3 Introduction

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

There are no figures in this section.

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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