequences for individuals or populations of dwarf or pygmy sperm whales would be expected.

Recovery from a TTS effect (i.e., temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Animals would not fully recover from the PTS effect. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal’s ability to detect biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for an individual given that many mammals lose their hearing ability as they age. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Dolphins and Small Toothed Whales (Delphinids)

Fraser's dolphin and pantropical spotted dolphin are the only two Delphinids (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) that modeling predicts may be affected by explosions. One TTS level exposure is predicted for Fraser’s dolphin, and one TTS level exposure is predicted for pantropical spotted dolphin per year. No MMPA Level A exposures are predicted for either species.

As with other marine mammal species, recovery from a TTS effect (i.e., temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal’s ability to detect biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for an individual given that many mammals lose their hearing ability as they age (Ridgway et al. 1997; Southall et al. 2007; Kloepper et al. 2010).

Research and observations (Section 3.4.3.1.2.6, Behavioral Responses) suggest that if delphinids are exposed to explosions, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Some behavioral impacts could take place at distances of approximately 970 m (0.6 mi.) for a Bombing Exercise (air-to-surface) event, although significant behavioral effects are much more likely at higher received levels closer to the sound and energy source. Resting sites for spinner dolphins have been identified in nearshore waters of the

Study Area (see Section 3.4.2.23.2). As shown in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1), three major training exercises and one mine warfare activity (the Limpet Mine Neutralization System/Shock Wave Generator activity) could involve some level of activity in nearshore or littoral waters. However, use of explosives would occur in offshore areas of the Study Area or in areas specifically designated for detonations and would be unlikely to affect resting spinner dolphins. Spinner dolphins have been cited in the vicinity of FDM, and although multiple training activities use explosives at FDM, all detonations would occur on land. No exposures of spinner dolphins to explosives effects are predicted by the Navy's Acoustics Effects Model.

Overall, the number of predicted behavioral reactions is low, and occasional behavioral responses are unlikely to cause long-term consequences for individual animals or marine mammal populations. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce potential impacts.

Conclusion

Training activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2) include sound or energy from underwater explosions resulting from activities as described in Table 2.8-1 of Chapter 2 (Description of Proposed Action and Alternatives) and in Section 3.0.5.2.1.2 (Explosives). There are no modeled effects to marine mammals as a result of the No Action Alternative. Under Alternative 1 and Alternative 2 the proposed actions resulting in exposures are identical, and these activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of explosives during training activities under Alternative 1 and Alternative 2:

- *May expose marine mammals up to 6 times annually to sound or pressure levels that would be considered Level B harassment*
- *May expose marine mammals up to 1 time annually to sound or pressure levels that would be considered Level A harassment*

(There are no model-predicted effects to marine mammals as a result of the No Action Alternative for training activities using explosive sources)

Pursuant to the ESA, the use of explosives during training activities as described for all alternatives (No Action Alternative, Alternative 1, and Alternative 2):

- *May affect, but is not likely to adversely affect blue whale, humpback whale, sei whale, fin whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-2–Table 2.8-4) and Section 3.0.5.2.1.2 (Explosives), testing activities under Alternative 1 and Alternative 2 would use underwater detonations and explosive ordnance. There are no testing activities using explosives or other impulse sound sources under the No Action Alternative.

Testing activities involving explosives could be conducted throughout the Study Area and would typically occur more than 3 nm from shore. Exceptions to this are testing activities that occur in Apra Harbor and other nearshore shallow water locations designated for military use and where similar activities have historically occurred.

As presented in Table 3.4-24, only non-TTS (behavioral) exposures for testing activities are predicted by the Navy's Acoustics Effects Model. No TTS level, MMPA Level A, injury, or mortality exposures are predicted from testing activities using explosive sound sources. Under Alternative 1, 15 behavioral exposures per year to marine mammals are predicted from impulse sound sources used during the proposed testing activities. Under Alternative 2, 18 behavioral exposures per year are predicted.

Mysticetes

There are no MMPA Level A or Level B exposures on mysticetes from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Blue Whales (Endangered Species Act-Listed)

There are no predicted impacts on blue whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Fin Whales (Endangered Species Act-Listed)

There are no predicted impacts on fin whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Humpback Whales (Endangered Species Act-Listed)

There are no predicted impacts on humpback whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Sei Whales (Endangered Species Act-Listed)

There are no predicted impacts on sei whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Odontocetes

Predicted effects to odontocetes from testing activities using explosive sources under Alternative 1 and Alternative 2 are on *Kogia* species.

Sperm Whales (Endangered Species Act-Listed)

There are no predicted impacts on sperm whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Beaked Whales

There are no predicted impacts on beaked whales from explosive sources associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy and dwarf sperm whales (genus: *Kogia*) (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) may be exposed to impulse sound or energy from explosions and detonations associated with testing activities throughout the year. Acoustic modeling predicts that dwarf sperm whales could be exposed to impulse sounds resulting in 12 non-TTS behavioral responses per year under Alternative 1 and 14 non-TTS behavioral responses per year under Alternative 2. Acoustic modeling predicts that pygmy sperm whales could be exposed to impulse sounds resulting in 3 non-TTS behavioral exposures per year under Alternative 1 and 4 non-TTS behavioral exposures per year under Alternative 2. No TTS level exposures or MMPA Level A exposures for any species are predicted. No long-term consequences for individuals or populations of *Kogia* species would be expected.

Table 3.4-24: Alternative 1 and Alternative 2 Annual Testing Exposure Summary for Explosive Sources[1]

Species	Level B			Level A			
	Behavioral		TTS	PTS	GI Injury	Lung Injury	Mortality
	Alternative 1	Alternative 2					
Blainville's Beaked Whale	0	0	0	0	0	0	0
Blue Whale	0	0	0	0	0	0	0
Bottlenose Dolphin	0	0	0	0	0	0	0
Bryde's Whale	0	0	0	0	0	0	0
Minke Whale	0	0	0	0	0	0	0
Cuvier's Beaked Whale	0	0	0	0	0	0	0
Dwarf Sperm Whale	12	14	0	0	0	0	0
False Killer Whale	0	0	0	0	0	0	0
Fin Whale	0	0	0	0	0	0	0
Fraser's Dolphin	0	0	0	0	0	0	0
Ginkgo-toothed Beaked Whale	0	0	0	0	0	0	0
Humpback Whale	0	0	0	0	0	0	0
Killer Whale	0	0	0	0	0	0	0
Longman's Beaked Whale	0	0	0	0	0	0	0
Melon-headed Whale	0	0	0	0	0	0	0
Omura's Whale	0	0	0	0	0	0	0
Pantropical Spotted Dolphin	0	0	0	0	0	0	0
Pygmy Killer Whale	0	0	0	0	0	0	0
Pygmy Sperm Whale	3	4	0	0	0	0	0
Risso's Dolphin	0	0	0	0	0	0	0
Rough Toothed Dolphin	0	0	0	0	0	0	0
Sei Whale	0	0	0	0	0	0	0
Short-finned Pilot Whale	0	0	0	0	0	0	0
Sperm Whale	0	0	0	0	0	0	0
Spinner Dolphin	0	0	0	0	0	0	0
Striped Dolphin	0	0	0	0	0	0	0
Total Predicted Exposures	**15**	**18**	**0**	**0**	**0**	**0**	**0**

[1] There are no predicted exposures from impulse sounds under the No Action Alternative.

Notes: GI = gastrointestinal, PTS = permanent threshold shift, TTS = temporary threshold shift

Dolphins and Small Toothed Whales (Delphinids)

There are no predicted impacts on delphinids from impulse sources (explosions and detonations) associated with testing activities under all alternatives (No Action Alternative, Alternative 1, and Alternative 2).

Conclusion

Testing activities under Alternative 1 and Alternative 2 that use explosives, as described in Table 2.8-2 through Table 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives), generate impulse sound or energy from underwater explosions (see Section 3.0.5.2.1.2,Explosives). There are no testing activities under the No Action Alternative that use explosives. Under Alternative 1 and Alternative 2 testing activities that use explosives may result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of explosives during testing activities under Alternative 1:

- *May expose marine mammals up to 15 times annually to sound or pressure levels that would be considered Level B harassment*

Pursuant to the MMPA, the use of explosives during testing activities under Alternative 2:

- *May expose marine mammals up to 18 times annually to sound or pressure levels that would be considered Level B harassment*

Pursuant to the ESA, the use of explosives during testing activities under Alternative 1 and Alternative 2:

- *May affect, but is not likely to adversely affect blue whale, humpback whale, sei whale, fin whale, and sperm whale*

3.4.4.2.4 Impacts from Swimmer Defense Airguns

Marine mammals could be exposed to sound from swimmer defense airguns during pierside integrated swimmer defense and stationary source testing activities. Swimmer defense airgun testing involves a limited number (up to 100 per event) of impulses from a small (60-cubic-inch [in.^{3}] [983-cubic-centimeter {cm^3}]) airgun. Section 3.0.5.2.1.3 (Swimmer Defense Airguns) provides additional details on the use and acoustic characteristics of swimmer defense airguns.

Activities using swimmer defense airguns were modeled using the Navy Acoustic Effects Model. Model predictions indicate that no marine mammals would be exposed to sound or acoustic energy from swimmer defense airguns that would likely elicit a physiological or behavioral response.

3.4.4.2.4.1 No Action Alternative

Training Activities

Training activities under the No Action Alternative do not include the use of the swimmer defense airguns.

Testing Activities

Testing activities under the No Action Alternative do not include the use of the swimmer defense airguns.

3.4.4.2.4.2 Alternative 1

Training Activities

Training activities under Alternative 1 do not include the use of the swimmer defense airguns.

Testing Activities

Approximately 11 testing activities using swimmer defense airguns would occur annually under Alternative 1.

Pierside integrated swimmer defense testing involves a limited number of impulses from a small airgun in waters of inner Apra Harbor (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-3). The pierside areas where these activities are proposed are inshore, with high levels of activity and therefore elevated levels of ambient noise (Appendix I.3, Sources of Sound). Additionally these areas have low densities of marine mammals. Therefore, auditory masking to marine mammals due to the limited testing of the swimmer defense airgun associated with integrated pierside swimmer defense is unlikely. Airguns would be fired up to 100 times during each activity at an irregular interval as required for the testing objectives. Areas adjacent to Navy pierside locations where these tests would take place are industrialized, and the waterways are open to vessel traffic in addition to military vessels using the pier.

An impulsive sound is generated when the air is almost instantaneously released into the surrounding water, an effect similar to popping a balloon in air. Generated impulses would have short durations, typically a few hundred milliseconds. The root-mean-squared sound pressure level and sound exposure level at a distance 1 m from the airgun would be approximately 200–210 dB re 1 µPa and 185–195 dB re 1 μPa^2-s, respectively. Swimmer defense airguns lack the strong shock wave and rapid pressure increase that would be expected from explosive detonations.

Impulses from swimmer defense airguns could potentially cause temporary hearing loss (i.e., TTS) for animals within a few meters of the sound source. However, TTS is very unlikely given the relatively low source levels, the likelihood marine mammals would avoid the source following the initial impulse, and the implementation of mitigation measures. The Navy Acoustic Effects Model predicted that no marine mammals would be exposed to impulse sounds from swimmer defense airguns at levels capable of causing TTS or PTS. The Navy Acoustic Effects Model also predicted that no marine mammals would be exposed to levels likely to cause meaningful behavioral responses.

The behavioral response of marine mammals to airguns, especially with multiple airguns firing simultaneously and repeating at regular intervals, has been well studied in conjunction with seismic surveys (e.g., oil and gas exploration). Many of these studies are reviewed above in Section 3.4.3.1.2.6 (Behavioral Responses). However, the swimmer defense airgun testing involves the use of only one small (60 $in.^3$ [983 cm^3]) airgun firing a limited number of times, so reactions from marine mammals would likely be much less than what is noted in studies of marine mammal reactions during large-scale seismic studies. Furthermore, the swimmer defense airgun has limited overall use throughout the year. Behavioral impacts on marine mammals are not expected from testing of the swimmer defense airgun.

Marine mammals listed under the ESA are unlikely to enter Apra Harbor where swimmer defense testing of airguns would take place; therefore it is highly unlikely that any ESA-listed marine mammals would be exposed to impulse sounds from swimmer defense airguns.

Pursuant to the MMPA, impulse sounds from swimmer defense airguns during testing activities under Alternative 1 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, impulse sounds from swimmer defense airguns:

- *Would have no effect on blue whale, humpback whale, sei whale, fin whale, and sperm whale*

3.4.4.2.4.3 Alternative 2

Training Activities

Training activities under Alternative 2 do not include the use of the swimmer defense airguns.

Testing Activities

Approximately 11 testing activities using swimmer defense airguns would occur annually under Alternative 2. Under Alternative 2, the annual testing activities involving the use of the swimmer defense airguns are the same as the testing activities proposed under Alternative 1.

Pursuant to the MMPA, impulse sounds from swimmer defense airguns during testing activities under Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, impulse sounds from swimmer defense airguns:

- *Would have no effect on blue whale, humpback whale, sei whale, fin whale, and sperm whale*

3.4.4.2.5 Impacts from Weapons Firing, Launch, and Impact Noise

Marine mammals may be exposed to weapons firing and launch noise and sound from the impact of non-explosive ordnance on the water's surface. A detailed description of these stressors is provided in Section 3.0.5.2.1.4 (Weapons Firing, Launch, and Impact Noise). Reactions by marine mammals to these specific stressors have not been recorded, however marine mammals would be expected to react to weapons firing, launch, and non-explosive impact noise as they would other transient sounds (see Section 3.4.3.1.2.5, Behavioral Responses).

3.4.4.2.5.1 No Action Alternative

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, training activities under the No Action Alternative include activities that produce in water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface. Noise associated with weapons firing and the impact of non-explosive practice munitions could happen at any location within the Study Area but generally would occur at locations greater than 12 nm (and for some activities greater than 25 nm or 50 nm) from shore for safety reasons (see Chapter 2, Description of Proposed Action and Alternatives, and Table 2.8-1). The majority of training activities that would involve weapons firing and ordnance impacts with the water's surface are included in the Primary Mission Areas of anti-surface warfare, major training activities, and mine warfare.

Anti-surface warfare activities and anti-air warfare (surface-to-air) activities would involve the use of non-explosive and explosive ordnance such as small-, medium-, and large-caliber projectiles; missiles; rockets; and bombs. The majority of these activities are gunnery exercises involving the use of small- and medium-caliber rounds. Thirteen major training activities would also occur under the No Action Alternative annually. Some anti-air warfare activities involve weapons firing; however, the majority would occur at altitudes well above the water's surface and would be unlikely to generate noise that would affect marine mammals. Effects to marine mammals from impulse sources (e.g., explosives) are analyzed in Section 3.4.4.2 (Impacts from Impulse Sources [Explosives and Detonations]).

A gun fired from a ship on the surface of the water propagates a blast wave away from the gun muzzle into the water (see Section 3.0.5.2.1.4, Weapons Firing, Launch, and Impact Noise). Average peak sound pressure in the water measured directly below the muzzle of the gun and under the flight path of the shell (assuming it maintains an altitude of only a few meters above the water's surface) was approximately 200 dB re 1 µPa (U.S. Department of the Navy 2000; Yagla and Stiegler 2003). Animals at the surface of the water, in a narrow footprint under a weapons trajectory, could be exposed to naval gunfire noise and may exhibit brief startle reactions, avoidance, diving, or no reaction at all. Due to the short-term, transient nature of gunfire noise, animals are unlikely to be exposed multiple times within a short period. Behavioral reactions would likely be short-term (minutes) and are unlikely to lead to substantial costs or long-term consequences for individuals or populations.

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. These sounds would be transient and of short duration, lasting no more than a few seconds at any given location. Many missiles and targets are launched from aircraft, which would produce minimal noise in the water due to the altitude of the aircraft at launch. Missiles and targets launched by ships or near the water's surface may expose marine mammals to levels of sound that could produce brief startle reactions, avoidance, or diving. Due to the short-term, transient nature of launch noise, animals are unlikely to be exposed multiple times within a short period. Behavioral reactions would likely be short-term (minutes) and are unlikely to lead to long-term consequences for individuals or populations.

Mines, non-explosive bombs, and intact missiles and targets could impact the water's surface with great force and produce a large impulse and loud noise (see Section 3.0.5.2.1.4, Weapons Firing, Launch, and Impact Noise). Marine mammals within a few meters could experience some temporary hearing loss, although the probability is low of the non-explosive ordnance landing within this range while a marine mammal is near the surface. Animals that are within the area may hear the impact of non-explosive ordnance on the surface of the water and would likely alert, startle, dive, or flee the immediate area. Significant behavioral reactions from marine mammals would not be expected due to non-explosive ordnance water-surface impact noise, therefore long-term consequences for the individual and population are unlikely.

Mitigation measures implemented by the Navy (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) are designed to reduce potential impacts from the firing of large caliper (5-inch [in.] gun) weapons and certain non-explosive ordnance (non-explosive bombs and mine shapes) water-surface impact associated with the proposed military training activities. Long-term consequences to individuals or populations of marine mammals are not expected to result from weapons firing, launch, and non-explosive ordnance water-surface impact associated with the proposed training events.

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise from training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Tables 2.8-2 to 2.8-4, there are no testing activities that would produce weapons firing, launch, and impact noise proposed under the No Action Alternative.

3.4.4.2.5.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. Under Alternative 1, the number of annual activities that involve weapons firing would increase over the No Action Alternative. Even with an increase in the level of activity under Alternative 1, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.5.1 (No Action Alternative – Training).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. Testing activities that produce in-water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface would occur under Alternative 1 and would increase over the No Action Alternative, because there are no testing activities that use weapons or other ordnance under the No Action Alternative (see Chapter 2, Description of Proposed Action and Alternatives, and Tables 2.8-2 to 2.8-4).

The majority of testing activities that would involve weapons firing and ordnance impacts with the water's surface are Air-to-Surface Missile Test, Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sonobuoy), Anti-Surface Warfare Mission Package Testing, and Kinetic Energy Weapon Testing (see Chapter 2, Description of Proposed Action and Alternatives, and Tables 2.8-2 and 2.8-3).

These activities would use both non-explosive and explosive medium-caliber rounds, large-caliber projectiles, and missiles. Impacts from impulse sources (e.g., explosives) are analyzed in Section 3.4.4.2 (Impacts from Impulse Sources [Explosives and Detonations]). Although the activities proposed under Alternative 1 increase over the No Action Alternative, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.5.1 (No Action Alternative – Training).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.5.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. Proposed training activities under Alternative 2 are nearly identical to training activities proposed under Alternative 1 (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-1).

The locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.5.1 (No Action Alternative – Training) and Section 3.4.4.2.5.2 (Alternative 1 – Training).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. The number of testing activities proposed under Alternative 2 is approximately a 10 percent increase over the number of testing activities proposed under Alternative 1. Even with the increase in the number of activities proposed under Alternative 2, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.5.2 (Alternative 1 – Testing).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.6 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 is provided in Section 3.0.5.2.1.5 (Vessel Noise). Vessel movements involve transits to and from ports to various locations within the Study Area, and 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).

Several studies have shown that marine mammals may abandon inshore and nearshore habitats with high vessel traffic, especially in areas with regular marine mammal watching (see discussion in Section 3.4.3.1.2.5, Behavioral Responses). Vessel traffic in the Mariana Islands and the Study Area is considerably less than in other U.S. ports where a larger population and greater commercial commerce occurs (Section 3.12, Socioeconomics). As discussed in Section 3.0.5.2.1.5 (Vessel Noise) Navy ships make up only a small proportion of the total ship traffic. According to Mintz and Filadelfo (2011), Navy ships account for 6 percent of the total ship presence within the U.S. EEZ. Although the study did not include analysis of vessel traffic and associated vessel noise in Guam and the CNMI (the geographic scope was the continental United States and Hawaii), the conclusions of the study are relevant to vessel noise in the Study Area. The study concluded that the contribution of Navy vessel traffic to overall broadband noise levels was relatively small compared with the contribution from commercial vessel traffic. Even during times of heavy military activity, such as during major training activities in military operating areas, and despite being a major presence, military vessels are a relatively minor source of radiated broadband noise. This is because military ships are generally quieter than commercial vessels of similar size (Mintz and Filadelfo 2011).

Even in the most concentrated U.S. ports and inshore areas, proposed military vessel transits are unlikely to cause long-term abandonment of habitat by a marine mammal. Most documented examples of abandonment of habitat are in association with activities that involve the pursuit of marine mammals (Section 3.4.3.1.2.5, Behavioral Responses). The military will not be pursuing marine mammals during any training and testing activities.

Auditory masking can occur due to vessel noise, potentially masking vocalizations and other biologically important sounds (e.g., sounds of prey or predators) that marine mammals may rely upon. Marine mammals have been recorded in several instances altering and modifying their vocalizations to compensate for the masking noise from vessels or other sources of acoustic energy. Potential masking from a transiting vessel can vary depending on the ambient noise level within the environment (see Appendix H.1, Conceptual Framework for Assessing Effects from Sound Producing Activities); the received level and frequency of the vessel noise; and the received level and frequency of the sound of biological interest. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 µPa, primarily at lower frequencies (below 100 Hz). Inshore noise levels, especially around busy ports, can exceed 120 dB re 1 µPa (Urick 1983). When the noise level is above the sound of interest, and in a similar frequency band, auditory masking could occur (see Appendix H, Biological Resource Methods). This analysis assumes that any sound that is above ambient noise levels and within an animal's hearing range may potentially cause masking of biologically important sounds. The degree to which a biologically important sound is masked increases with increasing noise levels; an anthropogenic sound that is just-detectable over ambient noise levels is unlikely to actually cause any substantial masking. Masking caused by noise from passing vessels or other sources of acoustic energy (e.g., sonar) would be short-term, intermittent, and therefore unlikely to result in any substantial costs or consequences to individual animals or populations. Areas with increased levels of ambient noise from anthropogenic sound sources, such as areas around busy shipping lanes and near harbors and ports, may cause sustained levels of auditory masking for marine mammals, which could reduce an animal's ability to find prey, find mates, socialize, avoid predators, or navigate. However, military vessels make up a very small percentage of the overall vessel traffic, and the rise of ambient noise levels in shipping lanes and near harbors and ports is a problem related to all ocean users including commercial and recreational vessels and shoreline development and industrialization.

Surface combatant ships (e.g., guided missile destroyer, guided missile cruiser, and Littoral Combat Ship) and submarines are designed to be very quiet to evade enemy detection and typically travel at speeds of 10 or more knots (5.1 m/second). Actual acoustic signatures and source levels of combatant ships and submarine are classified, however they are quieter than most other motorized ships. A typical commercial fishing vessel produces about 158 dB re 1 µPa at 1 m (see Section 3.0.5.2.1.5, Vessel Noise, for a description of typical noise from commercial and recreational vessels). Even with technology intended to limit sound emission, surface combatant ships and submarines still produce noise and are likely to be detectable by marine mammals over open-ocean ambient noise levels (discussed in Section H.1, Conceptual Framework for Assessing Effects from Sound Producing Activities) at distances of up to a few kilometers, which could cause some auditory masking to marine mammals for a few minutes as the vessel passes. Other military ships and small craft have higher noise levels, similar to equivalently sized commercial ships and private vessels. Therefore, in the open ocean, away from relatively noisy shipping lanes, noise from non-combatant Navy vessels may be detectable over ambient noise levels for tens of kilometers and some auditory masking, especially for mysticetes, is possible. In noisier inshore areas around Navy ports and ranges, vessel noise may be detectable above ambient noise levels for only several hundred meters. Some auditory masking to marine mammals is likely from non-combatant military vessels, on par with similar commercial and recreational vessels, especially in quieter, open-ocean environments.

Vessel noise has the potential to disturb marine mammals and elicit an alerting, avoidance, or other behavioral reaction. Most studies have reported that marine mammals react to vessel noise and traffic with short-term interruption of behavior or social interactions (Watkins 1981; Richardson et al. 1995; Magalhães et al. 2002; Noren et al. 2009). Some species respond negatively by retreating or responding to the vessel antagonistically, while other animals seem to ignore vessel noises altogether (Watkins 1986). Marine mammals are frequently exposed to vessels due to research, ecotourism, commercial and private vessel traffic, and government activities. It is difficult to differentiate between responses to vessel noise and visual cues associated with the presence of a vessel; thus, it is assumed that both play a role in prompting reactions from animals.

Based on studies on a number of species, mysticetes are not expected to be disturbed by vessels that maintain a reasonable distance from them; however, behavioral responses will vary with vessel size, geographic location, and tolerance levels of individuals.

Odontocetes could have a variety of reactions to passing vessels including attraction, increased travelling time, a decrease in feeding behaviors, diving, or avoidance of the vessel, which may vary depending on their prior experience with vessels. Passive acoustic monitoring of marine mammal vocalizations at the Navy's instrumented ranges in Hawaii and the Bahamas have documented the presence of beaked whales on the ranges (Marques et al. 2009). Site fidelity of Cuvier's beaked whales was documented by Falcone et al. (2009) at the Navy's instrumented range offshore of San Diego in Southern California. The passive acoustic monitoring and photo-identification study recorded 37 groups of Cuvier's beaked whales from 2006 to 2008, and the researchers reported that the average group size was higher than had previously been reported. Additional behavioral response studies (Aguilar de Soto et al. 2006; Tyack et al. 2011; Southall et al. 2012b) have indicated that while beaked whales exposed to vessel and other anthropogenic noise will change behavior and leave the immediate area of the noise source, within 2–3 days they have re-inhabited the previously vacated areas.

3.4.4.2.6.1 No Action Alternative

Training Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.6 (No Action Alternative: Current Military Readiness within the MITT Study Area), training activities under the No Action Alternative include vessel movement in many events. Military vessel traffic could occur anywhere within the Study Area.

Under the No Action Alternative, approximately 600 training activities involving vessel movement would occur annually and would generate some level of vessel noise.

Military vessel traffic related to the proposed training activities would pass near marine mammals only on an incidental basis, and would constitute an insignificant contribution to vessel traffic in the Study Area. Marine mammals exposed to a passing military vessel may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to vessels are not likely to disrupt major behavioral patterns or to result in serious injury to any marine mammals. Acoustic masking may occur due to vessel sounds, especially from non-combatant ships. Acoustic masking may prevent an animal from perceiving biologically relevant sounds during the period of exposure, potentially resulting in missed opportunities to exploit resources.

Navy mitigation measures include several provisions to avoid approaching marine mammals (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring, for a detailed description of mitigation measures) which would further reduce any potential impacts from vessel noise. Long-term consequences to individuals or populations of marine mammals are not expected to result from vessel noise associated with the proposed training events.

Pursuant to the MMPA, vessel noise during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

<u>**Testing Activities**</u>

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), only one testing activity is proposed under the No Action Alternative (Table 2.8-4). The Office of Naval Research's North Pacific Acoustic Lab deep water experiment would occur once per year. This activity could take place anywhere within the Study Area where conditions (e.g., water depth) meet the requirements of the activity. The number of proposed testing activities under the No Action Alternative that involve vessel movement is fewer than the number of proposed training activities under the No Action Alternative, described above in Section 3.4.4.2.6.1 (No Action Alternative – Training). No long-term consequences are anticipated from the training activities, which would involve more vessel traffic; therefore, no long-term consequences to individuals or populations of marine mammals are expected to result from vessel noise associated with the proposed testing event.

Pursuant to the MMPA, vessel noise during testing activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during testing activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.6.2 Alternative 1

<u>**Training Activities**</u>

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As discussed in Chapter 2 (Description of Proposed Action and Alternatives), training activities under Alternative 1 include an increase in the number of activities that would involve vessel movement over the No Action Alternative.

Under Alternative 1, approximately 2,500 training activities involving vessel movement would occur annually and would generate some level of vessel noise. This represents an increase in activity of approximately 300 percent over the No Action Alternative.

Military vessel traffic related to the proposed training activities would pass near marine mammals only on an incidental basis and would constitute an insignificant contribution to vessel traffic in the Study Area. Marine mammals exposed to a passing military vessel may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to vessels are not likely to disrupt major behavioral patterns or to result in serious injury to any marine mammals. Acoustic masking may occur due to vessel sounds, especially from non-combatant ships. Acoustic masking may prevent an animal from perceiving biologically relevant sounds during the period of exposure, potentially resulting in missed opportunities to exploit resources.

Some training activities involving vessel movement have the potential to occur, at least partially, in nearshore or littoral waters of the Study Area (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-1). It is possible, although unlikely, that these activities may occur in proximity to spinner dolphin resting areas identified in Section 3.4.2.23.2 (Spinner Dolphin, Geographic Range and Distribution). Several of these training activities occur infrequently (1–4 times per year). Other training activities would occur in nearshore areas where non-military activities also occur (e.g., Apra Harbor), which are unlikely to be spinner dolphin resting areas. To date, there have been no sightings of spinner dolphins in Apra Harbor.

Mitigation, as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), for activities occurring in offshore and nearshore areas of the Study Area would include surveying for marine mammals, including resting spinner dolphins, prior to conducting the activity. Given that nearshore activities occur infrequently, they would be unlikely to occur in the vicinity of spinner dolphin resting areas, and mitigation to avoid potential effects would be conducted, no long-term consequences to spinner dolphins, such as habitat abandonment, are anticipated.

The number of training activities that involve vessel movement (and vessel noise) under Alternative 1 would increase over the number proposed under the No Action Alternative; however, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.6.1 (No Action Alternative – Training).

Pursuant to the MMPA, vessel noise during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As discussed in Chapter 2 (Description of Proposed Action and Alternatives, Tables 2.8-3 and 2.8-4), testing activities under Alternative 1 include an increase in vessel movement over the No Action Alternative.

Only one testing activity is proposed under the No Action Alternative. Under Alternative 1, approximately 159 testing activities involving vessel movement would occur annually and would generate some level of vessel noise.

The number of testing activities that involve vessel movement (and vessel noise) under Alternative 1 would increase over the number proposed under the No Action Alternative; however, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.6.1 (No Action Alternative – Training).

Pursuant to the MMPA, vessel noise during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.6.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities, which includes the addition of platforms and systems. As discussed in Chapter 2 (Description of Proposed Action and Alternatives, Tables 2.8-1), training activities under Alternative 2 include an increase in vessel movement over the No Action Alternative and Alternative 1.

Under Alternative 2, approximately 2,600 training activities involving vessel movement would occur annually and would generate some level of vessel noise. This represents an increase in activity of approximately 300 percent over the No Action Alternative, and is nearly equivalent to Alternative 1.

Military vessel traffic related to the proposed training activities would pass near marine mammals only on an incidental basis and would constitute an insignificant contribution to vessel traffic in the Study Area. Marine mammals exposed to a passing military vessel may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to vessels are not likely to disrupt major behavioral patterns or to result in serious injury to any marine mammals. Acoustic masking may occur due to vessel sounds, especially from non-combatant ships. Acoustic masking may prevent an animal from perceiving biologically relevant sounds during the period of exposure, potentially resulting in missed opportunities to exploit resources.

Some training activities involving vessel movement have the potential to occur, at least partially, in nearshore or littoral waters of the Study Area (see Chapter 2, Description of Proposed Action and Alternatives, Table 2.8-1). It is possible, although unlikely, that these activities may occur in proximity to spinner dolphin resting areas identified in Section 3.4.2.23.2 (Spinner Dolphin, Geographic Range and Distribution). Several of these training activities occur infrequently (1–4 times per year). Other training activities would occur in nearshore areas where non-military activities also occur (e.g., Apra Harbor), which are unlikely to be spinner dolphin resting areas. To date, there have been no sightings of spinner dolphins in Apra Harbor.

Mitigation, as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) for activities occurring in offshore and nearshore areas of the Study Area would include surveying for marine mammals, including resting spinner dolphins, prior to conducting the activity. Given that nearshore activities occur infrequently, would be unlikely to occur in the vicinity of spinner dolphin resting areas, and mitigation to avoid potential effects would be conducted, no long-term consequences to spinner dolphins, such as habitat abandonment, are anticipated.

The number of training activities that involve vessel movement (and vessel noise) under Alternative 1 would increase over the number proposed under the No Action Alternative; however, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.6.1 (No Action Alternative – Training).

Pursuant to the MMPA, vessel noise during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. Testing activities under Alternative 2 include an increase in vessel movement over the No Action Alternative and Alternative 1.

The number of proposed testing activities that involves vessel movement increases from 1 under the No Action Alternative to 187 under Alternative 2 (Chapter 2, Description of Proposed Action and Alternatives, Tables 2.8-3 and 2.8-4). The 187 testing activities involving vessel movement represent less than a 20 percent increase over the number of testing activities proposed under Alternative 1.

The number of testing activities that involve vessel movement (and vessel noise) under Alternative 2 would increase over the number proposed under the No Action Alternative and Alternative 1; however, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.4.2.6.1 (No Action Alternative – Training).

Pursuant to the MMPA, vessel noise during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, vessel noise during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.7 Impacts from Aircraft Noise

Marine mammals may be exposed to aircraft-generated noise wherever aircraft overflights occur in the Study Area. Fixed and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area. Most of these sounds would be concentrated around airbases and fixed ranges within each of the range complexes. Aircraft can produce extensive airborne noise from either turbofan or turbojet engines. A severe but infrequent type of aircraft noise is a sonic boom, produced when a fixed-wing aircraft (e.g., F/A-18 fighter jet) 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 (including sonic booms) is provided in Section 3.0.5.2.1.6 (Aircraft Overflight Noise).

3.4.4.2.7.1 No Action Alternative

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), training activities under the No Action Alternative include fixed- and rotary-wing aircraft overflights. More than 5,300 training activities involving some level of aircraft activity are proposed under the No Action Alternative.

Marine mammals may respond to both the physical presence and to the noise generated by aircraft, making it difficult to attribute causation to one or the other stimulus. In addition to noise produced, all low-flying aircraft make shadows, which can cause animals at the surface to react. Helicopters may also produce strong downdrafts, a vertical flow of air that becomes a surface wind, which can also affect an animal's behavior at or near the surface.

Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors, but significant acoustic energy is primarily transmitted into the water directly below the craft in a narrow cone, as discussed in greater detail in Section 3.0.4 (Acoustic and Explosives Primer). Underwater sounds from aircraft are strongest just below the surface and directly under the aircraft. The maximum sound levels at 6 ft. (2 m) below the surface from an aircraft overflight are approximately 152 dB re 1 µPa for an F/A-18 aircraft at 300 m altitude; approximately 125 dB re 1 µPa for an H-60 helicopter hovering at 50 ft. (15 m); and under ideal conditions, sonic booms from aircraft at an altitude of approximately 1 km could generate a SPL of 178 dB re 1 µPa at the water's surface (see Section 3.0.5.2.1.6, Aircraft Overflight Noise), for additional information on aircraft noise characteristics).

See Section 3.4.3.1.2.5 (Behavioral Responses), for a review of research and observations regarding marine mammal behavioral reactions to aircraft overflights; many of the observations cited in this section are of marine mammal reactions to aircraft flown for whale-watching and marine research purposes. Marine mammal survey aircraft are typically used to locate, photograph, track, and sometimes follow animals for long distances or for long periods of time, all of which results in the animal being much more frequently located directly beneath the aircraft (in the cone of the loudest noise and in the shadow of the aircraft) for extended periods. Navy aircraft would not follow or pursue marine mammals. In contrast to whale watching excursions or research efforts, Navy overflights would not result in prolonged exposure of marine mammals to overhead noise.

Most fixed-wing military aircraft flights would occur above 3,000 ft. (900 m), and often at much higher altitudes (e.g., 20,000 ft. [6,000 m]) in the Study Area. Rotary wing aircraft typically fly at lower altitudes (less than 1,000 ft. [100 m]) and may hover at less than 100 ft. (30 m) during certain training and testing activities. In most cases, exposure of a marine mammal to fixed-wing or rotary-wing aircraft presence and noise would last for only seconds as the aircraft quickly passes overhead. Animals would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Takeoffs and landings occur at established airfields as well as on vessels at sea at unspecified locations across the Study Area. Takeoff and landings from Navy vessels could startle marine mammals; however, these events only produce in-water noise at any given location for a brief period of time as the aircraft climbs to cruising altitude. As discussed in Section 3.0.5.2.1.6 (Aircraft Overflight Noise), marine mammals show little to no reaction from aircraft overflights above 2,000 ft. (600 m). Some sonic booms from aircraft could startle marine mammals, but these events are transient and happen infrequently at any given location within the Study Area. Repeated exposure to most individuals over short periods (days) is extremely unlikely. No long-term consequences for individuals or populations would be expected.

Low flight altitudes of helicopters during some anti-submarine warfare and mine warfare activities, often under 100 ft. (30 m), may elicit a somewhat stronger behavioral response due to the proximity to marine mammals; the slower airspeed and therefore longer exposure duration; and the downdraft created by the helicopter's rotor. Marine mammals would likely avoid the area under the helicopter. It is unlikely that an individual would be exposed repeatedly for long periods of time as these aircraft typically transit open ocean areas within the Study Area. The consensus of all the studies reviewed is that aircraft noise would cause only small temporary changes in the behavior of marine mammals. Specifically, marine mammals located at or near the surface when an aircraft flies overhead at low altitudes may startle, divert their attention to the aircraft, or avoid the immediate area by swimming away or diving.

Under the No Action Alternative, the number of overflights, typical altitudes, and distribution throughout the year and over the Study Area would result in a low probability of exposing marine mammals to aircraft noise. Even if a mysticete or odontocete were exposed to overflight noise, no long-term consequences to the individual or populations of marine mammals would be anticipated. Short-term reactions to aircraft are not likely to disrupt major behavior patterns such as migrating, breeding, feeding, and sheltering, or to result in serious injury to any marine mammals. No long-term consequences for individuals or populations would be expected.

Pursuant to the MMPA, aircraft overflight noise during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, aircraft overflight noise during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), there are no proposed testing activities using aircraft under the No Action Alternative (see Tables 2.8-2 to 2.8-4).

3.4.4.2.7.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. Under Alternative 1, more than 19,600 aircraft-related activities would occur throughout the Study Area. This represents an increase in activity of approximately 300 percent over the No Action Alternative.

Neither the locations nor the flight profiles (altitude, airspeed, and duration) would change between the No Action Alternative and Alternative 1. Even with an increase in the number of aircraft overflights, the majority of flight time would occur at altitudes greater than 3,000 ft. above the water’s surface. As discussed in Section 3.4.4.2.7.2 (No Action Alternative – Training) marine mammals are unlikely to be disturbed by high altitude overflights. Therefore, the severity of impacts would not be discernible from those described in Section 3.4.4.2.7.2 (No Action Alternative – Training).

Pursuant to the MMPA, aircraft overflight noise during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, aircraft overflight noise during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. Under Alternative 1, up to 390 aircraft-related testing activities would occur throughout the Study Area.

The locations and flight profiles (altitude, airspeed, and duration) of testing activities involving aircraft would be similar to training activities involving aircraft. Even with an increase in the number of aircraft overflights, the majority of flight time would occur at altitudes greater than 3,000 ft. (914.4 m) above the water’s surface. As discussed in Section 3.4.4.2.7.2 (No Action Alternative – Training) marine mammals are unlikely to be disturbed by high altitude overflights. Therefore, the severity of impacts would not be discernible from those described in Section 3.4.4.2.7.2 (No Action Alternative – Training).

Pursuant to the MMPA, aircraft overflight noise during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, aircraft overflight noise during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.2.7.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities.

Under Alternative 2, more than 21,000 aircraft-related training activities would occur throughout the Study Area. This represents an increase in activity of approximately 300 percent over the No Action Alternative, and is approximately equivalent to the level of activity proposed under Alternative 1.

Neither the locations nor the flight profiles (altitude, airspeed, and duration) would change between the No Action Alternative and Alternative 1. Even with an increase in the number of aircraft overflights, the majority of flight time would occur at altitudes greater than 3,000 ft. (914.4 m) above the water’s surface. As discussed in Section 3.4.4.2.7.2 (No Action Alternative – Training) marine mammals are unlikely to be disturbed by high altitude overflights. Therefore, the severity of impacts would not be discernible from those described in Section 3.4.4.2.7.2 (No Action Alternative – Training).

Pursuant to the MMPA, aircraft overflight noise during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, aircraft overflight noise during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities, which includes the addition of platforms and systems.

Under Alternative 2, up to 436 aircraft-related testing activities would occur throughout the Study Area. This represents approximately a 10 percent increase over the level of activity proposed under Alternative 1.

Neither the locations nor the flight profiles (altitude, airspeed, and duration) would change from Alternative 1. Even with an increase in the number of aircraft overflights, the majority of flight time would occur at altitudes greater than 3,000 ft. (914.4 m) above the water's surface. As discussed in Section 3.4.4.2.7.2 (No Action Alternative – Training) marine mammals are unlikely to be disturbed by high altitude overflights. Therefore, the severity of impacts would not be discernible from those described in Section 3.4.4.2.7.2 (No Action Alternative – Training).

Pursuant to the MMPA, aircraft overflight noise during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, aircraft overflight noise during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.3 Energy Stressors

This section analyzes the potential impacts of energy stressors used during training and testing activities within the Study Area. The detailed analysis which follows includes the potential impacts of devices that purposefully create an electromagnetic field underwater (e.g., some mine neutralization systems; see Section 2.3.5, Mine Warfare Systems).

Two types of devices proposed for use in the Study Area that have the potential to be energy stressors are lasers and the kinetic energy weapon. However, neither device is analyzed as a potential biological stressor. Laser devices can be organized into two categories: (1) high-energy lasers and (2) low-energy lasers. High-energy lasers are used as weapons to disable surface targets (e.g., small boats). High-energy lasers are not proposed for use in the Study Area, and will not be discussed further. Low-energy lasers are used to illuminate or designate targets, to guide weapons, and to detect or classify mines. Low-energy lasers were briefly analyzed in Section 3.0.5.2.2.2 (Lasers) and were determined to have no impacts to biological resources, including marine mammals, and will not be analyzed further. The kinetic energy weapon (commonly referred to as the rail gun) is under development and will likely be tested and eventually used in training events aboard surface vessels, firing non-explosive projectiles at sea-based targets. The system uses stored electrical energy to accelerate the projectile, which is fired at supersonic speeds over great distances. The system charges for 2 minutes and fires in less than 1 second; therefore, any electromagnetic energy released would be done over a very short time period. Also, the system would be shielded so as not to affect shipboard controls and systems. The amount of electromagnetic energy released from this system would likely be low and contained on the surface vessel. Therefore, this device is not expected to result in any impacts to marine mammals.

3.4.4.3.1 Impacts from Electromagnetic Devices

For a discussion of the types of activities that purposefully create an electromagnetic field underwater, where these activities would occur, and how many events would occur under each alternative, refer to Section 3.0.5.2.2.1 (Electromagnetic Devices).

The devices producing an electromagnetic field (and analyzed in this section) are towed mine countermeasure systems. These systems use electric current to generate a magnetic field, which simulates a vessel's magnetic field. In an actual mine clearing operation, the magnetic field would trigger an enemy mine designed to sense a vessel's magnetic field.

Neither regulations nor scientific literature provide threshold criteria for assessing potential effects from the generation of a magnetic field. Data regarding the influence of magnetic fields on cetaceans are inconclusive. Dolman et al. (2003) provides a literature review of the influences on cetaceans of marine wind farms, which use undersea cables to transmit electrical current to shore. The electrical current conducted by undersea power cables induces a magnetic field around those cables. The literature focuses on harbor porpoises and dolphin species, because these species are found in nearshore habitats. Teilmann et al. (2002) evaluated the frequency of harbor porpoise presence at wind farm locations around Sweden. Although the influence of the electromagnetic field was not specifically addressed, the presence of cetacean species at least implies that those species are not repelled by the presence of a magnetic field around undersea cables associated with offshore wind farms.

Based on the available literature, no evidence of electrosensitivity in marine mammals was found except recently in the Guiana dolphin (Czech-Damal et al. 2011). Normandeau et al. (2011) concluded there was behavioral, anatomical, and theoretical evidence indicating cetaceans sense magnetic fields. Most of the evidence in this regard is indirect evidence from correlation of sighting and stranding locations suggesting that cetaceans may be influenced by local variation in the earth's magnetic field (Hui 1985: Kirschvink 1990; Klinowska 1985; Walker et al. 1992). Results from one study in particular showed that long-finned and short-finned pilot whales, striped dolphin, Atlantic spotted dolphin, Atlantic white-sided dolphin, fin whale, common dolphin, harbor porpoise, sperm whale, and pygmy sperm whale were found to strand in areas where the earth's magnetic field was locally weaker than surrounding areas (negative magnetic anomaly) (Kirschvink 1990). Results also indicated that certain species may be able to detect total intensity changes of only 0.05 microtesla (0.05×10^{-6} tesla) (Kirschvink et al. 1986). The Tesla is the unit of measure for the intensity or magnitude of a magnetic field. For reference, the magnetic field near a small bar magnet is approximately 0.1 tesla (Halliday and Resnick 1988). This gives insight into what changes in intensity levels some species are capable of detecting, but does not provide experimental evidence of levels to which animals may physiologically or behaviorally respond.

Anatomical evidence suggests the presence of magnetic material in the brain of some marine mammals (i.e., bottlenose dolphin, Cuvier's beaked whale, and the humpback whale) and in the tongue and lower jawbones of harbor porpoise (Bauer et al. 1985; Kirschvink 1990). Zoeger et al. (1981) found what appeared to be nerve fibers associated with the magnetic material in a Pacific common dolphin (*Delphinus* spp.) and proposed that it may be used as a magnetic field receptor. The only experimental study involving physiological response comes from Kuznetsov (1999), who exposed bottlenose dolphins to permanent magnetic fields and showed reactions (both behavioral and physiological) to magnetic field intensities of 32, 108 and 168 microteslas during 79 percent, 63 percent, and 53 percent of the trials, respectively (as summarized in Normandeau et al. 2011). Behavioral reactions of bottlenose dolphins included sharp exhalations, acoustic activity, and movement, and physiological reactions included a change in heart rate.

Potential impacts to marine mammals associated with magnetic fields are dependent on the animal's proximity to the source and the strength of the magnetic field. As discussed in Section 3.0.5.2.2.1 (Electromagnetic Devices), electromagnetic fields associated with naval training and testing activities are relatively weak (only 10 percent of the earth's magnetic field at 79 ft. [24 m]), temporary, and localized. Once the source is turned off or moves from the location, the magnetic field is gone. A marine mammal would have to be present within the magnetic field (approximately 700 ft. [200 m] from the source) during the activity in order to detect it.

3.4.4.3.1.1 No Action Alternative

Training Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), there are no training activities that involve the use of electromagnetic devices under the No Action Alternative (Table 2.8-1).

Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), there are no testing activities that involve the use of electromagnetic devices under the No Action Alternative (Table 2.8-2 to Table 2.8-4).

3.4.4.3.1.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

As indicated in Section 3.0.5.2.2.1 (Electromagnetic Devices), training activities involving electromagnetic devices under Alternative 1 occur up to five times annually as part of mine countermeasure (towed mine detection) and Civilian Port Defense activities. Table 2.8-1 lists the number and location of training activities that use electromagnetic devices. These training activities would typically take place in an area designated for mine warfare training located north of Apra Harbor. The easternmost boundary of this area is located approximately 2.4 nm from land, which is the shortest distance between the mine warfare training area and Guam. Training activities would be conducted closer to the center of the area and farther from land.

Although it is not fully understood, based on the available evidence described above, it is probable that cetacea use the earth's magnetic field for movement or migration. If an animal was exposed to the moving electromagnetic field source and if sensitive to that source, it is conceivable that this electromagnetic field could have an effect while in proximity to a cetacean and thereby impacting that animal's navigation. Potential impacts from training with electromagnetic devices would be temporary and minor. The natural behavioral patterns of any affected marine mammals would not be significantly altered or abandoned based on: (1) the relatively low intensity of the magnetic fields generated (discussed above), (2) the very localized affect of the moving electromagnetic field, (3) infrequent occurrence of the stressor, (4) the duration of the mine neutralization activity (hours for shipboard systems; minutes for airborne systems), and (5) this activity typically occurs in waters closer to shore where magnetic fields are less likely to be the primary cue for a cetacean navigating in that environment. For these reasons, it is extremely unlikely that any effects would occur, and if they did their temporary nature would make those effects insignificant. Long-term consequences to individuals or populations of marine mammals are not expected to result from the use of electromagnetic devices.

Pursuant to the MMPA, the use of electromagnetic devices during training activities under Alternative 1 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of electromagnetic devices during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-3, mission package testing for new ship systems includes the use of electromagnetic devices (devices that use electric current to generate magnetic fields for detecting mines). Under Alternative 1, the Naval Sea Systems Command will engage in up to 32 Mine Counter Measure mission package testing activities per year.

As described under Section 3.4.4.3.1.2 (Alternative 1 – Training), it is extremely unlikely that any effects would occur, and if they did their temporary nature would make those effects negligible. Long-term consequences to individuals or populations of marine mammals are not expected to result from the use of electromagnetic devices.

Pursuant to the MMPA, the use of electromagnetic devices during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of electromagnetic devices during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.3.1.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities, which includes platforms and systems. As indicated in Section 3.0.5.2.2.1 (Electromagnetic Devices), training activities involving electromagnetic devices under

Alternative 2 occur up to five times annually as part of mine countermeasure (towed mine detection) and Civilian Port Defense activities. Table 2.8-1 lists the number and location of training activities that use electromagnetic devices.

As described under Section 3.4.4.3.1.2 (Alternative 1 – Training), it is extremely unlikely that any effects would occur, and if they did their temporary nature would make those effects insignificant. Long-term consequences to individuals or populations of marine mammals are not expected to result from the use of electromagnetic devices.

Pursuant to the MMPA, the use of electromagnetic devices during training activities under Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of electromagnetic devices during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-3, mission package testing for new ship systems includes the use of electromagnetic devices (magnetic fields generated underwater to detect mines). Under Alternative 2, the Naval Sea Systems Command will engage in up to 36 Mine Counter Measure mission package testing activities per year.

As described under Section 3.4.4.3.1.2 (Alternative 1 – Training), it is extremely unlikely that any effects would occur, and if they did their temporary nature would make those effects negligible. Long-term consequences to individuals or populations of marine mammals are not expected to result from the use of electromagnetic devices.

Pursuant to the MMPA, the use of electromagnetic devices during testing activities under Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of electromagnetic devices during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.4 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance to include the potential for strike during training and testing activities within the Study Area from (1) Navy vessels, (2) in-water devices, (3) military expended materials to include non-explosive practice munitions and fragments from high-explosive munitions, and (4) seafloor devices.

The way a physical disturbance may affect a marine mammal would depend in part on the relative size of the object, the speed of the object, the location of the mammal in the water column, and reactions of marine mammals to anthropogenic activity, which may include avoidance or attraction. It is not known at what point or through what combination of stimuli (visual, acoustic, or through detection in pressure changes) an animal becomes aware of a vessel or other potential physical disturbances prior to reacting or being struck. Refer to Sections 3.4.4.2.6 (Impacts from Vessel Noise) and 3.4.4.2.7 (Impacts from Aircraft Noise) for the analysis of the potential for disturbance from acoustic stimuli.

If a marine mammal responds to physical disturbance, the individual must stop whatever it was doing and divert its physiological and cognitive attention in response to the stressor. The energetic costs of reacting to a stressor are dependent on the specific situation, but one can assume that the caloric requirements of a response may reduce the amount of energy available to the mammal for other functions, such as reproduction, growth, and homeostasis (Wedemeyer et al. 1990). Given that the presentation of a physical disturbance should be very rare and brief, the cost from the response is likely to be within the normal variation experiences by an animal in its daily routine unless the animal is struck. If a strike does occur, the cost to the individual could range from slight injury to death.

3.4.4.4.1 Impacts from Vessels

Interactions between surface vessels and marine mammals have demonstrated that surface vessels can be a source of acute and chronic disturbance for marine mammals (Hewitt 1985; Watkins 1986; Au and Green 2000; Magalhães et al. 2002; Richter et al. 2003; Nowacek et al. 2004a,b; Bejder et al. 2006; Richter et al. 2006; Nowacek et al. 2007; Würsig and Richardson 2008; Lusseau et al. 2009; Carrillo and Ritter 2010; Glass et al. 2010; Henry et al. 2011; Pace 2011). While the analysis of potential impact form the physical presence of the vessel is presented here, the analysis of potential impacts in response to sounds are addressed in Section 3.4.4.2.6 (Impacts from Vessel Noise).

These studies establish that marine mammals are likely to engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two. Though the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels. In one study, North Atlantic right whales were documented to show little overall reaction to the playback of sounds of approaching vessels, but that they did respond to an alert signal by swimming strongly to the surface (Nowacek et al. 2004a). Aside from the potential for an increased risk of collision addressed below, physical disturbance from vessel use is not expected to result in more than a short-term behavioral response.

Vessel speed, size, and mass are all important factors in determining potential impacts of a vessel strike to marine mammals (Silber et al. 2010; Vanderlaan and Taggart 2007; Wiley et al. 2011; Gende et al. 2011; Conn and Silber 2013). For large vessels, speed and angle of approach can influence the severity of a strike. Based on modeling, Silber et al. (2010) found that whales at the surface experienced impacts that increased in magnitude with the ship’s increasing speed. Results of the study also indicated that potential impacts were not dependent on the whale’s orientation to the path of the ship, but that vessel speed may be an important factor. At ship speeds of 15 knots or higher (7.7 m/second), there was a marked increase in intensity of centerline impacts to whales. Results also indicated that when the whale was below the surface (about one to two times the vessel draft), there was a pronounced propeller suction effect. This suction effect may draw the whale into the hull of the ship, increasing the probability of propeller strikes (Silber et al. 2010).

Vessel strikes from commercial, recreational, and military vessels are known to affect large whales and have resulted in serious injury and occasional fatalities to cetaceans (Lammers et al. 2003; Douglas et al. 2008; Abramson et al. 2009; Laggner 2009; Berman-Kowalewski et al. 2010; National Marine Fisheries Service 2010; Calambokidis 2012). Reviews of the literature on ship strikes mainly involve collisions between commercial vessels and whales (e.g., Laist et al. 2001; Jensen and Silber 2004). The ability of any ship to detect a marine mammal and avoid a collision depends on a variety of factors, including environmental conditions, ship design, size, speed, and manning, as well as the behavior of the animal. Key points in discussions of military vessels in relationship to ship strike include:

- Many military ships have their bridges positioned closer to the bow, offering better visibility ahead of the ship.
- There are often aircraft associated with the training or testing activity, which can often more readily detect marine mammals in the vicinity of a vessel or ahead of a vessel's present course before crew on the vessel would be able to detect them.
- Military ships are generally much more maneuverable than commercial merchant vessels, and if marine mammals are spotted in the path of the ship, would be capable of changing course more quickly. military ships operate at the slowest speed possible consistent with either transit needs or training or testing needs. While minimum speed is intended as a fuel conservation measure particular to a certain ship class, secondary benefits include better ability to spot and avoid objects in the water including marine mammals. In addition, a standard operating procedure for military vessels is to maneuver the vessel to maintain a distance of at least 500 yd. (457 m) from any observed whale and to avoid approaching whales head-on, as long as safety of navigation is not imperiled.
- The crew size on military vessels is generally larger than merchant ships, allowing for the possibility of stationing more trained Lookouts on the bridge. At all times when vessels are underway, trained Lookouts and bridge navigation teams are used to detect objects on the surface of the water ahead of the ship, including marine mammals. Additional Lookouts, beyond those already stationed on the bridge and on navigation teams, are positioned as Lookouts during some training events.
- Military Lookouts receive extensive training including Marine Species Awareness Training, which instructs Lookouts to recognize marine species detection cues (e.g., floating vegetation or flocks of seabirds) as well as provides additional information to aid in the detection of marine mammals.

Submarines, when on the surface, use trained Lookouts serving the same function as they do on surface ships and are thus able to detect and avoid marine mammals. When submerged, submarines are generally slow moving (to avoid detection), and therefore marine mammals at depth with a submarine are likely able to avoid collision with the submarine. The Navy's mitigation measures are detailed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring).

Mysticetes. Vessel strikes have been documented for almost all of the rorqual whale species. This includes blue whales (Berman-Kowalewski et al. 2010; Van Waerebeek et al. 2007; Calambokidis 2012), fin whales (Van Waerebeek et al. 2007, Douglas et al. 2008), sei whales (Felix and Van Waerebeek 2005, Van Waerebeek et al. 2007), Bryde's whales (Felix and Van Waerebeek 2005; Van Waerebeek et al. 2007), minke whales (Van Waerebeek et al. 2007), and humpback whales (Lammers et al. 2003; Van Waerebeek et al. 2007; Douglas et al. 2008).

Odontocetes. In general, odontocetes move quickly and seem to be less vulnerable to vessel strikes than other cetaceans; however, most small whale and dolphin species have at least occasionally suffered from vessel strikes including: killer whale (Van Waerebeek et al. 2007; Visser and Fertl 2000), short-finned and long-finned pilot whales (Aguilar et al. 2000; Van Waerebeek et al. 2007), bottlenose dolphin (Bloom and Jager 1994; Van Waerebeek et al. 2007; Wells and Scott 1997), spinner dolphin

(Camargo and Bellini 2007; Van Waerebeek et al. 2007), striped dolphin (Van Waerebeek et al. 2007), and pygmy sperm whales (*Kogia breviceps*) (Van Waerebeek et al. 2007). Beaked whales documented in vessel strikes include: Cuvier's beaked whale (Aguilar et al. 2000; Van Waerebeek et al. 2007), and several species of *Mesoplodon* beaked whale (Van Waerebeek et al. 2007). However, evidence suggests that beaked whales may be able to hear the low-frequency sounds of large vessels and thus avoid collision (Ketten 1998). Sperm whales may be exceptionally vulnerable to vessel strikes as they spend extended periods of time "rafting" at the surface in order to restore oxygen levels within their tissues after deep dives (Jaquet and Whitehead 1996; Watkins et al. 1999). There were also instances in which sperm whales approached vessels too closely and were cut by the propellers (Aguilar de Soto et al. 2006).

Some training activities may occur, at least partially, in nearshore waters of the Study Area and would have the potential to disturb resting spinner dolphins (see Section 3.4.2.23, Spinner Dolphin, for locations of spinner dolphin resting areas). As shown in Chapter 2 (Description of Proposed Action and Alternatives, Table 2.8-1), portions of three major training exercises (Maritime Homeland Defense/Security Mine Countermeasure Exercise, Marine Air Ground Task Force Exercise [Amphibious], and Special Purpose Marine Air Ground Task Force Exercise) may occur in nearshore or littoral waters. Combined, these exercises would occur seven times per year. In addition, the following training activities involving vessel movement would occur in nearshore waters: the Amphibious Rehearsal, No Landing – Marine Air Ground Task Force training activity (12 times per year); the Limpet Mine Neutralization System/Shock Wave Generator activity (40), Surface Ship Sonar Maintenance (48), Submarine Sonar Maintenance (42), and Submarine Navigation (8). Mitigation, as described in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would include surveying for marine mammals, including resting spinner dolphins, prior to conducting the activity. Given that nearshore areas where military activities take place are unlikely to coincide with spinner dolphin resting sites, and mitigation to avoid potential effects would be conducted, vessel strikes on spinner dolphins are not anticipated.

3.4.4.4.1.1 No Action Alternative, Alternative 1, and Alternative 2

<u>Training and Testing Activities</u>

As indicated in Section 3.0.5.2.3.2 (Vessels), most training activities involve the use of vessels. These activities could be widely dispersed throughout the Study Area and the year. Under the three alternatives, the proposed training and testing activities would not result in any appreciable changes from the manner in which the military has trained and would remain consistent with the range of variability observed over the last decade. Consequently, the military does not anticipate vessel strikes will occur within the Study Area under any of the alternatives. The difference in the number of events from the No Action Alternative to Alternative 1 and Alternative 2 is described in Section 3.0.5.2.3.2 (Vessels), and is not likely to change the probability of a vessel strike in any meaningful way.

There are no records of any military vessel strikes to marine mammals in the Study Area. In areas outside the Study Area (e.g., HRC and SOCAL), there have been recorded military vessel strikes of large whales. However, these are areas where the number of military vessels is much higher and training and testing activities occur more often than in the MITT Study Area.

As described above in this section and in Section 3.4.2 (Affected Environment), mysticetes and sperm whales are particularly susceptible to ship strikes. In addition to the greater number of military vessels, the estimated densities of humpback whales, blue whales, and fin whales are at least an order of magnitude higher in the Navy's SOCAL Operating Area than in the MITT Study Area. The density estimates of sperm whales and minke whales in the MITT Study Area are similar to the estimates for SOCAL. Given these disparities, the likelihood of a vessel strike is minimal and far less than in the SOCAL Operating Area.

Because there are no known ship strikes of marine mammals by Navy or U.S. Coast Guard vessels in the MITT Study Area, there are no data to conduct an analysis of the probability of a ship strike based on historical data, as was done for the Hawaii-Southern California Training and Testing EIS/OEIS (U.S. Department of the Navy 2013b). However, 76 sightings of large whales (including sperm whale, humpback whale, sei whale, Bryde's whale, and unidentified large whales) were made during the 2007 Mariana Islands Sea Turtle and Cetacean Survey (MISTCS) (Fulling et al. 2011), and 13 large whales were sighted by Navy Lookouts during a training exercise conducted in the Mariana Islands Range Complex (MIRC) from 16 to 21 September 2010 (U.S. Department of the Navy 2011). While the sightings from MISTCS, a dedicated line transect survey, do not reflect the encounter rate expected for military training and testing activities, the survey results do confirm the presence of large whales in the Study Area. Additionally, the 2011 exercise monitoring report confirms that large whales can be sighted by Navy Lookouts in the vicinity of a military exercise (U.S. Department of the Navy 2011).

In order to account for the accidental nature of a possible ship strike in general, and potential risk from any vessel movement within the Study Area, the military has sought take authorization in the event a military ship strike does occur within the Study Area during the 5-year period of NMFS' final authorization. Given that there are no data from which to estimate the potential for a strike to occur in the Study Area, the military will request authorization for mortality or serious injury from vessel strike to no more than five large whales as a result of training and testing activities over the course of the 5 years of the rulemaking issued by NMFS for the Study Area. This would consist of no more than one large whale in any given year of the following species: fin whale, blue whale, humpback whale, Bryde's whale, Omura's whale, sei whale, minke whale, or sperm whale.

Pursuant to the MMPA, the use of vessels during training and testing activities under the No Action Alternative, Alternative 1, and Alternative 2 may result in Level A harassment or mortality to species of large whales in the Study Area, including fin whale, blue whale, humpback whale, Bryde's whale, Omura's whale, sei whale, minke whale, and sperm whale. Impact from the use of vessels from training and testing activities is not expected to result in Level B harassment of marine mammals.

Pursuant to the ESA, the use of vessels during training and testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2:

- *May affect, and is likely to adversely affect the ESA-listed fin whale, blue whale, humpback whale, sei whale, and sperm whale*

3.4.4.4.2 Impacts from In-Water Device Strikes

In-water devices are generally smaller (several inches to 111 ft. [34 m]) than most Navy vessels. For a discussion of the types of activities that use in-water devices, where they are used and how many events would occur under each alternative, see Section 3.0.5.2.3.3 (In-Water Devices).

Devices that would pose the greatest collision risk to marine mammals are those operated at high speeds and are unmanned. These are mainly limited to the unmanned surface vehicles such as high-speed targets and unmanned undersea vehicles such as light and heavy weight 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 acoustic homing programs of U.S. Navy torpedoes are sophisticated and would not confuse the acoustic signature of a marine mammal with a submarine/target. All exercise torpedoes are recovered and refurbished for eventual re-use. Review of the exercise torpedo records indicates there has never been an impact to a marine mammal or other marine organism.

Since some in-water devices are identical to support craft, marine mammals could respond to the physical presence of the device as discussed in Section 3.4.4.4.1 (Impacts from Vessels). Physical disturbance from the use of in-water devices is not expected to result in more than a momentary behavioral response.

Devices such as unmanned underwater vehicles that move slowly through the water are highly unlikely to strike marine mammals because the mammal could easily avoid the object. Towed devices 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 thousands of exercises in which torpedoes were fired or in-water devices used, there have been no recorded or reported instances of a marine species strike from a torpedo or any other in-water device. Strikes by torpedoes or other in-water devices on individual marine mammals are not anticipated, and no long-term consequences to populations of marine mammals are expected to result from the use of in-water devices.

3.4.4.4.2.1 No Action Alternative, Alternative 1 and Alternative 2

Training Activities

In-water devices used for training activities in the Study Area are described in Section 3.0.5.2.3.3 (In-Water Devices). Under the No Action Alternative, approximately 174 training activities per year may use some type of in-water device. Under Alternative 1 and Alternative 2, the number of proposed annual training activities would increase by approximately 600 percent over the No Action Alternative. Torpedoes, unmanned underwater vehicles, unmanned targets, and other in-water devices could be used throughout the year and in multiple locations in the Study Area; however, nearly half of the activities using in-water devices would occur beyond 12 nm from shore. As described above, no impacts to marine mammals are anticipated from the use of in-water devices during training activities.

Pursuant to the MMPA, the use of in-water devices during training activities under the No Action Alternative, Alternative 1, or Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of in-water devices during training activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

In-water devices used for testing activities in the Study Area are described in Section 3.0.5.2.3.3 (In-Water Devices). Under the No Action Alternative, one testing activity per year may use some type of in-water device. Under Alternative 1 and Alternative 2, the number of proposed annual testing activities would increase to 320 under Alternative 1 and 362 under Alternative 2. Torpedoes, unmanned underwater vehicles, and other in-water devices could be used throughout the year and in multiple locations in the Study Area. As described above, no impacts to marine mammals are anticipated from the use of in-water devices during testing activities.

Pursuant to the MMPA, the use of in-water devices during testing activities under the No Action Alternative, Alternative 1, or Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of in-water devices during testing activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.4.3 Impacts from Military Expended Materials

This section analyzes the strike potential to marine mammals from the following categories of military expended materials: (1) non-explosive practice munitions; (2) fragments from high-explosive munitions; and (3) expended materials other than ordnance, such as sonobuoys, ship hulks, expendable targets and aircraft stores (fuel tanks, carriages, dispensers, racks, carriages, or similar types of support systems on aircraft that could be expended or recovered). For a discussion of the types of activities that use military expended materials, where they are used, and how many events would occur under each alternative, see Section 3.0.5.2.3 (Physical Disturbance and Strike Stressors).

While disturbance or strike from an item falling through the water column is possible, it is not very likely because the objects generally sink slowly through the water and can be avoided by most marine mammals. Therefore, the discussion of military expended materials strikes will focus on the potential of a strike at the surface of the water. For expended materials other than ordnance, potential strike is limited to expendable torpedo targets, sonobuoys, pyrotechnic buoys and aircraft stores.

While no strike from military expended materials has ever been reported or recorded, the possibility of a strike still exists. Therefore, the potential for marine mammals to be struck by military expended materials was evaluated using statistical probability analysis to estimate the likelihood. Specific details of the analysis approach, including the calculation methods, are presented in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures).

To estimate the likelihood of a strike, a worst-case scenario was calculated using the marine mammal with the highest average density in areas with the highest military expended material expenditures. These highest estimates would provide reasonable comparisons for all other areas and species. For estimates of expended materials in all areas, see Section 3.0.5.2.3 (Physical Disturbance and Strike Stressors).

For all the remaining marine mammals with lesser densities, this highest likelihood would overestimate the likelihood or probability of a strike. Because the ESA has a specific standards for understanding the likelihood of impacts to each endangered species, estimates were made for all endangered marine mammals found in the areas where the highest levels of military expended materials would be expended. In this way, the appropriate ESA conclusions could be based on the highest estimated probabilities of a strike for those species.

Input values include munitions data (frequency, footprint and type), size of the training or testing area, marine mammal density data and size of the animal. To estimate the potential of military expended materials to strike a marine mammal, the impact area of all bomb, projectiles, acoustic countermeasures, expendable torpedo targets, sonobuoys and pyrotechnic buoys was totaled over 1 year in the area for each of the alternatives.

The potential for a marine mammal strike is influenced by the following assumptions:

- The statistical analysis is two-dimensional and assumes that all marine mammals would be at or near the surface 100 percent of the time, when in fact, marine mammals spend up to 90 percent of their time under the water (Costa and Block 2009).
- The statistical analysis also does not take into account the fact that most of the projectiles fired during training and testing activities are fired at targets, and most projectiles hit those targets, so only a very small portion of those would hit the water with their maximum velocity and force.
- The statistical analysis assumes the animal is stationary and does not account for any movement of the marine mammal or any potential avoidance of the training or testing activity.

The potential of fragments from explosive munitions or expended material other than ordnance to strike a marine mammal is likely lower than for the worst-case scenario calculated above as those events happen with much lower frequency. Fragments may include metallic fragments from the exploded target, as well as from the exploded ordnance.

Marine mammal species that occur in the Study Area may be exposed to the risk of military expended material strike. The critical habitat would not be impacted by military expended materials as a physical disturbance and strike stressor. The results of the statistical analysis provide a reasonably high level of certainty that marine mammals would not be struck by military expended materials. See Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), for a description of mitigation measures proposed to help further reduce the potential impacts of military expended materials strikes on marine mammals.

3.4.4.4.3.1 No Action Alternative, Alternative 1, and Alternative 2

Training and Testing Activities

As shown in Section 3.0.5.2.3.4 (Military Expended Materials), a wide variety of expended materials are used during training and testing activities. Military expended materials used in the Study Area include all sizes of non-explosive practice munitions, fragments from explosive munitions, and expended materials other than ordnance, such as sonobuoys.

Under Alternatives 1 and 2, the use of military expended materials from training activities increases by approximately 130 percent compared to the No Action Alternative. There are no testing activities under the No Action Alternative that use military expended materials, and the number of military expended materials used in testing activities under Alternatives 1 and 2 is approximately 10 percent of the total used in training activities.

The results of the statistical analysis provided in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures) present the probability of a strike from military expended materials as a percent of training or testing activities under the No Action Alternative, Alternative 1, and Alternative 2. The results indicate with a reasonable level of certainty that marine mammals would not be struck by non-explosive practice munitions or by military expended materials other than munitions during training or testing activities. The results of the analysis range from zero (i.e., or a zero percent chance of a strike by a military expended material over the course of a year), to a high of approximately eight one-hundredths of one percent (0.08 percent) of a chance of being struck by a military expended material. However, as discussed above, this does not take into account assumptions that likely overestimate impact probability and the behavior of the species (e.g., melon-headed whales generally occur in large pods and are relatively easy to spot), which would make the risk of a strike even lower.

The increase in expended materials from the No Action Alternative–Alternatives 1 and 2 results in a corresponding increase of the risk of a strike as shown in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures), but it does not change the underlying conclusion that the use of military expended materials is not expected to result in the physical disturbance or a strike of marine mammals. Furthermore, Navy mitigation measures addressing the use of sonobuoys and other military expended materials require that the area is clear of marine mammals before deploying sonobuoys or other types of military expended materials (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring).

Pursuant to the MMPA, the use of military expended materials during training or testing activities under the No Action Alternative, Alternative 1, or Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials during training or testing activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.4.4 Impacts from Seafloor Devices

For a discussion of the types of activities that use seafloor devices, where they are used, and how many events would occur under each alternative, see Section 3.0.5.2.3.5 (Seafloor Devices). These include items placed on, dropped on or moved along the seafloor, such as mine shapes, anchor blocks, anchors, bottom-placed instruments, and bottom-crawling unmanned underwater vehicles. As discussed in Section 3.4.4.4.3 (Impacts from Military Expended Materials), objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most marine mammals. The only seafloor device used during training and testing activities that has the potential to strike a marine mammal at or near the surface is an aircraft deployed mine shape, which is used during aerial mine laying activities. These devices are identical to non-explosive practice bombs, therefore the analysis of the potential impacts from those devices are covered in the military expended material strike section.

3.4.4.4.4.1 No Action Alternative, Alternative 1, and Alternative 2

<u>Training Activities</u>

As indicated in Section 3.0.5.2.3.5 (Seafloor Devices), some training activities, including mine warfare, precisions anchoring, and anti-submarine warfare activities under the No Action Alternative, Alternative 1, and Alternative 2 make use of seafloor devices. Under the No Action Alternative, 44 training activities per year would use seafloor devices. Under Alternative 1 and Alternative 2, 136 training activities would use seafloor devices.

Some seafloor devices are put into place prior to or during the training activity and recovered following the activity (e.g., anchors used in Precision Anchoring activities and moored mine shapes used in some mine warfare activities). Recovery of other types of seafloor devices (e.g., air-deployed, non-explosive mine shapes) would not be practical or even possible, because of factors inhibiting recovery, such as water depth. Considering that activities using seafloor devices would only be conducted 136 times per year and that many seafloor devices would be recovered, it is unlikely that marine mammals would come into contact with these devices while they are being deployed, recovered, or during the training activity.

Pursuant to the MMPA, the use of seafloor devices during training activities under the No Action Alternative, Alternative 1, or Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of seafloor devices during training activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *Would have no effect on the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As indicated in Section 3.0.5.2.3.5 (Seafloor Devices), one testing activity under the No Action Alternative would use seafloor devices. Under Alternatives 1 and 2, up to 68 testing activities would use seafloor devices.

Testing activities using seafloor devices include the North Pacific Acoustic Lab Philippine Sea Experiment conducted by the Office of Naval Research, which would occur once per year, the integrated swimmer defense airgun activity conducted 11 times per year, and Mine Countermeasure Mission Package Testing (up to 36 times per year) (see Chapter 2, Description of Proposed Action and Alternatives, Tables 2.8-3 and 2.8-4). Seafloor devices are put into place prior to or during the testing activity and recovered following the activity. Considering that activities using seafloor devices would only occur 68 times per year and that all devices used during swimmer defense airgun testing and moored mine shapes used in MCM Mission Package testing would be recovered, it is unlikely that marine mammals would come into contact with these devices while they are being deployed or during the testing activity.

Pursuant to the MMPA, the use of seafloor devices during testing activities under the No Action Alternative, Alternative 1, or Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of seafloor devices during testing activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *Would have no effect on the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.5 Entanglement Stressors

This section analyzes the potential for entanglement of marine mammals as the result of proposed training and testing activities within the Study Area. This analysis includes the potential impacts from two types of military expended materials: (1) fiber optic cables and guidance wires and (2) decelerators/

parachutes. The number and location of training and testing events that involve the use of items that may pose an entanglement risk are provided in Section 3.0.5.2.4 (Entanglement Stressors).

These materials may have the potential to entangle and could be encountered by marine mammals in the Study Area at the surface, in the water column, or along the seafloor. The properties and size of these military expended materials makes entanglement unlikely. For example, the majority of the "parachutes" expended are 18 in. (45.7 cm) diameter cruciform ("X" shaped) decelerators attached with short lines to the top of sonobuoys and are therefore very unlikely entanglement hazards for most marine mammals. In addition, there has never been a reported or recorded instance of a marine mammal entangled in military expended materials; however, the possibility still exists. Since potential impacts depend on how a marine mammal encounters and reacts to items that pose an entanglement risk, the following subsections discuss research relevant to specific groups or species. Most entanglements discussed in the following sections are attributable to marine mammal encounters with fishing gear or other non-military materials that float or are suspended at the surface.

3.4.4.5.1 Mysticetes

The minimal estimate of the percentage of humpback whales that have been non-lethally entangled in their lifetime is 52 percent with a maximal estimate of 78 percent (Neilson et al. 2009). Cassoff et al. (2011) report that in the western North Atlantic, mortality entanglement has slowed the recovery of some populations of mysticetes. Included in their analysis of 21 entanglement related mortalities were minke, Bryde's, North Atlantic right whale, and humpback whales.

There are no data available for the MITT Study Area. However, in the Hawaiian Islands in 2006 and 2007, there were 26 entanglements in each of those 2 years (National Marine Fisheries Service 2007). In 2008 there were 15 entanglements (National Marine Fisheries Service 2008b), and in the Hawaiian Islands during the 2009–2010 humpback season, the Hawaiian Islands Large Whale Entanglement Response Network received 32 reports of entangled humpback whales, with 19 of these reports were confirmed and amounted to 11 different animals entangled in various types of gear (National Marine Fisheries Service 2010).

Military expended material is expected to sink to the ocean floor. There are no mysticete species that feed off the bottom in the areas where activities make use of military expended materials could encounter them.

3.4.4.5.2 Odontocetes

Heezen (1957) reported two confirmed instances of sperm whales entangled in the slack lengths of telegraph cable near cable repair sites along the seafloor. These whales likely became entangled while feeding along the bottom, as the cables were most often found wrapped around the jaw. Juvenile harbor porpoise exposed to 0.5 in. diameter (13-millimeter [mm] diameter) white nylon ropes in both vertical and horizontal planes treated the ropes as barriers, more frequently swimming under than over them (Kastelein et al. 2005). Bottlenose dolphins have also been observed to feed off the bottom in shallow water in the Bahamas (Herzing et al. 2003).

Walker and Coe (1990) provided data on the stomach contents from 16 species of odontocetes with evidence of debris ingestion. Of the odontocete species occurring in the Study Area, only sperm whale, Blainville's beaked whale, and Cuvier's beaked whale had ingested items (likely incidentally) that do not float, indicating the likelihood of foraging at the seafloor.

3.4.4.5.3 Impacts from Fiber Optic Cables and Guidance Wires

For a discussion of the types of activities that use fiber optic cables and guidance wires and how many events would occur under each alternative, see Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires). The likelihood of a marine mammal encountering and becoming entangled in a fiber optic cable depends on several factors. The amount of time that the cable is in the same vicinity as a marine mammal can increase the likelihood of it posing an entanglement risk. Since the cable will only be within the water column during the activity and while it sinks, the likelihood of a marine mammal encountering and becoming entangled within the water column is extremely low. The length of the fiber optic cable varies (up to about 900 ft. [274 m]), and greater lengths may increase the likelihood that a marine mammal could become entangled. The behavior and feeding strategy of a species can determine whether they may encounter items on the seafloor, where cables will be available for longer periods of time. There is potential for those species that feed on the seafloor to encounter cables and potentially become entangled, however the relatively few cables being expended within the Study Area limits the potential for encounters. The physical characteristics of the fiber optic material render the cable brittle and easily broken when kinked, twisted, or bent sharply (i.e., to a radius greater than 360 degrees). Thus, the physical properties of the fiber optic cable would not allow the cable to loop, greatly reducing or eliminating any potential issues of entanglement with regard to marine life.

Similar to fiber optic cables discussed above, guidance wires may pose an entanglement threat to marine mammals either in the water column or after the wire has settled to the sea floor. The likelihood of a marine mammal encountering and becoming entangled in a guidance wire depends on several factors. With the exception of a chance encounter with the guidance wire while it is sinking to the seafloor (at an estimated rate of 0.7 ft. [0.2 m] per second), it is most likely that a marine mammal would only encounter a guidance wire once it had settled on the sea floor. Since the guidance wire will only be within the water column during the activity and while it sinks, the likelihood of a marine mammal encountering and becoming entangled within the water column is extremely low. In addition, based on degradation times the guide wires would break down within 1–2 years and therefore no longer pose an entanglement risk. The length of the guidance wires vary, but greater lengths increase the likelihood that a marine mammal could become entangled. The behavior and feeding strategy of a species can determine whether they may encounter items on the seafloor, where guidance wires will most likely be available. There is potential for those species that feed on the seafloor to encounter guidance wires and potentially become entangled; however, the relatively few guidance wires being expended within the Study Area limits the potential for encounters.

Marine mammal species that occur within the Study Area were evaluated based on the likelihood of encountering these items. There are no mysticete species in the Study Area that feed off the bottom in the areas where these activities occur. Odontocete species, that occur in these areas and that forage on the bottom, (e.g., beaked whales) could potentially encounter these items.

The chance that an individual animal would encounter expended cables or wires is low based on the distribution of both the cables and wires expended, the fact that the wires and cables will sink upon release, and the relatively few marine mammals that are likely to feed on the bottom in the deeper waters (e.g., average depth in Warning Area [W]-517 is 19,600 ft. [6,000 m]) where these would be expended. It is probably very unlikely that an animal would get entangled even if it encountered a cable or wire while it was sinking or upon settling to the seafloor. An animal would have to swim through loops or become twisted within the cable or wire to become entangled and, given the properties of the expended fiber optic cables and guidance wires (low breaking strength and sinking rates), this seems unlikely. Furthermore, an animal may initially become entangled in a cable or wire but easily become free, and therefore no long-term impacts would occur. Based on the estimated concentration of expended cables and wires, impacts from cables or wires are extremely unlikely to occur.

3.4.4.5.3.1 No Action Alternative

Training Activities

As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), training activities under the No Action Alternative would expend approximately 40 guidance wires annually, and no activities would expend fiber optic cables. Based on the discussion above, impacts on marine mammals from the use of guidance wires during training activities under the No Action Alternative are not anticipated. Long-term consequences to individuals or populations of marine mammals are not expected to result from the use of guidance wires.

Pursuant to the MMPA, the use of guidance wires during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of guidance wires during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), no testing activities under the No Action Alternative would expend fiber optic cables or guidance wires.

3.4.4.5.3.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), 4 training activities would use approximately 16 fiber optic cables and 40 training activities would use 40 guidance wires annually under Alternative 1.

The number of events using guidance wires is the same as under the No Action Alternative. The number of fiber optic cables that would be expended annually increased from zero under the No Action Alternative to 16 under Alternative 1. Based on the discussion above, and the minimal increase in the use of fiber optic cables, impacts on marine mammals from the use of guidance wires and fiber optic cables during training activities under Alternative 1 are not anticipated and would not be discernible from impacts described under Section 3.4.4.5.3 (Impacts from Fiber Optic Cables and Guidance Wires).

Pursuant to the MMPA, the use of fiber optic cables and guidance wires during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), two testing activities under Alternative 1 would expend 20 guidance wires, and 32 testing activities under Alternative 1 would expend 128 fiber optic cables annually. Based on the discussion above, impacts on marine mammals from the use of fiber optic cables and guidance wires during testing activities under Alternative 1 are not anticipated and would not be discernible from impacts described under Section 3.4.4.5.3 (Impacts from Fiber Optic Cables and Guidance Wires).

Pursuant to the MMPA, the use of fiber optic cables and guidance wires during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.5.3.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus modifications of existing capabilities and adjustments to the type and tempo of training and testing activities. As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), the number of expended guidance wires and fiber optic cables under Alternative 2 is identical to Alternative 1. Therefore, the predicted impacts for Alternative 2 are identical to those described above under Alternative 1 – Training. Based on the discussion above, impacts on marine mammals from the use of fiber optic cables and guidance wires during training activities under Alternative 2 are not anticipated and would not be discernible from impacts described under Section 3.4.4.5.3 (Impacts from Fiber Optic Cables and Guidance Wires).

Pursuant to the MMPA, the use of fiber optic cables and guidance wires during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. As presented in Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires), the number of expended guidance wires under Alternative 2 is identical to Alternative 1. The number of fiber optic cables used under Alternative 2 increases to 144 per year (less than a 13 percent increase). Therefore, the predicted impacts for Alternative 2 are approximately the same as those described above under Alternative 1 – Testing. Based on the discussion above, impacts on marine mammals from the use of fiber optic cables and guidance wires during testing activities under Alternative 2 are not anticipated and would not be discernible from impacts described under Section 3.4.4.5.3 (Impacts from Fiber Optic Cables and Guidance Wires).

Pursuant to the MMPA, the use of fiber optic cables and guidance wires during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.5.4 Impacts from Decelerators/Parachutes

Refer to Section 3.0.5.2.4.2 (Decelerators/Parachutes), for information on the types of training and testing activities that involve the use of decelerators/parachutes and the geographic areas where they would be expended. Training and testing activities that introduce decelerators/parachutes into the water column can occur anywhere in the Study Area.

As described in Section 3.0.5.2.4.2 (Decelerators/Parachutes), decelerators/parachutes used during the proposed activities are small, ranging in size from 18 to 48 in. (46 to 122 cm), and are made of cloth and nylon. Many decelerators/parachutes have weights attached to the lines for rapid sinking. The vast majority of expended decelerators/parachutes are small (18 in. [45.7 cm]) cruciform-shaped decelerators used with sonobuoys. These have short attachment lines and upon water impact may remain at the surface for 5–15 seconds before the decelerator/parachute and its housing sink to the seafloor. The average water depth in W-517 is approximately 19,600 ft. (6,000 m).

Entanglement of a marine mammal in a decelerator/parachute assembly at the surface or within the water column would be very unlikely, since the decelerator/parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. Once on the seafloor, if strong enough bottom currents are present, the small fabric panels may temporarily billow and pose an entanglement threat to marine animals with bottom-feeding habits; however, the probability of a marine mammal encountering a decelerator/parachute assembly on the seafloor and accidental entanglement in the small, cruciform fabric panel or short suspension lines is unlikely.

The chance that an individual animal would encounter expended decelerators/parachutes is low based on the distribution of the decelerators/parachutes expended, the fact that decelerator/parachute assemblies are designed to sink upon release, and the relatively few marine mammals that feed on the bottom. If a marine mammal did become entangled in a parachute, it could easily become free of the parachute because the parachutes are made of very light-weight fabric. Based on the information summarized within the introduction to Section 3.4.4.5 (Entanglement Stressors), mysticetes found within the Study Area are not bottom feeders; therefore, they are not expected to encounter decelerators/parachutes on the seafloor.

The possibility of odontocetes (sperm whale, Blainville's beaked whale, Cuvier's beaked whale) becoming entangled exists when they are feeding on the bottom in areas where decelerators/parachutes have been expended. This is unlikely as decelerators/parachutes are used in events that generally occur in deeper waters where these species are not likely to be feeding on the bottom (Whitehead 2003) and the majority of decelerators/parachutes used are relatively small. There has never been any recorded or reported instance of a marine mammal becoming entangled in a decelerator/parachute.

3.4.4.5.4.1 No Action Alternative

Training Activities

As presented in Section 3.0.5.2.4.2 (Decelerators/Parachutes), approximately 8,000 decelerators/parachutes would be expended annually during training activities.

A calculation was made to estimate the highest possible concentration of expended decelerators/parachutes that could be expected in the Study Area. The result is a concentration of approximately one decelerator/parachute per 7 square nautical miles (nm^2) of ocean area. Based on the description of decelerators/parachutes in Section 3.4.4.5.4 (Impacts from Decelerators/Parachutes) and the estimated low density of decelerators/parachutes, impacts on marine mammals from the use of decelerators/parachutes during training activities under the No Action Alternative are not anticipated.

Pursuant to the MMPA, the use of decelerators/parachutes during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As presented in Section 3.0.5.2.4.2 (Decelerators/Parachutes), there are no testing activities under the No Action Alternative that would expend decelerators/parachutes.

3.4.4.5.4.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As presented in Section 3.0.5.2.4.2 (Decelerators/Parachutes, Tables 3.0-33 and 3.0-49), approximately 11,000 decelerators/parachutes would be expended annually during training activities under Alternative 1. This represents a 35 percent increase in the number of expended decelerators/parachutes over the No Action Alternative.

A calculation was made to estimate the highest possible concentration of expended decelerators/parachutes that could be expected in a worst-case scenario. The result is a concentration of approximately one decelerator/parachute per 4 nm^2 of ocean area within the Study Area. Based on the description of decelerators/parachutes in Section 3.4.4.5.4 (Impacts from Decelerators/Parachutes) and the estimated low density of decelerators/parachutes, impacts on marine mammals from the use of decelerators/parachutes during training activities under Alternative 1 are not anticipated.

Pursuant to the MMPA, the use of decelerators/parachutes during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As presented in Section 3.0.5.2.4.2 (Decelerators/Parachutes), approximately 1,700 decelerators/parachutes would be expended annually during testing activities under Alternative 1.

A calculation was made to estimate the highest possible concentration of expended decelerators/parachutes that could be expected in a worst-case scenario. The result is a concentration of approximately one decelerator/parachute per 14 nm^2 of ocean area within the Study Area. Based on the description of decelerators/parachutes in Section 3.4.4.5.4 (Impacts from Decelerators/Parachutes) and the estimated low density of decelerators/parachutes, impacts on marine mammals from the use of decelerators/parachutes during testing activities under Alternative 1 are not anticipated.

Pursuant to the MMPA, the use of decelerators/parachutes during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.5.4.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. Decelerators/Parachutes could be expended anywhere in the Study Area during training activities. As shown in Section 3.0.5.2.4.2 (Decelerators/Parachutes), the number of decelerators/parachutes used during training activities is identical under Alternatives 1 and 2. Therefore, the predicted impacts for Alternative 2 are identical to those described under Alternative 1 – Training.

Pursuant to the MMPA, the use of decelerators/parachutes during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. As presented in Section 3.0.5.2.4.2 (Decelerators/Parachutes), approximately 1,900 decelerators/parachutes would be expended annually during testing activities under Alternative 2. This represents a 10 percent increase in the number of expended decelerators/parachutes over the Alternative 1.

A calculation was made to estimate the highest possible concentration of expended decelerators/ parachutes that could be expected in a worst-case scenario. The result is a concentration of approximately one decelerator/parachute per 13 nm^2 of ocean area within the Study Area. Based on the description of decelerators/parachutes in Section 3.4.4.5.4 (Impacts from Decelerators/Parachutes) and the estimated low density of decelerators/parachutes, impacts on marine mammals from the use of decelerators/parachutes during testing activities under Alternative 2 are not anticipated.

Pursuant to the MMPA, the use of decelerators/parachutes during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.6 Ingestion Stressors

This section analyzes the potential impacts of the various types of ingestion stressors used during training and testing activities within the Study Area. This analysis includes the potential impacts from two categories of military expended materials: (1) munitions (both non-explosive practice munitions and fragments from explosive munitions); and (2) materials other than ordnance including fragments from targets, chaff, flares, and decelerators/parachutes. For a discussion of the types of activities that use these materials, where they are used, and how many events would occur under each alternative, please see Section 3.0.5.2.5 (Ingestion Stressors).

The distribution and density of expended items plays a central role in the likelihood of impact on marine mammals. The military conducts training and testing activities throughout the Study Area and these activities are widely distributed and low in density. As suggested by the seafloor survey reported in Watters et al. (2010), even in areas such as Southern California (within the Navy's SOCAL Range Complex) where Navy has been undertaking training and testing activities for decades, the density of materials expended by Navy is negligible in comparison to commercial fishing and urban refuse resulting in marine debris available on seafloor. Watters et al. (2010) found an estimated 320 anthropogenic items per square kilometer on Southern California seafloor and encountered only one item (identified as "artillery") that was of likely military origin. The majority of material expended during military training and testing would likely penetrate into the seafloor and not be accessible to most marine mammals.

Since potential impacts depend on where these items are expended and how a marine mammal feeds, the following subsections discuss important information for specific groups or species.

3.4.4.6.1 Mysticetes

Species that feed at the surface or in the water column include blue, fin, Bryde's, Omura's, minke, and sei whales. While humpback whales feed predominantly by lunging through the water after krill and fish, there are instances of humpback whales disturbing the bottom in an attempt to flush prey, the northern sand lance (*Ammodytes dubius*) (Hain et al. 1995). Humpback whales are not known to bottom feed while in the Study Area. In a comprehensive review of documented ingestion of debris by marine mammals, there are two species of mysticetes (bowhead and minke whale) with records of having ingested debris items that included plastic sheeting and a polythene bag (Laist 1997). Based on the available evidence, and because minke whales and humpback whales occur in the Study Area and are known to forage at or near the seafloor, it is possible but unlikely they may ingest items found on the seafloor.

3.4.4.6.2 Odontocetes

Beaked whales use suction feeding to ingest benthic prey and may incidentally ingest other items (MacLeod et al. 2003). Both sperm whales and beaked whales are known to incidentally ingest foreign objects while foraging; however, this does not always result in negative consequences to health or vitality (Laist 1997; Walker and Coe 1990). While this incidental ingestion has led to sperm whale mortality in some cases (Jacobsen et al. 2010), Whitehead (2003) suggested the scale to which this affects sperm whale populations was not substantial. Sperm whales are recorded as having ingested fishing net scraps, rope, wood, and plastic debris such as plastic bags and items from the seafloor (Walker and Coe 1990; Whitehead 2003). In addition, the results presented in Whitehead (2003) suggest that ingestion of non-food items is more likely at higher latitudes than at lower latitudes.

Recently weaned juveniles, who are investigating multiple types of prey items, may be particularly vulnerable to ingesting non-food items as found in a study of juvenile harbor porpoise (Baird and Hooker 2000). A male pygmy sperm whale reportedly died from blockage of two stomach compartments by hard plastic, and a Blainville's beaked whale washed ashore in Brazil with a ball of plastic thread in its stomach (Derraik 2002). In a comprehensive review of documented ingestion of debris by marine mammals, odontocetes had the most ingestion records with 21 species represented (Laist 1997). Walker and Coe (1990) provided data on the stomach contents from of 16 species of odontocetes with evidence of debris ingestion. Of these odontocete species, only sperm whale, Blainville's beaked whale, Cuvier's beaked whale had ingested non-floating items (e.g., stones, metal, and glass) presumably while foraging from the seafloor. Bottlenose dolphins have also been observed to feed off the bottom in shallow water in the Bahamas (Herzing et al. 2003). Table 3.4-25 lists odontocete species found in the Study Area that are known to have ingested marine debris.

Table 3.4-25: Odontocete Marine Mammal Species that Occur in the Study Area and Are Documented to Have Ingested Marine Debris

Blainville's beaked whale	Risso's dolphin
Bottlenose dolphin	Rough-toothed dolphin
Cuvier's beaked whale	Short-finned pilot whale
Dwarf sperm whale	Sperm whale
Pygmy sperm whale	Striped dolphin

Source: Walker and Coe 1990

3.4.4.6.3 Impacts from Munitions

Many different types of explosive and non-explosive practice munitions are expended during training and testing activities. This section analyzes the potential for marine mammals to ingest non-explosive practice munitions and fragments from explosive munitions.

Types of non-explosive practice munitions generally include projectiles, missiles, and bombs. Of these, only small- or medium-caliber projectiles would be small enough for a marine mammal to ingest. Small- and medium-caliber projectiles include all sizes up to and including 2.25 in. (57 mm) in diameter. These solid metal materials would quickly move through the water column and settle to the sea floor. Ingestion of non-explosive practice munitions is not expected to occur in the water column because the ordnance sinks quickly. Instead, they are most likely to be encountered by species that forage on the bottom. Other military expended materials such as targets, large-caliber projectiles, intact training and testing bombs, guidance wires, 55-gallon drums, sonobuoy tubes, and marine markers are too large for marine mammals to consume.

Types of explosive munitions that can result in fragments include demolition charges, neutralizers, projectiles, missiles, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the NEW and munitions type; however, typical sizes of fragments are unknown. These solid metal materials would quickly move through the water column and settle to the seafloor; therefore, ingestion is not expected by most species. Fragments are primarily encountered by species that forage on the bottom.

Based on the information summarized above in 3.4.4.6 (Ingestion Stressors), mysticetes found within the Study Area, with the potential exception of humpback whale and minke whale, are not expected to encounter non-explosive practice munitions or fragments from explosive munitions on the seafloor. Ingestion of non-explosive practice munitions or fragments from explosive munitions by odontocetes feeding off the bottom is unlikely. If ingestion were to occur, it would d be incidental with items being potentially consumed along with bottom-dwelling prey.

3.4.4.6.3.1 No Action Alternative

<u>Training Activities</u>

<u>Explosive munitions and non-explosive practice munitions</u>

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under the No Action Alternative, more than 61,700 explosive munitions and non-explosive practice munitions considered an ingestion risk would be used during training activities annually in the Study Area. Of that total, 60,000 are non-explosive, small-caliber projectiles, and the remaining are explosive munitions, including bombs, medium- and large-caliber projectiles, missiles, and rockets, that could introduce fragments potentially small enough to be ingested by a bottom feeding marine mammal. All explosive bombs, missiles, and large-caliber projectiles would be used over deep, offshore waters greater than 12 nm (and in some cases greater than 50 nm) from shore. Over 60 percent of non-explosive, small-caliber projectiles would be expended greater than 12 nm from shore.

The number of munitions and explosive munitions fragments that an individual animal could encounter would generally be low, based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not ingest every munitions or munitions fragment it encountered, and if a munition or munitions fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. Wells et al. (2008) showed that even ingestion of certain items (e.g., hooks), if they do not become embedded in tissue, may not result in injury or mortality to the individual. Therefore, potential impacts of munitions ingestion would be limited to the unlikely event where a marine mammal might ingest an item that subsequently becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, ingestion of munitions used during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, ingestion of munitions used during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), there are no testing activities proposed under the No Action Alternative that would use explosive munitions or non-explosive practice munitions in the Study Area.

3.4.4.6.3.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 1, approximately 97,000 explosive munitions and non-explosive practice munitions considered an ingestion risk would be used during training activities annually in the Study Area. Of that total, 86,000 are non-explosive, small-caliber projectiles, and the remaining are explosive munitions, including bombs, medium- and large-caliber projectiles, missiles, and rockets, that could introduce fragments potentially small enough to be ingested by a bottom feeding marine mammal. The number of explosive munitions and non-explosive practice munitions proposed under Alternative 1 represents an increase of 57 percent over the number proposed under the No Action Alternative. All explosive bombs, missiles, rockets, and large-caliber projectiles would be used over deep, offshore waters greater than 12 nm (and in some cases greater than 50 nm) from shore. Approximately 45 percent of non-explosive, small-caliber projectiles would be expended greater than 12 nm from shore, and 98 percent of explosive medium-caliber projectiles would be expended greater than 12 nm from shore.

The number of munitions and explosive munitions fragments that an individual animal could encounter would generally be low, based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not ingest every munitions or munitions fragment it encountered, and if a munition or munitions fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. Wells et al. (2008) showed that even ingestion of certain items (e.g., hooks), if they do not become embedded in tissue, may not result in injury or mortality to the individual. Therefore, potential impacts of munitions ingestion would be limited to the unlikely event where a marine mammal might ingest an item that subsequently becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, ingestion of munitions used during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, ingestion of munitions used during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 1, approximately 11,000 explosive munitions and non-explosive practice munitions considered an ingestion risk would be used during testing activities annually in the Study Area. Of that total, approximately 4,000 are non-explosive, small-caliber or medium-caliber projectiles, and the remaining 7,000 are explosive munitions. Eighty-seven percent of the explosive munitions are medium- and large-caliber projectiles, and the remaining 13 percent are missiles, rockets, and torpedoes.

Explosive munitions could introduce fragments potentially small enough to be ingested by a bottom feeding marine mammal. The number of explosive munitions and non-explosive practice munitions proposed under Alternative 1 is an increase over the number proposed under the No Action alternative, because no testing activities would use munitions under the No Action Alternative.

The number of munitions and explosive munitions fragments that an individual animal could encounter would generally be low, based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not ingest every munitions or munitions fragment it encountered, and if a munition or munitions fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. Wells et al. (2008) showed that even ingestion of certain items (e.g., hooks), if they do not become embedded in tissue, may not result in injury or mortality to the individual. Therefore, potential impacts of munitions ingestion would be limited to the unlikely event where a marine mammal might ingest an item that subsequently becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, ingestion of munitions used during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, ingestion of munitions used during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.6.3.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities.

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 2, approximately 97,000 explosive munitions and non-explosive practice munitions considered an ingestion risk would be used during training activities annually in the Study Area. Of that total, 86,000 are non-explosive, small-caliber projectiles, and the remaining are explosive munitions, including bombs, medium- and large-caliber projectiles, missiles, and rockets, that could introduce fragments potentially small enough to be ingested by a bottom feeding marine mammal. The number of explosive munitions and non-explosive practice munitions proposed under Alternative 2 represents an increase of 57 percent over the number proposed under the No Action Alternative and is approximately equivalent to Alternative 1. All explosive bombs, missiles, rockets, and large-caliber projectiles would be used over deep, offshore waters greater than 12 nm (and in some cases greater than 50 nm) from shore. Approximately 45 percent of non-explosive, small-caliber projectiles would be expended greater than 12 nm from shore, and 98 percent of explosive medium-caliber projectiles would be expended greater than 12 nm from shore.

The number of munitions and explosive munitions fragments that an individual animal could encounter would generally be low, based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not ingest every munitions or munitions fragment it encountered, and if a munition or munitions fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. Wells et al. (2008) showed that even ingestion of certain items (e.g., hooks), if they do not become embedded in tissue, may not result in injury or mortality to the individual. Therefore, potential impacts of munitions ingestion would be limited to the unlikely event where a marine mammal might ingest an item that subsequently becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, ingestion of munitions used during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, ingestion of munitions used during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

Explosive munitions and non-explosive practice munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 2, approximately 13,000 explosive munitions and non-explosive practice munitions considered an ingestion risk would be used during testing activities annually in the Study Area. Of that total, approximately 5,000 are non-explosive small-caliber or medium-caliber projectiles, and the remaining 8,000 are explosive munitions. Eighty-eight percent of the explosive munitions are medium- and large-caliber projectiles, and the remaining 12 percent are missiles, rockets, and torpedoes.

Explosive munitions could introduce fragments potentially small enough to be ingested by a bottom-feeding marine mammal. The number of explosive munitions and non-explosive practice munitions proposed under Alternative 2 is an increase over the number proposed under the No Action Alternative, because no testing activities would use munitions under the No Action Alternative. The number of explosive munitions and non-explosive practice munitions proposed under Alternative 2 is an increase approximately 25 percent over the number proposed under Alternative 1.

The number of munitions and explosive munitions fragments that an individual animal could encounter would generally be low, based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not ingest every munitions or munitions fragment it encountered, and if a munition or munitions fragment were ingested, an animal may attempt to reject it when it realizes the item is not food. Wells et al. (2008) showed that even ingestion of certain items (e.g., hooks), if they do not become embedded in tissue, may not result in injury or mortality to the individual. Therefore, potential impacts of munitions ingestion would be limited to the unlikely event where a marine mammal might ingest an item that subsequently becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, ingestion of munitions used during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, ingestion of munitions used during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.6.4 Impacts from Military Expended Materials Other than Munitions

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), several different types of materials other than munitions are expended at sea during training and testing activities. The following military expended materials other than munitions have the potential to be ingested by bottom feeding marine mammals:

- Target-related materials
- Chaff (including fibers, end caps, and pistons)
- Flares (including end caps and pistons)
- Decelerators/Parachutes (cloth, nylon, and metal weights)

Target-Related Materials

At-sea targets are usually remotely operated airborne, surface, or subsurface traveling units, many of which are designed to be recovered for reuse. If they are severely damaged or displaced, targets may sink before they can be retrieved. Expendable targets include air-launched decoys, marine markers (smoke floats), cardboard boxes, and 10 ft. (3 m) diameter red balloons tethered by a sea anchor. Most target fragments would sink quickly in the sea. Floating material, such as Styrofoam, may be lost from target boats and remain at the surface for some time.

Chaff

Chaff is an electronic countermeasure designed to reflect radar waves and obscure aircraft, vessels, and other equipment from radar tracking sources. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (U.S. Air Force 1997). Chaff is released or dispensed in cartridges or projectiles that contain millions of chaff fibers. When deployed, a diffuse cloud of fibers undetectable to the human eye is formed. Chaff is a very light material that can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (U.S. Air Force 1997; Arfsten et al. 2002). Doppler radar has tracked chaff plumes containing approximately 900 grams of chaff drifting 200 mi. (322 km) from the point of release, with the plume covering greater than 400 mi.^{3} (1,700 km^3) (Arfsten et al. 2002).

The chaff concentrations that marine mammals could be exposed to following release of multiple cartridges (e.g., following a single day of training) is difficult to accurately estimate because it depends on several unknown factors. First, specific release points are not recorded and tend to be random, and chaff dispersion in air depends on prevailing atmospheric conditions. After falling from the air, chaff fibers would be expected to float on the sea surface for some period, depending on wave and wind action. The fibers would be dispersed further by sea currents as they float and slowly sink toward the bottom. Chaff concentrations in benthic habitats following release of a single cartridge would be lower than the values noted in this section, based on dispersion by currents and the enormous dilution capacity of the receiving waters.

Several literature reviews and controlled experiments have indicated that chaff poses little risk, except at concentrations substantially higher than those that could reasonably occur from military training (U.S. Air Force 1997; Hullar et al. 1999; Arfsten et al. 2002). Nonetheless, some marine mammal species within the Study Area could be exposed to chaff through direct body contact and ingestion. Chemical alteration of water and sediment from decomposing chaff fibers is not expected to result in exposure. Based on the dispersion characteristics of chaff, it is likely that marine mammals would occasionally come in direct contact with chaff fibers while at the water's surface and while submerged, but such contact would be inconsequential. Chaff is similar to fine human hair (U.S. Air Force 1997). Because of the flexibility and softness of chaff, external contact would not be expected to impact most wildlife (U.S. Air Force 1997), and the fibers would quickly wash off shortly after contact. Given the properties of chaff, skin irritation is not expected to be a problem (U.S. Air Force 1997). Arfsten et al. (2002), Hullar et al. (1999), and U.S. Air Force (1997) reviewed the potential effects of chaff inhalation on humans, livestock, and animals and concluded that the fibers are too large to be inhaled into the lung. The fibers are predicted to be deposited in the nose, mouth, or trachea and are either swallowed or expelled; however, these reviews did not specifically consider marine mammals.

Based on the small size of chaff fibers, it appears unlikely that marine mammals would confuse the fibers with prey or purposefully feed on chaff fibers. However, marine mammals could occasionally ingest low concentrations of chaff incidentally from the surface, water column, or seafloor. While no studies were conducted to evaluate the effects of chaff ingestion on marine mammals, the effects are expected to be negligible, based on the low concentrations that could reasonably be ingested, the small size of chaff fibers, and available data on the toxicity of chaff and aluminum. In laboratory studies conducted by the University of Delaware (Hullar et al. 1999), blue crabs and killifish were fed a food-chaff mixture daily for several weeks, and no significant mortality was observed at the highest exposure treatment. Similar results were found when chaff was added directly to exposure chambers containing filter-feeding menhaden. Histological examination indicated no damage from chaff exposures. A study on calves that were fed chaff found no evidence of digestive disturbance or other clinical symptoms (U.S. Air Force 1997).

Chaff cartridge plastic end caps and pistons would also be released into the marine environment, where they would persist for long periods and could be ingested by marine mammals. Chaff end caps and pistons sink in saltwater (Spargo 2007), which reduces the likelihood of ingestion by marine mammals at the surface or in the water column.

Flares

Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic end cap and piston (approximately 1.4 in. [3.6 cm] in diameter).

An extensive literature review and controlled experiments conducted by the U.S. Air Force demonstrated that self-protection flare use poses little risk to the environment or animals (U.S. Air Force 1997). Nonetheless, marine mammals within the vicinity of flares could be exposed to light generated by the flares. Pistons and end caps from flares would have the same impact on marine mammals as discussed under chaff cartridges. It is unlikely that marine mammals would be exposed to any chemicals that produce either flames or smoke since these components are consumed in their entirety during the burning process. Animals are unlikely to approach or get close enough to the flame to be exposed to any chemical components.

Decelerators/Parachutes

Aircraft-launched sonobuoys, lightweight torpedoes (such as the MK 46 and MK 54) and targets use nylon decelerators/parachutes ranging in size from 18 to 48 in. (46 to 122 cm) in diameter. The majority of expended decelerators/parachutes are cruciform decelerators associated with sonobuoys, which are relatively small, and have short attachment lines. Decelerators/parachutes are made up of cloth and nylon, with weights attached to the lines for rapid sinking upon impact with the water. At water impact, the decelerator/parachute assembly is expended, and it sinks away from the unit. The decelerator/parachute assembly may remain at the surface for a short time before it and its housing sink to the seafloor, where it becomes flattened (Environmental Sciences Group 2005). Some decelerators/parachutes are weighted with metal clips to hasten their descent to the seafloor.

Ingestion of a decelerator/parachute by a marine mammal at the surface or within the water column would be unlikely, since the decelerator/parachute would not be available for very long before it sinks. Once on the seafloor, if bottom currents are present, the fabric cruciform panel may temporarily billow and be available for potential ingestion by marine animals with bottom-feeding habits.

Based on the information summarized above in 3.4.4.6 (Ingestion Stressors), mysticetes found within the Study Area, with the potential exception of humpback whale and minke whale, are not expected to encounter decelerators/parachutes on the seafloor. Ingestion of decelerators/parachutes by odontocetes feeding off the bottom is unlikely. If ingestion were to occur, it would be incidental with decelerators/parachutes potentially consumed along with bottom-dwelling prey.

3.4.4.6.4.1 No Action Alternative

Training Activities

As discussed in Section 3.4.4.6 (Ingestion Stressors), under the No Action Alternative, training activities would release military expended materials other than munitions in the Study Area. Target-related material, chaff, flares, decelerators/parachutes, and their subcomponents have the potential to be ingested by a marine mammal. Although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

Under the No Action Alternative, approximately 19,700 military expended materials other than munitions would be used during training activities. Approximately 60 percent of these items are chaff and flares, all of which would be expended in deep waters beyond 12 nm from shore. The smaller items discussed here may pose a hazard to marine mammals; however, as discussed in Section 3.4.4.6.3 (Impacts from Munitions), the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event.
- The limited period of time these military expended materials would remain in the water column.
- The unlikely chance that a marine mammal might encounter and swallow these items on the sea floor, particularly given that many of these items would be expended over deep, offshore waters.
- The ability of many marine mammals to reject and not swallow non-food items incidentally ingested.

The impacts of ingesting military expended materials other than munitions would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of decelerators/parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials other than munitions during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), there are no testing activities proposed under the No Action Alternative that would use military expended materials in the Study Area.

3.4.4.6.4.2 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

As discussed in Section 3.4.4.6 (Ingestion Stressors), under Alternative 1, training activities would release military expended materials other than munitions in the Study Area. Target-related material, chaff, flares, decelerators/parachutes, and their subcomponents have the potential to be ingested by a marine mammal. Although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

Under Alternative 1, approximately 63,000 military expended materials other than munitions would be used during training activities. Approximately 80 percent of these items are chaff and flares, all of which would be expended in deep waters beyond 12 nm from shore. Overall, this would be a 220 percent increase over the number of military expended materials other than munitions proposed under the No Action Alternative.

The smaller items discussed here may pose a hazard to marine mammals; however, as discussed in Section 3.4.4.6.3 (Impacts from Munitions), the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event.
- The limited period of time these military expended materials would remain in the water column.
- The unlikely chance that a marine mammal might encounter and swallow these items on the sea floor, particularly given that many of these items would be expended over deep, offshore waters.
- The ability of many marine mammals to reject and not swallow non-food items incidentally ingested.

The impacts of ingesting military expended materials other than munitions would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of decelerators/parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials other than munitions during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.7 (Alternative 1 [Preferred Alternative]: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems), Alternative 1 consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to the location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 1, testing activities involving military expended materials other than munitions take place in the Study Area.

Under Alternative 1, approximately 3,000 military expended materials other than munitions would be used during testing activities. Approximately 60 percent of these items are decelerators/parachutes and 30 percent are chaff and flares. The remaining 10 percent are targets. The number of military expended materials used under Alternative 1 is an increase over the number proposed under the No Action Alternative, because there are no testing activities under the No Action Alternative that would use these materials.

Decelerators/parachutes, chaff, flares, and fragments from targets have the potential to be ingested by marine mammals. Although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam and other small items may float for some time before sinking.

The smaller items discussed here may pose a hazard to marine mammals; however, as discussed in Section 3.4.4.6.3 (Impacts from Munitions), the impacts from ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event.
- The limited period of time these military expended materials would remain in the water column.
- The unlikely chance that a marine mammal might encounter and swallow these items on the sea floor, particularly given that many of these items would be expended over deep, offshore waters.
- The ability of many marine mammals to reject and not swallow non-food items incidentally ingested.

The impacts of ingesting military expended materials other than munitions would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of decelerators/parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials other than munitions during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.6.4.3 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities.

As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 2, training activities would release military expended materials other than munitions in the Study Area. Target-related material, chaff, flares, decelerators/parachutes, and their subcomponents have the potential to be ingested by a marine mammal. Although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

Under Alternative 2, approximately 68,000 military expended materials other than munitions would be used during training activities. Approximately 80 percent of these items are chaff and flares, all of which would be expended in deep waters beyond 12 nm from shore. Overall, this would be a 250 percent increase over the number of military expended materials other than munitions proposed under the No Action Alternative and a 10 percent increase over Alternative 1.

The smaller items discussed here may pose a hazard to marine mammals; however, as discussed in Section 3.4.4.6.3 (Impacts from Munitions), the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event.
- The limited period of time these military expended materials would remain in the water column.
- The unlikely chance that a marine mammal might encounter and swallow these items on the sea floor, particularly given that many of these items would be expended over deep, offshore waters.
- The ability of many marine mammals to reject and not swallow non-food items incidentally ingested.

The impacts of ingesting military expended materials other than munitions would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of decelerators/parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials other than munitions during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Section 2.8 (Alternative 2: Includes Alternative 1 Plus Adjustments to the Type and Tempo of Training and Testing Activities), Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities. As discussed in Section 3.0.5.2.5 (Ingestion Stressors), under Alternative 2, testing activities involving military expended materials other than munitions take place in the Study Area.

Under Alternative 2, approximately 3,200 military expended materials other than munitions would be used during testing activities. Approximately 60 percent of these items are decelerators/parachutes and 30 percent are chaff and flares. The remaining 10 percent are targets. The number of military expended materials used under Alternative 2 is an increase over the number proposed under the No Action Alternative, because there are no testing activities under the No Action Alternative that would use these materials. The number of military expended materials proposed under Alternative 2 is an increase of approximately 10 percent over the number proposed under Alternative 1.

Decelerators/parachutes, chaff, flares, and fragments from targets have the potential to be ingested by a marine mammal. Although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam and other small items may float for some time before sinking.

The smaller items discussed here may pose a hazard to marine mammals; however, as discussed in Section 3.4.4.6.3 (Impacts from Munitions), the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event.
- The limited period of time these military expended materials would remain in the water column.
- The unlikely chance that a marine mammal might encounter and swallow these items on the sea floor, particularly given that many of these items would be expended over deep, offshore waters.
- The ability of many marine mammals to reject and not swallow non-food items incidentally ingested.

The impacts of ingesting military expended materials other than munitions would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of decelerators/parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, the use of military expended materials other than munitions during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.4.7 Secondary Stressors

This section analyzes potential impacts to marine mammals exposed to stressors indirectly through effects on habitat and prey availability from impacts associated with sediments and water quality. For the purposes of this analysis, indirect impacts to marine mammals via sediment or water that do not require trophic transfer (e.g., bioaccumulation) in order to be observed are considered here. It is important to note that the terms "indirect" and "secondary" do not imply reduced severity of environmental consequences, but instead describe how the impact may occur in an organism. Additionally, the transportation of marine mammals (the Navy's marine mammal system) in association with Force Protection and Mine Warfare events is presented to detail the lack of potential for the introduction of disease or parasites from those marine mammals to the Study Area. The potential for impacts from all of these secondary stressors are discussed below.

Stressors from military training and testing activities could pose indirect impacts to marine mammals via habitat degradation or an effect on prey availability. The stressors include (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 to sediments and water quality are discussed in Section 3.1 (Sediments and Water Quality).

3.4.4.7.1 Explosives

In addition to directly impacting marine mammals, underwater explosions could impact other species in the food web, including prey species that marine mammals feed upon. The impacts of explosions would differ depending upon the type of prey species in the area of the blast.

In addition to physical effects of an underwater blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to explosions that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals (Hanlon and Messenger 1996). The abundances of prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Alternatively, any prey species that would be directly injured or killed by the blast could draw in scavengers from the surrounding waters that would feed on those organisms, and in turn could be susceptible to becoming directly injured or killed by subsequent explosions. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting effect on prey availability or the pelagic food web would be expected.

3.4.4.7.2 Explosive Byproducts and Unexploded Ordnance

High-order explosions consume most of the explosive material, creating typical combustion products. In the case of Royal Demolition Explosive, 98 percent of the products are common seawater constituents, and the remainder is rapidly diluted below threshold effect level (Section 3.1, Sediments and Water Quality, Table 3.1-9). Explosive byproducts associated with high order detonations present no indirect stressors to marine mammals through sediment or water. However, low-order detonations and unexploded ordnance present elevated likelihood of impacts to marine mammals.

Deposition of undetonated explosive materials into the marine environment can be reasonably well estimated by the known failure and low-order detonation rates of explosives (Section 3.1, Sediments and Water Quality, Table 3.1-5). Marine mammals may be exposed by contact with the explosive, contact with contaminants in the sediment or water, and ingestion of contaminated sediments.

Indirect impacts of explosives and unexploded ordnance to marine mammals via sediment is possible in the immediate vicinity of the ordnance. Degradation of explosives proceeds through several pathways is discussed in Section 3.1.3.1 (Explosives and Explosive Byproducts). Degradation products of Royal

Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen and Lotufo 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6–12 in. (0.15–0.3 m) away from degrading ordnance, the concentrations of these compounds were not statistically distinguishable from background beyond 3–6 ft. (1–2 m) from the degrading ordnance (Section 3.1.3.1, Explosives and Explosive Byproducts). Taken together, it is possible that marine mammals could be exposed to degrading explosives, but it would be within a very small radius of the explosive (1–6 ft. [0.3–2 m]).

In 2010, an investigation of a World War II underwater munitions disposal site in Hawaii (University of Hawai'i 2010) provides information in this regard. Among the purposes of the investigation were to determine whether these munitions, which had been on the seafloor for approximately 75 years, had released constituents (including explosive components and metals) that could be detected in sediment, seawater, or marine life nearby and whether there were significant ecological differences between the dump site and a "clean" reference site. Samples analyzed showed no confirmed detection for explosives. For metals, although there were localized elevated levels of arsenic and lead in several biota samples and in the sediment adjacent to the munitions, the origin of those metals could not be definitively linked to the munitions since comparison of sediment between the clean reference site and the disposal site both had relatively little anthropogenic component, and especially in comparison to samples for ocean disposed dredge spoils sites (locations where material taken from the dredging of harbors on Oahu was disposed). Observations and data collected also did not indicate any adverse impact on the ecology of the dump site.

Given that the concentration of munitions/explosions, expended material, or devices would never exceed that of a World War II dump site in any of the proposed actions, the water quality effects from the use of munitions, expended material, or devices would be negligible and would have no long-term effect on water quality and therefore would not constitute a secondary indirect stressor for marine mammals.

3.4.4.7.3 Metals

Metals are introduced into seawater and sediments as a result of training and testing activities involving ship hulks, targets, ordnance, munitions, and other military expended materials (Section 3.1.3.2, Metals). Some metals bioaccumulate, and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals (see Section 3.3, Marine Habitats, and Section 4.0, Cumulative Impacts). Indirect impacts of metals to marine mammals via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Marine mammals may be exposed by contact with the metal, contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Concentrations of metals in sea water are orders of magnitude lower than concentrations in marine sediments. It is extremely unlikely that marine mammals would be indirectly impacted by metals via the water and few marine mammal species feed primarily on the seafloor where they would come into contact with marine sediments.

3.4.4.7.4 Chemicals

Several military training and testing activities introduce potentially harmful chemicals into the marine environment; principally, flares and propellants for rockets, missiles, and torpedoes. Properly functioning flares missiles, rockets, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment. The greatest risk to marine mammals would be from perchlorate released from flares, missile, and rockets that operationally fail. Perchlorate is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals. Marine mammals could be exposed to water containing perchlorate if in an area when and where one of these failed items occurred. However, rapid dilution would occur, and toxic concentrations are unlikely to be encountered in seawater.

3.4.4.7.5 Transmission of Marine Mammal Diseases and Parasites

The U.S. Navy deploys trained Atlantic bottlenose dolphins (*Tursiops truncatus*) and California sea lions (*Zalophus californianus*) for integrated training involving two primary mission areas; to find objects such as inert mine shapes, and to detect swimmers or other intruders around Navy facilities such as piers. When deployed, the animals are part of what the Navy refers to as Marine Mammal Systems. These Marine Mammal Systems include one or more motorized small boats, several crew members, and a trained marine mammal. Based on the standard procedures with which these systems are deployed, it is not reasonably foreseeable that use of these marine mammals systems would result in the transmission of disease or parasites to cetacea or pinniped in the Study Area based on the following.

Each trained animal is deployed under behavioral control to find the intruding swimmer or submerged object. Upon finding the 'target' of the search, the animal returns to the boat and alerts the animal handlers that an object or swimmer has been detected. In the case of a detected object, the human handlers give the animal a marker that the animal can bite onto and carry down to place near the detected object. In the case of a detected swimmer, animals are given a localization marker or leg cuff that they are trained to deploy via a pressure trigger. After deploying the localization marker or leg cuff the animal swims free of the area to return to the animal support boat. For detected objects, human divers or remote vehicles are deployed to recover the item. Swimmers that have been marked with a leg cuff are reeled-in by security support boat personnel via a line attached to the cuff.

Marine mammal systems deploy approximately 1–2 weeks before the beginning of a training exercise to allow the animals to acclimate to the local environment. There are 4–12 marine mammals involved per exercise. Systems typically participate in object detection and recovery, both participating in mine warfare events, and assisting with the recovery of inert mine shapes at the conclusion of an event. Marine Mammal Systems may also participate in port security and anti-terrorism/force protection events.

During the past 40 years, the Navy Marine Mammal Program has deployed globally. To date, there have been no known instances of deployment-associated disease transfer to or from Navy marine mammals. Navy animals are maintained under the control of animal handlers and are prevented from having sustained contact with indigenous animals.

When not engaged in the training event, Navy Marine Mammals are either housed in temporary enclosures or aboard ships involved in training exercises. All marine mammal waste is disposed of in a manner approved for the specific holding facilities. When working, sea lions are transported in boats and dolphins are transferred in boats or by swimming along-side the boat under the handler’s control. Their open-ocean time is under stimulus control and is monitored by their trainers.

Navy marine mammals receive excellent veterinarian care (per SECNAVINST 3900.41E). Appendix A, Section 8, of the Swimmer Interdiction Security System Final EIS (U.S. Department of the Navy 2009) provides an overview of the veterinary care provided for the Navy's marine mammals. Appendix B, Section 2, of the Swimmer Interdiction Security System Final EIS provides detailed information on the health screening process for communicable diseases. The following is a brief summary of the care received by all of the Navy's marine mammals:

1. Qualified veterinarians conduct routine and pre-deployment health examinations on the Navy's marine mammals; only animals determined as healthy are allowed to deploy.
2. Restaurant-quality frozen fish are fed to prevent diseases that can be caused by ingesting fresh fish (e.g., parasitic diseases).
3. Navy animals are routinely dewormed to prevent parasitic and protozoal diseases.
4. If a valid and reliable screening test is available for a regionally relevant pathogen (e.g., polymerase chain reaction assays for morbillivirus), such tests are run on appropriate animal samples to ensure that animals are not shedding these pathogens.

The Navy Marine Mammal Program routinely does the following to further mitigate the low risk of disease transmission from captive to wild marine mammals during training events:

1. Marine mammal waste is disposed of in an approved system dependent upon the animal's specific housing enclosure and location.
2. Onsite personnel are made aware of the potential for disease transfer, and report any sightings of wild marine mammals so that all personnel are alert to the presence of the animal.
3. Marine mammal handlers visually scan for indigenous marine animals, for at least 5 minutes before animals are deployed and maintain a vigilant watch while the animal is working in the water. If a wild marine mammal is seen approaching or within 100 m, the animal handler will hold the marine mammal in the boat or recall the animal immediately if the animal has already been sent on the mission.
4. The Navy obtains appropriate state agriculture and other necessary permits and strictly adheres to the conditions of the permit.

Due to the very small amount of time that the Navy marine mammals spend in the open ocean; the control that the trainers have over the animals; the collection and proper disposal of marine mammal waste; the exceptional screening and veterinarian care given to the Navy's animals; the visual monitoring for indigenous marine mammals; and an over 40-year track record with zero known incidents, there is no scientific basis to conclude that the use of Navy marine mammals during training activities would have an impact on wild marine mammals.

3.4.4.7.6 No Action Alternative, Alternative 1, and Alternative 2

Training Activities

Pursuant to the MMPA, secondary stressors from training activities under the No Action Alternative, Alternative 1, and Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, secondary stressors from training activities under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but are not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

Testing Activities

Pursuant to the MMPA, secondary stressors from testing activities under the No Action Alternative, Alternative 1, and Alternative 2 are not expected to result in Level A or Level B harassment of marine mammals.

Pursuant to the ESA, secondary stressors from testing activities under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but are not likely to adversely affect the blue whale, fin whale, humpback whale, sei whale, and sperm whale*

3.4.5 Summary of Impacts on Marine Mammals

3.4.5.1 Combined Impacts of All Stressors

As described in Section 3.0.5.4 (Resource-Specific Impacts Analysis for Multiple Stressors), 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 the analyses of each stressor in the sections above and summarized in Sections 3.4.5.3 (Marine Mammal Protection Act Determinations), and 3.4.5.4 (Endangered Species Act Determinations).

There are generally two ways that a marine mammal could be exposed to multiple stressors. The first would be if a marine mammal were exposed to multiple sources of stress from a single event or activity (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 as described in the proposed action involve multiple stressors; therefore it is likely that if a marine mammal were within the potential impact range of those activities, they may be impacted by multiple stressors simultaneously. This would be even more likely to occur during large-scale exercises or events that span a period of days or weeks (such as a sinking exercise or composite training unit exercise).

Secondly, a marine mammal could be exposed to a combination of stressors from multiple activities over the course of its life; however, combinations are unlikely to co-occur because training and testing activities are generally separated in space and time in such a way that it would be very unlikely that any individual marine mammal would be exposed to stressors from multiple activities. 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. The majority of the proposed activities are unit level. 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). Time is a factor with respect to the probability of exposure. Because most Navy stressors persist for a time shorter than or equal to the duration of the activity, the odds of exposure to combined stressors is lower than would be the case for persistent stressors. For example, strike stressors cease with the passage of the object; ingestion stressors cease (mostly) when the object settles to the seafloor. The animal would have to be present during each of the brief windows that the stressors exist.

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 strike and disturbance stressors via 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 interactions are speculative, and without data on the combination of multiple Navy stressors, the synergistic impacts from the combination of Navy stressors are difficult to predict in any meaningful way. Navy research and monitoring efforts include data collection through conducting long-term studies in areas of Navy activity, occurrence surveys over large geographic areas, biopsy of animals occurring in areas of Navy activity, and tagging studies where animals are exposed to Navy stressors. These efforts are intended to contribute to the overall understanding of what impacts may be occurring overall to animals in these areas. Starting in 2015, specific allocation of monitoring effort (research objectives, studies, and focus) within the Study Area will be included in a monitoring plan to be developed in cooperation with NMFS.

U.S. Navy-funded monitoring results from surveys conducted in the Study Area

From 2010 through December 2013, Navy-funded marine mammal surveys in the Study Area completed over 1,979 hours of on-effort visual surveys covering over 35,538 km, and resulting in the sighting of over 358 cetacean groups. Species identified included bottlenose, pan-tropical spotted, and spinner dolphins; and sperm, short-finned pilot, pygmy killer and dwarf sperm whales. Over 53,668 photographs were taken, and eight passive acoustic monitoring devices were deployed around the Mariana Islands for detecting and identifying marine mammals by their calls. Additionally, 10 satellite tags have been deployed on dolphins and small whales in the Marianas, and 189 biopsies have been collected for genetic analysis. Acoustic data analysis is ongoing on Navy and NMFS (Pacific Islands Fisheries Science Center) archived data sets.

3.4.5.2 Summary of Observations During Previous Navy Activities

Since 2006, the Navy, non-Navy marine mammal scientists, and research institutions have conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where the Navy has been and proposes to continue training and testing. Data collected from Navy monitoring, scientific research findings, and annual reports have been provided to NMFS[8] and may provide information relevant to the analysis of impacts to marine mammals for a variety of reasons, including data on species distribution, habitat use, and evaluating potential animal responses to Navy activities. Monitoring is performed using a variety of methods, including visual surveys from surface vessels and aircraft, as well as passive acoustics. Navy monitoring can generally be divided into two types of efforts: (1) collecting long-term data on distribution, abundance, and habitat use patterns within Navy activity areas; and (2) collecting data during individual training or testing activities. Navy also contributes to funding of basic research, including behavioral response studies specifically designed to determine the effects to marine mammals from the Navy's main mid-frequency surface ship anti-submarine warfare active acoustic (sonar) system.

The majority of the training and testing activities the military is proposing for the next five years are similar if not identical to activities that have been occurring in the same locations for decades. For example, the mid-frequency sonar system on the cruisers, destroyers, and frigates has the same sonar system components in the water as was first deployed in the 1970s. While the signal analysis and

[8] Navy monitoring reports are available at the Navy website, www.navymarinespeciesmonitoring.us/, and also at the NMFS website; www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

computing processes onboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed. For this reason, the history of past marine mammal observations, research, and monitoring reports remain applicable to the analysis of effects from the proposed future training and testing activities. In addition, because there is a longer (6-year) record of monitoring Navy activities in the Pacific and because there is more available science specific to the areas where Navy has historically trained and tested in waters off the California coast and Hawaii, the research and monitoring record from those areas is informative with regard to assessing the effects of military training and testing in general.

In the Mariana Islands, the first exercise-related investigation involved an aerial monitoring survey after the Valiant Shield training exercise in July 2007. That survey covered 2,352 km of linear effort. There were no reports of strandings, distressed, or injured animals during that survey effort (Mobley 2007) and stranded animals in the Mariana Islands have never been reported in association with military activities. Regular monitoring for compliance with the ESA and MMPA consultation began in 2010. Forty sightings of marine mammals were reported by Navy Lookouts aboard Navy ships within the Study Area from 2009 to 2013, as presented in the Annual Marine Species Monitoring Reports submitted to NMFS and Navy Exercise Reports (e.g., U.S. Department of the Navy 2011 and additional reports at the website cited in the reference citation and footnote below). During these observations, mainly from major training exercises, there were no reported observations of adverse reactions by marine mammals.

The Navy and NMFS determined during the permitting process that monitoring in the Study Area should focus on augmenting existing baseline data, such as the data the Navy proactively collected during the large-vessel MISTCS (Fulling et al. 2011; Norris et al. 2012), instead of focusing on exercise monitoring in Guam and the Mariana Islands. The Navy's Scientific Advisory Group (SAG) concurred with this approach, and a regional SAG meeting specific to monitoring in the MIRC was conducted in October 2011 to help shape the current monitoring plan. The monitoring plan, therefore, presently includes small vessel surveys, satellite tagging, biopsy, photo-identification, passive acoustic monitoring, and acoustic data analysis. The results from the Navy's monitoring efforts to date have been posted on the NMFS' Office of Protected Resources website as well as on the Navy's Marine Species Monitoring website.[9]

In the Mariana Islands, Navy-funded marine species monitoring has included small vessel surveys, tagging, biopsy, and photo-identification during 2010, 2011, 2012, and 2013 off Guam, Saipan, Tinian, Rota, and Aguigan, as well as the deployment of passive acoustic monitoring devices and analysis of acoustic data. The monitoring efforts in the MIRC beginning in 2013 have been adjusted using the Adaptive Management Process in coordination with NMFS to structure the monitoring plan based on scientific monitoring questions rather than metrics of effort for each monitoring methodology. In addition to the Navy-funded monitoring described above, the Navy also co-funded additional visual surveys conducted by the NMFS' Pacific Islands Fisheries Science Center from 2009 to 2013. U.S. Pacific Fleet funding in the Study Area as part of the overall Navywide funding in marine mammal research and monitoring programs was over $3.4 million from 2010 to 2013.

Navy-funded marine species surveys in the Action Area from February 2011 through December 2013 completed more than 1,979 hours of on-effort visual surveys covering over 35,538 km and resulting in the sighting of 358 marine mammal groups. Species identified included bottlenose, pan-tropical spotted, and spinner dolphins; and sperm, short-finned pilot, pygmy killer, and dwarf sperm whales. More than

[9] www.navymarinespeciesmonitoring.us

53,668 photographs were taken, and eight passive acoustic monitoring devices were deployed around the Mariana Islands for detecting and identifying marine mammals by their calls. Additionally, 10 satellite tags have been deployed on dolphins and small whales in the Marianas, and 189 biopsies have been collected for genetic analysis. Acoustic data analysis is ongoing on Navy and NMFS (Pacific Islands Fisheries Science Center) archived data sets.

The small boat surveys conducted by the Pacific Islands Fisheries Science Center around Guam and the CNMI, include: (1) surveys off Guam and Saipan from 9 February to 3 March 2010 (Oleson and Hill 2010; Ligon et al. 2011), (2) surveys off Guam from 17 February to 3 March 2011 (HDR 2011), (3) surveys off Guam and other islands in the CNMI from 26 August to 29 September 2011 (Hill et al. 2012), (4) surveys off Guam and Saipan from 15 to 29 March 2012 (HDR EOC 2012), and (5) surveys off Guam and other islands in the CNMI at various times between May and July 2012 (Hill et al. 2013). In addition, the Pacific Islands Fisheries Science Center conducted a large vessel cetacean and oceanographic survey between Honolulu and Guam and within the EEZs of Guam and CNMI from 20 January to 3 May 2010 (Oleson and Hill 2010).

Hill et al. (2013) reported 17 cetacean sightings during 11 surveys off Guam and 20 cetacean sightings over the course of 20 surveys off the CNMI. Species sighted off Guam included bottlenose dolphins, spinner dolphins, pantropical spotted dolphins, and short-finned pilot whales. During the 20 surveys within waters less than 32 nm from shore in the CNMI, 22 cetacean sightings were recorded. Seventy-two percent of sightings in waters of the CNMI occurred in the waters surrounding the islands of Saipan, Tinian, and Aguijan. However, the encounter rate around the island of Rota was greater than elsewhere in the survey area, and species sighted at Rota were in approximately the same location when they were sighted during surveys conducted in 2011, suggesting that the area is consistently used by those species. Ligon et al. (2011) reported data on sightings over a total of 16 days, 10 of which were conducted off Guam, and 6 off Saipan. The researchers reported 18 sightings consisting of three identified species: spinner dolphin, sperm whale, and pantropical spotted dolphin. The pantropical spotted dolphins were only spotted off Guam, whereas the other species were sighted off both Guam and Saipan. A survey off the western and northern coasts of Guam in February and March of 2011 recorded nine cetacean sightings consisting of seven groups of spinner dolphins, one mixed-species group of short-finned pilot whales and bottlenose dolphins, and one unidentified small dolphin (HDR 2011). The large scale survey conducted by Oleson and Hill (2010) was divided into four components: (1) a survey along a transit route from Hawaii to Guam, (2) a survey of waters around Micronesia and the CNMI, (3) a survey along a transit route from Guam to Hawaii, and (4) a small-boat survey of the waters surrounding Guam, Saipan, and Tinian. Combined, the four surveys were conducted over 62 days, spanned over 4,000 nm, reported sightings of 73 cetacean groups, compiled over 5,500 photographs, and took 13 biopsies. Hill et al. (2012) conducted small boat surveys of the waters surrounding Guam and the islands of Saipan, Tinian, Rota, and Aguijan in the CNMI. Eight cetacean groups were sighted during the nine surveys conducted off Guam. The species sighted included bottlenose dolphin, spinner dolphin, pantropical spotted dolphin, and short-finned pilot whale. Spinner dolphins were the most frequently encountered species. During the 21 surveys conducted in the CNMI waters, 30 sightings of cetacean groups were recorded. The species encountered included the same four species sighted off Guam as well as pygmy killer whales and a dwarf sperm whale. The species-specific subsections of Section 3.4.2 (Affected Environment) provide additional details on these recent surveys.

Observations from research occurring in the other Navy range complexes (e.g., HRC, SOCAL, and Atlantic Fleet Active Sonar Training [known as AFAST]) are also discussed in this section and demonstrate a continued commitment to expanding the knowledge of marine mammal occurrence and abundance in

Navy operating areas. In the Pacific, the vast majority of scientific field work, research, and monitoring efforts have been expended in Southern California and Hawaii where Navy has historically concentrated training and testing activities. Since 2006, across all Navy Range Complexes (in the Atlantic, Gulf of Mexico, and the Pacific), there have been a total of 69 reports (Major Exercise Reports, Annual Exercise Reports, and Annual Monitoring Reports; Table 3.4-26) submitted to NMFS to further research goals aimed at understanding Navy's impact on the environment as it carries out its mission to train and test. In addition to this multi-year record of reports from across the Navy, there has also been ongoing behavioral response research efforts (in Southern California and the Bahamas) specifically focused on determining the potential effects from Navy mid-frequency sonar (De Ruiter et al. 2013a, Goldbogen et al. 2013, Tyack et al. 2011). This multi-year compendium of monitoring, observation, study, and broad scientific research is informative with regard to assessing the effects of military training and testing in general. Given this record involves the same military training and testing activities being considered for the MITT Study Area and includes all the marine mammal taxonomic families present and many of the same species as those expected within the MITT Study Area, this broad record covering Navy activities elsewhere is applicable to assessing locations such as the Mariana Islands.

In the Hawaii and Southern California Navy training and testing ranges from 2009 to 2012, Navy-funded marine mammal monitoring research completed over 5,000 hours of visual survey effort covering over 65,000 nm, sighted over 256,000 individual marine mammals, took more than 45,600 digital photos and 36 hours of digital video, attached 70 satellite tracking tags to individual marine mammals, and collected over 40,000 hours of passive acoustic recordings. In Hawaii alone between 2006 and 2012, there were 21 scientific marine mammal surveys conducted before, during, or after major exercises.

Table 3.4-26: Navy Reporting of Monitoring and Major Exercises

Year Submitted	Range	Document
2006	Hawaii Range Complex	RIMPAC 06 Exercise After Action Report
2007	Mariana Islands Range Complex	Marine Mammal Monitoring Surveys in Support of "Valiant Shield" Training Exercises
	Mariana Islands Range Complex	Valiant Shield Exercise After Action Report
	Hawaii Range Complex	Undersea Warfare Training Exercise (USWEX) After Action Report
2008	Southern California Range Complex	Composite Training Unit Exercise 08-1, Oct–Nov 2007
	Hawaii Range Complex	Undersea Warfare Training Exercise (USWEX) After Action Report
	Hawaii Range Complex	Aerial Surveys of Marine Mammals Performed in Support of USWEX Exercises
	Hawaii Range Complex	RIMPAC 08 Exercise After Action Report
	Hawaii Range Complex	Marine Mammal and Sea Turtle Monitoring Survey in Support of Navy Training Exercises in the Hawaii Range Complex
	Cherry Point and Charleston/Jacksonville Operating Areas	USS Nassau Expeditionary Strike Group Composite Training Unit Exercise 08-01
2009	Southern California Range Complex	Annual Range Complex Exercise Report, January–August 2009
	Hawaii Range Complex and Southern California Range Complex	Marine Mammal Monitoring, Annual Report 2009
	Atlantic Fleet Active Sonar Training Study Area	Annual Range Complex Exercise Report, January–August 2009
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Annual Range Complex Exercise Report (Explosive Training Activities), 2009
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Marine Mammal Monitoring, Annual Report 2009
	Jacksonville Range Complex	Cruise Report, Marine Mammal Monitoring, UNITAS GOLD 2009

Table 3.4-26: Navy Reporting of Monitoring and Major Exercises (continued)

Year Submitted	Range	Document
2010	Atlantic Fleet Active Sonar Training Study Area	Marine Species Monitoring, Annual Report for 2009
	Southern California Range Complex and Hawaii Range Complex	Annual Range Complex Exercise Report, August 2009–August 2010
	Hawaii Range Complex and Southern California Range Complex	Marine Mammal Monitoring, 2010 Annual Report
	Atlantic Fleet Active Sonar Training Study Area	Annual Range Complex Exercise Report, August 2009–August 2010
	Atlantic Fleet Active Sonar Training Study Area	Marine Species Monitoring, Annual Report for 2010
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Annual Range Complex Exercise Report (Explosive Training Activities), 2010
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Marine Mammal Monitoring, Annual Report 2009
	Naval Surface Warfare Center Panama City Division Study Area	Marine Species Monitoring, Annual Report for 2010
	Naval Surface Warfare Center Panama City Division Study Area	Annual Mission Activities Report, 2010
2010	VACAPES Range Complex	Cruise Report, Marine Mammal Monitoring, Mine Neutralization Exercise Events, August 2009
	Jacksonville Range Complex	Jacksonville (JAX) Southeast Anti-Submarine Warfare Integration Training Initiative (SEASWITI) Marine Species Monitoring (2 reports: (1) Aerial Surveys and (2) Vessel) Surveys)
	Jacksonville Range Complex	Jacksonville (JAX) Gunnery Exercise (GUNEX), Marine Species Monitoring
	Jacksonville Range Complex	Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study, Southeastern Antisubmarine Warfare Integrated Training Initiative (SEASWITI), March 2010
	Jacksonville Range Complex	Jacksonville (JAX) MISSILEX, Marine Species Monitoring
	Jacksonville Range Complex	Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study, Southeastern Antisubmarine Warfare Integrated Training Initiative (SEASWITI), June 2010

Table 3.4-26: Navy Reporting of Monitoring and Major Exercises (continued)

Year Submitted	Range	Document
2011	Jacksonville Range Complex	Trip Report, FIREX Marine Mammal Monitoring
	Southern California Range Complex and Hawaii Range Complex	Annual Range Complex Exercise Report, August 2010–August 2011
	Hawaii Range Complex and Southern California Range Complex	Marine Mammal Monitoring, 2011 Annual Report
	Mariana Islands Range Complex	Annual Range Complex Exercise Report, August 2010–February 2011
	Mariana Islands Range Complex	Marine Species Monitoring, Annual Report
	Northwest Training Range Complex	Annual Range Complex Exercise Report, Year 1, November 2010–May 2011
	Northwest Training Range Complex	Annual Range Complex Monitoring Report, Year 1, November 2010–May 2011
	Atlantic Fleet Active Sonar Training Study Area	Annual Range Complex Exercise Report, August 2010–August 2011
	Atlantic Fleet Active Sonar Training Study Area	Marine Species Monitoring, Annual Report for 2011
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Annual Range Complex Exercise Report (Explosive Training Activities), 2010
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Marine Species Monitoring, Annual Report for 2010
	VACAPES Range Complex	Trip Report, Marine Mammal Monitoring, Mine Neutralization Exercise Event, August 2010
	VACAPES Range Complex	Virginia Capes (VACAPES) FIREX & ASW Training Events, Marine Species Monitoring
	VACAPES Range Complex	Virginia Capes (VACAPES) FIREX with IMPASS, Marine Species Monitoring
	VACAPES Range Complex	Virginia Capes (VACAPES) Anti-Submarine Warfare Exercise (ASWEX), Marine Species Monitoring
	Cherry Point Range Complex	Cherry Point (CHPT) Firing Exercise (FIREX) with Integrated Maritime Portable Acoustic Scoring and Simulator (IMPASS), Marine Species Monitoring
	Cherry Point Range Complex	Pamlico Sound Barge Sinking Event, Long Shoal Naval Ordnance Target and Scoring Tower Replacement, Marine Species Monitoring
	Jacksonville Range Complex	Jacksonville (JAX) Anti-Submarine Warfare Exercise (ASWEX), Marine Species Monitoring
	VACAPES Range Complex	Trip Report, Marine Mammal Monitoring, Mine Neutralization Exercise Event, Aug 2011

Table 3.4-26: Navy Reporting of Monitoring and Major Exercises (continued)

Year Submitted	Range	Document
2011	Keyport Range Complex	Annual Range Complex Exercise Report, Year 1, April 2011–September 2011
	Keyport Range Complex	Annual Range Complex Monitoring Report, Year 1, April 2011–November 2011
	Naval Surface Warfare Center Panama City Division Study Area	Marine Species Monitoring, Annual Report for 2011
	Naval Surface Warfare Center Panama City Division Study Area	Annual Mission Activities Report, 2011
	Northwest Training Range Complex	Annual Range Complex Exercise Report, Year 1, November 2010–May 2011
	Northwest Training Range Complex	Annual Range Complex Monitoring Report, Year 1, November 2010 –May 2011
	Gulf of Alaska	Annual Monitoring Report, 2011, Year 1
2012	Mariana Islands Range Complex	Annual Range Complex Exercise Report, 16 February 2011–15 February 2012
	Mariana Islands Range Complex	Marine Species Monitoring, Annual Report
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Annual Range Complex Exercise Report (Explosive Training Activities), 2011
	Virginia Capes, Jacksonville, Cherry Point, Northeast, and Gulf of Mexico Range Complexes	Marine Species Monitoring, Annual Report for 2011
	Jacksonville Range Complex	Jacksonville (JAX) Maverick Missile Exercise (MAVEX) Event, Marine Species Monitoring
	Jacksonville Range Complex	Cruise Report, Marine Mammal Monitoring, ASWEX
	Jacksonville Range Complex	Jacksonville (JAX) Firing Exercise (FIREX) with Integrated Maritime Portable Acoustic Scoring and Simulator (IMPASS), Marine Species Monitoring
	Southern California Range Complex	Marine Species Monitoring, 2012 Annual Report
	Hawaii Range Complex	Marine Species Monitoring, 2012 Annual Report
	Jacksonville Range Complex	An Analysis of Marine Acoustic Recording Unit (MARU) Data Collected off Jacksonville, Florida in Fall 2009 and Winter 2009–2010
	Northwest Training Range Complex	Annual Range Complex Unclassified Exercise Report
	Northwest Training Range Complex	Annual Range Complex Monitoring Report
	Northwest Training Range Complex	Environmental Monitoring Report, EOD/UNDET
2013	Mariana Islands Range Complex	Annual Range Complex Exercise Report, 2013
	Mariana Islands Range Complex	Marine Species Monitoring, Annual Report
	Naval Surface Warfare Center, Panama City Division	Testing AN/AQS-20A Mine Reconnaissance Sonar System in the Navy's NSWC PCD Testing Range, Marine Species Monitoring, Annual Report
2014	Mariana Islands Range Complex	Marine Species Monitoring, Annual Report
	Mariana Islands Range Complex	Annual Range Complex Exercise Report, 2014

Notes: (1) These reports are publically available at the Navy website (www.navymarinespeciesmonitoring.us/) and from the NMFS Office of Protected Resources website at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications. (2) NSWC = Naval Surface Warfare Center, PCD = Panama City Division.

The Navy has continued to review emergent science and fund research to better assess the potential impacts that may result from the continuation of ongoing training and testing in the historically used range complexes worldwide. Along with behavioral response studies and the results of research efforts and monitoring before, during, and after training and testing events across the Navy since 2006, the Navy's assessment is that it is unlikely there will be impacts to populations of marine mammals (such as whales, dolphins and porpoise) having any long-term consequences as a result of the proposed continuation of training and testing in the ocean areas historically used by the Navy including the Study Area.

This assessment of likelihood is based on four indicators from areas in the Pacific where Navy training and testing has been ongoing for decades: (1) evidence suggesting or documenting increases in the numbers of marine mammals present, (2) examples of documented presence and site fidelity of species and long-term residence by individual animals of some species, (3) use of training and testing areas for breeding and nursing activities, and (4) 6 years of comprehensive monitoring data indicating a lack of any observable effects to marine mammal populations as a result of Navy training and testing activities.[10] While there is evidence that shows increases and/or viability of marine mammal populations, there is no direct evidence from years of monitoring on Navy ranges that indicate any long-term consequences to marine mammal populations as a result of ongoing training and testing. Barring any evidence to the contrary, therefore, what limited and preliminary evidence there is from the Navy's 70 reports and other focused scientific investigations should be considered. This is especially the case given the widespread public misperception that Navy training and testing, especially involving use of mid-frequency sonar, would cause grave impacts and result in countless numbers of marine mammals being injured or killed. Examples to the contrary, which present results from studies conducted where the Navy has been training and testing for decades, can be found throughout the scientific literature.

Work by Moore and Barlow (2011) indicate that since 1991, there is strong evidence of increasing fin whale abundance in the California Current area, which includes offshore waters of the U.S. west coast up to the Canadian border. They predict continued increases in fin whale numbers over the next decade, and that perhaps fin whale densities are reaching "current ecosystem limits." Research by Falcone and Schorr (2012) suggests that fin whales may have population sub-units with higher-than-expected residency to the Southern California Bight, which includes part of the Navy's SOCAL Range Complex. Similar findings have also documented the seasonal range expansion and increasing presence of Bryde's whales south of Point Conception in Southern California (Kerosky et al. 2012; Smultea and Jefferson 2014). Findings from Smultea and Jefferson (2014) for these same waters off Southern California, including the SOCAL Range Complex, appear to show that since the 1950s, humpback whales and Risso's dolphins have increased in relative occurrence while common bottlenose and northern right whale dolphins; Dall's porpoise; and gray whales, killer whales, minke whales, Cuvier's beaked whales, and sperm whales do not appear to have changed. There is possible indication of recent decreased relative occurrence of the Pacific white-sided dolphin, and short-finned pilot whales have not been recorded in the area since the 1990s, concurrent with the observed relative increase in Risso's dolphins (Smultea and Jefferson 2014).

For the portion of the blue whale population in the Pacific (along the U.S. west coast) that includes Southern California as part of its range, there has been an upward trend in abundance (Calambokidis et

[10] Monitoring of Navy activities began in July 2006 as a requirement under issuance of an Incidental Harassment Authorization by NMFS for the Rim of the Pacific exercise and has continued to the present for Major Training Events in Hawaii, Southern California, and the Mariana Islands as well as other monitoring as part of the coordinated efforts under the Navy's Integrated Comprehensive Monitoring Plan developed in coordination with NMFS and other interested parties.

al. 2009b). Berman-Kowalewski et al. (2010) report that in 2007, the number of blue whales in the Santa Barbara Channel (just north of the Navy's SOCAL Range Complex) was at the highest count since 1992. For humpback whales that winter in the Hawaiian Islands, research has confirmed that the overall humpback whale population in the North Pacific has continued to increase and is now greater than some prior estimates of pre-whaling abundance (Barlow et al. 2011).The Hawaiian Islands, where the HRC has been located for decades, continue to function as a critical breeding, calving, and nursing area for this endangered species. National Marine Fisheries Service (2013) has recently proposed humpbacks in the North Pacific be delisted in light of strong indicators of their recovery.

As increases in population would seem to indicate, evidence for the presence or residence of marine mammal individuals and populations would also seem to suggest a lack of long-term or detrimental effects from Navy training and testing historically occurring in the same locations. For example, photographic records spanning more than two decades demonstrated there had been resightings of individual beaked whales (from two species: Cuvier's and Blainville's beaked whales), suggesting long-term site fidelity to the area west of the Island of Hawaii (McSweeney et al. 2007). This is specifically an area in the Hawaiian Islands where the Navy has been using mid-frequency sonar during anti-submarine warfare training (including relatively intense choke point or swept channel events) over many years. Passive acoustic detection of Blainsville's and Cuvier's beaked whales in waters surrounding Saipan as well as other areas of the Pacific Ocean (e.g., Wake Atoll and Palmyra Atoll) from 2005 to 2011 indicate long-term site fidelity in these areas as well (Baumann-Pickering et al. 2012). Similar findings of high site fidelity have been reported for the area west of Hawaii involving pygmy killer whales (*Feresa attenuata*) (McSweeney et al. 2009). Similarly, the intensively used instrumented range at PMRF remains the likely foraging area (given its proximity) for a resident pod of spinner dolphins that was the focus for part of the monitoring effort during the 2006 Rim of the Pacific Exercise. More recently at PMRF, Martin and Kok (2011) reported on the presence of minke whales, humpback whales, beaked whales, pilot whales, and sperm whales on or near the range during a Submarine Commander Course involving three surface ships and a submarine using mid-frequency sonar over the span of the multi-day event. The analysis showed it was possible to evaluate the behavioral response of minke whale and found there did not appear to be a significant reaction by the minke whale to the mid-frequency sonar transmissions (although overall minke calling rates were reduced during the training event). In subsequent analysis of the data set, Manzano-Roth et al. (2013) determined that beaked whales (tentatively identified as Blainville's beaked whales) continued to make foraging dives, but at reduced dive rates, at estimated distances of 13 to 52 km from active mid-frequency sonar. The animals shifted to the southern edge of the range and exhibited differences in the vocal period duration of the dive and dive rate. The estimated mean received level on the beaked whale group was 109 dB re 1 μPa)

Humpback whales are documented as the species which has received the highest sound pressure levels from training activities using U.S. Navy MFAS (i.e., at least 183 dB re 1 μPa) based upon an analysis which utilized shipboard Marine Mammal Observer sightings on 18 February 2011 (Farak et al 2011) combined with PMRF range hydrophone data (Martin and Manzano-Roth 2012). Analysis of PMRF hydrophone data for the purpose of estimating received levels on marine mammals has also been done in conjunction with satellite tagged animals (Baird et al. 2014) and aerial focal follows (i.e., when a single animal is tracked and observed; Mobley and Pacini 2013). Passive acoustic monitoring of PMRF hydrophones during Navy training for the month of February from 2011 to 2013 has shown that the number of acoustically identified minke whales is reduced during periods when MFAS is used compared to other periods of time (Martin et al. 2014, Martin et al. *in press*). Acoustic analysis has also shown that marine mammals near the sea surface can be exposed to higher estimated receive levels due to ducted sound propagation, which typically exists at PMRF. Behaviors observed during a focal follow aerial survey of a humpback whale in conjunction with estimated received levels derived from passive acoustic data are reported as a case study of a single focal follow occurring in the vicinity of MFAS (Mobley et al. 2013).

Sperm whales have been observed by marine mammal observers aboard Navy surface ships and detected by PMRF range hydrophones during Navy training events; however, MFAS was not active so no behavioural response data exists for naval training activities (Miller et al. 2012, Sivle et al. 2012). However, a sperm whale was tagged for a controlled exposure experiment during a behavioral response study at the range. The sperm whale did not appear to demonstrate obvious behavioral changes in dive pattern or production of clicks (Southall et al. 2011).

In Southern California, based on a series of surveys from 2006 to 2008 and the high number encounter rate, Falcone et al. (2009) proposed that their observations suggested the ocean basin west of San Clemente Island may be an important region for Cuvier's beaked whales. For over three decades, this ocean area west of San Clemente has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific, given the proximity to the naval installations in San Diego. Data from visual surveys documenting the presence of Cuvier's beaked whales for the ocean basin west of San Clemente Island (Falcone et al. 2009; Falcone and Schorr 2012, 2014; Smultea and Jefferson 2014) are consistent with concurrent results from passive acoustic monitoring that estimated regional Cuvier's beaked whale densities were higher than indicated by the NMFS's broad scale visual surveys for the U.S. west coast (Hildebrand and McDonald 2009). Photo identification methods in the Southern California Range Complex have identified approximately 100 individual Cuvier's beaked whales, with 40 percent having been seen in more than 1 year and with time spans between sightings of up to 7 years (Falcone and Schorr 2014). The Navy's use of the Southern California Range Complex has not precluded beaked whales from continuing to inhabit the area, nor has there been documented declines or beaked whale mortalities in the area associated with Navy training and testing activities. The long-term presence of beaked whales at the Navy range off Southern California is consistent with that for a similar Navy instrumented range (AUTEC) located off Andros Island in the Bahamas where Blainville's beaked whales (Mesoplodon densirostris) are routinely acoustically detected (see McCarthy et al. 2011, Tyack et al. 2011).

Moore and Barlow (2013) have noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. There are scientific caveats and limitations to the data used for this analysis, as well as oceanographic and species assemblage changes on the U.S. Pacific coast not thoroughly addressed. Interestingly, however, in the small portion of that area overlapping the Navy's SOCAL Range Complex, long-term residency by individual Cuvier's beaked whales and higher densities provide indications that the proposed decline noted elsewhere is not apparent where the Navy has been intensively training and testing with sonar and other systems for decades. While it is possible that a downward trend in beaked whales may have gone unnoticed at the range complex (due to a lack of survey precision) or that beaked whale densities may have been higher before the Navy began using sonar earlier in the 1900s, there are no data to suggest that beaked whale numbers have declined on the range where Navy sonar use has routinely occurred and as Moore and Barlow (2013) point out, it remains clear that the Navy range in Southern California continues to support high densities of beaked whales. Navy funding for monitoring of beaked whale and other marine species (involving visual survey, passive acoustic recording, and tagging studies) will continue in Southern California to develop additional data toward a clearer understanding of marine mammals inhabiting the Navy's range complexes.

To summarize, while the evidence covers most marine mammal taxonomic suborders, it is limited to a few species and only suggestive of the general viability of those species in intensively used Navy training and testing areas (Barlow et al. 2011; Calambokidis et al. 2009b; Falcone et al. 2009; Littnan 2011; Martin and Kok 2011; McCarthy et al. 2011; McSweeney et al. 2007; McSweeney et al. 2009; Moore and Barlow 2011; Tyack et al. 2011; Southall et al. 2012a). There is no direct evidence that routine Navy training and testing spanning decades has negatively impacted marine mammal populations at any Navy Range Complex. Although there have been a few strandings associated with use of sonar in other locations, as Ketten (2012) has recently summarized, “to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result of anthropogenic noise exposures, including sonar.” Therefore, based on the best available science (McSweeney et al. 2007; Falcone et al. 2009; McSweeney et al. 2009; Littnan 2010; Barlow et al. 2011; Martin and Kok 2011; McCarthy et al. 2011; Moore and Barlow 2011; Tyack et al. 2011; Southall et al. 2012a; Manzano-Roth et al. (2013); Smultea and Jefferson 2014), including data developed in the series of 70 reports submitted to NMFS, the Navy believes that long-term consequences for individuals or populations are unlikely to result from military training and testing activities in the MITT Study Area.

Until an incident in March 2011, there were no known incidents or records of any explosives training activity involving injury to a marine mammal. At the SSTC at Coronado, California, on average per year there are approximately 415 in-water detonations occurring during an estimated 311 training events at that location. Despite the Navy’s excellent decades-long track record, on 4 March 2011, an underwater demolition training event resulted in the known mortalities to four[11] long-beaked common dolphins. Range clearance procedures had been implemented, and there were no marine mammals in the area when the timed-fuse countdown to detonation began. Personnel moved back from the site, and just before the detonation was to occur, dolphins were observed moving into the clearance zone. Due to the danger to personnel, the Navy could not attempt to divert those animals, stop the timer, or disarm the explosive. As a result of this incident, in consultation with NMFS, the Navy modified the mitigation measures in existence when this incident occurred to prevent a reoccurrence (see Chapter 5 regarding Mine Neutralization Activities Using Diver-Placed Time-Delay Firing Devices). There are no underwater demolition training events or use of timed-fuses associated with underwater demolition proposed for the Study Area or as part of the Carrier Strike Group exercise or Sinking Exercise.

Although potential impacts to certain marine mammal species from the Proposed Action may include injury or mortality, impacts are not expected to decrease the overall fitness of any given population. In cases where potential impacts rise to the level that warrants mitigation, mitigation measures designed to reduce the potential impacts are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring).

3.4.5.3 Marine Mammal Protection Act Determinations

Pursuant to the MMPA, the Navy is seeking a 5-year Letter of Authorization from the NMFS for certain training and testing activities (the use of sonar and other acoustic sources, explosives, and vessels), as described under the Preferred Alternative (Alternative 1). The use of sonar and other active acoustic

[11] Immediately after the detonation at the Silver Strand Training Complex (Coronado, California), Navy personnel found and recovered three dead long-beaked common dolphins; they reported the incident to the Navy chain of command, who informed NMFS, and Navy then transferred the recovered animals to the local stranding network for necropsy. Three days later, a long-beaked common dolphin was discovered at Oceanside, California (approximately 40 mi. [65 km] up the coast), and another was discovered 10 days after the training event at La Jolla, California (approximately 15 mi. [45 km] from the training site). Due to the species being one which commonly strands and the number of days and distance from the event, the association of this last stranded animals with the event is not certain (see Danil and St. Leger 2011).

sources and explosives may result in Level A harassment or Level B harassment of certain marine mammals. The use of vessels may result in Level A harassment, including mortality, of certain marine mammal species.

Refer to Section 3.4.4.1 (Impacts from Sonar and Other Active Acoustic Sources) for details on the estimated impacts from sonar and other active acoustic sources, Section 3.4.4.2 (Impacts from Explosives) for details on the estimated impacts from explosives, and Section 3.4.4.4.1 (Impacts from Vessel Strikes) for details on the estimated impacts from the use of vessels in the Study Area.

Military training and testing activities producing weapons firing, launch, and impact noise; vessel noise, aircraft noise; energy emissions; and impulses from swimmer defense airguns are not expected to result in Level A or Level B harassment of any marine mammals. Military training and testing activities using in-water devices, seafloor devices, fiber optic cables and guidance wires, decelerators/parachutes, non-explosive practice munitions, and other military expended materials are not expected to result in Level A or Level B harassment of any marine mammals. Secondary stressors (impacts to habitat or prey from explosives and byproducts, metals, chemicals, and transmission of disease and parasites) are also not expected to result in Level A or Level B harassment of any marine mammals.

3.4.5.4 Endangered Species Act Determinations

The NMFS administers the ESA for marine mammals in the Study Area. The guidelines followed to make a determination of no effect; may affect, not likely to adversely affect; or may affect, likely to adversely affect can be found in the *Endangered Species Act Consultation Handbook* (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

In accordance with ESA requirements, the Navy will undertake Section 7 consultation with NMFS for the proposed activities in the MITT Study Area under Alternative 1 as the preferred alternative. Table 3.4-27 provides the determinations made for each sub-stressor and ESA-listed marine mammal species pursuant to the ESA from the analysis presented in the sections previously. There is no ESA-designated critical habitat in the Study Area.

Table 3.4-27: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 1)

Activity		Species				
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Sperm Whale
Acoustic Stressors						
Sonar and Other Active Acoustic Sources	Training Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect
	Testing Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect
Explosives	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Swimmer Defense Airguns	Testing Activities	No Effect	No Effect	No Effect	No Effect	No Effect
Weapons Firing, Launch, and Impact Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Aircraft Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.4-27: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 1) (continued)

Activity		Species				
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Sperm Whale
Vessel Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Energy Stressors						
Electromagnetic Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Physical Disturbance and Strike Stressors						
Vessels	Training Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect
	Testing Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect
In-Water Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Military Expended Materials	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.4-27: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 1) (continued)

Activity		Species				
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Sperm Whale
Seafloor Devices	Training Activities	No Effect	No Effect	No Effect	No Effect	No Effect
	Testing Activities	No Effect	No Effect	No Effect	No Effect	No Effect
Entanglement Stressors						
Fiber Optic Cables and Guidance Wires	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Decelerators/ Parachutes	Training Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect
	Testing Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect
Ingestion Stressors						
Military Expended Materials from Munitions	Training Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect
	Testing Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect
Military Expended Materials other than Munitions	Training Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect
	Testing Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect

Table 3.4-27: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 1) (continued)

Activity		Species				
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Sperm Whale
Secondary Stressors						
Secondary Stressors	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

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3.5 Sea Turtles

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3.5 SEA TURTLES

SEA TURTLES SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following have been analyzed for sea turtles:

- Acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise)
- Energy (electromagnetic devices)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices)
- Entanglement (fiber optic cables and guidance wires, and decelerators/parachutes)
- Ingestion (munitions and military expended materials other than munitions)
- Secondary (impacts associated with sediments and water quality)

Preferred Alternative (Alternative 1)[1]

- Acoustic: Pursuant to the Endangered Species Act (ESA), the use of sonar and other active acoustic sources may affect and is likely to adversely affect ESA-listed green, hawksbill, loggerhead, and leatherback sea turtles. The use of sonar and other active acoustic sources may affect but is not likely to adversely affect ESA-listed olive ridley sea turtles. The use of explosives may affect and is likely to adversely affect ESA-listed green and hawksbill sea turtles, but is not likely to adversely affect ESA-listed loggerhead, olive ridley, and leatherback sea turtles. The use of swimmer defense airguns would have no effect on ESA-listed green, hawksbill, loggerhead, olive-ridley, and leatherback sea turtles. Weapons firing, launch, and impact noise; vessel noise; and aircraft noise may affect but are not likely to adversely affect green, hawksbill, loggerhead, olive-ridley, and leatherback sea turtles.
- Energy: Pursuant to the ESA, energy sources used during training and testing activities may affect but are not likely to adversely affect the ESA-listed green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.
- Physical Disturbance and Strike: Pursuant to the ESA, physical disturbance and strike stressors may affect but are not likely to adversely affect the ESA-listed green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.
- Entanglement: Pursuant to the ESA, fiber optic cables and guidance wires, and decelerators/parachutes may affect but are not likely to adversely affect the ESA-listed green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.
- Ingestion: Pursuant to the ESA, the potential for ingestion of munitions and military expended materials other than munitions may affect but are not likely to adversely affect the ESA-listed green, hawksbill, loggerhead, olive ridley and leatherback sea turtles.
- Secondary: Pursuant to the ESA, secondary stressors would not affect sea turtles because changes in sediments and water quality from explosives, explosive byproducts and unexploded ordnance, metals, and chemicals are not likely to be detectable, and no detectable changes in growth, survival, propagation, or population-levels of sea turtles are anticipated.

[1]There is no critical habitat for any of the five listed sea turtles in the Study Area.

3.5.1 INTRODUCTION

This section analyzes potential impacts on sea turtles found in the Mariana Islands Training and Testing (MITT) Study Area (Study Area). Table 3.5-1 introduces the species presented in this analysis. Section 3.5.2 (Affected Environment) describes the affected environment. The analysis and summary of potential impacts of the Proposed Action are provided in Sections 3.5.3 (Environmental Consequences) and 3.5.4 (Summary of Impacts on Sea Turtles).

The status of sea turtle populations is determined primarily from assessments of the adult female nesting population. Much less is known about other life stages of these species. The National Research Council (National Research Council 2010) recently reviewed the current state of sea turtle research, and concluded that relying too much on nesting beach data limits a more complete understanding of sea turtles and the evaluation of management options for their overall health and recovery.

The five sea turtle species potentially found in the MITT Study Area are listed under the Endangered Species Act (ESA) as endangered or threatened. Section 3.0 discusses the regulatory framework of the ESA. The status, presence, and nesting occurrence of sea turtles in the MITT Study Area are listed by region in Table 3.5-1. There is no critical habitat for any of the five listed sea turtles in the Study Area.

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, 7]	
Common Name	**Scientific Name**	**Endangered Species Act Status**	**Open Ocean/Transit Corridor**	**Coastal**
Family Cheloniidae (hard-shelled sea turtles)				
Green sea turtle	*Chelonia mydas*	Endangered/ Threatened[2]	Yes	Yes[5]
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	Yes	Yes[5]
Loggerhead sea turtle	*Caretta caretta*	Endangered/ Threatened[3]	Yes[6]	Yes[6]
Olive ridley sea turtle	*Lepidochelys olivacea*	Endangered/ Threatened[4]	Yes[6]	Yes[6]
Family Dermochelyidae (leatherback sea turtle)				
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	Yes[6]	Yes[6]

[1] MITT Study Area = Mariana Islands Training and Testing Study Area

[2] Breeding populations of green sea turtles in Florida and 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] The Northeast Atlantic Ocean, Mediterranean Sea, North Indian Ocean, North Pacific Ocean, and South Pacific Ocean Distinct Population Segments are listed as Endangered, and the Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean and Southwest Indian Ocean Distinct Population Segments are listed as threatened.

[4] Breeding populations of olive ridley 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.

[5] Indicates nesting activity within the Study Area. Only green sea turtles and hawksbill sea turtles are known to nest in the Study Area.

[6] Species occurrence is only expected during migratory movements through the MITT Study Area and therefore may be present, albeit at extremely low densities.

[7] Occurrence designations from the Marine Species Density Report (U.S. Department of the Navy 2012).

3.5.2 AFFECTED ENVIRONMENT

Sea turtles are highly migratory, and are present in coastal and open ocean waters of the Study Area. Most sea turtles generally inhabit tropical and temperate waters because they are poikilothermic, which means their internal temperature varies with the environment and they need a warm environment to help maintain body temperature. Leatherbacks are the exception, and are more likely to be found in colder waters at higher latitudes because of their unique ability to maintain an internal body temperature higher than that of the environment (Dutton 2006). Habitat use varies among species and within the life stages of individual species, correlating primarily with the distribution of preferred food sources, as well as the locations of nesting beaches.

Sea turtles use a variety of mechanisms and environmental cues to guide their movements on land and at sea (Lohmann and Lohmann 1996b; Lohmann et al. 1997; Putnam et al. 2011). Hatchlings are strongly attracted to light (Witherington and Bjorndal 1991), and use light wavelengths and shape patterns to find the ocean after emerging from the nest (Lohmann et al. 1997; Witherington 1992). Once in the ocean, hatchlings use wave energy to navigate offshore (Lohmann and Lohmann 1992). In the open ocean, turtles determine their position and direction by using the earth's magnetic field as a "magnetic map"; this map helps them locate seasonal feeding and breeding grounds and return to the beaches where they were born to nest (Fuxjager et al. 2011; Lohmann and Lohmann 2006; Lohmann et al. 1997). The stimuli that help sea turtles find their nesting beaches are still poorly understood, particularly the fine-scale navigation that occurs as turtles approach the site, and could also include chemical and acoustic cues.

Sea turtles produce large numbers of offspring as an evolutionary response to environmental variability, lack of parental care, and high levels of egg and hatchling mortality. Death is presumed to be highest during this phase of development, due to predation of eggs and hatchlings and because of ocean currents that sweep hatchlings into waters too cold for their survival (Conant et al. 2009). Depending on the species, open-ocean juveniles can spend 2–14 years drifting, foraging, and developing. The post-hatchling and early juvenile period has been described as "the lost years" because of a general lack of information about this part of their life history (Witham 1980) during which the turtles remain in oceanic waters, are free floating and opportunistically consume epipelagic prey (McClellan and Read 2007, Carr 1987, Bjorndal et al. 2000). Older juveniles remain in the open ocean, but are active feeders.

After this open ocean juvenile phase, hawksbill, loggerhead, and green sea turtles settle into coastal habitats, and are dedicated to a specific home range until adulthood (McClellan and Read 2007, Bjorndal and Bolten 1988, National Marine Fisheries Service and U.S. Fish and Wildlife Service 1991) Leatherback and olive ridley turtles are thought to remain primarily in the open ocean throughout their lives, except for when mating in coastal waters and when females come ashore to lay eggs. Adults of all species have the ability to migrate long distances across large expanses of the open ocean, primarily between nesting and feeding grounds.

Survival rates are believed to be highest during the adult stage because these turtles can protect themselves more effectively from predators; juveniles, while still at risk from predators and fishery interactions, are at less risk than hatchlings as they are generally not at risk from land-based and nearshore sources of mortality due to their open ocean use at the juvenile stage (Conant et al. 2009).

3.5.2.1 Diving

Sea turtle dive depth and duration varies by species, the age of the animal, the location of the animal, and the activity (foraging, resting, and migrating). The diving behavior of a particular species or individual has implications for our ability to detect them for mitigation and monitoring. 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.

3.5.2.1.1 Green Sea Turtle

Four Pacific Ocean studies (Brill et al. 1995; Hatase et al. 2006; I-Jiunn 2009; Rice and Balazs 2008) and one Atlantic study (Hays et al. 2000) assessed green turtle diving ability. Additional studies have been performed in the Galapagos (Seminoff et al. 2008), Brazil (Godley et al. 2008), Caribbean (Blumenthal et al. 2006), and Mediterranean (Godley et al. 2002). In the open ocean, Hatase et al. (2006) observed that green turtles dove to a maximum of 265 feet (ft.) (80.8 meters [m]), although typically no greater than 131 ft. (39.9 m). Green turtles migrating between the northwestern and main Hawaiian Islands reached a maximum depth greater than 445 ft. (135.6 m) at night (the deepest dives ever recorded for a green turtle) with a mean maximum night dive depth of 115 to 164 ft. (35 to 50 m) but only 14.1 ft. (4.3 m) during the day (Rice and Balazs 2008). In their coastal habitat, green turtles typically make dives shallower than 100 ft. (30.5 m) (Godley et al. 2002, Hatase et al. 2006, Hays et al. 2000, Hochscheid et al. 2005) and often do not exceed 55 ft. (16.8 m) (Hays et al. 2000; Rice and Balazs 2008), although they are known to feed and rest at depths of 65 to 165 ft. (19.8 to 50.3 m) (Balazs 1980; Brill et al. 1995).

Green turtle resting dives (i.e., more than 90 percent of dive time spent at maximum depth) can exceed 3.5 hours (Rice and Balazs 2008), but are generally less than 1 hour (I-Jiunn 2009). Feeding dives are shorter, with maximum durations of just over an hour, and average durations up to 30 minutes (Brill et al. 1995; I-Jiunn 2009).

3.5.2.1.2 Hawksbill Sea Turtle

Hawksbill foraging dive durations are often a function of turtle size, with larger turtles diving deeper and longer. Shorter and more active foraging dives occur predominantly during the day, while longer resting dives occur at night (Blumenthal et al. 2009; Storch et al. 2005; van Dam and Diez 1996). Lutcavage and Lutz (1997) cited a maximum dive duration of 73.5 minutes for a female hawksbill in the United States (U.S.) Virgin Islands. Van Dam and Diez (1996) reported foraging dives at a study site in the northern Caribbean ranged from 19 to 26 minutes at depths of 26.3 to 32.8 ft. (8.02 to 9.9 m), with resting night dives from 35 to 47 minutes. Foraging dives of immature hawksbills are shorter, ranging from 8.6 to 14.0 minutes, with a mean and maximum depth of 16.4 and 65.6 ft. (4.9 and 19.9 m), respectively (van Dam and Diez 1996). Blumenthal et al. (2009) reported consistent diving characteristics for juvenile hawksbill in the Cayman Islands, with an average daytime dive depth of 25 ft. (7.6 m) and a maximum depth of 140 ft. (42.7 m) and a mean nighttime dive depth of 15 ft. (4.6 m). A change in water temperature affects dive duration; cooler water temperatures in the winter result in increased nighttime dive durations (Storch et al. 2005).

3.5.2.1.3 Loggerhead Sea Turtle

Studies of loggerhead diving behavior indicate varying mean depths and surface intervals, depending on whether they were located in shallow coastal waters (short surface intervals) or in deeper, offshore areas (longer surface intervals) (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009). Loggerhead diving behavior has been investigated in the Mediterranean (Godley et al. 2003, Casale et al. 2012) and the Caribbean (Blumenthal et al. 2006). Loggerhead turtles foraging in the nearshore habitat dive to the seafloor (average depth 165 to 490 ft. [50.3 to 149.4 m]) and those in the open-ocean habitat dive in the 0 to 80 ft. (0 to 24.4 m) depth range (Hatase et al. 2007). Dive duration was significantly longer at night and increased in warmer waters. Loggerhead turtles dived for longer and became more quiescent at lower temperatures, but as long as temperatures were above 10 degrees Celsius (°C), they retained their ability to move to another place or even to forage when they had the opportunity (Hochscheid et al. 2007).The average overall dive duration was 25 minutes, although dives exceeding 300 minutes were recorded. Turtles in the open-ocean habitat exhibited mid-water resting dives at around 45 ft. (13.7 m), where they could remain for many hours. This appears to be the main function of many of the night dives recorded (Hatase et al. 2007). Another study on coastal foraging loggerheads by Sakamoto et al. (1993) found that virtually all dives were shallower than 100 ft. (30.5 m).

Satellite telemetry data from 17 juvenile loggerhead turtles showed that turtles spent more than 80 percent of their time at depths less than 5 m, and more than 90 percent of their time at depths less than 15 m (Howell et al. 2010). Hawkes et al. (2007) noted that loggerhead turtles spent most of the time diving at depths less than 164 ft. (50 m) in depth. On average, loggerhead turtles spend over 90 percent of their time underwater (Renaud and Carpenter 1994). Studies investigating dive characteristics of loggerheads under various conditions confirm that loggerheads do not dive particularly deep in the open-ocean environment (approximately 80 ft. [24.4 m]) but will forage to bottom depths of at least 490 ft. (149.4 m) in coastal habitats (Hatase et al. 2007; Polovina et al. 2003).

3.5.2.1.4 Olive Ridley Sea Turtle

Most studies on olive ridley diving behavior have been conducted in shallow coastal waters (Beavers and Cassano 1996; Sakamoto et al. 1993); however, Polovina et al. (2003) radio tracked two olive ridleys (and two loggerheads) caught in commercial fisheries. The results show that the olive ridleys dove deeper than loggerheads, but spent only about 10 percent of time at depth deeper than 100 ft. (30.5 m). Daily dives of 656.2 ft. (200 m) occurred, with one dive recorded at 833.3 ft. (254 m) (Polovina et al. 2003). The deeper-dive distribution of olive ridleys is also consistent with their oceanic habitat, which differs from the loggerhead habitat. Olive ridleys are found south of the loggerhead habitat in the central portion of the subtropical gyre. The oceanography of this region is characterized by a warm surface layer with a deep thermocline depth and an absence of strong horizontal temperature gradients and physical or biological fronts (Polovina et al. 2003).

3.5.2.1.5 Leatherback Sea Turtle

The leatherback is the deepest diving sea turtle, with a recorded maximum depth of 4,200 ft. (1,280 m), although most dives are much shallower (usually less than 820 ft. [250 m]) (Doyle et al. 2008, Dodge et al. 2014, Houghton et al. 2008, Hays et al. 2004a, Sale et al. 2006). Leatherbacks are also capable of diving for a longer time than any other sea turtles species. The longest recorded dive time is 86.5 minutes, during which the turtle dove to a depth of 3,891 ft. (1,186 m) (López-Mendilaharsu et al. 2009). Diving activity (including surface time) is influenced by a suite of environmental factors (i.e., water temperature, availability and vertical distribution of food resources, bathymetry) that result in spatial and temporal variations in dive behavior (James et al. 2006, Sale et al. 2006). Leatherbacks dive deeper and longer in the lower latitudes versus the higher latitudes (James et al. 2005), where they are known to dive in waters with temperatures just above freezing (James et al. 2006, Jonsen et al. 2007). James et al. (2006) noted that dives in higher latitudes are punctuated by longer surface intervals and more time at the surface, perhaps in part to thermoregulate (i.e., bask). Tagging data also revealed that changes in individual turtle diving activity appear to be related to water temperature, suggesting an influence of seasonal prey availability on diving behavior (Hays et al. 2004a). While transiting, leatherbacks make longer and deeper dives (James et al. 2006, Jonsen et al. 2007). It is suggested that leatherbacks make scouting dives while transiting as an efficient means for sampling prey density and perhaps also to feed opportunistically at these times (James et al. 2006, Jonsen et al. 2007). In the Atlantic, Hays et al.

(2004b) determined that migrating and foraging adult leatherbacks spent 71 to 94 percent of their diving time at depths from 230 to 361 ft. (70.1 to 110 m).

In their warm-water nesting habitats, dives are likely constrained by bathymetry adjacent to nesting sites during this time (Myers and Hays 2006). For example, patterns of relatively deep diving are recorded off St. Croix in the Caribbean (Eckert et al. 1986) and Grenada (Myers and Hays 2006) in areas where deep waters are close to shore. A maximum depth of 1,560 ft. (475.5 m) was recorded by Eckert (Eckert et al. 1986), although even deeper dives were inferred where dives exceeded the maximum range of the time depth recorder (Eckert S. et al. 1989). Shallow diving occurs where shallow water is close to the nesting beach in areas such as the China Sea (Eckert et al. 1996, Chan et al. 2007), Costa Rica (Southwood et al. 1999), and French Guiana (Fossette et al. 2007). Studies of leatherback diving during their internesting periods (i.e., time intervals spent at sea between consecutive nesting events) in the Eastern Pacific show shallower maximum dive depths than in other areas where deeper water is available (Wallace et al. 2005).

3.5.2.2 Hearing and Vocalization

The auditory system of the sea turtle appears to work via water and bone conduction, with lower frequency sound conducted through to skull and shell, or via direct stimulation of the tympanum (Christensen-Dalsgaard et al. 2012).The water and bone conduction does not appear to function well for hearing in air (Lenhardt et al. 1983), though recent research has shown that sea turtles are capable of hearing in air, and although it is difficult to compare aerial and underwater thresholds directly, frequencies of sensitivity are similar for several species tested (Dow Piniak et al. 2011, 2012a, 2012b).

Sea turtles do not have external ears or ear canals to channel sound to the middle ear, nor do they have a specialized eardrum. Instead, fibrous and fatty tissue layers on the side of the head may serve as the sound receiving membrane in the sea turtle (Ketten 2008), a function similar to that of the eardrum in mammals, or may serve to release energy received via bone conduction (Lenhardt et al. 1983). Sound is transmitted to the air-filled middle ear where sound waves cause movement of cartilaginous and bony structures that interact with the inner ear (Ridgway et al. 1969). Unlike mammals, the cochlea of the sea turtle is not elongated and coiled and likely does not respond well to high frequencies, a hypothesis supported by a limited amount of information on sea turtle auditory sensitivity (Martin et al. 2012; Lavender et al. 2011; Dow Piniak et al. 2011, 2012a, 2012b; Bartol et al. 1999; Ridgway et al. 1969).

Investigations suggest that sea turtle auditory sensitivity is limited to low-frequency bandwidths (< 1,000 Hertz [Hz]), such as the sounds of waves breaking on a beach. The role of underwater low-frequency hearing in sea turtles is unclear. It has been suggested that sea turtles may use acoustic signals from their environment as navigational cues during migration and to identify their natal beaches (Lenhardt et al. 1983) or to locate prey or avoid predators.

Recent work using auditory evoked potentials have shown that hawksbill sea turtles are able to detect sounds in both air and water. However, ranges of maximum sensitivity and thresholds differed between the two media, though in general, sensitivities were higher at frequencies below 1,000 Hz (Dow Piniak et al. 2011, 2012b).

Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol 1999, Ridgway 1969, Lenhardt 1994, Bartol and Ketten 2006, Lenhardt 2002). Hearing below 80 Hz is less sensitive but still potentially usable (Lenhardt 1994). Greatest sensitivities are from 300 to 400 Hz for the green sea turtle (Ridgway 1969) and around 250 Hz or below for juvenile loggerheads (Bartol 1999). Bartol et al. (1999) reported that the range of effective hearing for juvenile loggerhead sea turtles is from at least 250 to 750 Hz using the auditory brainstem response technique. Juvenile and sub-adult green sea turtles detect sounds from 100 to 500 Hz underwater, with maximum sensitivity at 200 and 400 Hz (Bartol and Ketten 2006). Auditory brainstem response recordings on green sea turtles showed a peak response at 300 Hz (Yudhana et al. 2010). Juvenile Kemp's ridley turtles detected underwater sounds from 100 to 500 Hz, with a maximum sensitivity between 100 and 200 Hz (Bartol and Ketten 2006). Recent work using auditory evoked potentials has shown that leatherback sea turtles are able to detect sounds in both air and water. However, ranges of maximum sensitivity and thresholds differed between the two media—between 50 and 1,200 Hz in water and 50 and 1,600 Hz in air, with maximum sensitivity between 100 and 400 Hz in water and 50 and 400 Hz in air, and sharp decreases in sensitivity above 400 Hz in both media (Dow Piniak et al. 2012a).

Sub-adult green sea turtles show, on average, the lowest hearing threshold at 300 Hz (93 decibels [dB] referenced to [re] 1 micropascal [µPa]), with thresholds increasing at frequencies above and below 300 Hz, when thresholds were determined by auditory brainstem response (Bartol and Ketten 2006). Auditory brainstem response testing was also used to detect thresholds for juvenile green sea turtles (lowest threshold 93 dB re 1 µPa at 600 Hz) and juvenile Kemp's ridley sea turtles (thresholds above 110 dB re 1 µPa across hearing range) (Bartol and Ketten 2006). Auditory thresholds for yearling and 2-year-old loggerhead sea turtles were also recorded. Both yearling and 2-year-old loggerhead sea turtles had the lowest hearing threshold at 500 Hz (yearling: approximately 81 dB re 1 µPa; 2-year-olds: approximately 86 dB re 1 µPa), with thresholds increasing rapidly above and below that frequency (Bartol and Ketten 2006). In terms of sound production, nesting leatherback turtles were recorded producing sounds (sighs or belch-like sounds) up to 1,200 Hz with most energy ranging from 300 to 500 Hz (Bartol and Ketten 2006).

Popper et al. (2014) summarized in a technical report the outcome of a working group session that evaluated the sound detection capabilities for a wide range of sea turtles and fishes, which were organized into broad groups based on how they detect sound. The technical report presents sound exposure guidelines for assessing how a variety of natural and anthropogenic sound sources may affect fish and sea turtle species.

In terms of sound production, nesting leatherback turtles have been recorded producing sounds (sighs or belch-like sounds) up to 1,200 Hz with most energy ranging from 300 to 500 Hz (Cook and Forrest 2005). These noises are guttural exhalations made during the nesting process; turtles do not make audible sounds for communication, navigation, or foraging (as in marine mammals).

3.5.2.3 General Threats

While each of the sea turtle species in the MITT Study Area have unique life histories and habitats, threats are common among all species. On beaches, wild dogs, pigs, and other animals destroy sea turtle nests. Humans continue to harvest eggs and nesting females in some parts of the world, threatening some Pacific Ocean sea turtle populations (Maison et al. 2010). Coastal development can cause beach erosion and introduce non-native vegetation, leading to a subsequent loss of nesting habitat. It can also introduce or increase the intensity of artificial light, which can impact nesting behavior of adult females or confuse hatchlings and lead them away from the water, thereby increasing the chances of hatchling mortality. Threats in nearshore foraging habitats include fishing activities and habitat degradation. Fishing activities can injure turtles via hooks and lines or drown juvenile and adult sea turtles, because they are prone to becoming entangled in fishing gear and nets. Habitat degradation issues such as poor water quality, invasive species, and disease can alter ecosystems, limiting the availability of food and altering survival rates (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998a, b, c, d, e, f).

Bycatch in commercial fisheries, ship strikes, and marine debris are the primary, human related threats in the offshore environment (Lutcavage and Lutz 1997). One comprehensive study estimated that, worldwide, approximately 85,000 turtles were taken between the years of 1990 and 2008 from bycatch in commercial fisheries (Wallace et al. 2010). However, due to the small percentage of fishing effort observed and reported (typically < 1 percent of total fleets), and to a global lack of bycatch information from small-scale fisheries, this likely underestimates the true total by at least two orders of magnitude. Precise data are lacking for sea turtle mortalities directly caused by ship strikes; however, live and dead turtles are often found with deep cuts and fractures indicative of collision with a boat hull or propeller (Hazel et al. 2007; Lutcavage and Lutz 1997). Marine debris can also be a problem for sea turtles through entanglement or ingestion. Sea turtles can mistake plastic bags for jellyfish, which are eaten by many turtle species in early life phases, and exclusively by leatherback turtles throughout their lives. One study found plastic in 37 percent of dead leatherbacks and determined that 9 percent of those deaths were a direct result of plastic ingestion (Mrosovsky et al. 2009). Other marine debris, including derelict fishing gear and cargo nets, can entangle and drown turtles of all life stages. In studying ingestion in 115 green and hawksbill sea turtles stranded in Queensland, Schuyler et al. (2012) found that the probability of debris ingestion was inversely correlated with size (curved carapace length), and when broken down into size classes, smaller pelagic turtles were significantly more likely to ingest debris than larger benthic feeding turtles.

Global climate change trends, with predictions of increased ocean and air temperatures, showing increasing acidification of oceans, and sea level rise, may adversely impact turtles in all life stages Schofield et al. 2010, Witt et al. 2010, Hawkes et al. 2009, Poloczanska et al. 2009, Fuentes et al. 2011). Effects include embryo deaths caused by high nest temperatures, skewed sex ratios because of increased sand temperature, loss of nesting habitat to beach erosion, coastal habitat degradation (e.g., coral bleaching), and alteration of the marine food web, which can decrease the availability of prey species. Each sea turtle recovery plan has detailed descriptions of threats in the nesting and marine environment, ranking the seriousness of threats in each of the U.S. Pacific coast states and territories (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998a, b, c, d, e, f). See Chapter 4 (Cumulative Impacts) for further descriptions of threats to sea turtles and ongoing conservation concerns.

3.5.2.4 Green Sea Turtle (*Chelonia mydas*)

3.5.2.4.1 Status and Management

Green turtles are classified as threatened under the ESA throughout their Pacific range, except for the population that nests on the Pacific coast of Mexico (identified by the National Marine Fisheries Service [NMFS] and U.S. Fish and Wildlife Service [USFWS] [1998b] as *[C. m.] agassizii*), which is classified as endangered. There is no critical habitat for the green sea turtle in the Study Area.

3.5.2.4.2 Habitat and Geographic Range

The green turtle is distributed worldwide across tropical and subtropical coastal waters between 45° North (N) and 40° South (S) (State of the World's Sea Turtles 2012). Major nesting beaches are found throughout the western and eastern Atlantic, Indian, and western Pacific Oceans, and are found in more than 80 countries worldwide (Hirth 1997). Green turtles nest on beaches of the Mariana Islands, and feed and migrate throughout all waters of the Study Area.

Green turtle eggs incubate in the sand for approximately 48 to 70 days. Green turtle hatchlings are 2 inches (in.) (5.08 centimeters [cm]) long, and weigh approximately 1 ounce (oz.) (28.3 grams [g]).

3.5.2.4.2.1 Open Ocean

When they leave the nesting beach, hatchlings begin an oceanic phase (Carr 1987), floating passively in current systems (gyres), where they develop (Carr and Meylan 1980). Post-hatchlings live at the surface in the open ocean for approximately 1 to 3 years (Hirth 1997). Reich et al. (2007) used stable isotope analyses to demonstrate recruitment of oceanic juvenile green turtles to neritic habitats (in the western Atlantic) at around 3 years of age. Upon reaching the juvenile stage (estimated at 5 to 6 years and shell length of 8 to 10 in. [20.3 to 25.4 cm]), they actively move to lagoons and coastal areas that are rich in seagrass and algae (Bresette et al. 2006; Musick and Limpus 1997; Limpus 2008). The optimal habitats for late juveniles and adults are warm, quiet, and shallow (10 to 33 ft. [3.05 to 10.1 m]) waters, with seagrasses and algae that are near reefs or rocky areas used for resting (Makowski et al. 2006). This habitat is where they will spend most of their lives (Bjorndal and Bolten 1988; Makowski et al. 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 1991). A small number of green turtles appear to remain in the open ocean for extended periods, perhaps never moving to coastal feeding sites, though the reasons for this behavior is not yet understood (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a; Pelletier et al. 2003).

Green turtles are highly migratory throughout their lives. They may travel thousands of kilometers (km) between their juvenile developmental grounds and adult breeding and nesting grounds (Mortimer and Portier 1989). When they reach sexual maturity, green turtles begin migrating regularly between feeding grounds and nesting areas every few years (Hirth 1997). Green turtles are estimated to reach sexual maturity at between 20 and 50 years. This prolonged time to maturity has been attributed to their low energy plant diet (Bjorndal 1995) and may be the highest age for maturity of all sea turtle species (Limpus 2008, Chaloupka and Musick 1997, Hirth 1997, National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a). Once mature, green turtles may reproduce for 17 to 23 years (Carr et al. 1978). Both males and females migrate, typically along coastal routes from breeding areas to feeding grounds, although some populations migrate thousands of kilometers across entire oceans (Carr 1986, 1987; Mortimer and Portier 1989). Following nesting migrations, green turtles often return to the same feeding areas (Godley et al. 2002; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a) where they have specific home ranges and movement patterns (Seminoff et al. 2002). Sea turtle tagging successfully began in 2013 under the monitoring program and preliminary results are within the U.S. Department of the Navy's (Navy's) 2014 annual report to NMFS.

3.5.2.4.2.2 Coastal

Green sea turtles return to their nesting (natal) beaches to nest every 2 to 5 years (Hirth 1997). This irregular pattern can cause wide year-to-year changes in numbers of nesting females at a given nesting beach. Each female nests between three and five times per season, laying an average of 115 eggs in each nest. Based on an average of three nests per season and 100 eggs per nest, a single adult female may deposit 9 to 33 clutches (900 to 3,300 eggs) during her lifetime (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b). The number of eggs per clutch is a function of when in the season it is laid. Larger clutches tend to be laid in the early part of the breeding season (Limpus 2008).

On Navy lands on Guam, the beach with the highest nesting abundance is Apra Harbor's Spanish Steps, which is closed for most of the year because of explosive safety arcs from Kilo Wharf. Green sea turtle nesting activity was also found at Adotgan Dangkolo on Orote Peninsula. Haputo Beach, Naval Base Guam Telecommunications Site, is an occasional nesting location with "extensive" foraging use within the Haputo embayment. On Andersen Air Force Base, the Division of Aquatic and Wildlife Resources has monitored sea turtle nesting activity on the 26 miles (mi.) (42 km) of shoreline that make up Andersen Air Force Base beaches since 1984. Nesting at Andersen Air Force Base occurs along the northern shoreline. Nesting surveys have indicated that adult green turtles utilize most, if not all, of the limited beaches on Tinian for nesting. The beaches that are most often utilized are Unai Dankulo (Long Beach), Unai Barcinas, Unai Leprosarium, and Unai Lamlam (U.S. Department of the Navy 2010).

3.5.2.4.3 Population and Abundance

Based on data from 46 nesting sites around the world, between 108,761 and 150,521 female green sea turtles nest each year (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a), which is a 48 to 65 percent decline in the number of females nesting annually (based on a simple linear regression rather than historical abundance observations) over the past 100 to 150 years (Seminoff and Marine Turtle Specialist Group Green Turtle Task Force 2004). At least 189 nesting sites are scattered across the western Pacific Ocean, with an estimated 22,800 to 42,580 females nesting in the Pacific Ocean each year (Maison et al. 2010; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a).

Data from 32 green turtle nesting sites throughout the nesting range estimated that over the last three generations (spanning approximately 130 years), female green turtles have declined globally by 48 to 67 percent (Seminoff and Marine Turtle Specialist Group Green Turtle Task Force 2004). However, and in contrast, many green turtle nesting populations are actually on the increase as a result of direct conservation action and are not under threat of extinction. Chaloupka et al. (2008a) provides evidence of increasing population trends in four major green turtle nesting populations in the Pacific that have been increasing over the past 25 years (Hawaii, USA; Raine Island and Heron Island, Australia; and Ogawasara Islands, Japan). Tiwari et al. (2010) provide information on nesting data in the Main Hawaiian Islands that also support the increasing population trend. Historically, the Philippines (Turtle Islands) and Turtle Islands Park of Sabah, Malaysia are two of the most important insular nesting colonies in Southeast Asia (Seminoff and Marine Turtle Specialist Group Green Turtle Task Force 2004). There is evidence to suggest that green turtle populations nesting in Sabah are stable or increasing, with trends from 1993 to 2001 showing a continued upward trend (Bastinal 2002; Seminoff and Marine Turtle Specialist Group Green Turtle Task Force 2004). Nesting in the Philippines has declined over time, although there are over 3,000 nesting females per year (Seminoff and Marine Turtle Specialist Group Green Turtle Task Force 2004). Additionally, there appears to be a robust green turtle nesting population in Yap State, Federated States of Micronesia with a total of 888 individual nesting green turtles tagged on Gielop Island between 2005 and 2007 (Maison et al. 2010). It is important to note, however, that increases in population abundance at individual nesting sites do not necessarily reflect population-level increases in abundance.

Green turtles are by far the most abundant sea turtle found throughout the Marianas archipelago. At least 189 nesting sites are scattered across the western Pacific Ocean, with an estimated 22,800–42,580 females nesting in the Pacific Ocean each year (Maison et al. 2010; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a). Long-term information regarding nesting population trends in Guam or Commonwealth of the Northern Mariana Islands is not available. There is, however, indication that the Marianas may provide more important foraging nearshore habitat than nesting (Kolinski et al.

2001; Pultz et al. 1999). Aerial surveys conducted by the Guam Division of Aquatic and Wildlife Resources indicate the year-round presence of green sea turtles in Guam's nearshore waters (Kolinski et al. 2001, National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998a, Pultz et al. 1999). Recent Navy surveys have estimated the nearshore density to be approximately 1 animal per 3.4 square kilometers (km^2) (1.31 square miles [$mi.^2$]) (excluding within Apra Harbor, where density is much higher, variable, and more finite in resolution). Aggregations of foraging and resting green turtles are often seen in close proximity to Guam's well-developed seagrass beds and reef flats, which are found in Cocos Lagoon, Apra Harbor, along Tarague Beach and Hila'an; in deeper waters south of Falcona Beach; and at several other locations throughout the island's shelf (U.S. Department of the Navy 2003b). Recreational Self Contained Underwater Breathing Apparatus (SCUBA) divers regularly see green turtles at the following sites off Guam: Boulder Alley, Ane Caverns, Napoleon Cut, Gab Gab I, and the Wall. Guam Division of Aquatic and Wildlife Resources aerial surveys have identified turtles within Agat Bay, and stranded sea turtles have been recovered from the bay (including one with spear gun injuries).

On Tinian, green turtle abundance and densities are highest along the island's relatively uninhabited east coast. The most recent estimate of the number of green turtles inhabiting the nearshore waters around Tinian was 832 turtles in 2001 (Kolinski et al. 2006) and densities of approximately 11.8 animals per km^2.

Green turtles are not as abundant at Farallon de Medinilla (FDM) as they are at some of the larger islands of the Marianas chain. At FDM, at least 9 green turtles were observed during underwater surveys in both 1999 and 2000, at least 12 green turtles were observed during surveys in 2001, and 4 were observed at the northern end of the island in 2003 (U.S. Department of the Navy 2005). Most green turtles at FDM were found either swimming over the reef platform or resting in holes or caves (U.S. Department of the Navy 2005). Due to strong current and tidal conditions, the beaches at FDM are very susceptible to inundation and are highly unsuitable for nesting (U.S. Department of the Navy 2003a). Also, seagrasses and benthic algae are relatively sparse around the island and can probably support no more than a few green turtles at a time (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998a). Seven sea turtles were documented in 2006 and 19 in 2007 during monthly monitoring (helicopter surveys) of FDM (U.S. Department of the Navy 2010). Monthly observations are usually low (between one and three turtle sightings); however, 12 turtles were observed in waters off FDM on 13 November 2007 (U.S. Department of the Navy 2010). Identifying sea turtles to the species level is not possible due to safe flying heights of the helicopter, although due to the higher abundance of green sea turtles relative to hawksbill turtles, the majority of sea turtle observations are assumed to be green sea turtles (U.S. Department of the Navy 2010).

Based on the above information, green turtles are expected to occur year round in all shelf waters of the MITT Study Area from FDM to Guam. Around the larger islands, green turtle occurrence is concentrated in waters less than 328 ft. (99.9 m) deep, approximately 11.8 animals per km^2 (4.6 $mi.^2$). It is at these water depths where green turtle foraging and resting habitats (e.g., fringing reefs, reef flats, and seagrass beds) are usually found. Although there may not be long-term data available for Guam or Commonwealth of the Northern Mariana Islands, data from other Pacific regions show that green sea turtles exhibit strong site fidelity to nearshore foraging habitats for extended periods of time (Balazs and Chaloupka 2004; Balazs 1994). Beyond the shelf break, green turtle occurrence is low/unknown, and assumed to be approximately 1 animal per 2.558 km^2 (0.988 $mi.^2$) (U.S. Department of the Navy 2012). Nesting females and early juveniles are known to move through oceanic waters of the Marianas chain during their reproductive and developmental migrations (Kolinski et al. 2006), but likely do not do so in large numbers.

3.5.2.4.4 Predator-Prey Interactions

The green turtle is the only sea turtle that is mostly herbivorous (Mortimer 1995), although its diet changes throughout its life. While at the surface, hatchlings feed on floating patches of seaweed and, at shallow depths, on comb jellies and gelatinous eggs, appearing to ignore large jellyfish (Salmon et al. 2004). While in the open ocean, juveniles smaller than 8 to 10 in. (20.3 to 25.4 cm) eat worms, small crustaceans, aquatic insects, grasses, and algae (Bjorndal 1997). After settling into a coastal habitat, juveniles eat mostly seagrass or algae (Balazs et al. 1994; Mortimer 1995). Some juveniles and adults that remain in the open ocean, and even those in coastal waters, also consume jellyfish, sponges, and sea pens (Blumenthal et al. 2009; Godley et al. 1998; Hatase et al. 2006, Heithaus et al. 2002; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b; Parker and Balazs 2005). Adult green turtles feed primarily on seagrasses, macroalgae, and reef-associated organisms (Bjorndal 1997; Burke et al. 1991). They also consume jellyfish, salps, and sponges (Bjorndal 1997).

Predators of green turtles vary according to turtle location and size. Land predators that feed on eggs and hatchlings include ants, crabs, birds, and mammals, such as dogs, raccoons, feral pigs, and humans. Aquatic predators, mostly fish and sharks, impact hatchlings most heavily in nearshore areas. Sharks are also the primary predators of juvenile and adult turtles (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007a).

3.5.2.4.5 Species-Specific Threats

The primary, human related threats to green turtles in Guam and the Commonwealth of the Northern Mariana Islands include direct harvesting of sea turtles and eggs as well as habitat loss due to rapidly expanding tourism, including increased coastal development on nesting beaches (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998a, b). Another primary threat to green turtles that may be related to human activity is the disease fibropapillomatosis. Fibropapillomatosis may be caused by exposure in marine areas affected by agricultural, industrial, or urban pollution (Aguirre and Lutz 2004); however, Chaloupka et al. (2009) noted that the occurrence of fibropapillomatosis appears to be declining. Other general threats include habitat degradation by ungulates and nest predation by pigs, feral dogs, cats, and rats, as well as destruction of strand vegetation, compaction of sand on nesting beaches by vehicles and heavy equipment, and the use of excessive or inappropriate lighting on beaches.

3.5.2.5 Hawksbill Sea Turtle (*Eretmochelys imbricata*)

3.5.2.5.1 Status and Management

The hawksbill turtle is listed as endangered under the ESA (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c). In U.S. waters, hawksbill populations are noted as neither declining nor showing indications of recovery (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b). Critical habitat has not been designated for the hawksbill in the Pacific Ocean.

3.5.2.5.2 Habitat and Geographic Range

The hawksbill turtle is the most tropical of the world's sea turtles, rarely occurring beyond 30°N or 30°S in the Atlantic, Pacific, and Indian Oceans (Lazell 1980). While the hawksbill turtle lives a part of its life (post-hatchling and early juvenile) in the open ocean, it inhabits coastal waters in more than 108 countries (where it feeds on its preferred prey, sea sponges) and nests in at least 70 countries (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b).

3.5.2.5.2.1 Open Ocean

Hawksbill turtles inhabit oceanic waters as post-hatchlings and small juveniles, where they are sometimes associated with driftlines and floating patches of vegetation (Parker 1995; Limpus 2009; Witherington and Hirama 2006). As with all other turtle species, hawksbill hatchlings enter an oceanic phase (known as the "lost years") and may be carried great distances by surface currents. Although little is known about their open ocean stage, younger juvenile hawksbills have been found in association with brown algae in the Pacific Ocean (Musick and Limpus 1997; Parker 1995; Witherington and Hirama 2006; Witzell 1983) before settling into nearshore habitats as older juveniles.

3.5.2.5.2.2 Coastal

The developmental habitats for juvenile benthic-stage hawksbills include tropical, nearshore waters associated with coral reefs, hard bottoms, or estuaries with mangroves (Musick and Limpus 1997). Coral reefs are recognized as optimal hawksbill habitat for juveniles, subadults, and adults (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c). In nearshore habitats, resting areas for late juvenile and adult hawksbills are typically located in deeper waters than their foraging areas, such as sandy bottoms at the base of a reef flat. Late juveniles generally reside on shallow reefs less than 59 ft. (17.9 m) deep.

Preferred habitat for older juvenile hawksbill turtles is coral reefs, but hawksbills also inhabit seagrass, algal beds, mangrove bays, creeks, and mud flats (Mortimer and Donnelly 2008). Some juveniles may associate with the same feeding grounds for a decade or more (Meylan and Donnelly 1999), while others appear to migrate among multiple sites as they age (Musick and Limpus 1997). Indo-Pacific hawksbills are estimated to mature between 30 and 38 years old (Mortimer and Donnelly 2008).

As they mature into adults, hawksbills move to deeper habitats and may forage to depths greater than 297 ft. (90.5 m), though recent studies have shown that in the eastern tropical Pacific, some adults may continue to use nearshore estuaries and mangroves saltwater forests (Gaos 2011). Benthic stage hawksbills are seldom found in waters beyond the continental or insular shelf, unless they are in transit between distant foraging and nesting grounds (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c).

Once sexually mature, hawksbill turtles undertake breeding migrations between foraging grounds and breeding areas at intervals of several years (Dobbs et al. 1999, Witzell 1983). Although females tend to return to breed where they were born (Bowen and Karl 1997), they may have foraged hundreds or thousands of kilometers from their birth beaches as juveniles. Hawksbills were originally thought to be a nonmigratory species because of the proximity of suitable nesting beaches to coral reef feeding habitats and the high rates of marked turtles recaptured in these areas. Tagging studies have demonstrated that the adult female displays a high degree of fidelity to her chosen nesting beach, with most females returning to the same small beach for oviposition of their successive clutches within a nesting season and in successive nesting seasons (Limpus 2009). Some additional tagging studies have shown otherwise. For example, a post-nesting female traveled 995 mi. (1,601.3 km) between the Solomon Islands and Papua New Guinea (Meylan 1995), indicating that adult hawksbills are capable of migrating distances comparable to those of green and loggerhead turtles.

Hawksbills are solitary nesters on beaches throughout the tropics and subtropics. Adult female hawksbills return to their natal beaches every 2 to 3 years to nest. A female hawksbill lays between three and five clutches during a single nesting season, which contain an average of 130 eggs per clutch (Richardson et al. 1999). Hawksbills are unlikely to be encountered on the beaches of FDM, which are unsuitable for nesting because of tidal inundation of beach areas (U.S. Department of the Navy 2003b). There are only a few documented records of hawksbills nesting in the Marianas region although only a subset of the region's beaches is adequately surveyed for sea turtle nesting activity.

3.5.2.5.3 Population and Abundance

Nesting beach observations for hawksbill turtles in the Pacific Ocean have shown numerous nesting locations of hawksbills in the Pacific, with regional nesting occurring in Australia, Papau New Guinea, Palau, and Indonesia (State of the World's Sea Turtles 2012). Only five regional populations worldwide remain with more than 1,000 females nesting annually (two in Australia and one each in Indonesia, the Seychelles, and Atlantic Mexico) (Meylan and Donnelly 1999). The largest of these regional populations is in the South Pacific Ocean, where 6,000 to 8,000 hawksbills nest off the Great Barrier Reef (Limpus 1992).

Although there are only a few recent hawksbill occurrence records in the MITT Study Area (U.S. Department of the Navy 2003b), historical records indicate a likely presence of this species in the coastal waters surrounding the islands of the southern Marianas arc (i.e., from FDM south to Guam) (Kolinski et al. 2001). As a result, hawksbill turtles are expected to occur in all waters located inside the shelf break within the MITT Study Area, including within Guam's Apra Harbor. Since hawksbill turtles are critically endangered and do not occur in large numbers anywhere within the region, there are no areas of concentrated occurrence around Guam and the Commonwealth of the Northern Mariana Islands. In deeper waters beyond the shelf break (e.g., throughout Warning Area 517), the occurrence of the hawksbill turtle is low/unknown.

During aerial surveys between 1989 and 1991, hawksbills represented 13.2 percent of all sea turtles sighted around Guam. Hawksbills are typically found near river mouths as well as inside Apra Harbor. These are areas where sponges, their preferred food, are common. Sasa Bay, which is located in Apra Harbor, is the largest estuary in the Marianas, and appears to be an area where hawksbills are most often encountered (Kolinski et al. 2001).

Hawksbill turtles are also regular inhabitants of Tinian nearshore waters, although in much fewer numbers than green turtles, with recent surveys in 2013 observing two hawksbill turtles on the west coast of Tinian. Hawksbills typically display small home ranges, less than 4 km^2; however, one hawksbill turtle in the study was observed making a 286 km, 7-day trek from Tinian to Guam (Jones and Van Houtan 2013). Even though past surveys at Tinian (1984–1985, 1994–1995, and 2001) failed to produce a single sighting record, time and area constraints may have led to foraging hawksbills being missed (Kolinski et al. 2001; Pultz et al. 1999). Since hawksbills prefer to nest in areas with sufficient vegetative cover, it is possible that some nests are never found on surveyed beaches. Lund (1985) notes that hawksbill nests are often very difficult to identify when qualified observers are not present. Recent surveys by the Navy estimates the nearshore density of hawksbill turtles at Tinian and other Islands (excluding FDM) at 1 hawksbill turtle per 7.45 km^2 (2.88 $mi.^2$).

Occurrence records that exist for FDM are two in-water sightings at the southwestern corner of the island in 2001, and one at the northwest corner of the island in 2004 (U.S. Department of the Navy 2003b, 2004). Each of these observations was recorded during Navy-sponsored marine tow and SCUBA dive surveys around the island. Both of the hawksbills sighted in 2001 were immature individuals less than 20 in. (50.8 cm) in carapace length, while the individual observed in 2004 was somewhat larger at approximately 28 in. (71.1 cm) in carapace length (U.S. Department of the Navy 2004). The Pacific Navy Marine Species Density Database indicates a higher density at FDM than at other islands, approximately

1 hawksbill per 0.932 km^2 (0.36 mi.^{2}) in waters less than 100 m (328.1 ft.) deep (U.S. Department of the Navy 2012).

3.5.2.5.4 Predator-Prey Interactions

Hawksbills eat both animals and plants during the early juvenile stage, feeding on such prey as sponges, algae, mollusks, crustaceans, and jellyfish (Bjorndal 1997). Older juveniles and adults are more specialized, feeding primarily on sponges, which comprise as much as 95 percent of their diet in some locations, although the diet of adult hawksbills in the Indo-Pacific region includes other invertebrates and algae (Meylan 1988; Witzell 1983). The shape of their mouth allows hawksbills to reach into holes and crevices of coral reefs to find sponges and other invertebrates. Hawksbill turtles fill a unique ecological niche in marine and coastal ecosystems, supporting the natural functions of coral reefs by keeping sponge populations in check (Hill 1998, Leon and Bjorndal 2002). Feeding on sponges helps to control populations of sponges that may otherwise compete for space with reef-building corals (Hill 1998, Leon and Bjorndal 2002).

Predators of hawksbills vary according to turtle location and size. Land predators on eggs and hatchlings include ants, crabs, birds, and mammals, such as dogs, raccoons, and feral pigs. Aquatic predators, mostly fish and sharks, impact hatchlings most heavily in nearshore areas. Sharks are also the primary predators of juvenile and adult turtles (Stancyk 1982).

3.5.2.5.5 Species-Specific Threats

The hawksbill shell has been prized for centuries by artisans and their patrons for jewelry and other adornments. This trade, prohibited under the Convention on International Trade in Endangered Species of Wild Fauna and Flora, remains a critical threat to the species (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b).

An additional threat to hawksbill sea turtles is loss of nesting habitat caused by the expansion of resident human populations in coastal areas of the world, as well as the increased destruction or modification of coastal ecosystems to support tourism (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c). Coastal pollution as a result of increased development degrades water quality, particularly coral reefs, which are primary foraging areas for hawksbills.

3.5.2.6 Loggerhead Sea Turtle (*Caretta caretta*)

3.5.2.6.1 Status and Management

In a September 2011 rulemaking, the NMFS and USFWS determined that the loggerhead sea turtle is composed of nine distinct population segments, four listed as threatened (Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and Southwest Indian Ocean) and five as endangered (Northeast Atlantic Ocean, Mediterranean Sea, North Indian Ocean, North Pacific, and South Pacific) under the ESA to be effective 24 October 2011. No critical habitat is listed for the loggerhead, but the rulemaking indicated that critical habitat be designated after any listing revision (76 FR 58868).

3.5.2.6.2 Habitat and Geographic Range

The loggerhead is found in temperate to tropical regions and is generally found between 40°N and 40°S of the Atlantic, Pacific, and Indian Oceans and in the Mediterranean Sea (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007d). The loggerhead turtle is found in habitats ranging from coastal estuaries to the open ocean (Dodd 1988). The species may be found hundreds of miles out to sea, as well as in nearshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. The nearshore juvenile stage and adult foraging stage both occur in the nearshore zone. Coral reefs, rocky places, and ship wrecks are often used as feeding areas. The loggerhead turtles here are active and feed primarily on the bottom (epibenthic/demersal), though prey is also captured throughout the water column (Bjorndal 2003). The nearshore zone not only provides crucial foraging habitat, but can also provide inter-nesting and overwintering habitat. Tagging data revealed that migratory routes may be coastal or may involve crossing deep ocean waters (Peckham et al. 2007); an oceanic route may be taken even when a coastal route is an option (Schroeder et al. 2003).

3.5.2.6.2.1 Open Ocean

Loggerheads spend the first 7–11.5 years of their lives in the open ocean (Bjorndal et al. 2000). After hatchlings travel to oceanic habitats, they are often found in seaweed drift lines. Juvenile loggerhead turtles of the North Pacific occur in one of at least two distinct habitats for extended periods, the oceanic waters of the central North Pacific and the nearshore waters of the Baja California peninsula (Kobayashi et al. 2008). In the western North Pacific, Polovina et al. (2004) and Parker and Balazs (2005) found that juvenile and adult loggerheads (both in the western North Pacific Ocean) swim against weak prevailing currents because they are attracted to areas of high productivity. Similar observations have been made in the Atlantic (Hawkes et al. 2006). These results suggest that the location of currents and associated frontal eddies is important to the loggerhead's foraging during its open ocean stage (Mansfield et al. 2009; McClellan and Read 2007).

3.5.2.6.2.2 Coastal

At about 14 years old, some juveniles move to nearshore habitats close to their natal area, while others remain in the oceanic habitat or move back and forth between the two (McClellan and Read 2007, Mansfield et al. 2009, Musick and Limpus 1997). Turtles may use the same nearshore developmental habitat all through maturation or may move among different areas, finally settling in an adult foraging habitat. Loggerheads reach sexual maturity at around 35 years of age and move from subadult to adult coastal foraging habitats (Godley et al. 2003; Musick and Limpus 1997). Data from Japan (Hatase et al. 2002), Cape Verde (Hawkes et al. 2006), and Florida (Reich et al. 2007) indicate that at least some of the adult population forage in the open ocean.

Loggerheads typically nest on beaches close to reef formations and adjacent to warm currents (Dodd 1988). They prefer nesting beaches facing the open ocean or along narrow bays (Conant et al. 2009). Nesting beaches tend to be wide and sandy, backed by low dunes and fronted by a flat sandy approach from the water (Miller et al. 2003). Nests are typically laid between the high tide line and the dune front (Hailman and Elowson 1992). Within the north Pacific, loggerheads nest exclusively in Japan where a 50 to 90 percent decrease has been documented (Kamezaki et al. 2003). In the south Pacific, nesting beaches are restricted to eastern Australia and New Caledonia. Although the nesting trend in the north Pacific since 2001 has been on an upward trajectory (National Marine Fisheries Service 2008), these nesting populations continue to face impacts from directed hunting, coastal development, light pollution, beach armoring (Kamezaki et al. 2003), and incidental capture in coastal and pelagic fisheries (Peckham et al. 2007, Ishihara et al. 2011, Lewison et al. 2004). Beach erosion due to increased typhoon frequency and extreme temperatures are also known to cause high nest mortality.

Females lay three to five clutches of eggs, sometimes more, throughout a single nesting season (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007d). Clutch size is usually between 100 to 130 eggs (Dodd 1988). The temperature of a viable nest ranges between 26 and 32°C (79 and 90 degrees Fahrenheit). Eggs incubate for approximately 2 months before they hatch (Yntema and Mrosovsky 1980). An incubation temperature near the upper end of the viable range produces females, and an incubation temperature near the lower end produces male hatchlings (Yntema and Mrosovsky 1980).

3.5.2.6.3 Population and Abundance

The loggerhead sea turtle occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. However, the majority of loggerhead nesting is at the western rims of the Atlantic and Indian oceans (Encalada et al. 1998). South Florida and Masirah, Oman, are the only two nesting beaches in the world with greater than 10,000 females nesting per year. The total estimated nesting in the United States is approximately 68,000 to 90,000 nests per year. The major nesting concentrations in the United States are found in South Florida; however, loggerheads nest from Padre Island in South Texas to Virginia (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c). The only known nesting areas for loggerheads in the North Pacific are found in southern Japan (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c, Kamezaki et al. 2003).

Snover et al. (2010) combined nesting data from the Sea Turtle Association of Japan and data from Kamezaki et al. (2003) to analyze an 18-year time series of nesting data from 1990–2007. Nesting declined from an initial peak of approximately 6,638 nests in 1990–1991 to a low of 2,064 nests in 1997. During the past decade, nesting increased gradually to 5,167 nests in 2005, declined and then rose again to a high of just under 11,000 nests in 2008. While nesting numbers have gradually increased in recent years, historical evidence from Kamouda Beach, Japan (census data dates back to the 1950s) indicates that there has been a substantial decline over the last half of the 20th century (Kamezaki et al. 2003) and that current nesting represents a fraction of historical nesting levels.

There are no sighting, stranding, or nesting records for loggerhead turtles around Guam and the Commonwealth of the Northern Mariana Islands. As a result, loggerhead turtles are considered rare within the MITT Study Area. The nearest occurrences of this species are from the waters off Palau and the Philippines (Sagun et al. 2005). This species is more apt to be found in temperate waters of the North Pacific Ocean (i.e., north of 25°N) off of countries such as Japan, China, Taiwan, northwestern Mexico, and the southwestern U.S. including Hawaii (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998c; Polovina et al. 2001, 2004). However, Guam and the Commonwealth of the Northern Mariana Islands are identified as being within the species' overall range (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007d, Kobayashi et al. 2008). Also, the westward flowing current of the North Pacific Subtropical Gyre system, which late juvenile stage loggerheads use when returning to the western Pacific, passes through the Marianas region (Polovina et al. 2000). Given the paucity of animal sightings, for modeling purposes in the effects analysis that follows, a density of 0.000022 animals per km^2 (1 sea turtle per 45,454 km^2 [17,550 $mi.^2$]) is used to represent the occasional transit of the MITT Study Area (U.S. Department of the Navy 2012).

3.5.2.6.4 Predator-Prey Interactions

In both open ocean and nearshore habitats, loggerheads are primarily carnivorous, although they also consume some algal matter (Parker et al. 2005; Bjorndal 1997; Dodd 1988). The gut contents of post-hatchlings found in masses of Sargassum contained parts of Sargassum, zooplankton, jellyfish, larval shrimp and crabs, and gastropods (Carr and Meylan 1980; Richardson and McGillivary 1991; Witherington 1994). Both juveniles and adults forage in coastal habitats, where they feed primarily on the bottom, although they also capture prey throughout the water column (McClellan et al. 2010, Bjorndal 2003). Adult loggerheads feed on a variety of bottom-dwelling animals, such as crabs, shrimp, sea urchins, sponges, and fish. They have powerful jaws that enable them to feed on hard-shelled prey, such as whelks and conch. During migration through the open sea, they eat jellyfish, mollusks, flying fish, and squid.

Depredation of sea turtle eggs and hatchlings by native and introduced species occurs on almost all nesting beaches. Land predators that feed on eggs and hatchlings include crabs, insects, and mammals, such as feral/domestic dogs, foxes, and feral pigs. Aquatic predators, mostly fish and sharks, impact hatchlings most heavily in nearshore areas. Sharks are also the primary predators of juvenile and adult turtles (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998e).

3.5.2.6.5 Species-Specific Threats

In addition to the general threats described in the introduction to this resource, mortality associated with shrimp trawls in the Atlantic has been a substantial threat to juvenile loggerheads because these trawls operate in the nearshore habitats commonly used by this species. Although shrimping nets have been modified with turtle excluder devices to allow sea turtles to escape, the overall effectiveness of these devices has been difficult to assess (National Marine Fisheries Service and U.S. Fish and Wildlife 2009). Shrimp trawl fisheries account for the highest number of loggerhead sea turtle fishery mortalities; they are also captured and killed in trawls, traps and pots, longlines, and dredges.

3.5.2.6.6 Olive Ridley Sea Turtle (*Lepidochelys olivacea*)

3.5.2.6.7 Status and Management

Olive ridleys are classified as threatened under the ESA, although the Mexican Pacific coast nesting population is listed as endangered. Critical habitat has not been designated for the olive ridley.

3.5.2.6.8 Habitat and Geographic Range

The olive ridley is known as an open ocean species, but can be found in coastal areas. They are found in tropical waters of the south Atlantic, Indian, and Pacific Oceans.

3.5.2.6.8.1 Open Ocean

Most olive ridley turtles lead a primarily open ocean life (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f). Outside of the breeding season, the turtles disperse, neither males nor females migrate to one specific foraging area, and the olive ridleys tend to roam and occupy a series of feeding areas in the open ocean (Plotkin et al. 1994, Plotkin 2010, Whiting 2007). The olive ridley has a large range in tropical and subtropical regions in the Pacific Ocean, and is generally found between 40°N and 40°S. Both adult and juvenile olive ridley turtles typically inhabit offshore waters, foraging from the surface to a depth of 490 ft. (149.4 m) (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f).

Little is known about the age and sex distribution, growth, birth and death rates, or immigration and emigration of olive ridley turtles. Hatchling survivorship is unknown, although presumably, as with other turtles, many die during the early life stages. Both adults and juveniles occur in open sea habitats, often seen on at-sea transect studies (Eguchi et al. 2007). The median age to sexual maturity is 13 years, with a range of 10 to 18 years (Zug et al. 2006).

3.5.2.6.8.2 Coastal

Olive ridley turtles use two types of nesting strategies (Jensen et al. 2006). One strategy is to perform synchronized nesting, a phenomenon known as an arribada (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f), where hundreds to tens of thousands of olive ridley turtles emerge over a period of a few days. In the eastern Pacific Ocean, arribada nesting occurs throughout the year, although it peaks from August to November (Fonseca et al. 2009, Valverde 2012). Arribadas occur on several beaches in Mexico, Nicaragua, Costa Rica, and Panama. Olive ridley turtles also lay solitary nests throughout the world, although little attention has been given to this nesting strategy because of the dominant interest in arribada research (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b). Nesting occurs in at least 60 countries throughout the world (Abreu-Grobois and Plotkin 2008), including along nearly the entire Pacific Ocean coast of Mexico, with the greatest concentrations closer to arribada beaches.

Females and males begin to group in "reproductive patches" near their nesting beaches 2 months before the nesting season, and most mate near the nesting beaches, although mating has been observed throughout the year as far as 565 mi. (909.3 km) from the nearest mainland (Pitman 1990). Arribadas usually last from 3 to 7 nights, and due to the sheer number of nesters, later arrivers disturb and dig up many existing nests, lowering overall survivorship during this phase (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f). A typical female produces, on average, two clutches per nesting season, averaging 100–110 eggs at 14-day intervals for lone nesters and 28-day intervals for mass nesters (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007, Plotkin et al. 1994). Studies show that females that are part of arribadas remain within 3 mi. (4.8 km) of the beach most of the time during the internesting period (Kalb and Owens 1994). Incubation time from egg deposition to hatching is approximately 55 days (Pritchard and Plotkin 1995). Hatchlings emerge weighing less than 1 oz. (less than 28 g) and measuring about 1.5 in. (3.8 cm).

3.5.2.6.9 Population and Abundance

There has been a general decline in the abundance of this species since its listing in 1978. Even though there are no current estimates of worldwide abundance, the olive ridley is still considered the most abundant of the world's sea turtles (Pritchard 1997) and the most abundant sea turtle in the open ocean waters of the eastern tropical Pacific Ocean (Pitman 1990). However, the number of olive ridley turtles occurring in U.S. territorial waters is believed to be small (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f). Before the commercial exploitation of olive ridley turtles, this species was highly abundant in the eastern tropical Pacific Ocean, probably outnumbering all other sea turtle species combined in the area (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f).

Available information indicates that the population could be separated by ocean basins under the distinct population segment policy (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998e). 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 (Bowen and Karl 1997, Shankar et al. 2004).

The olive ridley nests in nearly 60 countries worldwide, in some locations with an estimated 800,000 females nesting annually Valverde et al. 2012). This is a dramatic decrease over the past 50 years, where the population from the five Mexican Pacific Ocean beaches was previously estimated at 10 million adults (Cliffton et al. 1995). Similarly, the largest nesting aggregation in the world used to occur in the Indian Ocean along the northeast coast of India (Orissa), where in 1991 over 600,000 turtles (from two separate arribadas) nested in a single week (Nmosovsky 2001; Shanker et al. 2004) and typical reported estimates have ranged from 100 to 800,000 nesting turtles (Shanker et al. 2004). Over the past 5 years at Gahirmatha (one of the Indian nesting sites), there has been an arribada nesting event in only 2 of those 5 years. Additionally, between 1996 and 2002, the average size of nesting females declined at that site, indicative of a declining population (National Oceanic and Atmospheric Administration 2011).

Between 2006 and 2010, at a mass-nesting site in Costa Rica, arribadas ranged between 3,564 and 476,550 egg-laying females. However, when compared with historical data, the population appears to have declined (Valverde et al. 2012).

Only one olive ridley record exists for Guam and the Commonwealth of the Northern Mariana Islands, an alleged capture in the waters near Saipan. The exact location of this capture, however, is unknown since the turtle was offered for sale in a local souvenir shop. The nearest in-water sightings of this species have occurred within the Yap Districts (Eckert et al. 1999; Pritchard and Plotkin 1995). It is possible that future occurrences could occur in the MITT Study Area and vicinity as olive ridleys have been satellite-tracked through North Pacific waters as far south as 8°N during developmental migrations (Eguchi et al. 2007; Polovina et al. 2004). The occurrence of the olive ridley turtle is rare throughout the year in all waters surrounding Guam and the Commonwealth of the Northern Mariana Islands that are seaward of the shelf break because they are primarily an oceanic species. In portions of the MITT Study Area located inside the shelf break (e.g., Apra Harbor, Agat Bay, nearshore waters around northern Tinian), olive ridley turtle sightings would be rare. Given the paucity of sightings of olive ridleys, for modeling purposes in the effects analysis that follows, a density of 0.000001 animal per km^2 is used to represent the occasional transit of the MITT Study Area by an olive ridley sea turtle (U.S. Department of the Navy 2012).

3.5.2.6.10 Predator-Prey Interactions

Olive ridley turtles are primarily carnivorous. They consume a variety of prey in the water column and on the seafloor, including snails, clams, tunicates, fish, fish eggs, crabs, oysters, sea urchins, shrimp, and jellyfish (Fritts 1981; Márquez M. 1990; Mortimer 1995; Polovina et al. 2004).

Predators contribute to egg loss and include coyotes, opossums, raccoons, feral dogs and pigs, and humans. The predators of hatchlings on the beach include crabs, snakes, iguanas, frigatebirds, vultures, coyotes, and raccoons; in the water they include predatory fish. As with all marine turtles, sharks are likely to be major predators of all age classes at sea (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998f).

3.5.2.6.11 Species-Specific Threats

The principal cause of the historical, worldwide decline of the olive ridley sea turtle is long-term collection of eggs and killing of adults on nesting beaches (Abreu-Grobis and Plotkin 2008). Because arribadas concentrate females and nests in time and space, they allow for mass killing of adult females as well as the taking of an extraordinary number of eggs. These threats continue in some areas of the world today, compromising efforts to recover this species (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b), though some regions are employing legal harvests as a management tool (Valverde et al. 2012).

3.5.2.7 Leatherback Sea Turtle (*Dermochelys coriacea*)

3.5.2.7.1 Status and Management

The leatherback turtle is listed as a single population, and is classified as endangered under the ESA.

In January 2012, NMFS designated critical habitat in the Pacific Ocean along California (from Point Arena to Point Arguello, east of the 3,000 m [9,842.5 ft.] depth contour) and Washington and Oregon (from Cape Flattery, Washington, to Cape Blanco, Oregon, east of the 2,000 m [6,561.7 ft.] depth contour)

(77 Federal Register 170-4201). There is no critical habitat designated for the leatherback sea turtle in the MITT Study Area.

3.5.2.7.2 Habitat and Geographic Range

The leatherback turtle is the most widely distributed of all sea turtles, found from tropical to subpolar oceans, and nests on tropical and occasionally subtropical beaches (Myers and Hays 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992). Found from 71°N to 47°S, it has the most extensive range of any adult turtle (Eckert et al. 2012). Leatherbacks are also the most migratory sea turtles and are able to tolerate colder water (thermoregulatory adaptations such as a counter-current heat exchange system, high oil content, and large body size allow them to maintain a core body temperature higher than that of the surrounding water) than other species (Hughes et al. 1998; James and Mrosovsky 2004).

3.5.2.7.2.1 Open Ocean

Adult leatherback turtles forage in temperate and subpolar regions in all oceans, and migrate to tropical nesting beaches between 30°N and 20°S. Hatchling leatherbacks head out to the open ocean, but little is known about their distribution for the first 4 years (Musick and Limpus 1997). Sightings of turtles smaller than 55 in. (139.7 cm) indicate that some juveniles remain in coastal waters in some areas (Eckert 2002).

As with other sea turtle species, limited information is available on the open ocean habitats used by hatchling and early juvenile leatherbacks (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992). Other than a general association with warm waters, little is known of the distribution of hatchling and early juvenile leatherbacks, although Eckert (2002) noted a gradual increase in turtle size with increasing latitude. Upwelling areas, such as equatorial convergence zones, are nursery grounds for hatchling and early juvenile leatherbacks, because these areas provide a good supply of prey (Musick and Limpus 1997).

3.5.2.7.2.2 Coastal

Throughout their lives, leatherbacks are essentially oceanic, yet they enter coastal waters to forage and reproduce (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992). The species is not typically associated with coral reefs, but is occasionally encountered in deep ocean waters near prominent island chains (Eckert 1993). There is evidence that leatherbacks are associated with oceanic front systems, which occur frequently along shelf breaks and the edges of oceanic gyre systems, and is often where their prey (mainly planktonic) is concentrated (Benson et al. 2011, Eckert 1993).

Leatherbacks have a wide nesting distribution, primarily on isolated mainland beaches in tropical oceans (mainly in the Atlantic and Pacific Oceans, with few in the Indian Ocean) and temperate oceans (southwest Indian Ocean) (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992), and to a lesser degree on some islands. Nesting leatherbacks prefer wide sandy beaches backed with vegetation (Eckert 1987; Hirth and Ogren 1987). For both the western and eastern Pacific Ocean populations, the nesting season extends from October through March, with a peak in December. The single exception is the Jamursba-Medi (Papua) stock, which nests from April to October, with a peak in August (Chaloupka et al. 2004). Typical clutches are 50 to more than 150 eggs, with the incubation period lasting around 65 days. Females lay an average of five to seven clutches in a single season (with a maximum of 11) with intervals of 8 to 10 days or longer (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992). Females remain in the general vicinity of the nesting habitat for their breeding period, which can last up to 4 months (Eckert, K. et al. 1989; Eckert S. et al. 1989; Keinath and Musick 1993), although they may nest on several islands in a chain during a single nesting season

(Pritchard 1982). Mating is thought to occur before or during the migration from temperate to tropical waters (Eckert and Eckert 1988).

3.5.2.7.3 Population and Abundance

Most stocks in the Pacific Ocean are faring poorly, where nesting populations have declined more than 80 percent since 1982 (Sarti-Martinez 2000), while western Atlantic and South African populations are generally stable or increasing (Turtle Expert Working Group 2007). Worldwide, the largest nesting populations now occur off of Gabon in equatorial West Africa (5,865 to 20,499 females nesting per year [Witt et al. 2009]), in the western Atlantic in French Guiana (4,500 to 7,500 females nesting per year [Dutton et al. 2007]) and Trinidad (estimated 6,000 turtles nesting annually [Eckert 2002]), and in the western Pacific in West Papua (formerly Irian Jaya), Indonesia (about 600 to 650 females nesting per year [Dutton et al. 2007]). By 2004, 203 nesting beaches from 46 countries around the world had been identified (Dutton 2006). Of these, 89 sites (44 percent) have generated data from beach monitoring programs. Although these data are beginning to form a global perspective, unidentified sites likely exist, and incomplete or no data are available for many known sites. Genetic studies have been used to identify two discrete leatherback populations in the Pacific Ocean (Dutton 2006): an eastern Pacific Ocean population, which nests between Mexico and Ecuador; and a western Pacific Ocean population, which nests in numerous countries, including Indonesia, Papua New Guinea, Solomon Islands, and Vanuatu. There are 28 known nesting sites for the western Pacific Ocean stock, with 5,000 to 9,100 leatherback nests laid annually across the western tropical Pacific Ocean, from Australia and Melanesia (Papua New Guinea, Solomon Islands, Fiji, and Vanuatu) to Indonesia, Thailand, and China (Chaloupka et al. 2004; Dutton 2006; Hirth et al. 1993; Hitipeuw et al. 2007; Suarez et al. 2000). Although, no more than 10 nests are estimated to be laid annually in Malaysia (Eckert et al. 2012) and only approximately 20 to 30 nests are laid in Fiji (Rupeni et al. 2002).

Leatherbacks have been in decline in all major Pacific basin rookeries (nesting areas/groups) (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007b, Turtle Expert Working Group 2007) for at least the last two decades (Sarti-Martinez et al. 1996, Spotila et al. 1996, Spotila et al. 2000). Causes for this decline include the nearly complete harvest of eggs and high levels of mortality during the 1980s, primarily in the high seas driftnet fishery, which is now banned (Chaloupka et al. 2004, Eckert and Sarti-Martinez 1997, Sarti-Martinez et al. 1996).

Of the three sea turtle species that have been sighted around Guam and the Commonwealth of the Northern Mariana Islands during marine surveys, the leatherback turtle is the least common (U.S. Department of the Navy 2003b). This species is occasionally encountered in the deep, pelagic waters of the Marianas archipelago, although only a few occurrence records exist (Eckert et al. 1999). Recent National Oceanic and Atmospheric Administration satellite tracking of leatherback turtles departing from regional nesting habitats transit through MITT waters (Benson et al. 2011; Benson et al. 2007; Kobayashi et al. 2008). As for nearshore waters, Eldredge (2003) noted a rescue in 1978 of a 249-pound (lb.) (112.9 kg) leatherback from waters southeast of Cocos Island, Guam. From 1987 to 1989, divers reported seeing leatherbacks in the waters off Harmon Point, Rota; however, none have been seen in the area in recent times (U.S. Department of the Navy 2010). Leatherbacks do not nest at any of the islands in Micronesia. As a result, the occurrence of leatherback turtles would be considered rare throughout the year in nearshore waters of the Study Area. Since leatherback occurrences in the waters off Guam and the Commonwealth of the Northern Mariana Islands would most likely involve individuals in transit, occurrence is not expected in coastal (i.e., shelf) waters around any of the islands in the Study Area. Given the paucity of animal sightings, for modeling purposes in the effects analysis that follows, a density of 0.000022 animal per km^2 is used to represent the occasional transit of the MITT Study Area (U.S. Department of the Navy 2012).

3.5.2.7.4 Predator-Prey Interactions

Leatherbacks lack the crushing and chewing plates characteristic of hard-shelled sea turtles that feed on hard-bodied prey (National Marine Fisheries Service 2010). Instead, they have pointed tooth-like cusps and sharp-edged jaws that are perfectly adapted for a diet of soft-bodied prey, such as jellyfish and salps (planktonic tunicate) (Bjorndal 1997; Grant and Ferrell 1993; James and Herman 2001; National Marine Fisheries Service and U.S. Fish and Wildlife Service 1992; Salmon et al. 2004). Leatherbacks feed from the surface as well as at depth, potentially diving up to 4,035 ft. (1,230 m) (Eckert S. et al. 1989; Eisenberg and Frazier 1983; Grant and Ferrell 1993; Hays et al. 2004a; Hays 2004b; Hays et al. 2004c; James et al. 2005; Salmon et al. 2004). Leatherbacks in the Caribbean may synchronize their diving patterns with the daily vertical migration of a deep-water ecosystem of fishes, crustaceans, gelatinous salps, and siphonophores, known as the deep scattering layer, which moves toward the surface of the ocean at dusk and rapidly descends in the morning (Eckert et al. 1986; Eckert, K. et al. 1989; Eckert, S. et al. 1989). A similar vertical migration of small fish and crustacean species has been studied in the Pacific, which migrates from approximately 1,300 to 2,300 ft. (396 to 701 m) during the day to near the surface at night (Benoit-Bird et al. 2001). Researchers studying known feeding grounds have observed leatherbacks foraging on jellyfish at the surface (Grant and Ferrell 1993; James and Herman 2001).

Predators contribute to egg loss and include feral pigs and dogs, crickets, raccoons and armadillos, lizards, crabs, ants, among others (Tapilatu and Tiwari 2007). Predation of hatchlings is commonly observed in birds and fish. As with all marine turtles, sharks are likely to be major predators of all age classes at sea, and killer whales predate leatherback adults (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998d).

3.5.2.7.5 Species-Specific Threats

In addition to the general threats described at the beginning of Section 3.5.2 (Affected Environment), harvest of leatherback sea turtle eggs and adult turtles continues to be a threat in many parts of the world. Additionally, incidental capture in longline and coastal gillnet fisheries has caused a substantial number of leatherback sea turtle deaths, likely because leatherback sea turtles dive to depths targeted by fishermen and are less maneuverable than other sea turtle species (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2007c).Mortality was observed most commonly occurring from incidental capture in driftnets, rather than from longlines (Alfaro-Shigueto et al. 2011). Further, because leatherback sea turtles distribution is so closely associated jellyfish aggregations, any changes in jellyfish distribution or abundance may be a threat to this species.

3.5.3 Environmental Consequences

This section presents the analysis of potential impacts on sea turtles from implementation of the project alternatives, including the No Action Alternative, Alternative 1, and Alternative 2. Each sea turtle substressor is introduced, analyzed by alternative, and analyzed for training activities and testing activities, and then an ESA determination is made by substressor. The stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors applicable to sea turtles in the MITT Study Area and analyzed below include the following:

- Acoustic (sonar and other active acoustic sources; underwater explosives; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise)

- Energy (electromagnetic devices)
- Physical disturbance and strike (vessels and in-water devices, military expended materials, and seafloor devices)
- Entanglement (fiber optic cables and guidance wires, and decelerators/parachutes)
- Ingestion (munitions and military expended materials other than munitions)
- Secondary (impacts associated with sediments and water quality)

The specific analysis of the training and testing activities presented in this section considers the relevant components and associated data within the geographic location of the activity (see Tables 2.8-1 through 2.8-4) and the resource.

3.5.3.1 Acoustic Stressors

3.5.3.1.1 Impulse and Non-Impulse Sound Sources

Assessing whether sounds may disturb or injure an animal involves understanding the characteristics of the acoustic sources, the animals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those animals.

The methods used to predict acoustic effects on sea turtles build upon the Conceptual Framework for Assessing Effects from Sound-Producing Activities (Appendix H, Biological Resource Methods). Additional research specific to sea turtles is presented where available.

3.5.3.1.2 Analysis Background and Framework

A range of impacts on sea turtles could occur depending on the sound source. The impacts of exposure to non-explosive, sound-producing activities or to sounds produced by an explosive detonation could include permanent or temporary hearing loss, changes in behavior, and physiological stress. In addition, potential impacts from an explosive impulse can range from physical discomfort to non-lethal and lethal injuries. Immediate non-lethal injury includes slight injury to internal organs and injury to the auditory system, which could reduce long-term fitness (lifetime reproductive success). Immediate lethal injury would be a result of massive combined trauma to internal organs as a direct result of proximity to the point of detonation.

3.5.3.1.2.1 Direct Injury

Direct injury from non-impulsive sound sources, such as sonar, is unlikely due to relatively lower peak pressures and slower rise times than potentially injurious sources such as explosives. Non-impulsive sources also lack the strong shock waves that are associated with explosives. Therefore, primary blast injury and barotrauma would not occur due to exposure to non-impulsive sources such as sonar and are only considered for explosive detonations.

The potential for trauma in sea turtles exposed to impulsive sources (e.g., explosions) has been inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Ketten et al. 1993; Richmond et al. 1973; Yelverton et al. 1973). The effects of an underwater explosion on a sea turtle are dependent upon multiple factors, including size, type, and depth of both the animal and the explosive, depth of the water column, and distance from the charge to the animal. Smaller sea turtles would generally be more susceptible to injury. The compression of blast-sensitive, gas-containing organs when a sea turtle increases depth reduces likelihood of injury to these organs. The location of the explosion in the water column and the underwater environment determines whether most energy is released into the water or the air and influences the propagation of the blast wave.

Primary Blast Injury and Barotrauma

The greatest potential for direct, non-auditory tissue impacts is primary blast injury and barotrauma after exposure to the shock waves of high-amplitude impulse sources, such as explosions. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to the high pressure of a blast or shock wave. Primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the pressure-sensitive components of the auditory system (discussed below) (Stuhmiller et al. 1991; Craig and Hearn 1998; Craig Jr. 2001), although additional injuries could include concussive brain damage and cranial, skeletal, or shell fractures (Ketten 1995). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of lung bruising, collapsed lung, traumatic lung cysts, or air in the chest cavity or other tissues (Stuhmiller et al. 1991). These injuries may be fatal depending on the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air blockage that can cause a stroke or heart attack by restricting oxygen delivery to these organs. Although often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer bruising and tearing from blast exposure, particularly in air-containing regions of the tract. Potential traumas include internal bleeding, bowel perforation, tissue tears, and ruptures of the hollow abdominal organs. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered. Non-lethal injuries could increase a sea turtle's risk of predation, disease, or infection.

Auditory Trauma

Components of the auditory system that detect smaller or more gradual pressure changes can also be damaged when overloaded at high pressures with rapid rise times. Rupture of the eardrum, while not necessarily a serious or life-threatening injury, may lead to permanent hearing loss (Ketten 1995, 1998). No data exist to correlate the sensitivity of the sea turtle tympanum and middle and inner ear to trauma from shock waves associated with underwater explosions (Viada et al. 2008).

The specific impacts of bulk cavitation on sea turtles are unknown (see Costanzo 2010, for an explanation of cavitation following an explosive detonation). The presence of a sea turtle within the cavitation region created by the detonation of small charges could annoy, injure, or increase the severity of the injuries caused by the shock wave, including injuries to the auditory system or lungs. Presence within the area of cavitation from a large charge, such as those used in ship shock trials, is expected to be an area of almost complete total physical trauma (Craig and Rye 2008). An animal located at (or in the immediate vicinity of) the cavitation closure depth would be subjected to a short duration ("water hammer") pressure pulse; however, direct shock wave impacts alone would be expected to cause auditory system injuries and could cause internal organ injuries.

3.5.3.1.2.2 Hearing Loss

Hearing loss could effectively reduce the distance over which sea turtles can detect biologically relevant sounds. Both auditory trauma (a direct injury discussed above) and auditory fatigue may result in hearing loss, but the mechanisms responsible for auditory fatigue differ from auditory trauma. Hearing loss due to auditory fatigue is also known as threshold shift, a reduction in hearing sensitivity at certain frequencies. Threshold shift is the difference between hearing thresholds measured before and after an intense, fatiguing sound exposure. Threshold shift occurs when hair cells in the ear fatigue, causing them to become less sensitive over a small range of frequencies related to the sound source to which an animal was exposed. Hair cells are part of the basilar membrane and are responsible for converting the mechanical movement of waves of sound to an electrochemical signal that is received by the auditory nerve. Each hair cell has a characteristic frequency that is correlated with its position along the basilar membrane. The actual amount of threshold shift depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure. No studies are published on inducing threshold shift in sea turtles; therefore, the potential for the impact on sea turtles is inferred from studies of threshold shift in other animals.

Temporary threshold shift (TTS) is a hearing loss that recovers to the original hearing threshold over a period of time. An animal may not even be aware of a TTS. It does not become deaf, but requires a louder sound stimulus (relative to the amount of TTS) to detect a sound within the affected frequencies. TTS may last several minutes to several days, depending on the intensity and duration of the sound exposure that induced the threshold shift (including multiple exposures).

Permanent threshold shift (PTS) is a permanent loss of hearing sensitivity at a certain frequency range. PTS is non-recoverable due to the destruction of tissues within the auditory system. The animal does not become deaf, but requires a louder sound stimulus (relative to the amount of PTS) to detect a sound within the affected frequencies. As the name suggests, the effect is permanent.

3.5.3.1.2.3 Auditory Masking

Auditory masking occurs when a sound prevents or limits the distance over which an animal detects other biologically relevant sounds. When a sound has a level above the sound of interest, and in a similar frequency band, auditory masking could occur (Appendix H, Biological Resource Methods). Any sound above ambient noise levels and within an animal's hearing range may potentially cause masking. The degree of masking increases with increasing noise levels; a noise that is just-detectable over ambient levels is unlikely to actually cause any substantial masking, whereas a louder noise may mask sounds over a wider frequency range. In addition, a continuous sound would have more potential for masking than a sound with a low duty cycle. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 µPa, especially at lower frequencies (below 100 Hz) and nearshore, ambient noise levels, especially around busy ports, can exceed 120 dB re 1 µPa (Urick 1983).

Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone.

Based on knowledge of sea turtle sensory biology (Martin et al. 2012, Crognale et al. 2008, Southwood et al. 2008, Bartol and Ketten 2006, Bartol and Musick 2003, Levenson et al. 2004), sea turtles may be able to detect objects within the water column (e.g., vessels, prey, predators) via some combination of auditory, visual or chemical cues. However, research examining the ability of sea turtles to avoid collisions with vessels and to avoid fishing gear (Southwood et al. 2008, Hazel et al. 2007) indicate that visual cues dominate over auditory, olfactory, and probably gustatory cues as well. Similarly, while sea turtles may rely somewhat on acoustic cues to identify nesting beaches, they appear to rely more heavily on other non-acoustic cues for navigation, such as magnetic fields (Lohmann 1991; Lohmann and Lohmann 1996a, b) and light (Avens and Lohmann 2003). Additionally, they are not known to produce sounds underwater for communication, navigation, or foraging. As a result, sound likely plays a limited role in a sea turtle's environment. It is unknown what role sound plays in a sea turtle environment; therefore, the potential for masking may be limited.

3.5.3.1.2.4 Physiological Stress

Sea turtles may exhibit a behavioral response or combinations of behavioral responses upon exposure to anthropogenic sounds. If a sound is detected, a stress response (i.e., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. Sea turtles 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 activities have the potential to provide additional stressors above and beyond those that occur in the absence of human activity.

Immature Kemp's ridley sea turtles show physiological responses to the acute stress of capture and handling through increased levels of the stress hormone corticosterone, along with biting and rapid flipper movement (Gregory and Schmid 2001). Kemp's ridley sea turtles are not found in the Study Area; however, they are closely related to olive ridley sea turtles, which are found in the Study Area. Studies involving Kemp's ridley sea turtles are applicable to olive ridleys when comparative studies for olive ridley sea turtles are lacking. Captive olive ridley hatchlings showed heightened blood glucose levels following retention in holding ponds, indicating physiological stress (Rees et al. 2008; Zenteno et al. 2008). Repeated exposure to stressors, including human disturbance such as vessel disturbance and anthropogenic sound, may result in negative consequences to the health and viability of an individual or population (Gregory and Schmid 2001). Factors to consider when predicting a stress or cueing response is whether an animal is naïve or has prior experience with a stressor. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation.

3.5.3.1.2.5 Behavioral Reactions

The response of a sea turtle to an anthropogenic sound will 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 source and whether it is perceived as approaching or moving away could also affect the way a sea turtle responds to a sound. Potential behavioral responses to anthropogenic sound could include startle reactions, disruption of feeding, disruption of migration, changes in respiration, alteration of swim speed, alteration of swim direction, area avoidance, and disruption of mating or reproduction (nesting).

There are limited studies of sea turtle responses to sounds. No studies have been performed to examine the response of sea turtles to sonar. However, based on their limited range of hearing, they may respond to sources operating below 2 kilohertz (kHz) but are unlikely to sense higher frequency sounds. A few studies examined sea turtle reactions to airguns, which produce broadband impulse sound. O'Hara and Wilcox (1990) attempted to create a sound barrier at the end of a canal using seismic airguns. They reported that loggerhead turtles kept in a 984 ft. x 148 ft. (300 m x 45 m) enclosure in a 10 m (32.8 ft.) deep canal maintained a standoff range of 98 ft. (30 m) from airguns fired simultaneously at intervals of 15 seconds with strongest sound components within the 25–1,000 Hz frequency range. More frequent airgun blasts did not produce behavior different from that observed at lower frequencies. Also, reverberation of acoustic stimuli off of canal walls confound observations as well as experimental conditions. McCauley et al. (2000) estimated that the received level at which turtles avoided sound in the O'Hara and Wilcox (1990) experiment was 175 to 176 dB re 1 µPa root mean square (rms).

Moein Bartol et al. (1995) investigated the use of air guns to repel juvenile loggerhead sea turtles from hopper dredges. Sound frequencies of the airguns ranged from 100 to 1,000 Hz at three levels: 175, 177, and 179 dB re 1 µPa at 1 m. The turtles avoided the airguns during the initial exposures (mean range of 24 m), but additional trials several days afterward did not elicit statistically significant avoidance. They concluded that this was due to either habituation or a temporary shift in the turtles' hearing capability. In a related study, Lenhart (1994) found no consistent response to a fixed sound source in net or tank studies with juvenile loggerheads.

McCauley et al. (2000) exposed caged green and loggerhead sea turtles to an approaching-departing single air gun to gauge behavioral responses. The trials showed that above a received level of 166 dB re 1 µPa (rms) the turtles noticeably increased their swimming activity compared to non-operational periods, with swimming time increasing as air gun levels increased during approach. Above 175 dB re 1 µPa (rms), behavior became more erratic, possibly indicating the turtles were in an agitated state (McCauley et al. 2000). The authors note that the point at which the turtles showed the more erratic behavior and exhibited possible agitation is expected to approximately equal the point at which active avoidance would occur for unrestrained turtles (McCauley et al. 2000).

No obvious avoidance reactions by free-ranging sea turtles, such as swimming away, were observed during a multi-month seismic survey using airgun arrays, although fewer sea turtles were observed when the seismic airguns were active than when they were inactive (Weir 2007). The author noted that sea state and the time of day affected both airgun operations and sea turtle surface basking behavior, making it difficult to draw conclusions from the data. DeRuiter and Doukara (2012) noted that 49 of 86 loggerhead turtles basking at the sea surface dove in response to airgun sound exposure, the majority of turtles observed while at the surface dove at or before their closest point of approach to the airgun array blasts, and that dive probability decreased with increasing distance from the airgun array.

3.5.3.1.2.6 Repeated Exposures

Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with energetic costs that can accumulate over time to cause long-term negative consequences for the individual. Conversely, some sea turtles may habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past did not accompany any overt threat, such as high levels of ambient noise found in areas of high vessel traffic (Hazel et al. 2007). In an experiment, after initial avoidance reactions, loggerhead sea turtles habituated to repeated exposures to airguns of up to a source level of 179 dB re 1 µPa in an enclosure. The habituation behavior was retained by the sea turtles when exposures were separated by several days (Moein Bartol et al. 1995).

3.5.3.1.3 Acoustic and Explosive Thresholds and Criteria

Animals generally do not hear equally well across their entire hearing range. Several studies using green, loggerhead, and Kemp's ridley turtles suggest sea turtles are most sensitive to low-frequency sounds, although this sensitivity varies slightly by species and age class (Bartol and Ketten 2006; Bartol et al. 1999; Lenhardt 1994; Ridgway et al. 1969). Sea turtles possess an overall hearing range between 100 Hz and 1 kHz, with an upper limit of 2 kHz (Bartol and Ketten 2006; Bartol et al. 1999; Lenhardt 1994; Ridgway et al. 1969).

Because hearing thresholds are frequency-dependent, an auditory weighting function can be derived for sea turtles (turtle-weighting, or T-weighting). The T-weighting function (Figure 3.5-1) defines lower and upper frequency boundaries beyond which sea turtle hearing sensitivity decreases. The single frequency cutoffs at each end of the frequency range where hearing sensitivity begins to decrease are based on the most liberal interpretations of sea turtle hearing abilities (10 Hz and 2 kHz). These boundaries are precautionary and exceed the demonstrated or anatomy-based hypothetical upper and lower limits of sea turtle hearing. Figure 3.5-1 shows the sea turtle auditory weighting function with lower and upper boundaries of 10 Hz and 2 kHz, respectively.

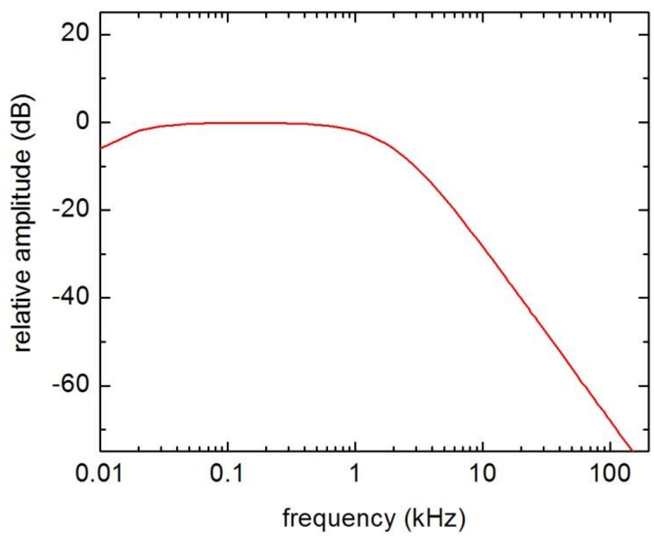

Figure 3.5-1: Auditory Weighting Function for Sea Turtles (T-Weighting)

The T-weighting function adjusts the received sound level based on sensitivity to different frequencies, emphasizing frequencies to which sea turtles are most sensitive and reducing emphasis on frequencies outside of their estimated useful range of hearing. For example, a 160 dB re 1 µPa tone at 10 kHz is estimated to be perceived by a sea turtle as a 130 dB re 1 µPa sound (i.e., 30 dB lower). Stated another way, a sound outside of the range of best hearing would have to be more intense to have the same impact as a sound within the range of best hearing. Weighting functions are further explained in Section 3.0.4 (Acoustic and Explosives Primer).

The Navy considers two primary categories of sound sources in its analyses of sound impacts on sea turtles: impulse sources (e.g., explosives, airguns, and weapons firing) and non-impulse sources (e.g., sonars, pingers, and countermeasure devices). General definitions of impulse and non-impulse sound sources are provided below. Acoustic impacts criteria and thresholds were developed in cooperation with the NMFS for sea turtle exposures to various sound sources. These acoustic impacts criteria are summarized in Table 3.5-2, Table 3.5-3, and Table 3.5-4. These criteria can be used to estimate the number of sea turtles impacted by training and testing activities that emit sound or explosive energy, as well as the severity of the immediate impacts. These criteria are used to quantify impacts from explosives, airguns, sonar, and other active acoustic sources. These criteria are also useful for qualitatively assessing activities that indirectly impart sound to water, such as firing of weapons and aircraft flights.

Table 3.5-2: Sea Turtle Impact Threshold Criteria for Non-Impulse Sources

Onset PTS	Onset TTS
198 dB SEL (T)	178 dB SEL (T)

Notes: (T) = Turtle Weighting Function, dB = decibels, PTS = Permanent Threshold Shift, TTS = Temporary Threshold Shift, SEL = Sound Exposure Level (the total acoustic energy in an event normalized to 1 second)

Table 3.5-3: Sea Turtle Impact Threshold Criteria for Impulse Sources

Impulse Sound Exposure Impact	Threshold Value
Onset Mortality (1 Percent Mortality Based on Extensive Lung Injury)	$= 91.4M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-s$
Onset Slight Lung Injury	$= 39.1M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-s$
Onset Slight Gastrointestinal Tract Injury	237 dB re 1 μPa SPL (104 psi)
Onset PTS	187 dB re 1 μPa^2-s SEL (T) or 230 dB re 1 μPa Peak SPL
Onset TTS	172 dB re 1 μPa^2-s SEL (T) or 224 dB re 1 μPa Peak SPL

Notes: μPa = micropascal, μPa^2-s = micropascal squared second, dB = decibels, D_{Rm} = depth of animal (meters), M = mass of animals (kilograms) as shown for each species in Table 3.5-4, PTS = Permanent Threshold Shift, re = referenced to, SEL = Sound Exposure Level, SPL = Sound Pressure Level, T= Turtle Weighting Function, TTS = Temporary Threshold Shift

Detailed description of the criteria and equations can be found in Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (U.S. Department of the Navy 2012b).

Table 3.5-4: Species-Specific Masses for Determining Onset of Extensive and Slight Lung Injury Thresholds

Common Name	Juvenile Mass (kg)	Reference
Loggerhead turtle	8.4	Southwood et al. (2007)
Green turtle	8.7	Wood and Wood (1993)
Hawksbill turtle	7.4	Okuyama et al. (2010)
Olive ridley turtle	6.3	McVey and Wibbels (1984) and Caillouet et al. (1986)[1]
Leatherback turtle	34.8	Jones (2009)

[1] McVey and Wibbels (1984) and Caillouet et al. (1986) measured masses for Kemp's ridley turtles, a closely related species to the olive ridley.

3.5.3.1.3.1 Categories of Sounds as Defined for Thresholds and Criteria

Categories of sound are discussed in Section 3.0.4 (Acoustic and Explosives Primer). Impulsive and non-impulsive are described again below with details specific to assigning acoustic and explosive criteria for predicting impacts on sea turtles.

3.5.3.1.3.2 Impulsive Sounds

Impulsive sounds (including explosions) have a steep pressure rise or rapid pressure oscillation, which is the primary reason the impacts of these sounds are considered separately from non-impulsive sounds. Impulsive sounds usually rapidly decay with only one or two peak oscillations and are of very short duration (usually 0.1 second or shorter). Rapid pressure changes may produce mechanical damage to the ear or other structures that would not occur with slower rise times found in non-impulsive signals. Impulse sources and sound analyzed in this document include explosives, airguns, sonic booms, and weapons firing.

3.5.3.1.3.3 Non-Impulsive Sounds

Non-impulsive sounds typically contain multiple pressure oscillations without a rapid rise time, although the total duration of the signal may still be quite short (0.1 second or shorter for some high frequency sources). Such sounds are typically characterized by a root mean square average sound pressure level or energy level over a specified period of time. Sonar and other active acoustic sources (e.g., pingers) are analyzed as non-impulsive sources in this document.

Intermittent non-impulsive sound sources produce sound for only a small fraction of the time that the source is in use (a few seconds or a fraction of a second, e.g., sonars and pingers), with longer silent periods in between the sound. Continuous sources are those that transmit sound for the majority of the time they are being used, often for many minutes, hours, or days. Vessel noise and aircraft noise are continuous noise sources analyzed in this document.

3.5.3.1.3.4 Criteria for Mortality and Injury from Explosives

There is a considerable body of laboratory data on actual injuries from impulse sounds, usually from explosive pulses, obtained from tests with a variety of vertebrate species (e.g., Goertner et al. 1994; Richmond et al. 1973; Yelverton et al. 1973). Based on these studies, potential impacts, with decreasing likelihood of serious injury or lethality, include onset of mortality, onset of slight lung injury, and onset of slight gastrointestinal injury.

In the absence of data specific to sea turtles, criteria developed to assess impacts on protected marine mammals are also used to assess impacts on protected sea turtles. These criteria are discussed below.

3.5.3.1.3.5 Criteria for Mortality and Slight Lung Injury

In air or submerged, the most commonly reported internal bodily injury due to explosive detonations is hemorrhaging in the fine structure of the lungs. The likelihood of internal bodily injury is related to the received impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973; Yelverton and Richmond 1981; Yelverton et al. 1973; Yelverton et al. 1975). Therefore, impulse is used as a metric upon which internal organ injury can be predicted. Onset mortality and onset slight lung injury are defined as the impulse level that would result in 1 percent mortality (most survivors have moderate blast injuries and should survive) and 0 percent mortality (recoverable, slight blast injuries) in the exposed population, respectively. Criteria for onset mortality and onset slight lung injury were developed using data from explosive impacts on mammals (Yelverton and Richmond 1981).

The impulse required to cause lung damage is related to the volume of the lungs. The lung volume is related to both the size (mass) of the animal and compression of gas-filled spaces at increasing water depth. Turtles have relatively low lung volume to body mass and a relatively stronger anatomical structure compared to mammals; therefore, application of the criteria derived from studies of impacts of explosives on mammals is conservative.

Table 3.5-4 provides a nominal conservative body mass for each sea turtle species based on juvenile mass. Juvenile body masses were selected for analysis given the early rapid growth of these reptiles (newborn turtles weigh less than 0.5 percent of maximum adult body mass). In addition, small turtles tend to remain at shallow depths in the surface pressure release zone, reducing potential exposure to injurious impulses. Therefore, use of hatchling weight would provide unrealistically low thresholds for estimating injury to sea turtles. The use of juvenile body mass rather than hatchling body mass was chosen to produce reasonably conservative estimates of injury.

The scaling of lung volume to depth is conducted for all species since data come from experiments with terrestrial animals held near the water's surface. The calculation of impulse thresholds consider depth of the animal to account for compression of gas-filled spaces that are most sensitive to impulse injury. The impulse required for a specific level of injury (impulse tolerance) is assumed to increase proportionally to the square root of the ratio of the combined atmospheric and hydrostatic pressures at a specific depth with the atmospheric pressure at the surface (Goertner 1982).

Very little information exists regarding the impacts of underwater detonations on sea turtles. Impacts on sea turtles from explosive removal operations range from non-injurious impacts (e.g., acoustic annoyance, mild tactile detection, or physical discomfort) to varying levels of injury (i.e., non-lethal and lethal injuries) (e.g., Klima et al. 1988; Viada et al. 2008). Often, impacts of explosive activities on turtles must be inferred from documented impacts on other vertebrates with lungs or other-gas containing organs, such as mammals and most fishes (Viada et al. 2008). The methods used by Goertner (1982) to develop lung injury criteria for marine mammals may not be directly applicable to sea turtles, as it is not known what degree of protection to internal organs from the shock waves is provided to sea turtles by their shell (Viada et al. 2008). However, the general principles of the Goertner model are applicable and should provide a protective approach to assessing potential impacts on sea turtles. The Goertner method predicts a minimum primary positive impulse value associated with onset of slight lung injury and onset of mortality, adjusted for assumed lung volume (correlated to animal mass) and depth of the animal. These equations are shown in Table 3.5-3.

3.5.3.1.3.6 Criteria for Onset of Gastrointestinal Tract Injury

Without data specific to sea turtles, data from tests with terrestrial animals are used to predict onset of gastrointestinal tract injury. It is shown that gas-containing internal organs, such as lungs and intestines, were the principle damage sites from shock waves in submerged terrestrial mammals (Clark and Ward 1943; Greaves et al. 1943; Richmond et al. 1973; Yelverton et al. 1973). Furthermore, slight injury to the gastrointestinal tract may be related to the magnitude of the peak shock wave pressure over the hydrostatic pressure and would be independent of the animal’s size and mass (Goertner 1982). Slight contusions to the gastrointestinal tract were reported during small charge tests (Richmond et al. 1973), when the peak was 237 dB re 1 µPa. Therefore, this value is used to predict onset of gastrointestinal tract injury in sea turtles exposed to explosions (see Table 3.5-3).

3.5.3.1.3.7 Criteria for Hearing Loss Temporary and Permanent Threshold Shift

Whereas TTS represents a temporary reduction of hearing sensitivity, PTS represents tissue damage that does not recover and permanent reduced sensitivity to sounds over specific frequency ranges (see Section 3.5.3.1.2.2, Hearing Loss). To date, no known data are available on potential hearing impairments (i.e., TTS and PTS) in sea turtles. Sea turtles, based on their auditory anatomy (Bartol and

Musick 2003a; Lenhardt et al. 1985; Wartzok and Ketten 1999; Wever 1978; Wyneken 2001), almost certainly have poorer absolute sensitivity (i.e., higher thresholds) across much of their hearing range than do the mid-frequency cetacean species. Therefore, applying TTS and PTS criteria derived from mid-frequency cetaceans to sea turtles should provide a protective approach to estimating acoustic impacts on sea turtles (PTS and TTS data are not available for low-frequency cetaceans). Criteria for hearing loss due to onset of TTS and PTS are based on sound exposure level (for non-impulse and impulse sources) and peak pressure (for impulse sources only).

To determine the sound exposure level, the turtle weighting function is applied to the acoustic exposure to emphasize only those frequencies within a sea turtle's hearing range. Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the received sound exposure level for a given individual. This conservatively assumes no recovery of hearing between exposures during a 24-hour period. The weighted sound exposure level is then compared to weighted threshold values for TTS and PTS. If the weighted exposure level meets or exceeds the weighted threshold, then the physiological impact (TTS or PTS) is assumed to occur. For impacts from exposures to impulse sources, the metric (peak pressure or sound exposure level) and threshold level that results in the longest range to impact is used to predict impacts. Exposures are not calculated for sound sources with a nominal frequency outside the upper and lower frequency hearing limits for sea turtles.

In addition to being discussed below, thresholds for onset of TTS and PTS for impulse and non-impulse sounds are summarized in Table 3.5-2 and Table 3.5-3.

3.5.3.1.3.8 Criteria for Non-Impulsive Temporary Threshold Shift

Based on best available science regarding TTS in marine vertebrates (Finneran et al. 2002; Southall et al. 2007) and the lack of information regarding TTS in sea turtles, the total T-weighted sound exposure level of 178 dB re 1 micro Pascal squared second (μPa^2-s) is used to estimate exposures resulting in TTS for sea turtles. The T-weighting function is used in conjunction with this non-pulse criterion, which effectively provides an upper cutoff of 2 kHz.

The T-weighted non-impulsive TTS threshold of 178 dB re 1 μPa^2-s sound exposure level was inadvertently based on Type II weighted cetacean TTS data rather than Type I weighted cetacean TTS data. This resulted in incorrectly lowering the turtle TTS threshold by 17 dB. The sea turtle non-impulsive TTS threshold, based on mid-frequency cetacean data, should be 17 dB higher than 178 dB re 1 μPa^2-s. Because an incorrectly lowered threshold was used to quantitatively analyze acoustic impacts on sea turtles in this EIS/OEIS, the quantitative impacts presented herein for non-impulsive TTS are conservative (i.e., over-predicted).

3.5.3.1.3.9 Criteria for Impulsive Temporary Threshold Shift

The sea turtle impulsive TTS threshold, which is based on Type I mid-frequency cetacean data (Southall et al. 2007), should be 178 dB re 1 μPa^2-s. However, during the modeling effort, the T-weighted impulsive TTS threshold of 172 dB re 1 μPa^2-s sound exposure level was inadvertently based on Type II weighted cetacean TTS data rather than Type I weighted cetacean TTS data. This resulted in incorrectly lowering the turtle TTS threshold. Because an incorrectly lowered threshold was used to quantitatively analyze acoustic impacts to sea turtles in this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), the quantitative impacts presented herein for impulsive TTS are conservative (i.e., over-predicted).

3.5.3.1.3.10 Criteria for Non-Impulsive Permanent Threshold Shift

Since no studies were designed to intentionally induce PTS in sea turtles, levels for onset of PTS for these animals must be estimated using TTS data and relationships between TTS and PTS established in terrestrial mammals. PTS can be estimated based on the growth rate of a threshold shift and the level of threshold shift required to potentially become non-recoverable. A variety of terrestrial and marine mammal data sources show that threshold shifts up to 40–50 dB may be recoverable, and that 40 dB is a reasonable upper limit of a threshold shift that does not induce PTS. This analysis assumes that continuous-type exposures producing threshold shifts of 40 dB or more always result in some amount of PTS.

Data from terrestrial mammal testing (Ward et al. 1958, 1959) show TTS growth of 1.5 to 1.6 dB for every 1 dB increase in sound exposure level. The difference between minimum measureable TTS onset (6 dB) and the 40 dB upper safe limit of TTS yields a difference of 34 dB. When divided by a TTS growth rate of 1.6 dB TTS per dB sound exposure level, there is an indication that an increase in exposure of a 21.25 dB sound exposure level would result in 40 dB of TTS. For simplicity and conservatism, the number was rounded down to 20 dB sound exposure level.

Therefore, non-impulse exposures of 20 dB sound exposure level above those producing a TTS may be assumed to produce a PTS. The onset of TTS threshold of 195 dB re 1 μPa^2-s for sea turtles has a corresponding onset of PTS threshold of 215 dB re 1 μPa^2-s. The T-weighting function is applied when using the sound exposure level-based thresholds to predict PTS (see Table 3.5-3).

However, the T-weighted non-impulse TTS threshold of 178 dB re 1 μPa^2-s sound exposure level used during acoustic modeling was inadvertently based on Type II weighted cetacean TTS data rather than Type I weighted cetacean TTS data. This resulted in incorrectly lowering the turtle TTS threshold by 17 dB; consequently, this also incorrectly lowered the sea turtle PTS threshold by 17 dB. The sea turtle non-impulse PTS threshold, based on mid-frequency cetacean data, should be 17 dB higher than 198 dB re 1 μPa^2-s. Because an incorrectly lowered threshold was used to quantitatively analyze acoustic impacts to sea turtles in this EIS/OEIS, the quantitative impacts presented herein for non-impulse PTS are conservative (i.e., over-predicted).

3.5.3.1.3.11 Criteria for Impulsive Permanent Threshold Shift

The sea turtle impulsive PTS threshold, which is based on Type I mid-frequency cetacean data (Southall et al. 2007), should be 198 dB re 1 μPa^2-s. However, during the modeling effort, the T-weighted impulsive PTS threshold of 187 dB re 1 μPa^2-s sound exposure level was inadvertently based on Type II weighted cetacean TTS data rather than Type I weighted cetacean TTS data. This resulted in incorrectly lowering the turtle TTS threshold. Because an incorrectly lowered threshold was used to quantitatively analyze acoustic impacts to sea turtles in this EIS/OEIS, the quantitative impacts presented herein for impulsive TTS are conservative (i.e., over-predicted).

3.5.3.1.3.12 Criteria for Behavioral Responses

A sea turtle's behavioral response to sound is assumed to be variable and context specific. For instance, a single impulse may cause a brief startle reaction. A sea turtle may swim farther away from the sound source, increase swimming speed, change surfacing time, and decrease foraging if the stressor continues to occur. For each potential behavioral change, the magnitude of the change ultimately would determine the severity of the response. It is assumed that most responses would be short-term avoidance reactions.

A few studies reviewed investigated behavioral responses of sea turtles to impulse sounds emitted by airguns (McCauley et al. 2000; Moein Bartol et al. 1995; O'Hara and Wilcox 1990). There are no studies of sea turtle behavioral responses to sonar. Cumulatively, available airgun studies indicate that perception and a behavioral reaction to a repeated sound may occur with sound pressure levels greater than 166 dB re 1 µPa rms, and that more erratic behavior and avoidance may occur at higher thresholds around 175–179 dB re 1 µPa rms (McCauley et al. 2000; Moein Bartol et al. 1995; O'Hara and Wilcox 1990). A received level of 175 dB re 1 µPa rms is more likely to be the point at which avoidance may occur in unrestrained turtles, with a comparable sound exposure level of 160 dB re 1 μPa^2-s (McCauley et al. 2000).

Airgun studies used sources that fired repeatedly over some duration. For single impulses at received levels below threshold shift (hearing loss) levels, the most likely behavioral response is assumed to be a startle response. Since no further sounds follow the initial brief impulse, the biological significance is considered to be minimal.

Based on the limited information regarding significant behavioral reactions of sea turtles to sound, behavioral responses to sounds are qualitatively assessed for sea turtles.

3.5.3.1.4 Quantitative Analysis

A number of computer models and mathematical equations can be used to predict how energy spreads from a sound source (e.g., sonar or underwater detonation) to a receiver (e.g., sea turtle). See Section 3.0.4 (Acoustic and Explosives Primer) for background information about how sound travels through the water. All modeling is an estimation of reality, with simplifications made both to facilitate calculations by focusing on the most important factors and to account for unknowns. For analysis of underwater sound impacts, basic models calculate the overlap of energy and marine life using assumptions that account for the many, variable, and often unknown factors that can greatly influence the result. Assumptions in previous Navy models intentionally erred on the side of overestimation when there were unknowns or when the addition of other variables was not likely to substantively change the final analysis. For example, because the ocean environment is extremely dynamic and information is often limited to a synthesis of data gathered over wide areas requiring many years of research, known information tends to be an average of the wide seasonal or annual variation that is actually present. The Equatorial Pacific El Niño disruption of the ocean-atmosphere system is an example of dynamic change where unusually warm ocean temperatures are likely to result in the redistribution of marine life and alter the propagation of underwater sound energy. Previous Navy modeling, therefore, made some assumptions indicative of a maximum theoretical propagation for sound energy (such as a perfectly reflective ocean surface and a flat seafloor). More complex computer models build upon basic modeling by factoring in additional variables in an effort to be more accurate by accounting for such things as bathymetry and an animal's likely presence at various depths.

For quantification of estimated marine mammal and sea turtle impacts resulting from sounds produced during Navy activities, the Navy developed a set of data and new software tools. This new approach is the resulting evolution of the basic modeling approaches used by the Navy previously and reflects a much more complex and comprehensive modeling approach as described below.

3.5.3.1.4.1 Navy Acoustic Effects Model

For this analysis of Navy training and testing activities at sea, the Navy developed a set of software tools and compiled data for quantifying predicted acoustic impacts. These databases and tools collectively form the Navy Acoustics Effects Model. Details of the Navy Acoustics Effects Model processes and the description and derivation of the inputs are presented in the Technical Report (Determination of Acoustic Effects on Marine Mammals and Sea Turtles for Navy Training and Testing Events). The following paragraphs provide an overview of the Navy Acoustics Effects Model process and its more critical data inputs.

The Navy Acoustic Effects Model improves upon previous modeling efforts in several ways. First, unlike earlier methods that modeled sources individually, the Navy Acoustic Effects Model has the capability to run all sources within a scenario simultaneously, providing a more realistic depiction of the potential effects of an activity. Second, previous models calculated sound received levels within set volumes of water and spread animals uniformly across the volumes. In the Navy Acoustic Effects Model, animals are distributed non-uniformly based on higher resolution species-specific density, depth distribution, and group size information. Animals serve as dosimeters, recording energy received at their location in the water column. Third, a fully three-dimensional environment is used for calculating sound propagation and animate exposure in the Navy Acoustic Effects Model, rather than a two-dimensional environment where the worse case sound pressure level across the water column is always encountered. Finally, current efforts incorporate site-specific bathymetry, sound speed profiles, wind speed, and bottom properties into the propagation modeling process rather than the flat-bottomed provinces used during earlier modeling. The following paragraphs provide an overview of the Navy Acoustic Effects Model process and its more critical data inputs.

Using the best available information on the estimated density of sea turtles in the area being modeled, the Navy Acoustics Effects Model derives an abundance (total number individuals) and distributes the resulting number of virtual animals ("animats") into an area bounded by the maximum distance that energy propagates out to a criterion threshold value (energy footprint). These animats are distributed based on density differences across the area and known depth distributions (dive profiles). Animats change depths every 4 minutes but do not otherwise mimic actual animal behaviors (such as avoidance or attraction to a stimulus).

Schecklman et al. (2011) argue that static distributions underestimate acoustic exposure compared to a model with fully three-dimensionally moving animals. However, their static method is different from the Navy Acoustic Effects Model in several ways. First, they distribute the entire population at depth with respect to the species-typical depth distribution histogram, and those animals remain static at that position throughout the entire simulation. In the Navy Acoustic Effects Model, animats are placed horizontally dependent upon non-uniform density information, and then move up and down over time within the water column by interrogating species-typical depth distribution information. Second, for the static method they calculate acoustic received level for designated volumes of the ocean and then sum the animals that occur within that volume, rather than using the animals themselves as dosimeters, as in the Navy Acoustic Effects Model. Third, Schecklman et al. (2011) run 50 iterations of the moving distribution to arrive at an average number of exposures, but because they rely on uniform horizontal density (and static depth density), only a single iteration of the static distribution is realized. In addition to moving the animats vertically, the Navy Acoustic Effects Model overpopulates the animats over a non-uniform density and then resamples the population a number of times to arrive at an average number of exposures as well. Tests comparing fully moving distributions and static distributions with vertical position changes at varying rates were compared during development of the Navy Acoustic Effects Model. For position updates occurring more frequently than every 5 minutes, the number of estimated exposures were similar between the Navy Acoustic Effects Model and the fully moving distribution, however, computational time was much longer for the fully moving distribution.

The Navy Acoustics Effects Model calculates the likely propagation for various levels of energy (sound or pressure) resulting from each non-impulse or impulse source used during a training or testing activity. This is done taking into account an activity location's actual bathymetry and bottom types (e.g., reflective), and estimated sound speeds and sea surface roughness. Platforms (such as a ship using one or more sound sources) are modeled as moving across an area, the size of which is representative of what would normally occur during a training or testing scenario. The model uses typical platform speeds and activity durations. Moving source platforms either travel along a predefined track or move along straight-line tracks from a random initial course, reflecting at the edges of a predefined boundary. Static sound sources are stationary in a fixed location for the duration of a scenario. Modeling locations were chosen based on historical data from ongoing activities and in an effort to include all the environmental variation within the MITT Study Area where similar activities might occur in the future.

The Navy Acoustics Effects Model then tracks the energy received by each animat within the energy footprint of the activity and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects to the animats within a scenario are then tallied and the highest order effect (based on severity of criteria; e.g., PTS over TTS) predicted for a given animat is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine animat could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the Study Area, sound may propagate beyond the boundary of the Study Area. Any exposures occurring outside the boundary of the MITT Study Area are counted as if they occurred within the MITT Study Area boundary.

3.5.3.1.4.2 Model Assumptions

There are limitations to the data used in the Navy Acoustics Effects Model, and results must be interpreted within the context of these assumptions. Output from the Navy Acoustic Effects Model relies heavily on the quality of both the input parameters and impact thresholds and criteria. When there was a lack of definitive data to support an aspect of the modeling (such as lack of well described diving behavior for all marine species), conservative assumptions believed to overestimate the number of exposures were chosen:

- Animats are modeled as being underwater and facing the source and therefore always predicted to receive the maximum sound level at their position within the water column (e.g., the model does not account for conditions such as body shading or an animal raising its head above water).
- Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating temporary or permanent hearing loss, because there are insufficient data to estimate a hearing recovery function for the time between exposures.

- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological impacts such as hearing loss, especially for slow-moving or stationary sound sources in the model.
- Animats are stationary horizontally and therefore do not avoid the sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels, especially those exposures that may result in permanent hearing loss (PTS).
- Animats receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury) assume an impulse delivery time adjusted for animal size and depth. Therefore, these impacts are overestimated at greater distances and increased depths.
- Mitigation measures implemented during training and testing activities that reduce the likelihood of exposing a sea turtle to higher levels of acoustic energy near the most powerful sound sources (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) were not considered in the model.

3.5.3.1.4.3 Sea Turtle Densities

A quantitative analysis of impacts on a species requires data on the abundance and concentration of the species population 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. There is no single source of density data for every area of the world, species, and season because of the fiscal costs, resources, and effort involved in providing survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the Study Area, the Navy compiled data from several sources. To compile and structure the most appropriate database of marine species density data, the Navy developed a protocol to select the best available data sources based on species, area, and time (season). The resulting Geographic Information System database called the Navy Marine Species Density Database (U.S. Department of the Navy 2012) includes seasonal density values for every marine mammal and sea turtle species present within the Study Area. All species density distributions matched the expected distributions from published literature and the NMFS stock assessments. In this analysis, sea turtle density data were used as an input in the Navy Acoustic Effects Model in their original temporal and spatial resolution.

3.5.3.1.5 Impacts from Sonar and Other Active Acoustic Sources

Sonar and other active acoustic sound sources emit sound waves into the water to detect objects, safely navigate, and communicate. These systems are used for anti-submarine warfare, mine warfare, navigation, sensing of oceanographic conditions (e.g., sound speed profile), and communication. General categories of sonar systems are described in Section 2.3 (Descriptions of Sonar, Ordnance/Munitions, Targets, and Other Systems Employed in Mariana Islands Training and Testing Activities) and Section 3.0.5.2.1 (Acoustic Stressors).

Potential direct impacts on sea turtles from exposure to sonar or other non-impulse underwater active acoustic sources include hearing loss due to threshold shift (permanent or temporary), masking of other biologically relevant sounds, physiological stress, or changes in behavior (see Section 3.5.3.1.2, Analysis Background and Framework). Direct injury and barotrauma from a primary blast would not occur from exposure to these sources due to slower rise times and lower peak pressures. As stated above, a TTS can be mild and recovery can take place within a matter of minutes to days and, therefore, is unlikely to cause long-term consequences to individuals or populations. There is no research to indicate whether sea turtles with PTS would suffer long-term consequences. Sea turtles probably do not rely on their auditory systems as a primary sense (Southwood et al. 2008), although little is known about how sea turtles use the narrow range of low-frequency sounds they might perceive in their environment (see Section 3.5.3.1.2.3, Auditory Masking). It is possible that some individuals that experience some degree of permanent hearing loss may have decreased abilities to find resources such as prey or nesting beaches or detect other relevant sounds such as vessel noise, which may lead to long-term consequences for the individual. Similarly, the effect of masking on sea turtles is difficult to assess.

There is little information regarding sea turtle responses to sound. It is anticipated that the intensity of their behavioral response to a perceived sound could depend on several factors, including species, the animal's age, reproductive condition, past experience with the sound exposure, behavior (foraging or reproductive), the received level from the exposure, as well as the type of sound (impulse or non-impulse) and duration of the sound (Appendix H, Biological Resource Methods). Behavioral responses may be short-term (seconds to minutes) and of little immediate consequence for the animal, such as simply orienting to the sound source. Alternatively, there may be a longer term response over several hours such as moving away from the sound source. However, exposure to loud sounds resulting from Navy training and testing at sea would likely be brief because ships and other participants are constantly moving and the animal would likely be moving as well. Animals that are resident during all or part of the year near Navy ports, piers, and near-shore facilities or on fixed Navy ranges are the most likely to experience multiple or repeated exposures. It is likely that a sea turtle could be exposed to sonar and other active acoustic sources multiple times in its lifetime, although the possibility of habituation is unknown. Most exposures would be intermittent and short-term when considered over the duration of a sea turtle's life span. In addition, most sources use frequencies that are higher than the best hearing range of sea turtles.

Most sonar and other active acoustic sources used during training and testing use frequency ranges that are higher than the estimated hearing range of sea turtles (10 Hz to 2 kHz). Therefore, most of these sources have no impact on sea turtle hearing. Only sonar with source levels greater than 160 dB re 1 µPa using frequencies within the hearing range of sea turtles were modeled for potential acoustic impacts on sea turtles. Other active acoustic sources with low source level, narrow beam width, downward directed transmission, short pulse lengths, frequencies above known hearing ranges, or some combination of these factors are not anticipated to result in impacts on sea turtles. These sources are the same or analogous to sound sources analyzed by other agencies and ruled on by NMFS to not result in impacts on protected species, including sea turtles, and therefore were not modeled and are addressed qualitatively in this EIS/OEIS (see Section 3.0.4.1.6 for a discussion of these sources). These sources generally have frequencies greater than 200 kHz and source levels less than 160 dB re 1 µPa. The types of sources with source levels less than 160 dB are primarily hand-held sonars, range pingers, transponders and acoustic communication devices.

Within this acoustics analysis, the numbers of sea turtles that may receive some form of hearing loss were predicted using the Navy Acoustics Effects Model (Section 3.5.3.1.4.1). To quantify the impacts of acoustic exposures to sea turtles, training and testing activities were modeled that employ acoustic sources using frequencies in the hearing range of sea turtles. These activities and the acoustic source classes used are listed in Model-Predicted Impacts. Most sonar and active acoustic sources used during training and testing use frequencies outside of the estimated hearing range of turtles.

3.5.3.1.5.1 Model-Predicted Impacts

Table 3.5-5 and Table 3.5-6 show predicted impacts on sea turtles from the Navy Acoustics Effects Model. The exposure estimates for each alternative represent the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. The predicted acoustic impacts do not take into account avoidance behavior or mitigation measures, such as establishing shut-down zones for certain sonar systems (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). Also see Table 3.4-9 in Section 3.4 (Marine Mammals) for an explanation of the post-model acoustic impact analysis process.

Table 3.5-5: Annual Total Model-Predicted Impacts on Sea Turtles for Training Activities Using Sonar and Other Active Non-Impulse Acoustic Sources

Sea Turtle Species	No Action Alternative		Alternative 1		Alternative 2	
	Temporary Threshold Shift	Permanent Threshold Shift	Temporary Threshold Shift	Permanent Threshold Shift	Temporary Threshold Shift	Permanent Threshold Shift
Green sea turtle	0	0	82	0	104	0
Hawksbill sea turtle	0	0	11	0	13	0
Loggerhead sea turtle	0	0	9	0	12	0
Olive ridley sea turtle	0	0	0	0	0	0
Leatherback sea turtle	0	0	7	0	9	0
TOTAL	**0**	**0**	**109**	**0**	**138**	**0**

Note: The timing, locations, and numbers of these activities would not substantially differ from year to year under each alternative.

Table 3.5-6: Annual Total Model-Predicted Impacts on Sea Turtles for Testing Activities Using Sonar and Other Active Non-Impulse Acoustic Sources

Sea Turtle Species	No Action Alternative		Alternative 1		Alternative 2	
	Temporary Threshold Shift	Permanent Threshold Shift	Temporary Threshold Shift	Permanent Threshold Shift	Temporary Threshold Shift	Permanent Threshold Shift
Green sea turtle	0	0	169	0	170	0
Hawksbill sea turtle	0	0	6	0	7	1
Loggerhead sea turtle	0	0	6	0	6	0
Olive ridley sea turtle	0	0	0	0	0	0
Leatherback sea turtle	0	0	5	0	6	0
TOTAL	**0**	**0**	**186**	**0**	**189**	**1**

Note: The timing, locations, and numbers of these activities would not substantially differ from year to year under each alternative.

3.5.3.1.5.2 No Action Alternative

Training Activities

Training activities under the No Action Alternative include activities that produce non-impulsive sound from the use of sonar and other active acoustic sources that fall within the hearing range of sea turtles. These activities could occur throughout the MITT Study Area open ocean areas. A more detailed description of these activities, the number of activities, and their proposed locations are presented in Table 2.8-1 of Chapter 2 (Description of Proposed Action and Alternatives). Use of sonar and other active acoustic sources during training activities is discussed in Section 3.0.4 (Acoustic and Explosives Primer).

If a source uses a frequency within a sea turtle's hearing range, and if the sea turtle is close enough to perceive the sound, the sea turtle may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. No sea turtles are expected to experience TTS or PTS from the minimal acoustic sources under the No Action Alternative. There are no model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources under the No Action Alternative (see Table 3.5-5). Sea turtles that reside during all or part of the year on a Navy range complex may be exposed several times throughout the year to sound from sonar and other active acoustic sources. Exposures to sonar and other active acoustic sources in open water areas would be intermittent and geographically variable. Pronounced reactions to acoustic stimuli could lead to a sea turtle expending energy and missing opportunities to forage or breed. In most cases acoustic exposures are intermittent, allowing time to recover from an incurred energetic cost, resulting in no long-term consequence.

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley or leatherback sea turtles.

Testing Activities

Testing activities potentially using non-impulsive acoustic sources under the No Action Alternative is restricted to the North Pacific Acoustic Lab Philippine Sea Experiment (Table 2.8-4). Research vessels, acoustic test sources, side scan sonar, ocean gliders, the existing moored acoustic tomographic array and distributed vertical line array, and other oceanographic data collection equipment will be used to collect information on the ocean environment and sound propagation during the 2018 data collection period. Currently, the array is being used to passively collect oceanographic and acoustic data in the region.

If a source uses a frequency within a sea turtle's hearing range, and if the sea turtle is close enough to perceive the sound, the sea turtle may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. No sea turtles are expected to experience TTS or PTS from the minimal acoustic sources under the No Action Alternative. Exposures to acoustic sources in open water areas would be intermittent and limited to the Philippine Sea Experiment. The intermittent acoustic exposures in this limited area would allow time to recover from an incurred energetic cost, resulting in no long-term consequence. Because most impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley or leatherback sea turtles.

3.5.3.1.5.3 Alternative 1

Training Activities

The number of annual training activities that produce in-water sound from sonar or other active acoustic sources that falls within the hearing range of sea turtles under Alternative 1 would increase over the No Action Alternative. The number of annual training activities that produce in-water sound from the use of sonar and other active acoustic sources under Alternative 1 would increase over the No Action Alternative (Table 3.0-8).

If a source uses a frequency within a sea turtle's hearing range, and if the sea turtle is close enough to perceive the sound, the sea turtle may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources under the Alternative 1 are shown in Table 3.5-5 for annual training activities. The results shown are the impacts on sea turtles predicted for 1 year of training. The impacts are predicted to increase compared to the No Action Alternative. Based on modeling, 109 TTS exposures and no PTS exposures are expected (Table 3.5-5). While no TTS or PTS was predicted by the Navy Acoustic Effects Model (NAEMO) modeling for olive ridley turtles, they may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. These impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness).

The TTS exposures could temporarily affect perception of sound within a limited frequency range. Sea turtles that reside during all or part of the year on a Navy range complex may be exposed several times throughout the year to sound from sonar and other active acoustic sources. Exposures to sonar and other active acoustic sources in open water areas would be intermittent and geographically variable. Pronounced reactions to acoustic stimuli could lead to a sea turtle expending energy and missing opportunities to forage or breed. In most cases acoustic exposures are intermittent, allowing time to recover from an incurred energetic cost, resulting in no long-term consequence.

The increase in predicted impacts on sea turtles could mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some animals are exposed, when compared to the No Action Alternative. However, the expected impacts on any individual sea turtle remain the same. Similarly, the model may over-predict acoustic impacts because it does not consider avoidance and the criteria to predict impacts are conservative. For the same reasons provided in for the No Action Alternative, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness) to most individuals. Although some individuals may experience long-term impacts, population-level impacts are not expected.

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities under Alternative 1 may affect, and is likely to adversely affect, green, hawksbill, loggerhead, or leatherback sea turtles. The use of sonar and other active acoustic sources during training activities under Alternative 1 may affect, but is not likely to adversely affect olive ridley sea turtles.

Testing Activities

Testing activities under Alternative 1 include activities that produce in-water sound from sonar or other active non-impulse acoustic sources that fall within the hearing range of sea turtles. A detailed description of these activities, the number of activities, and their proposed locations are presented in Tables 2.8-2 to 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives).

Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources under Alternative 1 are shown in Table 3.5-6 for annual testing activities. The impacts are predicted to increase compared to the No Action Alternative.

Although impacts could occur across all of the MITT Study Area due to various types of testing involving active acoustic sources, the portion of total predicted impacts are greater for certain activities, either due to the types of sources or the hours of use. Testing activities using sonar and other active acoustic sources are often multi-day activities during which active sources are used intermittently; therefore, some animals may be exposed multiple times over the course of a few days. Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources are shown in Table 3.5-6 for annual testing activities. The results shown are the impacts on sea turtles predicted for 1 year of testing under Alternative 1. Based on modeling, 186 TTS exposures and 0 PTS exposures are expected (Table 3.5-6). While no TTS or PTS was predicted by the NAEMO modeling for olive ridley turtles, they exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. These impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness).

If a source uses a frequency within a sea turtle's hearing range, and if the sea turtle is close enough to perceive the sound, they exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. The TTS exposures could temporarily affect perception of sound within a limited frequency range. Sea turtles that reside during all or part of the year on a Navy range complex may be exposed several times throughout the year to sound from sonar and other active acoustic sources. Exposures to sonar and other active acoustic sources in open water areas would be intermittent and geographically variable. Pronounced reactions to acoustic stimuli could lead to a sea turtle expending energy and missing opportunities to forage or breed. In most cases acoustic exposures are intermittent, allowing time to recover from an incurred energetic cost, resulting in no long-term consequence.

Because model-predicted impacts are conservative and most impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts. Although some individuals may experience long-term impacts, population-level impacts are not expected.

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities under Alternative 1 may affect, and is likely to adversely affect, green, hawksbill, loggerhead, or leatherback sea turtles. The use of sonar and other active acoustic sources during testing activities under Alternative 1 may affect, but is not likely to adversely affect olive ridley sea turtles.

3.5.3.1.5.4 Alternative 2

Training Activities

Training activities under Alternative 2 include activities that produce in-water sound from sonar or other active non-impulse acoustic sources that fall within the hearing range of sea turtles. A detailed description of these activities, the number of activities, and their proposed locations are presented in Tables 2.8-2 to 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives). Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources under the No Action Alternative are shown in Table 3.5-5 for annual training activities. The impacts are predicted to increase compared to the No Action Alternative.

Although impacts could occur across all of the MITT Study Area due to various types of training involving active acoustic sources, the portion of total predicted impacts are greater for certain activities, either due to the types of sources or the hours of use. Training activities using sonar and other active acoustic sources are often multi-day activities during which active sources are used intermittently; therefore, some animals may be exposed multiple times over the course of a few days. Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources are shown in Table 3.5-6 for annual training activities. The results shown are the impacts on sea turtles predicted for 1 year of testing. The impacts are predicted to increase compared to the No Action Alternative. Based on modeling, 138 TTS exposures and no PTS exposures are expected (Table 3.5-5). While no TTS or PTS was predicted by the NAEMO modeling for olive ridley turtles, the sea turtle may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. These impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness).

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities under Alternative 2 may affect, and is likely to adversely affect, green, hawksbill, loggerhead, or leatherback sea turtles. The use of sonar and other active acoustic sources during training activities under Alternative 2 may affect, but is not likely to adversely affect olive ridley sea turtles.

Testing Activities

Testing activities under Alternative 2 include activities that produce in-water sound from sonar or other active non-impulse acoustic sources that fall within the hearing range of sea turtles. A detailed description of these activities, the number of activities, and their proposed locations are presented in Tables 2.8-2 to 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives). Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources under Alternative 2 are shown in Table 3.5-6. The impacts are predicted to increase compared to the No Action Alternative.

Although impacts could occur across the Study Area due to various types of testing involving active acoustic sources, the portion of total predicted impacts are greater for certain activities, either due to the types of sources or the hours of use. Model-predicted acoustic impacts on sea turtles from exposure to sonar and other active acoustic sources for annually recurring testing activities under Alternative 2 are shown in Table 3.5-6. The results shown are the impacts on sea turtles predicted for 1 year of testing. The impacts are predicted to increase compared to the No Action Based on modeling, 189 TTS exposures and 1 PTS exposure could occur under Alternative 2 (Table 3.5-6). PTS due to testing with sonar and other active acoustic sources could permanently reduce perception of sound within a limited frequency range. This long-term consequence could impact an individual turtle's ability to sense biologically important sounds, such as predators or prey, reducing that animal's fitness. No TTS or PTS was predicted by the NAEMO modeling for olive ridley turtles, however, the sea turtle may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the area around the source, or they may exhibit no reaction at all. These impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness).

Despite the overall number of exposures increasing relative to the No Action Alternative, the modeled impacts on sea turtles are similar. Similarly, the model may over predict acoustic impacts because it does not consider avoidance and the criteria to predict impacts are conservative. For the same reasons provided for Alternative 1, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness) to most individuals. Although some individuals may experience long-term impacts, population-level impacts are not expected.

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities under Alternative 2 may affect, and is likely to adversely affect, green, hawksbill, loggerhead, or leatherback sea turtles. The use of sonar and other active acoustic sources during testing activities Alternative 2 may affect, but is not likely to adversely affect olive ridley sea turtles.

3.5.3.1.6 Impacts from Explosives

Explosions in the water or near the water's surface can introduce loud, impulse, broadband sounds into the marine environment. These sounds are likely within the audible range of most sea turtles, but the duration of individual sounds is very short. Energy from explosions is capable of causing mortalities, injuries to the lungs or gastrointestinal tract, TTS or PTS, or behavioral responses. The impacts on sea turtles from at-sea explosions depend on the net explosive weight of the charge, depth of the charge, the properties of detonations underwater, the animal's distance from the charge, the animal's location in the water column, and environmental factors such as water depth, water temperature, and bottom type. The net explosive weight accounts for the weight and the type of explosive material. Criteria for determining physiological impacts on sea turtles from impulse sound are discussed in Section 3.5.3.1.3 (Acoustic and Explosive Thresholds and Criteria).

Exposures that result in injuries such as non-lethal trauma and PTS may limit an animal's ability to find or obtain food, impact buoyancy, swimming ability, orientation, communicate with other animals, avoid predators, and interpret the environment around them. Impairment of these abilities can decrease an individual's chance of survival or impact its ability to successfully reproduce. Mortality of an animal will remove the animal entirely from the population as well as eliminate its future reproductive potential.

There is some limited information on sea turtle behavioral responses to impulse sound from airgun studies (see Section 3.5.3.1.3, Acoustic and Explosive Thresholds and Criteria) that can be used as a surrogate for explosive impact analysis. Any behavioral response to a single detonation would likely be a short-term startle response, if the animal responds at all. Multiple detonations over a short period may cause an animal to exhibit other behavioral reactions, such as interruption of feeding or avoiding the area.

3.5.3.1.6.1 Model-Predicted Impacts

The ranges to impacts from explosions of different charge weights for each of the specific criteria (onset mortality, onset slight lung injury, onset slight gastrointestinal tract injury, PTS, and TTS) are shown in Table 3.5-7. Sea turtles within these ranges are predicted by the model to receive the associated impact. Information regarding the ranges to impacts is important, not only for predicting acoustic impacts, but also for verifying the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher level impacts, especially physiological impacts on sea turtles. Because propagation of the acoustic waves is affected by environmental factors at different locations and because some criteria are partially based on sea turtle mass, the range of impacts for particular criteria will vary. The low value for each range of impact is the minimum range and the high value is the maximum range within which the impact could occur for various activities modeled for each explosive source class.

Table 3.5-7: Distance Impacts of In-Water Explosives on Sea Turtles from Representative Sources

Criteria/Predicted Impact[1]	Impact Predicted to Occur When Sea Turtle is at this Range (m) or Closer to a Detonation (Minimum Range Predicted to Maximum Range Predicted)			
	Source Class E2 (>0.25–0.5 lb. NEW)	Source Class E5 (>5–10 lb. NEW)	Source Class E9 (>100–250 lb. NEW)	Source Class E12 (>650–1,000 lb. NEW)
Onset Mortality (1 Percent Mortality)	12	47	137	204
Onset Slight Lung Injury	25	87	240	352
Onset Slight GI Tract Injury	25	71	147	274
Permanent Threshold Shift[2]	79	222	587	1,602
Temporary Threshold Shift[2]	178	598	1,711	3,615

[1] Criteria for impacts are discussed in Section 3.5.3.1.3 (Acoustic and Explosive Thresholds and Criteria).

[2] Modeling for Sound Exposure Level-based impulse criteria assumed explosive activity durations of one second. Actual durations may be less, resulting in smaller ranges to impact.

Notes: (1) GI = gastrointestinal, lb. = pounds, m = meters, NEW = net explosive weight

(2) Ranges determined using REFMS, Navy's explosive propagation model.

Based on the estimate of sound exposure level that could induce a sea turtle to exhibit avoidance behavior when exposed to repeated impulse sounds (see Section 3.5.3.1.3.12, Criteria for Behavioral Responses), the distance from an explosion at which a sea turtle may behaviorally react (e.g., avoid by moving farther away) can be estimated. If exposed to a single impulse sound, a sea turtle is assumed to exhibit a brief startle reaction that would likely be biologically insignificant.

Table 3.5-8, Table 3.5-9, and Table 3.5-10 present predicted impacts on sea turtles from explosive detonations estimated by the Navy Acoustic Effects Model, applying the impact threshold criteria shown in Table 3.5-3. The impact estimates for each alternative represent the total number of impacts and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year.

Some of the conservative assumptions made for the impact modeling and criteria may cause the impact predictions to be overestimated, as follows:

- Many explosions from ordnance such as bombs and missiles actually explode upon impact with above-water targets. For this analysis, sources such as these were modeled as exploding at depths of 1 m, overestimating the amount of explosive and acoustic energy entering the water.
- For predicting TTS and PTS based on sound exposure level, the duration of an explosion is assumed to be one second. Actual detonation durations may be much shorter, so the actual sound exposure level at a particular distance may be lower.
- Mortality and slight lung injury criteria are based on juvenile turtle masses, which substantially increases that range to which these impacts are predicted to occur compared to the ranges that would be predicted using adult turtle masses.
- As discussed in Section 3.5.3.1.3.9 (Criteria for Impulsive Temporary Threshold Shift) and Section 3.5.3.1.3.11 (Criteria for Impulsive Permanent Threshold Shift), the thresholds that were used to quantitatively predict onset of TTS and PTS for sea turtles were incorrectly lowered when developing sea turtle acoustic impact criteria based on cetacean data. Therefore, the predicted impacts shown above (PTS and TTS) are conservative (i.e., over-predicted).

Table 3.5-8: Annual Model-Predicted Impacts on Sea Turtles from Explosives for Training Activities under the No Action Alternative

Sea Turtle Species	Temporary Threshold Shift	Permanent Threshold Shift	GI Tract Injury	Slight Lung Injury	Mortality
Green sea turtle	6	0	0	1	0
Hawksbill sea turtle	2	0	0	0	0
Loggerhead sea turtle	0	0	0	0	0
Olive ridley sea turtle	0	0	0	0	0
Leatherback sea turtle	0	0	0	0	0
TOTAL	**8**	**0**	**0**	**1**	**0**

Notes: (1) GI = gastrointestinal. (2) The timing, locations, and numbers of these activities would not substantially differ from year to year under each alternative. The numbers presented in this table reflect post-modeling adjustments which decrease the potential for an impact on sea turtles.

Table 3.5-9: Annual Model-Predicted Impacts on Sea Turtles from Explosives for Training Activities under Alternative 1 and Alternative 2

Sea Turtle Species	Temporary Threshold Shift	Permanent Threshold Shift	GI Tract Injury	Slight Lung Injury	Mortality
Green sea turtle	11	1	0	3	1
Hawksbill sea turtle	3	0	0	1	1
Loggerhead sea turtle	0	0	0	0	0
Olive ridley sea turtle	0	0	0	0	0
Leatherback sea turtle	0	0	0	0	0
TOTAL	**14**	**1**	**0**	**4**	**2**

Notes: (1) GI = gastrointestinal. (2) The timing, locations, and numbers of these activities would not substantially differ from year to year under each alternative. The numbers presented in this table reflect post-modeling adjustments which decrease the potential for an impact on sea turtles.

Table 3.5-10: Annual Model-Predicted Impacts on Sea Turtles from Explosives for Testing Activities under the No Action Alternative, Alternative 1, and Alternative 2

Sea Turtle Species	Temporary Threshold Shift	Permanent Threshold Shift	GI Tract Injury	Slight Lung Injury	Mortality
Green sea turtle	0	0	0	0	0
Hawksbill sea turtle	0	0	0	0	0
Loggerhead sea turtle	0	0	0	0	0
Olive ridley sea turtle	0	0	0	0	0
Leatherback sea turtle	0	0	0	0	0
TOTAL	**0**	**0**	**0**	**0**	**0**

Notes: (1) GI = gastrointestinal. (2) The timing, locations, and numbers of these activities would not substantially differ from year to year under each alternative. The numbers presented in this table reflect post-modeling adjustments which decrease the potential for an impact on sea turtles.

The predicted acoustic impacts do not take into account mitigation measures implemented during many training and testing activities, such as exclusion zones around detonations. Smaller hatchling and early juvenile turtles tend to be near the surface.

3.5.3.1.6.2 No Action Alternative

Training Activities

Under the No Action Alternative, explosions during training activities would be spread throughout the Study Area. Explosions would occur during naval gunnery, missile exercises, bombing exercises, sinking exercise, tracking exercises, and mine warfare. The largest source class used during training under the No Action Alternative would be E12 (> 650–1,000 lb. [> 272.2–453.6 kg] NEW). However, of all explosives used for training under the No Action Alternative (844, Table 3.0-9) only four are of this source class, and this source class is only used in the MITT Study Area at distances greater than 50 nautical miles (nm) from shore. With the exception of those used at FDM and the nearshore underwater detonation sites, the vast majority of all explosives used under the No Action Alternative occur in areas greater than 3 nm from shore. There is a potential (albeit small) for aberrant ordnance at FDM to miss land-based targets and strike the beaches of FDM. However, the terrain of FDM does not provide any sea turtle nesting beaches; therefore, effects on sea turtles are not expected.

Under the No Action Alternative, training activities using explosions that could occur anywhere in the Study Area, including within nearshore shallow areas below the high tide line, are restricted to 50 detonations annually, all of them less than at or below the E5 source class (> 5–10 lb. [> 2.3–4.5 kg] NEW).

Modeling results indicate eight TTS exposures, zero PTS exposures, one exposure resulting in lung injury, and zero exposures resulting in mortality for sea turtles (Table 3.5-8). Any injured sea turtles could suffer reduced fitness and long-term survival. Some sea turtles beyond the ranges of the above impacts may behaviorally react if they hear a detonation. Activities consisting of single detonations, such as bombing and missile exercise, are expected to only elicit short-term behavioral reactions. If a sea turtle hears multiple detonations in a short period, such as during gunnery, firing, or sonobuoy exercises, it may react by avoiding the area. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of detonations and exposures would not occur over long durations, there would be an opportunity to recover from an incurred energetic cost.

Because model-predicted impacts are conservative and most impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Although a few individuals may experience long-term impacts and potential mortality, population-level impacts are not expected.

Pursuant to the ESA, the use of underwater explosives during training activities under the No Action Alternative may affect, and is likely to adversely affect, green and hawksbill sea turtles. Pursuant to the ESA, the use of underwater explosives during training activities under the No Action Alternative may affect, but is not likely to adversely affect loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under the No Action Alternative, there are no testing activities that involve explosive detonations.

3.5.3.1.6.3 Alternative 1

Training Activities

Under Alternative 1, the number of explosives used during training activities would rise from 844 to 9,696 per year and would be spread throughout the MITT Study Area (see Table 3.0-9). Explosives would occur during naval gunnery, missile exercises, bombing exercises, sinking exercise, tracking exercises, and mine warfare. The total number of explosive detonations that could occur in the shallow portions of the MITT Study Area increases. Similar to the No Action Alternative, the source class for these activities is E5 (> 5–10 lb. NEW) or less. The 8,601 additional detonations (less than E5) in all training areas (but potentially in shallow waters) would increase the disturbance of nearshore turtles. Aside from those used at FDM and the nearshore underwater detonation sites, most detonations would typically occur beyond approximately 3 nm from shore, minimizing impacts near nesting beaches or coastal habitats for sea turtles. There is a potential (albeit small) for aberrant ordnance at FDM to miss land-based targets and strike the beaches of FDM. Though detonations occur under Alternative 1 at FDM, the terrain of FDM does not provide any sea turtle nesting beaches; therefore, effects on sea turtles are not expected.

A small number of near-shore (within 3 nm) training activities could occur, potentially exposing some sea turtles approaching nesting beaches to impulse sounds over a short duration if the training occurred during nesting season or close to sea turtles nearshore habitats. In water training activities using lower NEW explosives (up to 20 lb. NEW) will occur at underwater detonation sites within Agat Bay Floating Mine Neutralization Site. At Piti Point Floating Mine Neutralization Site and Apra Harbor Underwater Detonation Site, the maximum NEW would remain the same as with the No Action Alternative (a maximum allowable threshold of 10 lb. NEW).

The remaining activities conducted under Alternative 1 utilizing explosive detonations would be restricted to portions of the MITT Study Area that are greater than 3 nm from the shore. Model-predicted impacts on sea turtles due to explosives used in annually recurring training activities under Alternative 1 are shown in Table 3.5-9. The results shown are the impacts on sea turtles predicted for 1 year of training.

Modeling results indicate 14 TTS exposures, 1 PTS exposure, 4 exposures resulting in lung injury, and 2 exposures resulting in mortality for sea turtles (Table 3.5-9). As mentioned above most detonations would typically occur beyond approximately 3 nm from shore, which minimizes the impacts near nesting beaches or coastal habitats for sea turtles. Any injured sea turtles could suffer reduced fitness and long-term survival. Sea turtles that experience PTS would have permanently reduced perception of sound within a limited frequency range. It is uncertain whether some permanent hearing loss over a part of a sea turtle's hearing range would have long-term consequences for that individual, as the sea turtle hearing range is already limited. A long-term consequence could be an impact on an individual turtle's ability to sense biologically important sounds, such as predators or prey, reducing that animal's fitness. PTS and TTS threshold criteria for sea turtles are conservatively based on criteria developed for mid-frequency marine mammals, so actual PTS and TTS impacts may be less than the predicted quantities.

Some sea turtles beyond the ranges of the above impacts may behaviorally react if they hear a detonation. If a sea turtle hears multiple detonations in a short period, such as during gunnery, firing, or sonobuoy exercises, it may react by avoiding the area. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of detonations and exposures would not occur over long durations, there would be an opportunity to recover from an incurred energetic cost.

Because model-predicted impacts are conservative and most impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Although a few individuals may experience long-term impacts and potential mortality, population-level impacts are not expected.

Pursuant to the ESA, the use of underwater explosives during training activities under Alternative 1 may affect, and is likely to adversely affect, green and hawksbill sea turtles. Pursuant to the ESA, the use of underwater explosives during training activities under Alternative 1 may affect, but is not likely to adversely affect loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Alternative 1 would introduce 2,885 explosive detonations per year (see Table 3.0-9). Over 90 percent of these activities occur at distances greater than 3 nm from shore within the MIRC. Model-predicted acoustic impacts on sea turtles due to explosives during annually recurring testing activities under Alternative 1 are shown in Table 3.5-10. The results shown are the impacts on sea turtles predicted for 1 year of testing. Modeling results indicate no exposures at the level predicted to cause TTS, PTS, gastrointestinal injury, lung injury, or mortality for sea turtles. Although a few individuals may experience behavioral reactions, population-level impacts are not expected.

Pursuant to the ESA, the use of underwater explosives during testing activities under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.6.4 Alternative 2

Training Activities

Under Alternative 2, the number and location of training activities increases to 9,992 explosive detonations (see Table 3.0-9); however, the new events are restricted to areas greater than 50 nm from the shore in the MITT Study Area. Model-predicted impacts on sea turtles due to explosives used in annually recurring training activities under Alternative 2 are shown in Table 3.5-9, and are identical to those for Alternative 1. The results shown are the impacts on sea turtles predicted for 1 year of training.

These results are the same as for Alternative 1; therefore, the impacts under Alternative 2 are expected to be the same as Alternative 1.

Pursuant to the ESA, the use of underwater explosives during training activities under Alternative 1 may affect, and is likely to adversely affect, green and hawksbill sea turtles. Pursuant to the ESA, the use of underwater explosives during training activities under Alternative 2 may affect, but is not likely to adversely affect, leatherback, loggerhead, and olive ridley sea turtles.

Testing Activities

Alternative 2 would increase the number of explosive detonations to 3,431 (see Table 3.0-9). Over 92 percent of these testing activities occur in waters greater than 3 nm from shore within the Study Area. Model-predicted acoustic impacts on sea turtles due to explosions during annually recurring testing activities under Alternative 2 are shown in Table 3.5-10. Modeling results indicate no exposures at levels expected to cause TTS, PTS, gastrointestinal injury, lung injury, or mortality for sea turtles. Although a few individuals may experience behavioral reactions only, population-level impacts are not expected.

Pursuant to the ESA, the use of underwater explosives during testing activities under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley and leatherback sea turtles.

3.5.3.1.7 Impacts from Swimmer Defense Airguns

Airguns can introduce brief impulse, broadband sounds into the marine environment. These sounds are probably within the audible range of most sea turtles. Sounds from airguns are capable of causing PTS or TTS or behavioral responses. Single, small swimmer defense airguns would not cause direct trauma to sea turtles. Impulses from these small airguns lack the strong shock wave and rapid pressure increases of explosions that can cause primary blast injury or barotraumas. The limited information on assessing sea turtle behavioral responses to impulse sounds is discussed in Section 3.5.3.1.2.5 (Behavioral Reactions).

The behavioral response of sea turtles to the repeated firing of airguns has been studied for seismic survey airguns (e.g., oil and gas exploration). Sea turtles were shown to avoid higher-level exposures or to agitate when exposed to higher-level sources. However, the airguns proposed for use in Navy testing are smaller, and fire a limited number of times, so reactions would likely be lesser than those observed in studies.

Activities that use airguns as part of Navy testing activities would only occur at pierside locations in Apra Harbor; therefore, sea turtles outside of these areas would not be affected.

3.5.3.1.7.1 Model-Predicted Impacts

For the analysis of hearing loss, airguns are treated as any other impulse sound source. Estimates of the number of sea turtles exposed to levels capable of causing these impacts were calculated using the Navy Acoustic Effects Model.

3.5.3.1.7.2 No Action Alternative

Training Activities

Training activities under the No Action Alternative do not use airguns.

Testing Activities

Testing activities under the No Action Alternative do not use airguns.

3.5.3.1.7.3 Alternatives 1 and 2

Training Activities

Training activities under Alternative 1 and 2 do not use airguns.

Testing Activities

Testing activities that impart underwater impulse noise from airguns under Alternative 1 and 2 include pierside integrated swimmer defense testing activities at pierside locations, as described in Table 2.8-3. Small airguns (60 cubic inches) would release impulses into waters around Navy piers in Apra Harbor during 11 annual activities. These areas are industrial, and the waterways carry a high volume of vessel traffic in addition to Navy vessels. These areas tend to have high ambient noise levels sea turtles are not expected because of the high levels of human activity.

Pursuant to the ESA, noise from swimmer defense airguns testing activities under Alternative 1 or Alternative 2 would have no effect on green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.8 Impacts from Weapons Firing, Launch, and Impact Noise

Sea turtles may be exposed to weapons firing and launch noise and noises from the impact of non-explosive ordnance on the water's surface. The noises produced by these activities are described in Section 3.0.5.2.1.4 (Weapons Firing, Launch, and Impact Noise). Reactions by sea turtles to these specific stressors have not been recorded; however, sea turtles may be expected to react to weapons firing, launch, and non-explosive impact noise as they would other transient sounds.

Sea turtles exposed to firing, launch, and non-explosive impact noise may exhibit brief startle reactions, avoidance, diving, or no reaction at all. Gunfire noise would typically consist of a series of impulse sounds. Due to the short term, transient nature of gunfire noise, animals are may be exposed multiple noises but over a short time period. Launch noise would be transient and of short duration, lasting no more than a few seconds at any given location as a projectile travels. Many missiles and targets are launched from aircraft, which would produce minimal noise in the water due to the altitude of the aircraft at launch. Any launch noise transmitted into the water would likely be due only to launches from vessels. Most activities would consist of single launches. Non-explosive bombs, missiles, and targets could impact the water with great force and produce a short duration impulse noise underwater that would depend on the size, weight, and speed of the object at impact.

Sea turtles that are within the area of any of these noises would likely alert, startle, dive, or avoid the immediate area. An animal near the surface directly beneath the firing of a large gun may possibly experience sound exposure levels sufficient to cause a threshold shift; however, this potential impact may be unlikely if a sea turtle reacts to the presence of the vessel prior to a large gunfire activity.

3.5.3.1.8.1 No Action Alternative

Training Activities

Training activities under the No Action Alternative include activities that produce in-water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface. Activities could occur throughout the Study Area.

A sea turtle very near a launch or impact location could experience hearing impacts, although the potential for this effect has not been studied and a sea turtle may avoid vessel interactions prior to the firing of a gun. Sea turtles that experience PTS would have permanently reduced perception of sound within a limited frequency range. It is uncertain whether some permanent hearing loss over a part of a sea turtle's hearing range would have long-term consequences for that individual, as the sea turtle hearing range is already limited. A long-term consequence could be an impact on an individual turtle's ability to sense biologically important sounds, such as predators or prey, reducing that animal's fitness. TTS would result in short-term reduced perception of sound within a limited frequency range, lasting from minutes to days, depending on the exposure.

Any behavioral reactions would likely be short-term and consist of brief startle reactions, avoidance, or diving. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of firings or launches and would not occur over long durations, there would be an opportunity to recover from an incurred energetic cost.

Although some individuals may be impacted by activities that include weapons firing, launch, and non-explosive impact, population-level impacts are not expected.

Pursuant to the ESA, noise from weapons firing, launch, and non-explosive impact during training activities under the No Action Alternative may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing activities under the No Action Alternative do not include weapons firing, launch, and impact noise (Tables 2.8-2 through 2.8-4).

3.5.3.1.8.2 Alternative 1

Training Activities

Training activities under the Alternative 1 that produce in-water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface would increase compared to the No Action Alternative. The locations and types of activities would be similar to those under the No Action Alternative. The number of activities and their proposed locations are described in Table 2.8-1 of Chapter 2 (Description of Proposed Action and Alternatives).

Although the impacts on sea turtles are expected to increase under Alternative 1 compared to the No Action Alternative, the expected impacts on any individual sea turtle would remain the same. For the same reasons provided for the No Action Alternative, although some individuals may be impacted by activities that include weapons firing, launch, and non-explosive impact, population-level impacts are not expected.

Pursuant to the ESA, noise from weapons firing, launch, and non-explosive impact during training activities under Alternative 1 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing activities under Alternative 1 include activities that produce in-water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface. Activities are spread throughout the MITT Study Area during air-to-surface missile tests, kinetic energy weapon testing, and anti-surface warfare mission package testing as described in Tables 2.8-2 through 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives).

A sea turtle very near a launch or impact location could experience hearing impacts, although the potential for this effect has not been studied and a sea turtle may avoid vessel interactions prior to the firing of a gun. Sea turtles that experience PTS would have permanently reduced perception of sound within a limited frequency range. It is uncertain whether some permanent hearing loss over a part of a sea turtle's hearing range would have long-term consequences for that individual, as the sea turtle hearing range is already limited. A long-term consequence could be an impact on an individual turtle's ability to sense biologically important sounds, such as predators or prey, reducing that animal's fitness. TTS would result in short-term reduced perception of sound within a limited frequency range, lasting from minutes to days, depending on the exposure.

Any behavioral reactions would likely be short-term and consist of brief startle reactions, avoidance, or diving. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of firings or launches and would not occur over long durations, there would be an opportunity to recover from an incurred energy cost.

Although some individuals may be impacted by activities that include weapons firing, launch, and non-explosive impact, population-level impacts are not expected.

Pursuant to the ESA, noise from weapons firing, launch, and non-explosive impact during testing activities under Alternative 1 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.8.3 Alternative 2

Training Activities

The number and location of training activities under Alternative 2 are identical to training activities under Alternative 1. Therefore, impacts and comparisons to the No Action Alternative will also be identical.

Pursuant to the ESA, noise from weapons firing, launch, and non-explosive impact during training activities under Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing activities under Alternative 2 include activities that produce in-water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface. Activities are spread throughout the MITT Study Area during air-to-surface missile tests, kinetic energy weapon testing anti-submarine warfare tracking tests, and anti-surface warfare mission package testing as described in Tables 2.8-2 and 2.8-3 of Chapter 2 (Description of Proposed Action and Alternatives).

A sea turtle very near a launch or impact location could experience hearing impacts, although the potential for this effect has not been studied and a sea turtle may avoid vessel interactions prior to the firing of a gun. Sea turtles that experience PTS would have permanently reduced perception of sound within a limited frequency range. It is uncertain whether some permanent hearing loss over a part of a sea turtle's hearing range would have long-term consequences for that individual, as the sea turtle hearing range is already limited. A long-term consequence could be an impact on an individual turtle's ability to sense biologically important sounds, such as predators or prey, thereby reducing that animal's fitness. TTS would result in short-term reduced perception of sound within a limited frequency range, lasting from minutes to days, depending on the exposure.

Any behavioral reactions would likely be short-term and consist of brief startle reactions, avoidance, or diving. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of firings or launches and would not occur over long durations, there would be an opportunity to recover from an incurred energy cost.

Although some individuals may be impacted by activities that include weapons firing, launch, and non-explosive impact, population-level impacts are not expected.

Pursuant to the ESA, noise from weapons firing, launch, and non-explosive impact during testing activities under Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.9 Impacts from Vessel and Aircraft Noise

<u>Vessel Noise</u>

Vessel movements could occur throughout the Study Area, although some portions would have limited or no activity. Many ongoing and proposed training and testing activities within the MITT Study Area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels). Activities involving vessel movements occur intermittently, and are variable in duration, ranging from a few hours up to 2 weeks. Additionally, a variety of smaller craft are operated within the Study Area. Small craft types, sizes, and speeds vary. During training, speeds generally range from 10 to 14 knots; however, ships and craft can and will, on occasion, operate within the entire spectrum of their specific operational capabilities. A detailed description of vessel noise is provided in Section 3.0.5.2.1.5 (Vessel Noise).

Vessel noise could disturb sea turtles and potentially elicit an alerting, avoidance, or other behavioral reaction. Sea turtles are frequently exposed to research, ecotourism, commercial, government, and private vessel traffic. Some sea turtles may have habituated to vessel noise, and may be more likely to respond to the sight of a vessel rather than the noise of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Any reactions are likely to be minor and short-term avoidance reactions, leading to no long-term consequences for the individual or population.

Auditory masking can occur from vessel noise, potentially masking biologically important sounds (e.g., sounds of prey or predators) that sea turtles may rely upon. Potential for masking can vary depending on the ambient noise level within the environment); the received level and frequency of the vessel noise; and the received level and frequency of the sound of biological interest. Masking by passing ships or other sound sources transiting the MITT Study Area would be short-term and intermittent, and therefore unlikely to result in any substantial energetic costs or consequences to individual animals or populations. Areas with increased levels of ambient noise from anthropogenic noise sources, such as areas around busy shipping lanes and near harbors and ports, may cause sustained levels of auditory masking for sea turtles, which could reduce an animal's ability to find prey, find mates, avoid predators, or navigate. However, Navy vessels make up a very small percentage of the overall traffic and the rise of ambient noise levels in these areas is a problem related to all ocean users including commercial and recreational vessels and shoreline development and industrialization.

Surface combatant ships (e.g., guided missile destroyer, guided missile cruiser, and Littoral Combat Ship) and submarines are designed to be very quiet to evade enemy detection. While surface combatants and submarines may be detectable by sea turtles over ambient noise levels at distances of up to a few kilometers, any auditory masking would be minor and temporary. Other Navy ships and small craft have higher source levels, similar to equivalently sized commercial ships and private vessels. Ship noise tends to be low-frequency and broadband; therefore, it may have the largest potential to mask all sea turtle hearing. Noise from large vessels and outboard motors on small craft can produce source levels of 160 dB to over 200 dB re 1 µPa at 1 m for some large commercial vessels and outboard engines. Therefore, in the open ocean, noise from noncombatant Navy vessels may be detectable over ambient levels for tens of kilometers, and some auditory masking is possible. In noisier nearshore areas around Navy ports and ranges, vessel noise may be detectable above ambient for only several hundred meters. Some auditory masking to sea turtles is likely from noncombatant Navy vessels, especially in quieter, open-ocean environments.

An approaching vessel may produce a noise shadow when the propulsion system is located at the rear of the vessel. The vessels that pose the greatest risk to sea turtles are small, fast-moving vessels typically used in coastal waters where sea turtle abundance is the greatest (Chaloupka et al. 2008b). These boats typically have propeller configurations above the depth of the keel, shielding noise waves from projecting forward of the vessel (Gerstein et al. 2009). Noise levels in front of the approaching vessel are lower because the ship's hull blocks the noise produced by the propulsion system (Gerstein et al. 2009). Low-frequency noises are refracted around the ship's hull, as shown by Gerstein et al. (2009), while mid-frequency and high frequency noises are refracted outward from the vessel trajectory. In response, marine animals that hear in the middle and high frequencies may move to a position closer to the approaching vessel's bow trajectory, increasing the potential for a strike. Low-frequency specialists, such as sea turtles, are less likely to be confused by a noise shadow produced by an approaching vessel because the noise shadow contains low-frequency noises. The potential for vessel strikes is discussed in more detail in Section 3.5.3.3 (Physical Disturbance and Strike Stressors). Navy ships make up a small portion of the total ship traffic, even in the most concentrated port and nearshore areas; therefore, proposed Navy vessel transits are unlikely to cause long-term abandonment of habitat by sea turtles.

Aircraft Noise

Fixed and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area. Sea turtles may be exposed to aircraft noise wherever aircraft overflights occur in the Study Area. Most of these noises would be centered around airbases and fixed ranges within each range complex. Aircraft produce extensive airborne noise from either turbofan or turbojet engines. Rotary-wing aircraft (helicopters) produce low-frequency noise and vibration (Pepper et al. 2003). A severe but infrequent type of aircraft noise is the sonic boom, produced when the aircraft exceeds the speed of sound. A detailed description of aircraft noise as a stressor is provided in Section 3.0.5.2.1.6 (Aircraft Overflight Noise).

Transmission of noise from a moving airborne source to a receptor underwater is influenced by numerous factors, but significant acoustic energy is primarily transmitted into the water directly below the craft in a narrow cone area, as discussed in greater detail in Section 3.0.4, Acoustic and Explosives Primer. Underwater noises from aircraft are strongest just below the surface and directly under the aircraft, and attenuate (reduce in level) with increasing depth. The maximum noise levels in water from aircraft overflights (Table 3.0-12) are approximately 148 dB re 1 µPa for an F/A-18 aircraft at 1,000 ft. (304.8 m) altitude; approximately 125 dB re 1 µPa for an H-60 helicopter hovering at 50 ft. (15.2 m); and under ideal conditions, sonic booms (Table 3.0-13) from aircraft at 1,000 ft. (304.8 m) could reach up to 178 dB re 1 µPa at the water's surface (see Section 3.0.5.2.1.6, Aircraft Overflight Noise, for additional information on aircraft sonic booms).

Sea turtles may respond to both the physical presence and to the noise generated by aircraft, making causation by one or the other stimulus difficult to determine. In addition to noise, all low-flying aircraft create shadows, to which animals at the surface may react. Helicopters may also produce strong downdrafts, a vertical flow of air that becomes a surface wind, which can also affect an animal's behavior at or near the surface.

In most cases, exposure of a sea turtle to fixed-wing or rotary-wing aircraft would last for only seconds as the aircraft quickly passes overhead. Animals would have to be at or near the surface at the time of an overflight to be exposed to appreciable noise levels. Take-offs and landings occur at established airfields as well as on vessels at sea across the Study Area. Take-offs and landings from Navy vessels could startle sea turtles; however, these activities only produce in-water noise at any given location for a brief period as the aircraft climbs to cruising altitude. Some sonic booms from aircraft could startle sea turtles, but these activities are transient and happen infrequently at any given location within the Study Area. Repeated exposure to most individuals over short periods (days) is unlikely, except for animals that reside in nearshore areas around Navy ports, or on Navy fixed-ranges, or during major training exercises.

Low flight altitudes of helicopters during some activities, which often occur under 100 ft. (30.5 m) altitude, may elicit a somewhat stronger behavioral response due to the proximity to the water; the slower airspeed and therefore longer exposure duration; and the downdraft created by the helicopter's rotor. Sea turtles would likely avoid the area under the helicopter. An individual likely would not be exposed repeatedly for long periods because these activities typically transit open ocean areas within the Study Area.

3.5.3.1.9.1 No Action Alternative

Training Activities

Training activities under the No Action Alternative include noise from vessel movements and fixed- and rotary-wing aircraft overflights. Navy vessel and aircraft traffic associated with training could occur in all of the range complexes and throughout the MITT Study Area while in transit.

Most vessel traffic would be concentrated in waters near naval port facilities, as well as smaller craft concentrations near training areas. Therefore, the majority of noise introduced into the water by vessel movements would be concentrated in these areas.

Helicopters typically train closer to shore and at lower altitudes than fixed-wing aircraft. Sea turtles foraging in shallow waters may be exposed to in-water noise from helicopter overflights. Sea turtles exposed to a passing Navy vessel or aircraft may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to aircraft or vessels are not likely to disrupt major behavioral patterns or to result in serious injury to any sea turtles. Acoustic masking may occur due to vessel noises, especially from noncombatant ships. Acoustic masking may prevent an animal from perceiving biologically relevant sounds during the period of exposure, potentially resulting in missed opportunities to obtain resources.

Long-term impacts due to the proposed activities are unlikely because the density of Navy ships in the MITT Study Area is low overall and many Navy ships are designed to be as quiet as possible. Abandonment of habitat is unlikely due to proposed Navy activities because of the low overall density of Navy vessel and aircraft in the Study Area. No long-term consequences for individuals or the population would be expected.

Pursuant to the ESA, noise from vessels and aircraft during training activities under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing activities under the No Action Alternative include noise from vessel movements and. Sea turtles exposed to a passing Navy vessel may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to vessels are not likely to disrupt major behavioral patterns or to result in serious injury to any sea turtles. Acoustic masking may occur due to vessel noises, especially from noncombatant ships. Acoustic masking may prevent an animal from perceiving biologically relevant sounds during the period of exposure, potentially resulting in missed opportunities to obtain resources.

Long-term impacts due to the proposed activities are unlikely because the density of Navy ships in the MITT Study Area is low overall and many Navy ships are designed to be as quiet as possible. Abandonment of habitat is unlikely due to proposed Navy activities because of the low overall density of Navy vessels in the Study Area. No long-term consequences for individuals or the population would be expected.

Pursuant to the ESA, noise from vessels during testing activities under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.9.2 Alternative 1

Training Activities

Training activities proposed under Alternative 1 would increase vessel traffic and aircraft flight hours compared to the No Action Alternative, increasing overall amounts of aircraft and vessel noise. Certain portions of the Study Area, such as areas near Navy ports and training ranges are used more heavily by vessels and aircraft than other portions of the Study Area. The types and locations of noise from vessels and aircraft would be similar to those under the No Action Alternative.

Although more sea turtle exposures to noise from vessels and aircraft could occur, predicted impacts from vessel or aircraft noise would not differ substantially from those under the No Action Alternative.

Significant behavioral reactions by sea turtles due to passing vessel or aircraft noise are not expected (for the same reasons stated for the No Action Alternative), even though the noise may cause short-term impacts, no long-term consequences for individuals or populations would be expected.

Pursuant to the ESA, noise from vessels and aircraft during training activities under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing activities proposed under Alternative 1 would increase Navy vessel traffic and aircraft overflights compared to the No Action Alternative, increasing overall amounts of vessel and aircraft noise. New vessels proposed for testing under Alternative 1 (see Section 2.7.3.2, Ships), such as the Littoral Combat Ship, are all fast-moving and designed to operate in nearshore waters. Overall noise levels may increase in these environments. The number of activities and proposed locations are discussed in further detail in Tables 2.8-2 through 2.8-4 of Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.5.2.1.5 (Vessel Noise), and Section 3.0.5.2.1.6 (Aircraft Overflight Noise).

Although more sea turtle exposures to noise from vessels and aircraft could occur, predicted impacts from vessel would not differ substantially from those under the No Action Alternative. Sea turtles exposed to a passing Navy aircraft may not respond at all, or they may exhibit a short-term behavioral response such as avoidance or changing dive behavior. Short-term reactions to aircraft are not likely to disrupt major behavioral patterns or to result in serious injury to any sea turtles. Significant behavioral reactions by sea turtles due to passing vessel or aircraft noise are not expected. For the same reasons stated for the No Action Alternative, even though the noise may cause short-term impacts, no long-term consequences for individuals or populations would be expected.

Pursuant to the ESA, noise from vessels and aircraft during testing activities under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.1.9.3 Alternative 2

Training Activities

The number and location of training activities under Alternative 2 are identical to training activities under Alternative 1. Therefore, impacts and comparisons to the No Action Alternative will also be identical.

Pursuant to the ESA, noise from vessels and aircraft during training activities under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Testing Activities proposed under Alternative 2 would increase Navy vessel traffic and aircraft overflights compared to the No Action Alternative, increasing overall amounts of vessel and aircraft noise. The types of activities and their locations would similar to those under Alternative 1, although overall activities would increase very slightly. The number of activities and proposed locations are discussed in further detail in Tables 2.8-2 and 2.8-3 of Chapter 2 (Description of Proposed Action and Alternatives), Section 3.0.5.2.1.5 (Vessel Noise), and Section 3.0.5.2.1.6 (Aircraft Overflight Noise).

Although more sea turtle exposures to noise from vessels and aircraft could occur, predicted impacts from vessel or aircraft noise would not differ substantially from those under Alternative 1. Significant behavioral reactions by sea turtles due to passing vessel or aircraft noise are not expected. For the same reasons stated for the No Action Alternative, even though vessel may cause short-term impacts, no long-term consequences for individuals or populations would be expected. Similarly, although aircraft noise may cause short-term impacts, no long-term consequences for individuals or populations would be expected.

Pursuant to the ESA, noise from vessels and aircraft during testing activities under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.2 Energy Stressors

This section evaluates the potential for sea turtles to be impacted by electromagnetic devices used during training and testing activities in the Study Area.

3.5.3.2.1 Impacts from Electromagnetic Devices

Several different types of electromagnetic devices are used during training and testing activities. For a discussion of the types of activities that use electromagnetic devices, where they are used, and how many activities will occur under each alternative, please see Section 3.0.5.2.2.1 (Electromagnetic Devices).

Well over a century ago, electromagnetic fields were introduced into the marine environment within the MITT Study Area from a wide variety of sources (e.g., power transmission cables), yet little is known about the potential impacts of these sources. Studies on behavioral responses to magnetic fields have been conducted on green and loggerhead sea turtles. Loggerheads were found to be sensitive to field intensities ranging from 0.0047 to 4000 microteslas, and green sea turtles were found to be sensitive to field intensities from 29.3 to 200 microteslas (Normandeau et al. 2011). Because these data are the best available information, this analysis assumes that the responses would be similar for other sea turtle species.

Sea turtles use geomagnetic fields to navigate at sea, and therefore changes in those fields could impact their movement patterns (Lohmann and Lohmann 1996; Lohmann et al. 1997). Turtles in all life stages orient to the earth's magnetic field to position themselves in oceanic currents; this helps them locate seasonal feeding and breeding grounds and to return to their nesting sites (Lohmann and Lohmann 1996; Lohmann et al. 1997). Experiments show that sea turtles can detect changes in magnetic fields, which may cause them to deviate from their original direction (Lohmann and Lohmann 1996; Lohmann et al. 1997). For example, Lohmann and Lohmann (1996) found that loggerhead hatchlings tested in a magnetic field of 52,000 nanoteslas swam eastward, and when the field was decreased to 43,000 nanoteslas, the hatchlings swam westward. Sea turtles also use nonmagnetic cues for navigation and migration, and these additional cues may compensate for variations in magnetic fields.

3.5.3.2.1.1 No Action Alternative

<u>Training Activities</u>

Under the No Action Alternative, there are no training activities that involve the use of electromagnetic devices.

Testing Activities

Under the No Action Alternative, there are no testing activities that involve the use of electromagnetic devices.

3.5.3.2.1.2 Alternative 1

Training Activities

As indicated in Section 3.0.5.2.2.1 (Electromagnetic Devices), training activities involving electromagnetic devices under Alternative 1 occur up to five times annually as part of mine countermeasure (MCM) (towed mine detection) and Civilian Port Defense activities. Table 2.8-1 lists the number and location of training activities that use electromagnetic devices. All sea turtle species in the MITT Study Area could potentially occur in these locations and would have the potential to be exposed to the electromagnetic fields.

If located in the immediate area (within about 650 ft. [198 m]) where electromagnetic devices are being used, sea turtles could deviate from their original movements (as shown by Normandeau et al. 2011), but the extent of this disturbance is likely to be inconsequential. The electromagnetic devices used in training activities are not expected to cause more than a short-term behavioral disturbance to sea turtles because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) very localized potential impact area, and (3) temporary duration of the activities (hours). Potential impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 1 may increase the risk of sea turtle exposures to electromagnetic energy. However, the use of electromagnetic devices is not expected to cause more than a short-term behavioral disturbance to sea turtles or have any lasting effects on their survival, growth, recruitment, or reproduction.

Pursuant to the ESA, the use of electromagnetic devices during training activities under Alternative 1 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Mission package testing for new ship systems includes the use of electromagnetic devices (magnetic fields generated underwater to detect mines). Under Alternative 1, the Naval Sea Systems Command will engage in up to 32 MCM mission package testing activities. All sea turtle species in the MITT Study Area could potentially occur in these locations and would have the potential to be exposed to the electromagnetic fields.

If located in the immediate area (within about 650 ft. [198 m]) where electromagnetic devices are being used, sea turtles could deviate from their original movements (as shown by Normandeau et al. 2011), but the extent of this disturbance is likely to be inconsequential. The electromagnetic devices used in testing activities are not expected to cause more than a short-term behavioral disturbance to sea turtles because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) very localized potential impact area, and (3) temporary duration of the activities (hours). Potential impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 1 may increase the risk of sea turtle exposures to electromagnetic energy. However, the use of electromagnetic devices is not expected to cause more than a short-term behavioral disturbance to sea turtles or have any lasting effects on their survival, growth, recruitment, or reproduction.

Pursuant to the ESA, the use of electromagnetic devices during testing activities under Alternative 1 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.2.1.3 Alternative 2

Training Activities

As indicated in Section 3.0.5.2.2.1 (Electromagnetic Devices), training activities involving electromagnetic devices under Alternative 2 occur up to five times annually as part of MCM (towed mine detection) and Civilian Port Defense activities. Table 2.8-1 lists the number and location of training activities that use electromagnetic devices.

If located in the immediate area (within about 650 ft. [198 m]) where electromagnetic devices are being used, sea turtles could deviate from their original movements (as shown by Normandeau et al. 2011), but the extent of this disturbance is likely to be inconsequential. The electromagnetic devices used in training activities are not expected to cause more than a short-term behavioral disturbance to sea turtles because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) very localized potential impact area, and (3) temporary duration of the activities (hours). Potential impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 2 may increase the risk of sea turtle exposures to electromagnetic energy. However, the use of electromagnetic devices is not expected to cause more than a short-term behavioral disturbance to sea turtles or have any lasting effects on their survival, growth, recruitment, or reproduction.

Pursuant to the ESA, the use of electromagnetic devices during training activities under Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

Testing Activities

Mission package testing for new ship systems includes the use of electromagnetic devices (magnetic fields generated underwater to detect mines). Under Alternative 2, the Naval Sea Systems Command will engage in up to 36 MCM mission package testing activities. All sea turtle species in the MITT Study Area could potentially occur in these locations and would have the potential to be exposed to the electromagnetic fields.

If located in the immediate area (within about 650 ft. [198 m]) where electromagnetic devices are being used, sea turtles could deviate from their original movements (as shown by Normandeau et al. 2011), but the extent of this disturbance is likely to be inconsequential. The electromagnetic devices used in testing activities are not expected to cause more than a short-term behavioral disturbance to sea turtles because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m from the source), (2) very localized potential impact area, and (3) temporary duration of the activities (hours). Potential impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 2 may increase the risk of sea turtle exposures to electromagnetic energy. However, the use of electromagnetic devices is not expected to cause more than a short-term behavioral disturbance to sea turtles or have any lasting effects on their survival, growth, recruitment, or reproduction.

Pursuant to the ESA, the use of electromagnetic devices during testing activities under Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, and leatherback sea turtles.

3.5.3.3 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance and strike stressors used by Navy during training and testing activities within the Study Area. The physical disturbance and strike stressors that may impact sea turtles include: (1) vessels, (2) in-water devices, (3) military expended materials, and (4) seafloor devices. Sections 3.0.5.2.1.1 (Sonar and Other Active Acoustic Sources) through 3.0.5.2.1.4 (Weapons Firing, Launch, and Impact Noise) contain the analysis of the potential for disturbance visual or acoustic cues. For a list of Navy activities that involve this stressor, refer to Table 3.0-7 (Stressors by Warfare and Testing Area).

The way a physical disturbance may affect a sea turtle would depend in part on the relative size of the object, the speed of the object, the location of the sea turtle in the water column, and the behavioral reaction of the sea turtle. It is not known at what point or through what combination of stimuli (visual, acoustic, or through detection in pressure changes) a sea turtle becomes aware of a vessel or other potential physical disturbances prior to reacting or being struck. Like marine mammals, if a sea turtle reacts to physical disturbance, the individual must stop its activity and divert its attention in response to the stressor. The energetic costs of reacting to a stressor are dependent on the specific situation, but one can assume that the caloric requirements of a response may reduce the amount of energy available for other biological functions. Given that the presentation of a physical disturbance should be very rare and brief, the cost from the response is likely to be within the normal variation experienced by a sea turtle during its daily routine unless the animal is struck. If a strike does occur, the cost to the individual could range from slight injury to death.

3.5.3.3.1 Impacts from Vessels

The majority of the training and testing activities under all alternatives involve some level of vessel activity. For a discussion of the types of activities that include the use of vessels, where they are used, and the speed and size characteristics of vessels used, see Section 3.0.5.2.3.2 (Vessels). Vessels include ships, submarines and boats ranging in size from small, 22 ft. (7 m) rigid hull inflatable boats to aircraft carriers with lengths up to 1,092 ft. (333 m). Large Navy ships generally operate at speeds in the range of 10 to 15 knots, and submarines generally operate at speeds in the range of 8 to 13 knots. Small craft (for purposes of this discussion less than 40 ft. [12 m] in length) have much more variable speeds (dependent on the mission). While these speeds are representative of most activities, some vessels need to operate outside of these parameters. For example, in order to produce the required relative wind speed over the flight deck, an aircraft carrier vessel group engaged in flight operations must adjust its speed through the water accordingly. Conversely, there are other instances such as launch and recovery of a small rigid hull inflatable boat, vessel boarding, search, and seizure training activities or retrieval of a target when vessels will be dead in the water or moving slowly ahead to maintain steerage. There are a few specific activities including high speed tests of newly constructed vessels such as aircraft carriers, amphibious assault ships and the Joint High Speed Vessel (which will operate at an average speed of 35 knots) where vessels will operate at higher speeds.

The number of Navy vessels in the MITT Study Area at any given time varies and is dependent local training or testing requirements. Most activities include either one or two vessels and may last from a few hours up to 2 weeks. Vessel movement as part of the Proposed Action would be widely dispersed throughout the Study Area, but more concentrated in portions of the MITT Study Area near ports, naval installations, range complexes and testing ranges.

Minor strikes may cause temporary reversible impacts, such as diverting the turtle from its previous activity or causing minor injury. Major strikes are those that can cause permanent injury or death from bleeding or other trauma, paralysis and subsequent drowning, infection, or inability to feed. Apart from the severity of the physical strike, the likelihood and rate of a turtle's recovery from a strike may be influenced by its age, reproductive state, and general condition. Much of what is written about recovery from vessel strikes is inferred from observing individuals some time after a strike. Numerous sea turtles bear scars that appear to have been caused by propeller cuts or collisions with vessel hulls (Hazel et al. 2007; Lutcavage et al. 1997; Lutcavage and Lutz 1997), suggesting that not all vessel strikes are lethal. Conversely, fresh wounds on some stranded animals may strongly suggest a vessel strike as the cause of death. The actual incidence of recovery versus death is not known, given available data.

Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open ocean and coastal areas, whether feeding or periodically surfacing to breathe. Sea turtles spend a majority of their time submerged (Renaud and Carpenter 1994; Sasso and Witzell 2006), though Hazel (2009) showed turtles staying within the top 3 m of water despite deeper water being available. Leatherback turtles are more likely to feed at or near the surface in open ocean areas. It is important to note that leatherbacks can forage for jellyfish at depth but bring them to the surface to ingest (James and Herman 2001, Benson et al. 2011, Fossette et al. 2007). Green, hawksbill, and loggerhead turtles are more likely to forage nearshore, and although they may feed along the seafloor, they surface periodically to breathe while feeding and moving between nearshore habitats. Olive ridleys can spend extended periods foraging at depth, even in open ocean areas (McMahon et al. 2007). Green and hawksbill sea turtles are the two most common sea turtles found in the nearshore environment of the Study Area. All sea turtle species are distributed widely in all offshore portions of the Study Area.

To assess the risk or probability of a physical strike, the number, size, and speed of Navy vessels were considered, as well as the sensory capability of sea turtles to identify an approaching vessel. Because of the wide dispersal of large vessels in open ocean areas and the widespread, scattered distribution of turtles at sea, strikes during open-ocean transits of Navy vessels are unlikely. For very large vessels, the bow wave may even preclude a sea turtle strike. The probability of a strike is further reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring), which include lookouts and "safe speed" procedures. Smaller, faster vessels that operate in nearshore waters, where green, hawksbill, olive ridley, and loggerhead sea turtles can be more densely concentrated, pose a greater risk (Chaloupka et al. 2008b), though the density of turtles in these areas remains low. Some vessels associated with training and testing can travel at high speeds, which increase the strike risk to sea turtles (Table 3.0-15) (Hazel et al. 2007). Vessels transiting in shallow waters to and from ports travel at slower speed and pose less risk of strikes to sea turtles (see Section 3.0.5.2.3, Physical Disturbance and Strike Stressors).

3.5.3.3.1.1 No Action Alternative, Alternative 1, and Alternative 2

Training Activities

As indicated in Section 3.0.5.2.3 (Physical Disturbance and Strike Stressors), the majority of the training activities under all alternatives involve vessels. See Table 3.0-15 for a representative list of Navy vessel sizes and speeds. Vessel activities could be widely dispersed throughout the Study Area, but would be more concentrated near naval ports, piers and range areas. There would be a higher likelihood of vessel strikes over nearshore than in the open ocean portions of the MITT Study Area because of the concentration of vessel movements in those areas. Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area. Given the concentration of Navy vessel movements near naval ports, piers and range areas, this training activity could overlap with sea turtles occupying these waters.

Under the No Action Alternative, Alternative 1 and Alternative 2, exposure to vessels used in training activities may cause short-term disturbance to an individual turtle, and if struck, it could lead to injury or death. As demonstrated by scars on all species of sea turtles, they are not always able to avoid being struck; therefore, vessel strikes are a potential cause of mortality for these species.

Because of the wide dispersal of large vessels in open ocean areas and the widespread, scattered distribution of turtles at sea, strikes during open-ocean transits of Navy vessels are unlikely. For very large vessels, the bow wave may even preclude a sea turtle strike. The probability of a strike anywhere in the MITT Study Area is further reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). Although the likelihood of being struck is minimal, sea turtles that overlap with Navy exercises are more likely to encounter vessels. Potential impacts of exposure to vessels may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment.

Amphibious vessels could contact sea turtle nesting beaches during Amphibious Assault and Amphibious Raid operations. These amphibious vessels would include MK V Special Operations Craft, Mechanized and Utility Landing Craft, Air Cushioned Landing Craft, and other boats for transporting people or equipment. Amphibious Assault and Amphibious Raid training could be conducted in the nearshore area including the surf zone up to the high tide line at Unai Chulu, Unai Babui, and Unai Dankulo, Tinian as well as Dry Dock Island in Apra Harbor, and Dadi Beach on Guam. Amphibious Raid activities could also be conducted on Rota, but are restricted to approaches via boat docks (no beach landings). In accordance with COMNAVMARIANASINST 3500.4, prior to beach landings by amphibious vehicles, known sea turtle nesting beaches are surveyed by Navy biologists for the presence of sea turtle nests no more than 6 hours prior to a landing exercise. Areas free of nests are flagged, and vehicles are directed to remain within these areas. Landing Craft Air Cushion (LCAC) landings on Tinian are scheduled for high-tide. LCACs stay on-cushion until clear of the water and within a designated Craft Landing Zone (CLZ). Within the CLZ, LCAC come off-cushion with the LCAC oriented to permit expeditious vehicle and cargo offload onto a cleared offload and vehicle traffic area. Although LCAC and expeditionary vehicle traffic typically do not leave ruts, some compaction of sand in vehicle tracks is possible. If restoration of beach topography is required it is conducted using non-mechanized methods. Additionally, Navy biologists monitor beaches during nighttime training landing exercises. If sea turtles are observed or known to be within the area, training activities are halted until all nests have been located and sea turtles have left the area. Identified nests are avoided during the night-time landing exercise.

Pursuant to the ESA, the use of vessels during training activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

As indicated in Section 3.0.5.2.3 (Physical Disturbance and Strike Stressors), most testing activities involve the use of vessels. However, the number of vessels used for testing activities is comparatively lower than the number of vessels used for training (less than 10 percent). In addition, testing often occurs jointly with training, so it is likely that the testing activity would occur on a training vessel. Vessel movement in conjunction with testing activities could be widely dispersed throughout the Study Area, but would be concentrated near naval ports, and piers. There would be a higher likelihood of vessel strikes over the nearshore portions of the MITT Study Area (most notably during the nesting/breeding season) because of the concentration of vessel movement in those areas.

Under the No Action Alternative, Alternative 1 and Alternative 2, exposure to vessels used in testing activities may cause short-term disturbance to an individual turtle and if struck, it could lead to injury or death. As demonstrated by scars on all species of sea turtles, they are not always able to avoid being struck; therefore, vessel strikes are a potential cause of mortality for these species.

Because of the wide dispersal of large vessels in open ocean areas and the widespread, scattered distribution of turtles at sea, strikes during open-ocean transits of Navy vessels are unlikely. For very large vessels, the bow wave may even preclude a sea turtle strike. The probability of a strike anywhere in the MITT Study Area is further reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). Although the likelihood of being struck is minimal, sea turtles that overlap with Navy activities are more likely to encounter vessels. Potential impacts of exposure to vessels may result in changes to an individual’s behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment.

Pursuant to the ESA, the use of vessels during testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.3.2 Impacts from In-Water Devices

In-water devices are generally smaller (several inches to 111 ft. [33.8 m]) than most Navy vessels. For a discussion of the types of activities that use in-water devices, where they are used, and how many activities would occur under each alternative, see Section 3.0.5.2.3.3 (In-Water Devices). See Table 3.0-16 for the types, sizes, and speeds of Navy in-water devices used in the Study Area.

Devices that pose the greatest collision risk to sea turtles are those that are towed or operated at high speeds and include: remotely operated high-speed targets and mine warfare systems. Devices that move slowly through the water column have a very limited potential to strike a sea turtle because sea turtles in the water could avoid a slow-moving object.

3.5.3.3.2.1 No Action Alternative, Alternative 1, and Alternative 2

Training Activities

Use of in-water devices is concentrated to anti-submarine warfare and mine warfare activities throughout the Study Area. Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area.

Under the No Action Alternative, Alternative 1 and Alternative 2, exposure to in-water devices used in training activities may cause short-term disturbance to an individual turtle, or if struck, it could lead to injury or death. These devices can operate anywhere from the water surface to the benthic zone. Certain devices do not have a realistic potential to strike living marine resources because they either move slowly through the water column (e.g., most unmanned undersurface vehicles) or are closely monitored by observers manning the towing platform (e.g., most towed devices). Because of their size and potential operating speed, in-water devices that operate in a manner with the potential to strike living marine resources are the Unmanned Surface Vehicles. Training activities that involve the use of unmanned surface or underwater activities include Amphibious Raid activities, which occur six times a year. The possibility of a strike anywhere in the MITT Study Area is reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring).

Although the likelihood of being struck is minimal, sea turtles that are present during Navy exercises are more likely to encounter in-water devices. Potential impacts of exposure to in-water devices may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. The impact of in-water devices on sea turtles is not likely to cause injury or mortality to individuals, and impacts to populations would be inconsequential because: (1) the area exposed to the stressor is extremely small relative to most sea turtle's ranges, (2) the activities are dispersed such that few individuals could conceivably be exposed to more than one activity, and (3) exposures would be localized. Activities involving in-water devices are not expected to yield any behavioral changes or lasting impacts on the survival, growth, recruitment, or reproduction of sea turtles species at the population level.

Pursuant to the ESA, the use of in-water devices during training activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under the No Action Alternative, Alternative 1 and Alternative 2, exposure to in-water devices used in testing activities may cause short-term disturbance to an individual turtle, or, if struck, it could lead to injury or death. However, these devices move slowly through the water column and have a very limited potential to strike a sea turtle because sea turtles in the water could avoid a slow moving object. Potential impacts of exposure to in-water devices may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Potential impacts of exposure to in-water devices are not expected to result in population-level impacts. There is no overlap of the stressor with any designated sea turtle critical habitat.

Pursuant to the ESA, the use of in-water devices during testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.3.3 Impacts from Military Expended Materials

This section analyzes the strike potential to sea turtles from the following categories of military expended materials: (1) all sizes of non-explosive practice munitions; (2) fragments from explosive munitions; and (3) expended materials other than ordnance, such as sonobuoys, ship hulks, expendable targets and unrecovered aircraft stores (fuel tanks, carriages, dispensers, racks, or similar types of support systems on aircraft).

While disturbance or strike from an item as it falls through the water column is possible, it is not very likely because the objects generally sink through the water slowly and can be avoided by most sea turtles. Therefore, the discussion of military expended materials strikes will focus on the potential of a strike at the surface of the water.

The potential for sea turtles to be struck by military expended materials was evaluated using statistical probability analysis (Appendix G, Statistical Probability Model for Estimating Direct Strike Impact and Number of Potential Exposures) to estimate the probability of striking a sea turtle for a worst-case scenario. Input values include munitions data (frequency, footprint, and type), size of the training and testing area, sea turtle density data, and size of the animal (area of potential impact). To estimate the potential to strike a sea turtle in a worst-case scenario, the impact area of all bombs and projectiles was totaled over 1 year in the training or testing area for each alternative with the highest projected use (concentration of military expended materials). Finally, the sea turtle species with the highest average seasonal density within the activity at each location was used.

The estimate of the potential for a sea turtle strike is influenced by the following assumptions:

- The estimate assumes that all sea turtles would be at or near the surface 100 percent of the time (two-dimensional), when in fact, sea turtles spend most of their time submerged (Renaud and Carpenter 1994; Sasso and Witzell 2006).
- That the animal is stationary and does not account for any movement of the sea turtle or any potential avoidance of the training or testing activity.

The model does not account for the ability of Navy observers to see and avoid sea turtles. The model also does not account for the fact that most of the projectiles fired during training and testing activities are fired at targets, and most projectiles hit those targets, so only a very small portion of those would hit the water with their maximum velocity and force. The potential of fragments from high-explosive munitions or expended material other than ordnance to strike a sea turtle is likely lower than for the worst-case scenario calculated below because those activities happen with much lower frequency. Fragments may include metallic fragments from the exploded target as well as from the exploded ordnance.

There is a remote possibility that an individual turtle at or near the surface may be struck directly if they are in the target area at the point of physical impact at the time of non explosive ordnance delivery. Expended munitions may strike the water surface with sufficient force to cause injury or mortality. While any species of sea turtle may move through the open ocean, most will only surface intermittently. Sea turtles are generally at the surface for short periods, and spend most of their time submerged

(Renaud and Carpenter 1994; Sasso and Witzell 2006). The leatherback turtle is more likely to be foraging at or near the surface in the open ocean than other species, but the likelihood of being struck by a projectile remains very low (Table 3.5-11).

Table 3.5-11: Estimated Sea Turtle Exposures from Direct Strike of Military Expended Materials by Area and Alternative

Mariana Islands Training and Testing Study Area						
Nearshore Area (MITT Study Area shallower than 200 m)						
Species	Training			Testing		
	No Action	Alternative 1	Alternative 2	No Action	Alternative 1	Alternative 2
Green Sea Turtle	0.00092	0.00231	0.00231	0.00001	0.00005	0.00005
Hawksbill Sea Turtle	0.00005	0.00014	0.00014	< 0.00001	< 0.00001	< 0.00001
Loggerhead Sea Turtle	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Olive Ridley Sea Turtle	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Leatherback Sea Turtle	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Open Ocean (MITT Study Area deeper than 200 m)						
Species	Training			Testing		
	No Action	Alternative 1	Alternative 2	No Action	Alternative 1	Alternative 2
All Turtle Species	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001

Notes: m = meter(s), MITT = Mariana Islands Training and Testing

The probability of a strike is further reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring).

3.5.3.3.3.1 No Action Alternative, Alternative 1, and Alternative 2

As described in Section 2.7, Alternative 1 consists of the No Action Alternative, plus the expansion of MITT Study Area boundaries and adjustments to location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. As described in Section 2.8, Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to the type and tempo of training and testing activities.

Training Activities

With the exception of those used at FDM, the majority of military expended materials (bombs, medium- and large-caliber projectiles, missiles, and decelerators/parachutes) are all used in areas of the MITT Study Area greater than 3 nm from shorelines, and the larger of these (bombs, missiles, large-caliber projectiles) are restricted to use in areas greater than 3 nm from shore. Small caliber projectiles would be used throughout the MITT Study Area. Table 3.5-11 presents the strike probabilities for each species of sea turtles, which are very small. The probabilities of a strike in the open ocean portion of the MITT Study Area, where the majority of materials are expended, is less than 0.00001 percent for all species of sea turtles.

Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area. Under the No Action Alternative, Alternative 1, and Alternative 2 exposures to military-expended materials used in training activities may cause short-term disturbance to an individual turtle, or, if struck, it could lead to injury or death. Potential impacts of exposure to military-expended materials may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Potential impacts of exposure to military-expended materials are not expected to result in population-level impacts.

With regards to military expended material used at FDM, there is a very low potential for aberrant ordnance to impact the nearshore waters surrounding land-based targets. The probability of direct strike in nearshore and offshore waters on sea turtles were calculated for areas where ordnance is targeted (expected to fall), and probabilities of strike were calculated to be near zero percent. Based on this calculation, it is even more unlikely for a direct strike on a sea turtle or marine mammal from aberrant ordnance at FDM.

Pursuant to the ESA, the use military expended materials during training activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

As indicated in Tables 2.8-2 through 2.8-4, there are no activities which would generate military expended materials in the MITT Study Area under the No Action Alternative.

Under Alternative 1 and 2, activities that could generate military expended materials would increase, and could take place throughout the Study Area. Similar to those for training activities, consequences of strikes or disturbances could include injury or mortality, particularly within the footprint of the object. Table 3.5-11 presents the strike probabilities for each species of sea turtles. The probabilities of a strike in the open ocean portion of the MITT Study Area, where the majority of materials are expended, is less than 0.00001 percent for all species of sea turtles.

Under Alternative 1 and Alternative 2, exposures to military expended materials used in testing activities may cause short-term disturbance to an individual turtle, or if struck, it could lead to injury or death. Potential impacts of exposure to military expended materials may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. The fitness of individual organisms could be impacted directly or indirectly, but not to the extent that the viability of populations or species would be impacted, primarily because the possibility of strike is so low.

Pursuant to the ESA, the use military expended materials during testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.3.4 Impacts from Seafloor Devices

For a discussion of the types of activities that use seafloor devices, where they are used, and how many activities would occur under each alternative, see Section 3.0.5.2.3.5 (Seafloor Devices). These include items that are placed on, dropped on, or moved along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed instruments, bottom-crawling unmanned undersea vehicles, and bottom-placed targets that are recovered (not expended). As discussed in Section 3.5.3.3.3 (Impacts from Military Expended Materials), objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most sea turtles.

3.5.3.3.4.1 No Action Alternative

Training Activities

Table 3.0-21 lists the number and location where seafloor devices are used. Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area.

Under the No Action Alternative, exposure to seafloor devices used in training activities may cause short-term disturbance to an individual turtle because if a sea turtle were struck, it could lead to injury or death. However, objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most sea turtles. Further, the potential for a sea turtle to be close to a seafloor device, and therefore be exposed, is very low, though if foraging along the bottom, exposure to a seafloor device could occur. However, the slow speed of these devices would minimize the potential impact from exposure. Exposure to seafloor devices is not expected to change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to seafloor devices is not expected to result in population-level impacts.

Pursuant to the ESA, the use of seafloor devices during training activities as described under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtle.

Testing Activities

Table 3.0-21 lists the number and location where seafloor devices are used. Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area.

Under the No Action Alternative, exposure to seafloor devices used in testing activities may cause short-term disturbance to an individual turtle, or if a sea turtle were struck, it could lead to injury or death. However, objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most sea turtles. Furthermore, the potential for a sea turtle to be close to a seafloor device, and therefore to be exposed, is very low, though if foraging along the bottom, exposure to a seafloor device could occur. However, the slow speed of these devices would minimize the potential impact from exposure. Exposure to seafloor devices is not expected to change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to seafloor devices is not expected to result in population-level impacts.

Pursuant to the ESA, the use of seafloor devices during testing activities as described under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles.

3.5.3.3.4.2 Alternative 1

Training Activities

Table 3.0-21 lists the number and location where seafloor devices are used. Any of the sea turtle species found in the MITT Study Area can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. These species are distributed widely in all offshore portions of the Study Area.

Under Alternative 1, exposure to seafloor devices used in training activities may cause short-term disturbance to an individual turtle because if a sea turtle were struck, it could lead to injury or death. However, objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most sea turtles. Furthermore, the potential for a sea turtle to be close to a seafloor device, and therefore to be exposed, is very low, because of the relative position of sea turtles within the water column and the wide distribution of habitats. Exposure to seafloor devices is not expected to change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to seafloor devices is not expected to result in population-level impacts.

Pursuant to the ESA, the use of seafloor devices during training activities as described under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles.

Testing Activities

The number and location of testing activities under Alternative 1 increases when compared to No Action Alternative (Table 3.0-21). Under Alternative 1, exposure to seafloor devices used in testing activities may cause short-term disturbance to an individual turtle, or if a sea turtle were struck, it could lead to injury or death. However, objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most sea turtles. Furthermore, the potential for a sea turtle to be close to a seafloor device, and therefore to be exposed, is very low, because of the relative position of sea turtles within the water column and the wide distribution of habitats. Exposure to seafloor devices is not expected to change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to seafloor devices is not expected to result in population-level impacts.

Pursuant to the ESA, the use of seafloor devices during testing activities as described under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles.

3.5.3.3.4.3 Alternative 2

Training Activities

The number and location of training activities under Alternative 2 are identical to those of the training activities under Alternative 1. Therefore, impacts and comparisons to the No Action Alternative would also be identical, as described in Section 3.5.3.3.4.2 (Alternative 1).

Pursuant to the ESA, the use of seafloor devices during training activities as described under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles.

Testing Activities

Table 3.0-21 lists the number and location where seafloor devices are used. The number and location of testing activities under Alternative 2 increases slightly (from 64 to 68 events) to those of the testing activities under the Alternative 1. Although the number of events utilizing seafloor devices increases, the potential for a sea turtle to be close to a seafloor device, and therefore to be exposed, remains very low, because of the relative position of sea turtles within the water column and the wide distribution of habitats. Exposure to seafloor devices is not expected to change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to seafloor devices is not expected to result in population-level impacts.

Pursuant to the ESA, the use of seafloor devices during testing activities as described under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles.

3.5.3.4 Entanglement Stressors

This section analyzes the potential entanglement impacts of the various types of expended materials used by the Navy during training and testing activities within the Study Area. This analysis includes the potential impacts from two types of military expended materials, including: (1) fiber optic cables and guidance wires, and (2) decelerators/parachutes. Aspects of entanglement stressors that are applicable to marine organisms in general are presented in Appendix H (Biological Resource Methods).

3.5.3.4.1 Impacts from Fiber Optic Cables and Guidance Wires

Fiber optic cables and guidance wires are used in several different training and testing activities. For a list of Navy activities that involve the use of fiber optic cables and wires, refer to Section 3.0.5.2.4.1 (Fiber Optic Cables and Guidance Wires). A sea turtle that becomes entangled in nets, lines, ropes, or other foreign objects under water may suffer only a temporary hindrance to movement before it frees itself. The turtle may suffer minor injuries but recover fully, or it may die as a result of the entanglement. Due to the physical characteristics of guidance wires and fiber optic cables detailed in Section 3.0.5.2.4 (Entanglement Stressors), these items pose a potential, although unlikely, entanglement risk to sea turtles.

The likelihood of a sea turtle encountering and becoming entangled in a fiber optic cable or guidance wire depends on several factors. The length of time that the fiber optic cable or guidance wire is near a sea turtle can affect the likelihood of it posing an entanglement risk. Because these items would only be in the water column during the activity and while it sinks, the likelihood of a sea turtle encountering a fiber optic cable in the water column and becoming entangled is extremely low. Guidance wires sink to the sea floor at a rate of 0.7 ft. (0.2 m) per second; therefore, it is most likely that a sea turtle would encounter a guidance wire once it had settled to the sea floor. The length of the cable or wire may influence the potential for a sea turtle to encounter or become entangled in these items. The lengths of fiber optic cables and guidance wires vary. Fiber optic cables can range in size up to about 900 ft. (300 m). Greater lengths of these items may increase the likelihood that a sea turtle could become entangled. The behavior and feeding strategy of a species can also determine whether they may encounter items on the seafloor, where fiber optic cables and guidance wires will most likely be available. There is a potential for those species that feed on the seafloor to encounter these items and become entangled; however, the relatively few fiber optic cables and guidance wires being expended within the MITT Study Area limits the potential for encounters. Lastly, the properties of the items themselves may limit the risk of entanglement. The physical characteristics of guidance wires and fiber optic cables are detailed in Section 3.0.5.2.4 (Entanglement Stressors). This analysis indicates that these items pose a potential, although unlikely, entanglement risk to sea turtles. For instance, the physical characteristics of the fiber optic material render the cable brittle and easily broken when kinked, twisted, or bent sharply (i.e., to a radius greater than 360 degrees). Thus, the fiber optic cable would not loop, greatly reducing or eliminating any potential issues of entanglement with regard to marine life. In addition, based on degradation times, the guidance wires would break down within 1–2 years and therefore no longer pose an entanglement risk.

The Navy previously analyzed the potential for entanglement of sea turtles by guidance wires and concluded that the potential for entanglement is low (U.S. Department of the Navy 1996). Except for a chance encounter with the guidance wire at the surface or in the water column while the cable or wire is sinking to the seafloor, a sea turtle would be vulnerable to entanglement only if its diving and feeding patterns place it in direct contact with the bottom. Bottom-feeding sea turtles tend to forage in nearshore areas, and these wires are expended in deeper waters.

3.5.3.4.1.1 No Action Alternative

Training Activities

As indicated in Chapter 2 (Description of Proposed Action and Alternatives), under the No Action Alternative, there are no Airborne mine neutralization activities (with explosive neutralizers) that expend fiber optic cables (Table 3.0-23) and 40 guidance wires expended from torpedoes (Table 3.0-24). Torpedoes expending guidance wire would occur in throughout the MITT Study Area during tracking exercises, all greater than 3 nm from the shore, where depths are greater than the diving abilities of sea turtles.

Any species of sea turtle that occurs in the MITT Study Area could at some point in time encounter expended cables or wires. The sink rates of fiber optic cables and guidance wires would rule out the possibility of them drifting great distances into nearshore and coastal areas where green, hawksbill, olive ridley, and loggerhead turtles are more likely to occur and feed on the bottom. The leatherback is more likely to co-occur with these activities, given its preference for open ocean habitats, but this species is known to forage on jellyfish at or near the surface.

Under the No Action Alternative, exposure to fiber optic cables and guidance wires used in training activities may cause short-term or long-term disturbance to an individual turtle because if a sea turtle were to become entangled in a fiber optic cable or guidance wire, it could free itself or it could lead to injury or death. Potential impacts of exposure to fiber optic cable or guidance wire may result in changes to an individual’s behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, cables and wires are generally not expected to cause disturbance to sea turtles because: (1) the number of fiber optic cables and guidance wires expended is relatively low, decreasing the likelihood of encounter; (2) the physical characteristics of the fiber optic cables and guidance wires; and (3) the behavior of the species, as sea turtles are unlikely to become entangled in an object that is resting on the seafloor. Potential impacts of exposure to fiber optic cables and guidance wires are not expected to result in population-level impacts.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during training activities as proposed under the No Action Alternative may affect, but is not likely to adversely affect green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under the No Action Alternative, no testing activities that could generate entanglement stressors are conducted in the Study Area.

3.5.3.4.1.2 Alternative 1

Training Activities

As indicated in Table 2.8-1 and Table 3.0-24, under Alternative 1, the number of torpedo activities that expended guidance wire is the same as the No Action Alternative. The torpedo activities using guidance wire under Alternative 1 would occur in the same geographic locations as the No Action Alternative. There would also be four fiber optic cables expended under Alternative 1 (Table 3.0-23).

Any species of sea turtle that occurs in the MITT Study Area could at some point in time encounter expended fiber optic cables or guidance wires. The sink rates of fiber optic cables and guidance wires would rule out the possibility of them drifting great distances into nearshore and coastal areas where green, hawksbill, olive ridley, and loggerhead turtles are more likely to occur and feed on the bottom. The leatherback is more likely to co-occur with these activities, given its preference for open ocean habitats, but this species is known to forage on jellyfish at or near the surface.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 1 may increase the risk of sea turtles being exposed to fiber optic cables and guidance wires. However, the expected impact on any exposed sea turtle remains the same. For the same reasons as stated in Section 3.5.3.4.1.1 (No Action Alternative), the use of fiber optic cables and guidance wires in training activities may cause short-term or long-term disturbance to an individual turtle, because if a sea turtle were to become entangled in a fiber optic cable or guidance wire, it could free itself or it could lead to injury or death. Potential impacts of exposure to fiber optic cable or guidance wire may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Potential impacts of exposure to fiber optic cables and guidance wires are not expected to result in population-level impacts.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during training activities as proposed under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

As indicated in Tables 2.8-2 through 2.8-4 and Table 3.0-24, under Alternative 1, the number of torpedo activities that expended guidance wire increases from that of the No Action Alternative from 0 to 20. Under Alternative 1, MCM mission package testing (Table 3.0-23) expends up to 48 fiber optic cables.

Any species of sea turtle that occurs in the MITT Study Area could at some point in time encounter expended fiber optic cables or guidance wires. The sink rates of fiber optic cables and guidance wires would rule out the possibility of them drifting great distances into nearshore and coastal areas where green, hawksbill, olive ridley, and loggerhead turtles are more likely to occur and feed on the bottom. The leatherback is more likely to co-occur with these activities, given its preference for open ocean habitats, but this species is known to forage on jellyfish at or near the surface.

Exposure to fiber optic cables and guidance wires used in testing activities may cause short-term or long-term disturbance to an individual turtle because if a sea turtle were to become entangled in a fiber optic cables and guidance wire, it could free itself or it could become injured or die. Potential impacts of exposure to fiber optic cables and guidance wire may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, fiber optic cables and guidance wires are generally not expected to cause disturbance to sea turtles because: (1) the number of fiber optic cables and guidance wires expended is relatively low, decreasing the likelihood of encounter; (2) the physical characteristics of the fiber optic cables and guidance wires; and (3) the behavior of the species, as sea turtles are unlikely to become entangled in an object that is resting on the seafloor. Potential impacts of exposure to fiber optic cables and guidance wires are not expected to result in population-level impacts.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during testing activities as proposed under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.4.1.3 Alternative 2

Training Activities

Activities proposed under Alternative 2 are the same as those proposed under Alternative 1. Therefore, the impact conclusion for Alternative 2 training activities is the same as for Alternative 1.

The entanglement of sea turtles by fiber optic cables or guidance wires is considered to be highly unlikely. If a sea turtle became entangled in a cable, however, the sea turtle would suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) could indirectly result in mortality while impairment of other activities (e.g., migration) could affect reproduction.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during training activities as proposed under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

As indicated in Table 2.8-2 through 2.8-4 and Table 3.0-24, under Alternative 1, the number of torpedo activities that expended guidance wire increases from that of the No Action Alternative from 0 to 20. Under Alternative 2, MCM mission package testing (Table 3.0-23) expends up to 56 fiber optic cables.

Any species of sea turtle that occurs in the MITT Study Area could at some point in time encounter expended by fiber optic cables or guidance wires. The sink rates of guidance wires would rule out the possibility of them drifting great distances into nearshore and coastal areas where green, hawksbill, olive ridley, and loggerhead turtles are more likely to occur and feed on the bottom. The leatherback is more likely to co-occur with these activities, given its preference for open ocean habitats, but this species is known to forage on jellyfish at or near the surface.

The entanglement of sea turtles by fiber optic cables or guidance wires is considered to be highly unlikely. If a sea turtle became entangled in a by fiber optic cables or guidance wire however, the sea turtle would suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) could indirectly result in mortality while impairment of other activities (e.g., migration) could affect reproduction.

Pursuant to the ESA, the use of fiber optic cables and guidance wires during testing activities as proposed under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.4.2 Impacts from Decelerators/Parachutes

Sonobuoys, lightweight torpedoes, targets, and other devices deployed by aircraft into the water use nylon decelerators/parachutes of various sizes. For example, a typical sonobuoy decelerator/parachute is about 18 in. (0.46 m) in diameter, with nylon suspension lines about 2 ft. (0.61 m) long. These decelerators/parachutes are not typically recovered after the activity (Appendix A, Training and Testing Activities Descriptions). Once a sonobuoy hits the water surface, its decelerator/parachute is designed to produce drag at the surface for 5 to 15 seconds, allowing for deployment of the sonobuoy, then the decelerator/parachute separates and sinks. The decelerator/parachute assembly contains metallic components, and could be at the surface for a short period before sinking to the seafloor. Sonobuoy decelerators/parachutes are designed to sink within 15 minutes, but the rate of sinking depends upon sea conditions and the shape of the decelerator/parachute and the duration of the descent would depend on the water depth. Prior to reaching the seafloor, it could be carried along in a current, or snagged on a hard structure near the bottom. Conversely, it could settle to the bottom, where it would be buried by sediment in most soft bottom areas. Decelerators/parachutes or decelerator/parachute lines may be a risk for sea turtles to become entangled, particularly while at the surface. A sea turtle would have to surface to breathe or grab prey from under the decelerator/parachute, and swim into the decelerator/parachute or its lines.

While in the water column, a sea turtle is less likely to become entangled because the decelerator/parachute would have to land directly on the turtle, or the turtle would have to swim into the decelerator/parachute before it sank. If the decelerator/parachute and its lines sink to the seafloor in an area where the bottom is calm, it would remain there undisturbed. Over time, it may become covered by sediment in most areas or colonized by attaching and encrusting organisms, which would further stabilize the material and reduce the potential for reintroduction as an entanglement risk.

If bottom currents are present, the canopy may billow and pose an entanglement threat to sea turtles that feed in benthic habitats (e.g., loggerhead sea turtles). Bottom-feeding sea turtles tend to forage in nearshore areas rather than offshore, where these decelerators/parachutes are used; therefore, sea turtles are not likely to encounter decelerators/parachutes once they reach the seafloor. Further, the deposition of a decelerator/parachute on the seafloor would occur in water depths that are greater than the diving abilities (and hence foraging abilities) of sea turtles. The potential for a sea turtle to encounter an expended decelerator/parachute at the surface or in the water column is extremely low, and is even less probable at the seafloor, given the general improbability of a sea turtle being near the deployed decelerator/parachute, as well as the general behavior of sea turtles.

3.5.3.4.2.1 No Action Alternative

Training Activities

Under the No Action Alternative, activities that involve air-dropped sonobuoys, torpedoes, or targets (and therefore the expending of unrecoverable decelerators/parachutes) include tracking and torpedo exercises involving helicopter platforms and fixed-wing aircraft. Under the No Action Alternative, approximately 8,032 decelerators/parachutes are expended during training activities (see Table 3.0-25). Decelerators/parachutes associated with training activities would be expended in the following locations in areas greater than 3 nm from shore throughout the Study Area. Activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600 ft.).

These exercises are widely dispersed in open ocean habitats, however, where sea turtles are lower in abundance than in nearshore habitats. Furthermore, entanglement of a sea turtle in a decelerator/parachute assembly is unlikely because the decelerator/parachute would have to land directly on a sea turtle, or a sea turtle would have to swim into it before it settles to the ocean floor, or the sea turtle would have to encounter the decelerator/parachute on the ocean floor. The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands, and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). If bottom currents are present, the canopy could billow and pose an entanglement threat to bottom-feeding sea turtles. However, the probability of a sea turtle encountering a decelerator/parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines are both considered low.

The entanglement of sea turtles in decelerator/parachute assemblies is considered to be highly unlikely. If a sea turtle became entangled in a decelerator/parachute assembly, however, the sea turtle may suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) may indirectly result in mortality while impairment of other activities (e.g., migration) may impair reproduction.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as proposed under the No Action Alternative may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under the No Action Alternative, no activities that would create entanglement hazards from decelerators/parachutes are conducted in the Study Area.

3.5.3.4.2.2 Alternative 1

Training Activities

Under Alternative 1, approximately 10,845 decelerators/parachutes would be expended during training activities, an increase from the number expended under the No Action Alternative (see Table 3.0-25). Decelerators/parachutes associated with these sonobuoys would be expended in the following locations in areas greater than 3 nm from shore throughout the Study Area. Similar to the No Action Alternative, activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600 ft.). Because they are in the air and water column for a time span of minutes it is improbable that such a decelerator/parachute deployed over water deeper than 183 m (600.4 ft.) could travel far enough to affect shallow-water areas.

The net increase in exercises that would expend decelerators/parachutes would increase the risk of entangling sea turtles. These exercises are widely dispersed in open ocean habitats, however, where sea turtles are lower in abundance than in nearshore habitats. Furthermore, entanglement of a sea turtle in a decelerator/parachute assembly is unlikely because the decelerator/parachute would have to land directly on a sea turtle, or a sea turtle would have to swim into it before it settles to the ocean floor, or the sea turtle would have to encounter the decelerator/parachute on the ocean floor. The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands (anywhere within the approximately 500,000 square nautical miles [nm^2] of the MITT Study Area), and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands, and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). If bottom currents are present, the canopy could billow and pose an entanglement threat to bottom-feeding sea turtles. However, the probability of a sea turtle encountering a decelerator/parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines are both considered low.

The entanglement of sea turtles in decelerator/parachute assemblies is considered to be highly unlikely. If a sea turtle became entangled in a decelerator/parachute assembly, however, the sea turtle would suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) could indirectly result in mortality while impairment of other activities (e.g., migration) could impair reproduction.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as proposed under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under Alternative 1, approximately 1,727 decelerators/parachutes would be expended during testing activities, an increase from the number expended under the No Action Alternative (see Table 3.0-25). These decelerators/parachutes would be expended in areas greater than 3 nm from shore throughout the Study Area. Similar to the training activities, activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600.4 ft.). Because they are in the air and water column for a time span of minutes it is improbable that such a decelerator/parachute deployed over water deeper than 183 m (600.4 ft.) could travel far enough to affect shallow-water areas.

The net increase in exercises that would expend decelerators/parachutes would increase the risk of entangling sea turtles. These exercises are widely dispersed in open ocean habitats, however, where sea turtles are lower in abundance than in nearshore habitats. Furthermore, entanglement of a sea turtle in a decelerator/parachute assembly is unlikely because the decelerator/parachute would have to land directly on a sea turtle, or a sea turtle would have to swim into it before it settles to the ocean floor, or the sea turtle would have to encounter the decelerator/parachute on the ocean floor. The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands (anywhere within the approximately 500,000 nm^2 of the MITT Study Area), and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands, and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). If bottom currents are present, the canopy could billow and pose an entanglement threat to bottom-feeding sea turtles. However, the probability of a sea turtle encountering a decelerator/parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines are both considered low.

The entanglement of sea turtles in decelerator/parachute assemblies is considered to be highly unlikely. If a sea turtle became entangled in a decelerator/parachute assembly, however, the sea turtle could suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) could indirectly result in mortality while impairment of other activities (e.g., migration) could impair reproduction.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities as proposed under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.4.2.3 Alternative 2

Training Activities

Alternative 2 training activities would use the same number of decelerators/parachutes as are proposed under Alternative 1; therefore, the conclusions for decelerator/parachute use under Alternative 2 are the same as under Alternative 1.

Pursuant to the ESA, the use of decelerators/parachutes during training activities as proposed under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under Alternative 2, approximately 1,912 decelerators/parachutes would be expended during testing activities, an increase from the number expended under the No Action Alternative (see Table 3.0-25). These decelerators/parachutes would be expended in areas greater than 3 nm from shore throughout the Study Area. Similar to the Alternative 1 activities, activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600.4 ft.). Because they are in the air and water column for a time span of minutes it is improbable that such a decelerator/parachute deployed greater than 3 nm from shore could travel far enough to affect shallow-water areas.

The net increase in exercises that would expend decelerators/parachutes would increase the risk of entangling sea turtles. These exercises are widely dispersed in open ocean habitats, however, where sea turtles are lower in abundance than in nearshore habitats. Furthermore, entanglement of a sea turtle in a decelerator/parachute assembly is unlikely because the decelerator/parachute would have to land directly on a sea turtle, or a sea turtle would have to swim into it before it settles to the ocean floor, or the sea turtle would have to encounter the decelerator/parachute on the ocean floor. The potential for sea turtles to encounter an expended decelerator/parachute assembly is extremely low, given the generally low probability of a sea turtle being at the exact point where the decelerator/parachute lands (anywhere within the approximately 500,000 nm^2 of the MITT Study Area), and the negative buoyancy of decelerator/parachute constituents (reducing the probability of contact with sea turtles near the surface). If bottom currents are present, the canopy could billow and pose an entanglement threat to bottom-feeding sea turtles. However, the probability of a sea turtle encountering a decelerator/parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines are both considered low.

The entanglement of sea turtles in decelerator/parachute assemblies is considered to be highly unlikely. If a sea turtle became entangled in a decelerator/parachute assembly, however, the sea turtle could suffer a temporary or permanent impairment of normal activities. Impairment of some activities (e.g., foraging) could indirectly result in mortality while impairment of other activities (e.g., migration) could impair reproduction.

Pursuant to the ESA, the use of decelerators/parachutes during testing activities as proposed under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.5 Ingestion Stressors

This section analyzes the potential ingestion impacts of the various types of expended materials used by the Navy during training and testing activities within the Study Area. This analysis includes two categories of military expended materials: (1) munitions (both non-explosive practice munitions and fragments from high-explosive munitions), which are expected to sink to the seafloor; and (2) military expended materials other than munitions (including fragments from targets, chaff, flares, and parachutes), which may remain at the surface or in the water column for some time prior to sinking.

Ingestion of expended materials by sea turtles could occur in all nearshore and open ocean areas, and can occur at the surface, in the water column, or at the seafloor depending on the size and buoyancy of the expended object and the feeding behavior of the turtle. Floating material could be eaten by turtles such as leatherbacks that feed at or near the water surface, while materials that sink to the seafloor pose a risk to bottom-feeding turtles such as loggerheads. Schuyler et al. (2012) observed that carapace length was inversely correlated with the probability of ingesting debris in green and hawksbill sea turtles; 54.5 percent of pelagic sized turtles had ingested debris, whereas only 25 percent of benthic feeding turtles were found with debris in their gastrointestinal system. Benthic phase turtles had a strong selectivity for soft, clear plastic, lending support to the hypothesis that sea turtles ingest debris because it resembles natural prey items such as jellyfish. Pelagic turtles were much less selective in their feeding, though they showed a trend towards selectivity for rubber items such as balloons. Most ingested items were plastic and were positively buoyant.

Leatherbacks feed primarily on jellyfish throughout the water column, and may mistake floating debris for prey. Items found in a sample of leatherbacks that had ingested plastic included plastic bags, fishing line, twine, Mylar balloon fragments, and a plastic spoon (Mrosovsky et al. 2009). Kemp’s ridleys, loggerheads, and green sea turtles in coastal Florida were found to ingest bits of plastic, tar, rubber, and aluminum foil (Bjorndal et al. 1994). Oceanic-stage loggerhead turtles in the North Atlantic Ocean were found to ingest “small pieces of hard plastic,” corks, and white Styrofoam pieces (Frick et al. 2009). Juvenile loggerheads in the Mediterranean ingested plastic most frequently, followed by tar, Styrofoam, wood, feathers, lines, and net fragments (Tomas et al. 2002). Similar trends in types of items ingested were observed in Kemp’s ridley, loggerhead, and green sea turtles off the Texas coast (Stanley et al. 1988). Conditions for marine pollution in the Pacific are similar to conditions in the Atlantic, Mediterranean, and the Gulf of Mexico; therefore, sea turtle ingestion rates of non-prey items in the Pacific is expected to be similar to other sea turtle habitats. The variety of items ingested by turtles suggests that feeding is nondiscriminatory, and they are prone to ingesting nonprey items. Ingestion of these items may not be directly lethal; however, ingestion of plastic and other fragments can restrict food intake and have sub-lethal impacts by reducing nutrient intake (McCauley and Bjorndal 1999). Poor nutrient uptake can lead to decreased growth rates, depleted energy, reduced reproduction, and decreased survivorship. These long-term sublethal effects may lead to population level impacts, but this is difficult to assess because the affected individuals remain at sea and the trends may only arise after several generations have passed.

Because bottom-feeding occurs in nearshore areas, materials that sink to the seafloor in the open ocean are less likely to be ingested due to their location, as depth in areas where ordnance is fired ranges from approximately 20 to 200 m (65.6 to 656.2 ft.) in areas far offshore. The consequences of ingestion could range from temporary and inconsequential to long-term physical stress, or even death.

3.5.3.5.1 Impacts from Munitions

Types of non-explosive practice munitions generally include projectiles, missiles, and bombs. Of these, only small or medium caliber projectiles would be small enough for a sea turtle to ingest. Small and medium caliber projectiles include all sizes up to and including 2.25 in. (5.7 cm) in diameter. These solid metal materials would quickly move through the water column and settle to the seafloor. Ingestion of non-explosive practice munitions is not expected to occur in the water column because the ordnance sinks quickly. Instead, they are most likely to be encountered by species that forage on the bottom. The types, numbers, and locations of activities using these devices under each alternative are discussed in Sections 3.0.5.2.5.1 (Non-Explosive Practice Munitions) and 3.0.5.2.5.2 (Fragments from Explosive Munitions). Because green, loggerhead, olive ridley, and hawksbill turtles feed along the seafloor, they are more likely to encounter munitions of ingestible size that settle on the bottom than leatherbacks that primarily feed at the surface. Furthermore, these four species typically use nearshore feeding areas, while leatherbacks are more likely to feed in the open ocean. Given the very low probability of a leatherback encountering and ingesting materials on the seafloor, this analysis will focus on green, loggerhead, olive ridley, and hawksbill turtles and ingestible materials expended nearshore, within range complexes and testing ranges.

3.5.3.5.1.1 No Action Alternative

Training Activities

The number and footprint of small- and medium-caliber projectiles (the only ingestible sizes) are detailed in Table 2.8-1. Any bottom-feeding sea turtle may occur in these range complexes. The number and footprint of high-explosive ordnance and munitions are detailed in Table 2.8-1; however, the fragment size cannot be quantified. The areas with the greatest amount of high-explosive ordnance and munitions would occur in open ocean portions the Study Area.

Sublethal effects due to ingestion of munitions used in training activities may cause short-term or long-term disturbance to an individual turtle because: (1) if a sea turtle were to incidentally ingest and swallow a projectile or solid metal high-explosive fragment, it could potentially disrupt its feeding behavior or digestive processes; and (2) if the item is particularly large in proportion to the turtle ingesting it, the projectile could become permanently encapsulated by the stomach lining, with a rare chance that this could impede the turtle’s ability to feed or take in nutrients. Potential impacts of exposure to munitions may result in changes to an individual’s behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, munitions used in training activities are generally not expected to cause disturbance to sea turtles because: (1) sea turtles are not expected to encounter most small- and medium-caliber projectiles or high-explosive fragments on the seafloor because of the depth at which these would be expended; and (2) in some cases a turtle would likely pass the projectile through their digestive tract and expel the item without impacting the individual. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the use of munitions of ingestible size during training activities under the No Action Alternative would have no affect leatherback sea turtles. The use of munitions of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

Testing Activities

Under the No Action Alternative, no activities utilizing small- or medium-caliber projectiles or high explosive ordnance are conducted in the Study Area.

3.5.3.5.1.2 Alternative 1

Training Activities

Under Alternative 1, the amount of small- and medium-caliber projectiles approximately doubles that of the No Action Alternative, from 86,500 to 171,640 projectiles (see Table 3.0-18). The number of activities that use high-explosive ordnance and munitions increases from 1,340 under the No Action Alternative to 10,006 under Alternative 1 (Table 3.0-19). In comparison to the No Action Alternative, the increase in training activities presented in Alternative 1 increases the risk of sea turtles being exposed to munitions; however, the expected impact on any exposed sea turtle remains the same. Sub-lethal effects due to ingestion of munitions used in training activities may cause short-term or long-term disturbance to an individual turtle. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the use of munitions of ingestible size during training activities under Alternative 1 would have not affect on leatherback sea turtles. The use of munitions of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

Testing Activities

The number of small- and medium-caliber projectiles (the only ingestible sizes) and explosives are detailed in Tables 3.0-18 and 3.0-19. Any bottom-feeding turtle may occur in the area where these are used, but green, olive ridley, and loggerhead turtles are most likely.

Sublethal effects due to ingestion of munitions used in testing activities may cause short-term or long-term disturbance to an individual turtle because: (1) if a sea turtle were to incidentally ingest and swallow a projectile or solid metal high-explosive fragment, it could potentially disrupt its feeding behavior or digestive processes; and (2) if the item is particularly large in proportion to the turtle ingesting it, the item could become permanently encapsulated by the stomach lining, with a rare chance that this could impede the turtle’s ability to feed or take in nutrients. Potential impacts of exposure to munitions may result in changes to an individual’s behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, munitions used in testing activities are generally not expected to cause disturbance to sea turtles because: (1) sea turtles are not expected to encounter most small- and medium-caliber projectiles or high-explosive fragments on the seafloor because of the depth at which these would be expended; and (2) in some cases a turtle would likely pass the projectile through their digestive tract and expel the item without impacting the individual. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the use of munitions of ingestible size during testing activities under Alternative 1 would have no effect on leatherback sea turtles. The use of munitions of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

3.5.3.5.1.3 Alternative 2

Training Activities

Under Alternative 2, the amount of small- and medium-caliber projectiles approximately doubles that of the No Action Alternative, from 86,500 to 173,890 projectiles (Table 3.0-18). The number of activities that use high-explosive ordnance and munitions increases from 1,340 under the No Action Alternative to 10,284 under Alternative 2 (Table 3.0-19). In comparison to the No Action Alternative, the increase in training activities presented in Alternative 1 increases the risk of sea turtles being exposed to munitions; however, the expected impact on any exposed sea turtle remains the same. Sub-lethal effects due to ingestion of munitions used in training activities may cause short-term or long-term disturbance to an individual turtle. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the use of munitions of ingestible size during training activities under Alternative 2 would have no effect on leatherback sea turtles. The use of munitions of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

Testing Activities

Under Alternative 2, the number of small- and medium-caliber projectiles (the only ingestible sizes) and explosives are detailed in Tables 3.0-18 and 3.0-19. Any bottom-feeding turtle may occur in areas where projectiles and explosives are used, but green, olive ridley, and loggerhead turtles are most likely.

Sublethal effects due to ingestion of munitions used in testing activities may cause short-term or long-term disturbance to an individual turtle because: (1) if a sea turtle were to incidentally ingest and swallow a projectile or solid metal high-explosive fragment, it could potentially disrupt its feeding behavior or digestive processes; and (2) if the item is particularly large in proportion to the turtle ingesting it, the item could become permanently encapsulated by the stomach lining, with a rare chance that this could impede the turtle's ability to feed or take in nutrients. Potential impacts of exposure to munitions may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, munitions used in testing activities are generally not expected to cause disturbance to sea turtles because: (1) sea turtles are not expected to encounter most small- and medium-caliber projectiles or high-explosive fragments on the seafloor because of the depth at which these would be expended; and (2) in some cases, a turtle would likely pass the projectile through their digestive tract and expel the item without impacting the individual. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the use of munitions of ingestible size during testing activities under Alternative 2 would have no effect on leatherback sea turtles. The use of munitions of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

3.5.3.5.2 Impacts from Military Expended Materials Other than Munitions

Fragments from targets, chaff, flare casings, and decelerators/parachutes are ingestion stressors introduced during training and testing activities and are being analyzed for sea turtles. A discussion of the types of these devices is presented in Sections 3.0.5.2.5.3 (Military Expended Materials Other than Munitions).

Because leatherbacks are more likely to feed at or near the surface, they are more likely to encounter materials at the surface than are other species of turtles that primarily feed along the seafloor. Furthermore, leatherbacks typically feed in the open ocean, while other species are more likely to feed in nearshore areas. Though they are bottom-feeding species that generally feed nearshore, green, hawksbill, olive ridley and loggerhead sea turtles may occur in the open ocean during migrations. Given the very low probability of nearshore, bottom-feeding species encountering and ingesting materials at the surface, this analysis focuses on leatherback sea turtles and those materials expended in the open ocean.

3.5.3.5.2.1 No Action Alternative

Training Activities

Under the No Action Alternative, some training activities use decelerators/parachutes of ingestible size. Under the No Action Alternative, approximately 8,032 decelerators/parachutes would be expended in locations greater than 3 nm from shore throughout the MITT Study Area (see Table 3.0-25). Activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600.4 ft.). Because the decelerators/parachutes sink, they are not expected to drift into another portion of the Study Area. Because of the low number of sonobuoys expended in the open ocean and the rapid sink rate of the decelerator/parachute, the likelihood of a leatherback encountering and ingesting a decelerator/parachute is extremely low. Because of the water depth over which these decelerators/parachutes are deployed, other sea turtle species are not likely to encounter a decelerator/parachute after it sinks through the water column.

Under the No Action Alternative, approximately 5,836 chaff cartridges would be expended by ships and aircraft during training activities (see Table 3.0-26). Although these fibers are too small for sea turtles to confuse with prey and forage, there is some potential for chaff to be incidentally ingested along with other prey items. If ingested, chaff is not expected to impact sea turtles, due to the low concentration that would be ingested and the small size of the fibers.

While no similar studies to those discussed in Section 3.0.5.2.5.3 (Military Expended Materials Other Than Munitions) on the effects of chaff have been conducted on sea turtles, they are also not likely to be impacted by incidental ingestion of chaff fibers. For instance, some sea turtles ingest spicules (small spines within the structure of a sponge) in the course of eating the sponges, without harm to their digestive system. Since chaff fibers are of similar composition and size as these spicules (Spargo 1999), ingestion of chaff should be inconsequential for sea turtles.

Sublethal effects due to ingestion of munitions used in training activities may cause short-term or long-term disturbance to an individual turtle because: (1) if a sea turtle were to incidentally ingest and swallow a projectile or solid metal high-explosive fragment, it could potentially disrupt its feeding behavior or digestive processes; and (2) if the item is particularly large in proportion to the turtle ingesting it, the projectile could become permanently encapsulated by the stomach lining, with a rare chance that this could impede the turtle's ability to feed or take in nutrients. Potential impacts of exposure to munitions may result in changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. However, munitions used in training activities are generally not expected to cause disturbance to sea turtles because: (1) sea turtles are not expected to encounter most small- and medium-caliber projectiles or high-explosive fragments on the seafloor because of the depth at which these would be expended; and (2) in some cases a turtle would likely pass the projectile through their digestive tract and expel the item without impacting the individual. Potential impacts of exposure to munitions are not expected to result in population-level impacts.

Pursuant to the ESA, the ingestion of military expended materials other than munitions during training activities under the No Action Alternative would have no effect on leatherback sea turtles. The use of materials of ingestible size may affect, but is not likely to adversely affect green, hawksbill, loggerhead, and olive ridley sea turtles.

Testing Activities

Under the No Action Alternative, no activities that would create ingestion stressors are conducted in the Study Area.

3.5.3.5.2.2 Alternative 1

Training Activities

Under Alternative 1, approximately 10,845 decelerators/parachutes would be expended during training activities in areas greater than 3 nm from shore throughout the MITT Study Area (see Table 3.0-25). The expended chaff would increase to approximately 25,840 canisters per year in areas greater than 3 nm from shore within the MITT Study Area compared with the No Action Alternative of 5,830 (see Table 3.0-26). The expended flares would increase to approximately 25,600 canisters per year in areas greater than 3 nm from shore within the MITT Study Area (see Table 3.0-27).

All sea turtle species would have the potential to be exposed to decelerators/parachutes, chaff, or flares in the Study Area, but given the very low probability of nearshore, bottom-feeding species encountering and ingesting materials at the surface, leatherback sea turtles are more likely to be exposed.

In comparison to the No Action Alternative, the increase in training activities presented in Alternative 1 increases the risk of sea turtles being exposed to decelerators/parachutes, chaff, and flares; however, the expected impact on any exposed sea turtle remains the same. For the same reasons stated for the No Action Alternative, sub-lethal effects due to ingestion of military expended materials other than munitions used in training activities may cause short-term or long-term disturbance to an individual turtle.

Pursuant to the ESA, the ingestion of military expended materials other than munitions during training activities under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under Alternative 1, some testing activities use decelerators/parachutes of ingestible size. Approximately 1,727 decelerators/parachutes would be expended in locations greater than 3 nm from shore throughout the MITT Study Area (see Table 3.0-25). Activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600.4 ft.). Because the decelerators/parachutes sink, they are not expected to drift into another portion of the Study Area. Because of the low number of sonobuoys expended in the open ocean and the rapid sink rate of the decelerator/parachute, the likelihood of a leatherback encountering and ingesting a decelerator/parachute is extremely low. Because of the water depth over which these decelerators/parachutes are deployed, other sea turtle species are not likely to encounter a decelerator/parachute after it sinks through the water column.

Pursuant to the ESA, the ingestion of military expended materials other than munitions during testing activities under Alternative 1 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.5.2.3 Alternative 2

Training Activities

The number and location of training activities under Alternative 2 are identical to training activities under Alternative 1. Therefore, impacts and comparisons to the No Action Alternative will be identical, and conclusions made for Alternative 1 are the same for Alternative 2.

Pursuant to the ESA, the ingestion of military expended materials other than munitions during training activities under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

Testing Activities

Under Alternative 2, some testing activities use decelerators/parachutes of ingestible size. Approximately 1,912 decelerators/parachutes would be expended in locations greater than 3 nm from shore throughout the MITT Study Area (see Table 3.0-25). Activities that expend sonobuoys and air-launched torpedo decelerators/parachutes generally occur in water deeper than 183 m (600.4 ft.). Because the decelerators/parachutes sink, they are not expected to drift into another portion of the Study Area. Because of the low number of sonobuoys expended in the open ocean and the rapid sink rate of the decelerator/parachute, the likelihood of a leatherback encountering and ingesting a decelerator/parachute is extremely low. Because of the water depth over which these decelerators/parachutes are deployed, other sea turtle species are not likely to encounter a decelerator/parachute after it sinks through the water column.

Pursuant to the ESA, the ingestion of military expended materials other than munitions during testing activities under Alternative 2 may affect, but is not likely to adversely affect, green, hawksbill, loggerhead, olive ridley, or leatherback sea turtles.

3.5.3.6 Secondary Stressors

This section analyzes potential impacts on sea turtles exposed to stressors indirectly through effects on habitat and prey availability from impacts associated with sediments and water quality. For the purposes of this analysis, secondary effects on sea turtles via sediment or water (not by trophic transfer, e.g., bioaccumulation) are considered here. It is important to note that the terms “indirect” and “secondary” do not imply reduced severity of environmental consequences, but instead describe *how* the impact may occur to an organism.

Stressors from Navy training and testing activities could pose secondary or indirect impacts on turtles via changes in habitat, sediment, or water quality. These include explosives and byproducts, metals, chemicals, and impacts on habitat. Activities associated with these stressors are detailed in Tables 2.8-1 to 2.8-4 and analyses of their potential impacts are discussed in Section 3.1 (Sediments and Water Quality) and Section 3.3 (Marine Habitats).

3.5.3.6.1 Explosives

In addition to the potential to affect turtle and turtle habitat, underwater explosions could affect other species in the food web, including prey species that sea turtles feed upon. The impacts of underwater explosions would differ, depending on the type of prey species in the area of the blast.

In addition to the physical effects of an underwater blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to detonations that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals (Mather 2004). The abundance of prey species near the detonation point could be diminished for a short period before being repopulated by animals from adjacent waters. Many sea turtle prey items, such as jellyfish and sponges, have limited mobility and ability to react to pressure waves. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting effect on prey availability or the pelagic food web would be expected. The Navy avoids conducting activity in ESA-listed coral habitats, which would minimize secondary effects to sea turtle species that rely on these habitats. Furthermore, most explosions occur in depths exceeding that which normally support seagrass beds, again protecting these habitats.

Strike warfare activities such as BOMBEX (Land) and MISSILEX involve the use of live munitions by aircrews that practice on ground targets on FDM. These warfare training activities occur on FDM and are limited to the designated impact zones along the central corridor of the island. Training activities may contribute to ongoing soil disturbance and erosion from natural causes on FDM and potential erosion of beach habitat. However, sea turtle nests are unlikely to be encountered on the beaches of FDM, which are unsuitable for nesting due to tidal inundation.

3.5.3.6.2 Explosion Byproducts and Unexploded Ordnance

Any explosive material not completely consumed during a detonation from ordnance disposal and mine clearance are collected after training is complete; therefore, potential impacts are assumed to be inconsequential and not detectable for these training and testing activities. Sea turtles may be exposed by contact with the explosive material, contact with contaminants in the sediment or water, and ingestion of contaminated sediments.

High-order explosions consume most of the explosive material, creating typical combustion products. In the case of Royal Demolition Explosive, 98 percent of the products are common seawater constituents and the remainder are rapidly diluted below threshold effect level (Table 3.1-9). Explosive byproducts from high-order detonations present no secondary stressors to turtles through sediment or water. However, low-order detonations and unexploded ordnance present elevated likelihood of impacts on sea turtles.

Secondary effects of explosives and unexploded ordnance on turtles via sediment are possible near the ordnance. Degradation of explosives proceeds via several pathways discussed in Section 3.1.3.1 (Explosives and Explosive Byproducts). Degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen and Lotufo 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6 to 12 in. (15.2 to 30.5 cm) away from degrading ordnance, concentrations of these compounds were not statistically distinguishable from background beyond 3 to 6 ft. (0.9 to 1.8 m) from the degrading ordnance (see Section 3.1.3.1.5.1, Explosives and Explosive Byproducts). Various lifestages of turtles could be impacted by the indirect effects of degrading explosives within a small radius of the explosive 1 to 6 ft. (0.3 to 1.8 m).

3.5.3.6.3 Metals

Metals are introduced into seawater and sediments by training and testing activities involving vessel hulks, targets, ordnance, munitions, and other military expended materials (see Section 3.1.3.2, Metals), the majority of which are deposited throughout the MITT Study Area (greater than 3 nm from shore). Some metals bioaccumulate, and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals (Section 3.3, Marine Habitats, and Chapter 4, Cumulative Impacts). Indirect impacts of metals on sea turtles via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Sea turtles may be exposed by contact with the metal, contact with contaminants in the sediment or water, or ingestion of contaminated sediments, though this exposure is anticipated to be minimal with deposition of metals in water depths greater than the diving ability of a sea turtle. Concentrations of metals in seawater are orders of magnitude lower than concentrations in marine sediments. It is extremely unlikely that sea turtles would be indirectly impacted by toxic metals via water.

3.5.3.6.4 Chemicals

Several Navy training and testing activities introduce potentially harmful chemicals into the marine environment; principally, flares and propellants for rockets, missiles, and torpedoes. Polychlorinated biphenyls (PCBs) are discussed in Section 3.1.3.3 (Chemicals Other Than Explosives). PCBs have a variety of effects on aquatic organisms. The chemicals persist in the tissues of animals at the bottom of the food chain. Thereafter, consumers of those species tend to accumulate PCBs at levels that may be many times higher than in water. In the past, PCBs have been raised as an issue because they have been found in certain solid materials on vessels used as targets during vessel-sinking exercises (e.g., insulation, wires, felts, and rubber gaskets). Currently, vessels used for sinking exercises are selected from a list of U.S. Navy-approved vessels that have been cleaned in accordance with EPA guidelines. Properly functioning flares missiles, rockets, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment. Sea turtles may be exposed by contact with contaminated water or ingestion of contaminated sediments.

Missile and rocket fuel poses no risk of secondary impact on sea turtles via sediment. In contrast, the principal toxic components of torpedo fuel, propylene glycol dinitrate and nitrodiphenylamine, adsorbs to sediments, has relatively low toxicity, and is readily degraded by biological processes. It is conceivable that various lifestages of sea turtles could be indirectly impacted by propellants via sediment in the immediate vicinity of the object (e.g., within a few inches), but these potential effects would diminish rapidly as the propellant degrades.

3.5.3.6.5 No Action Alternative, Alternative 1, and Alternative 2 – Training

Pursuant to the ESA, secondary stressors resulting from training activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but are not likely to adversely affect green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles sea turtles.

3.5.3.6.6 No Action Alternative, Alternative 1, and Alternative 2 – Testing

Pursuant to the ESA, secondary stressors resulting from testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2 may affect, but are not likely to adversely affect green, hawksbill, leatherback, loggerhead, or olive ridley sea turtles sea turtles.

3.5.4 Summary of Impacts on Sea Turtles

3.5.4.1 Combined Impacts of All Stressors

As described in Section 3.0.5.4 (Resource-Specific Impacts Analysis for Multiple Stressors), 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 the analyses of each stressor in the sections above and summarized in Endangered Species Act Determinations.

There are generally two ways that a sea turtle could be exposed to multiple stressors. The first would be if the animal were exposed to multiple sources of stress from a single activity (e.g., a mine warfare activity may involve explosives and vessels that could introduce potential acoustic and physical strike stressors). The potential for a combination of these impacts from a single activity would depend on the range of effects to each of the stressors and the response or lack of response to that stressor. Most of the activities as described in the Proposed Action involve multiple stressors; therefore, it is likely that if a sea turtle were within the potential impact range of those activities, they may be impacted by multiple stressors simultaneously. This would be more likely to occur during large-scale exercises or activities that span a period of days or weeks (such as a sinking exercise or composite training unit exercise).

Secondly, an individual sea turtle could be exposed to a combination of stressors from multiple activities over the course of its life. This is most likely to occur in areas where training and testing activities are more concentrated (e.g., near naval ports, testing ranges, and routine activity locations) and in areas that individual sea turtles frequently visit because it is within the animal's home range, migratory route, breeding area, or foraging area. Except for in the few concentrated areas mentioned above, combinations are unlikely to occur because training and testing activities are generally separated in space and time in such a way that it would be very unlikely that any individual sea turtles would be exposed to stressors from multiple activities. However, animals with a small home range intersecting an area of concentrated Navy activity have elevated exposure risks relative to animals that simply transit the area through a migratory route. Also, the majority of the proposed training and testing activities occur over a small spatial scale relative to the entire Study Area, have few participants, and are of a short duration (the order of a few hours or less).

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 strike and disturbance stressors via a decreased ability to detect and avoid threats. Sea turtles that experience behavioral and physiological consequences of ingestion stressors could be more susceptible to physical strike stressors via malnourishment and disorientation. These interactions are speculative, and without data on the combination of multiple Navy stressors, the synergistic impacts from the combination of Navy stressors on sea turtles are difficult to predict.

Although potential impacts on certain sea turtle species from the Proposed Action could include injury or mortality, impacts are not expected to decrease the overall fitness or result in long-term population-level impacts of any given population. In cases where potential impacts rise to the level that warrants mitigation, mitigation measures designed to reduce the potential impacts are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), which include safe speeds during operations, lookouts, and mitigation zones with shutdown procedures if animals enter during activities. The potential impacts anticipated from the Proposed Action are summarized in Endangered Species Act Determinations with respect to the ESA.

3.5.5 ENDANGERED SPECIES ACT DETERMINATIONS

Administration of ESA obligations associated with sea turtles are shared between NMFS and USFWS, depending on life stage and specific location of the sea turtle. NMFS has jurisdiction over sea turtles in the marine environment, and USFWS has jurisdiction over sea turtles on land. The Navy is consulting with NMFS on its determination of effect on the potential impacts of the Proposed Action. Because no nesting for any species of sea turtle is known to occur in the Study Area, consultation with USFWS is not required for sea turtles. Table 3.5-12 summarizes the Navy's determination of effect on ESA listed sea turtles for the Proposed Action.

Table 3.5-12: Summary of Effects and Impact Determinations for Sea Turtles

Stressor		Green Turtle	Hawksbill Turtle	Loggerhead Turtle	Olive Ridley Turtle	Leatherback Turtle
Acoustic Stressors						
Sonar and Other Active Acoustic Sources	Training Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, likely to adversely affect
	Testing Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, likely to adversely affect
Explosives	Training Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Swimmer Defense Airguns	Training Activities	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Testing Activities	No effect	No effect	No effect	No effect	No effect
Weapons Firing, Launch, and Impact Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Vessel and Aircraft Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Energy Stressors						
Electromagnetic Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.5-12: Summary of Effects and Impact Determinations for Sea Turtles (continued)

Stressor		Green Turtle	Hawksbill Turtle	Loggerhead Turtle	Olive Ridley Turtle	Leatherback Turtle
Physical Disturbance and Strike						
Vessels	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
In-Water Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Military Expended Materials	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Seafloor Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Entanglement Stressors						
Fiber Optic Cables and Guidance Wires	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Decelerators/ Parachutes	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.5-12: Summary of Effects and Impact Determinations for Sea Turtles (continued)

Stressor		Green Turtle	Hawksbill Turtle	Loggerhead Turtle	Olive Ridley Turtle	Leatherback Turtle
Ingestion						
Munitions	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	No effect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	No effect
Military Expended Materials other than Munitions	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

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