

Draft
Environmental Impact Statement/Overseas Environmental Impact Statement
Atlantic Fleet Training and Testing

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3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.0 INTRODUCTION

This chapter describes existing environmental conditions in the Atlantic Fleet Training and Testing (AFTT) 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 Atlantic Fleet Training and Testing Study Area) and depicted in Figure 2.1-1.

This section provides the ecological characterization of the Study Area and describes the resources evaluated in the analysis. The Overall Approach to Analysis section explains that each proposed military readiness activity was examined to determine which environmental stressors could potentially impact a resource.

The sections following 3.0 (Introduction) provide analyses for each resource. The physical resources (air quality, and sediments and water quality) are presented first (Sections 3.1 and 3.2, respectively). Because impacts to air or water quality could affect all other marine resources, any potential impacts on air quality or sediments and water quality were considered as potential secondary stressors on the remaining resources to be described: vegetation, invertebrates, habitats, fishes, marine mammals, reptiles, and birds (Sections 3.3 through 3.9). Following the biological resource sections are human resource sections: cultural, socioeconomic, and public health and safety (Sections 3.10, 3.11, and 3.12).

Resources Analyzed:

Physical Resources:

- Air Quality
- Sediments and Water Quality

Biological Resources:

- Vegetation
- Invertebrates
- Habitats
- Fishes
- Marine Mammals
- Reptiles
- Birds

Human Resources:

- Cultural
- Socioeconomic
- Public Health and Safety

3.0.1 NAVY COMPILED AND GENERATED DATA

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

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

3.0.1.1 Marine Species Monitoring and Research Programs

The Navy has been conducting marine species monitoring for compliance with the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) since 2006, both in association with training and testing events and independently. In addition to monitoring activities associated with regulatory

compliance, two other United States (U.S.) Department of the Navy (Navy) research programs provide extensive investments in basic and applied research: the Office of Naval Research Marine Mammals & Biology program, and the Living Marine Resources program. In fact, the U.S. Navy is one of the largest sources of funding for marine mammal research in the world. A survey of federally-funded marine mammal research and conservation conducted by the Marine Mammal Commission found that the U.S. Department of Navy was the second largest source of funding for marine mammal activities (direct project expenditures, as well as associated indirect or support costs) in the United States in 2014, second only to National Oceanic and Atmospheric Administration Fisheries (Purdy, 2016).

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

The two other Navy programs previously mentioned invest in research on the potential effects of sound on marine species and develop scientific information and analytic tools that support preparation of environmental impact statements (EISs) and associated regulatory processes under the MMPA and ESA, as well as support development of improved monitoring and detection technology and advance overall knowledge about marine species. These programs support coordinated science, technology, research, and development focused on understanding the effects of sound on marine mammals, including physiological, behavioral, ecological, and population-level effects¹. Additional information on these programs and other ocean resources-oriented initiatives can be found at the U.S. Navy Green Fleet – Energy, Environment, and Climate Change website.

3.0.1.2 Marine Species Density Database

A quantitative analysis of impacts on a species requires data on the occurrence, including abundance and concentration of the species population in the potentially impacted area. The most appropriate metric for this type of analysis is concentration of a species, known as density, which is the number of animals present per unit area. Estimating marine species density requires substantial surveys and effort to collect and analyze data to produce a usable estimate. The National Marine Fisheries Service is the primary agency responsible for estimating marine mammal and sea turtle density within the U.S. Exclusive Economic Zone. Other agencies and independent researchers often publish density data for species in specific areas of interest, including areas outside the U.S. Exclusive Economic Zone. In areas where surveys have not produced adequate data to allow robust density estimates, methods such as model extrapolation from surveyed areas, Relative Environmental Suitability models, or expert opinion are used to estimate occurrence. Modeled relationships rely on the location where the animals are

¹ A population-level impact is an impact on the population numbers (survival) or growth and reproductive rates (recruitment) of a particular marine mammal species or stock.

sighted, amount of survey effort, and the associated environmental variables (e.g., depth, sea surface temperature).

There is no single source of density data for every area of the world, species, and season because of the fiscal costs, resources, and effort involved in providing survey coverage to sufficiently estimate density. Therefore, to characterize marine species density for large areas, such as the AFTT Study Area, the Navy compiled data from multiple sources and developed a protocol to select the best available density estimates based on species, area, and time (i.e., season). When multiple data sources were available, the Navy ranked density estimates based on a hierarchical approach to ensure that the most accurate estimates were selected. The highest tier included peer-reviewed published studies of density estimates from spatial models since these provide spatially explicit density estimates with relatively low uncertainty. Other preferred sources included peer-reviewed published studies of density estimates derived from systematic line-transect survey data, the method typically used for the National Marine Fisheries Service (NMFS) marine mammal stock assessment reports. In the absence of survey data, information on species occurrence and known or inferred habitat associations have been used to predict densities using model-based approaches including Relative Environmental Suitability models. Because these estimates inherently include a high degree of uncertainty, they were considered the least preferred data source. In cases where a preferred data source was not available, density estimates were selected based on expert opinion from scientists. The resulting Geographic Information System database includes seasonal density values for every marine mammal and sea turtle species present within the Study Area (U.S. Department of the Navy, 2017c). These data are used as an input into the Navy Acoustic Effects Model. A detailed explanation of this analysis is provided in the technical report titled *Quantitative Analysis for Estimating Acoustic and Explosive Impacts to Marine Mammals and Sea Turtles* (U.S. Department of the Navy, 2017b).

3.0.1.3 Developing Acoustic and Explosive Criteria and Thresholds

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

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

loss in marine mammals was largely adopted by NMFS for species within their purview (National Marine Fisheries Service, 2016).

The Navy also uses criteria for estimating effects to fish and the ranges to which those effects are likely to occur. A working group of experts generated a technical report that provides numerical criteria and relative likelihood of effects to fish within different hearing groups (i.e., fishes with no swimbladder versus fishes with swimbladder used in hearing) (Popper et al., 2014). Details on criteria used to estimate impacts to marine fishes are contained within the appropriate stressor section (e.g., sonar and other transducers, explosives). This panel of experts (Popper et al., 2014) also provided criteria for sea turtles, assigning “low”, “medium,” and “high” probability of specific categories of behavioral impacts due to exposure to sources located at “near,” “intermediate,” and “far” distances.

3.0.1.4 Aquatic Habitats Database

The AFTT and Hawaii-Southern California Training and Testing (HSTT) Aquatic Habitat Database was developed after the completion of the 2013 AFTT and HSTT EIS/Overseas Environmental Impact Statement (OEIS) in order to refine the regional scale and overlapping habitat data used in the analysis of military expended materials and bottom explosives. The database includes more numerous data sources ranging from regional-to-local scale. These data sources are subsequently combined to create a non-overlapping mosaic of habitat information that presents the highest quality data for a given location. The database primarily includes areas within the Study Area; however, there are also specific point locations for selected habitat types (e.g., artificial substrate). The current database is limited to abiotic (physical rather than biological) substrate types assessed in Section 3.5 (Habitats) for the current AFTT and HSTT EIS documents. A detailed description of the database is included as a supporting technical document with associated Geographic Information System and database deliverables (U.S. Department of the Navy, 2016).

3.0.2 ECOLOGICAL CHARACTERIZATION OF THE STUDY AREA

The Study Area includes the intertidal and subtidal marine waters within the boundaries shown in Figure 2.1-1 but does not extend above the mean high tide line. Navy activities in the marine environment predominately occur within established operating areas (OPAREAs), range complexes, testing ranges, ports, and pierside locations. These locations are determined by Navy requirements, not to interfere with existing civilian and commercial maritime and airspace boundaries. The Navy-defined boundaries are not consistent with ecological boundaries, such as ecosystems, that may be more appropriate when assessing potential impacts on marine resources. Therefore, for the purposes of this document, the Navy analyzed the marine resources in an ecological context to the extent possible to more comprehensively assess the potential impacts. The Navy used biogeographic classification systems to frame this ecological context.

Biogeographic classifications organize and describe the patterns and distributions of organisms and the biological and physical processes that influence this distribution. These biogeographic classification systems and areas are described in Section 3.0.2.1 (Biogeographic Classifications).

3.0.2.1 Biogeographic Classifications

For context, the Navy organized the resources within coastal waters by large marine ecosystems, where primary productivity is higher than open ocean areas (Bergmann et al., 2015). Primary productivity is the rate of the formation of organic material from inorganic carbon via photosynthesis (e.g., by marine

vegetation) or chemical reactions. Resources within open ocean areas are characterized by main oceanographic features (currents, gyres).

The large marine ecosystem classification system originated in the mid-1980s as a spatial planning tool to address transboundary management issues such as fisheries and pollution (Duda & Sherman, 2002). Large marine ecosystems are “relatively large areas of ocean space of approximately 200,000 square kilometers (km²) or greater, adjacent to the continents in coastal waters where primary productivity is generally higher than in open ocean areas” (Bergmann et al., 2015). The large marine ecosystem concept for ecosystem-based management includes a five-module approach: (1) productivity, (2) fish and fisheries, (3) pollution and ecosystem health, (4) socioeconomics, and (5) governance. This approach is being applied to 16 international projects in Africa, Asia, Latin America, and Eastern Europe (Duda & Sherman, 2002) as well as to the large marine ecosystems in the AFTT Study Area described in the sections below (Aquarone & Adams, 2009c).

The large marine ecosystem classification system was advocated by the Council on Environmental Quality’s Interagency Ocean Policy Task Force (The White House Council on Environmental Quality, 2010) as a marine spatial framework for coordinating regional planning in the waters off of the United States. For this EIS/ OEIS, three main oceanographic features are used: the Labrador Current, the Gulf Stream, and the North Atlantic Gyre. The Study Area contains seven designated large marine ecosystems: the West Greenland Shelf, Newfoundland- Labrador Shelf, Scotian Shelf, Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea. The seven large marine ecosystems and three open ocean areas are shown in Figure 3.0-1 and outlined in Sections 3.0.2.1.1 (West Greenland Shelf Large Marine Ecosystem) through 3.0.2.1.10 (North Atlantic Gyre Open Ocean Area). Designated training and testing areas in relation to each of the large marine ecosystems and open ocean areas are presented in Figure 3.0-1.

3.0.2.1.1 West Greenland Shelf Large Marine Ecosystem

The West Greenland Shelf Large Marine Ecosystem (Figure 3.0-1) encompasses an area of 375,000 km² (Aquarone et al., 2009). No specifically designated training or testing areas fall within the West Greenland Shelf Large Marine Ecosystem; however, training may occasionally occur in this area during transit. See Chapter 2 (Description of Proposed Action and Alternatives) for locations of activities conducted outside of designated training and testing ranges, identified as “Other AFTT Areas.” Examples of these activities include gunnery exercises and anti-submarine warfare tracking exercises. This large marine ecosystem extends off the west coast of Greenland adjacent to Baffin Bay and the Davis Strait. Most of this ecosystem extends outside the Study Area; only the southwestern portion occurs within the Study Area (Figure 3.0-1). Other oceanic influences on this area are the West Greenland Current Front and the East Greenland Current. Significant structural features of this ecosystem include the Fyllass Bank and the Tasersuaq Estuary. Most of this large marine ecosystem is covered with ice during winter (Sherman & Hempel, 2009).

The West Greenland Shelf Large Marine Ecosystem provides resources for commercial fisheries (e.g., northern shrimp and flounder) and is an important feeding and migration area for the ESA-endangered Gulf of Maine Atlantic salmon (Fay et al., 2006). The average primary productivity within this large marine ecosystem is low: less than 150 grams (g) of carbon per square meter (m²) per year (Aquarone et al., 2009). Low primary productivity is a result of low numbers of primary producers (e.g., algae) that are responsible for most of the primary production in the ocean and form the base of the marine food web.

Refer to U.S. Department of the Navy (2012b) for more information. Less than 1 percent of the Study Area is in the West Greenland Shelf Large Marine Ecosystem.

3.0.2.1.2 Newfoundland-Labrador Shelf Large Marine Ecosystem

The Newfoundland-Labrador Shelf Large Marine Ecosystem (Figure 3.0-1) encompasses an area of approximately 896,000 km² (Aquarone & Adams, 2009a).

This large marine ecosystem extends off the east coast of Canada within the Labrador Current (Aquarone & Adams, 2009a). Other oceanic influences on this area are the Gulf Stream, Labrador Shelf-Slope Front, and Labrador Mid-Shelf Front. Important structural features of this ecosystem include a structurally complex seabed, 14 estuaries, and the Grand Banks, which is a rich fishing ground (Sherman & Hempel, 2009). The Newfoundland-Labrador Shelf Large Marine Ecosystem supplies an important ecosystem service by providing resources for commercial fisheries (e.g., cod, haddock, and pollock). The average primary productivity within this large marine ecosystem is moderate: 150–300 g of carbon per m² per year (Aquarone & Adams, 2009a).

No specifically designated training or testing areas fall within the Newfoundland-Labrador Shelf Large Marine Ecosystem; however, training may occasionally occur in this area during transit. See Chapter 2 (Description of Proposed Action and Alternatives) for locations of activities conducted outside of designated training and testing ranges, identified as “Other AFTT Areas.” Examples of these activities include gunnery exercises and anti-submarine warfare tracking exercises. Approximately 5 percent of the Study Area is located in the Newfoundland-Labrador Shelf Large Marine Ecosystem.

3.0.2.1.3 Scotian Shelf Large Marine Ecosystem

The Scotian Shelf Large Marine Ecosystem (Figure 3.0-1) encompasses an area of approximately 283,000 km² (Aquarone & Adams, 2009b). This large marine ecosystem is located off the coast of the Canadian province of Nova Scotia and extends to the shelf break (Aquarone & Adams, 2009b). The Laurentian Channel in the north separates this large marine ecosystem from the Newfoundland-Labrador Shelf Large Marine Ecosystem. Oceanic influences in this area are the Gulf Stream, Nova Scotia Current, Cape North Front, Cabot Strait Front, Gully Front, and Shelf-Slope Front. Important structural features of this ecosystem include the St. Lawrence Estuary and the complex topography of the area, which includes deep, mid-shelf basins, and many off-shore shallow banks (Sherman & Hempel, 2009). The Scotian Shelf Large Marine Ecosystem supplies an important ecosystem service by providing resources for commercial fisheries (e.g., cod, haddock, pollock, snow crab, northern shrimp, and short-finned squid). The average primary productivity within this large marine ecosystem is moderately high: 150–300 g of carbon per m² per year (Aquarone & Adams, 2009b).

No specifically designated training or testing areas fall within the Scotian Shelf Large Marine Ecosystem; however, training may occasionally occur in this area during transit. See Chapter 2 (Description of Proposed Action and Alternatives) for locations of activities conducted outside of designated training and testing ranges, identified as “Other AFTT Areas.” Examples of these activities include gunnery exercises and anti-submarine warfare tracking exercises. Approximately 1 percent of the Study Area is located in the Scotian Shelf Large Marine Ecosystem.

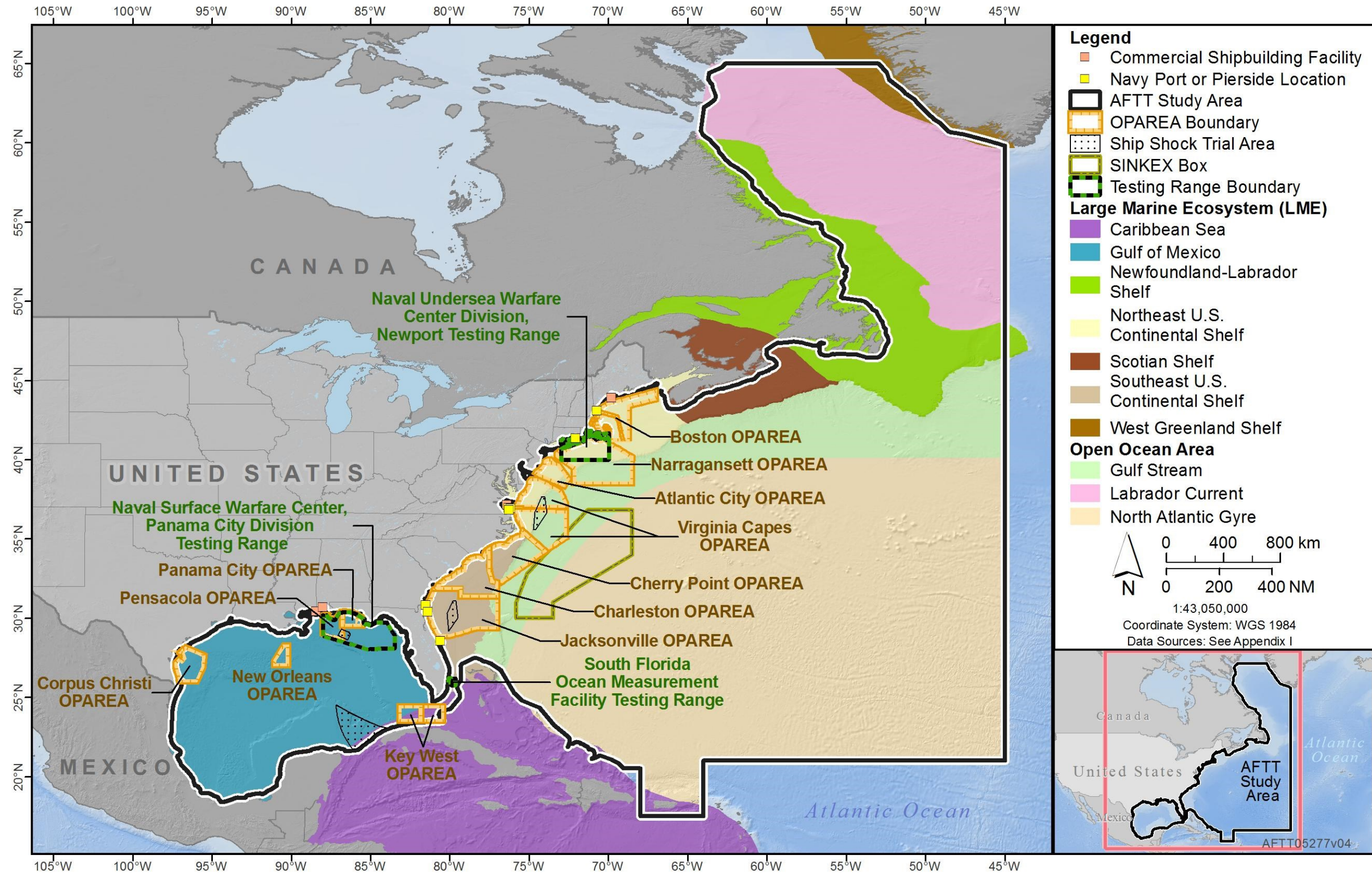


Figure 3.0-1: The Study Area with Large Marine Ecosystems and Open Ocean Areas

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3.0.2.1.4 Northeast United States Continental Shelf Large Marine Ecosystem

The Northeast U.S. Continental Shelf Large Marine Ecosystem (Figure 3.0-1) encompasses an area of approximately 310,000 km² (Aquarone & Adams, 2009c). This large marine ecosystem extends from the Gulf of Maine to Cape Hatteras, North Carolina. This area includes the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. For additional details on marine protected areas and national marine sanctuaries, see Section 6.1.2 (Marine Protected Areas).

Oceanic influences in this large marine ecosystem are the Gulf Stream, Cape North Front, Georges Bank Front, Maine Coastal Front, Mid-Shelf Front, Nantucket Shoals Front, and Shelf-Slope Front (Aquarone & Adams, 2009c). Important structural features of this ecosystem include 28 estuaries and river systems such as Penobscot Bay/River, Hudson River, Delaware Bay/River, and Chesapeake Bay (Sherman & Hempel, 2009). This large marine ecosystem also supplies an important ecosystem service by providing resources for commercial fisheries (e.g., cod, flounder, mackerel, lobster, sea scallops, and red crab). The Northeast U.S. Continental Shelf Large Marine Ecosystem is one of the most productive large marine ecosystems in the world, with a high average primary productivity of greater than 300 g of carbon per m² per year (Aquarone & Adams, 2009c).

A large proportion of Navy training and testing activities occur in the Northeast U.S. Continental Shelf Large Marine Ecosystem. To determine which designated training and testing areas (or portions of these areas) occur within this large marine ecosystem, refer to Figure 3.0-1, and for more information on the types of activities that will occur in an ecosystem, refer to Tables 2.3-1 through 2.3-5. Approximately 2 percent of the Study Area is located in the Northeast U.S. Continental Shelf Large Marine Ecosystem.

3.0.2.1.5 Southeast United States Continental Shelf Large Marine Ecosystem

The Southeast U.S. Continental Shelf Large Marine Ecosystem (Figure 3.0-1) encompasses an area of approximately 300,000 km² (Aquarone, 2009). This large marine ecosystem extends from Cape Hatteras, North Carolina, to the Straits of Florida (Aquarone, 2009). This area includes the Monitor and Gray's Reef National Marine Sanctuaries. For additional details on marine protected areas and national marine sanctuaries, see Section 6.1.2 (Marine Protected Areas).

Oceanic influences in this large marine ecosystem are the Gulf Stream, Inshore Gulf Stream Front, Mid-Shelf Front, and Offshore Gulf Stream Front. Important structural features of this ecosystem include many types of habitat such as coral reefs, estuaries, barrier islands, and coastal marshes (Sherman & Hempel, 2009). The calving grounds for the North Atlantic right whale are located in this large marine ecosystem, as discussed in Section 3.7 (Marine Mammals). The Southeast U.S. Continental Shelf Large Marine Ecosystem supplies important ecosystem services by providing resources for commercial fisheries (e.g., mackerel, swordfish, tuna, white shrimp, brown shrimp) and by supporting these fisheries with estuarine nurseries for these species. The Southeast U.S. Continental Shelf Large Marine Ecosystem includes important breeding areas for sea turtles. This large marine ecosystem is a moderately productive ecosystem, with an average primary productivity of 150–300 g of carbon per m² per year (Aquarone, 2009). This is comparable to productivity levels associated with the open ocean.

A large proportion of Navy training and testing activities occur in the Southeast U.S. Continental Shelf Large Marine Ecosystem. To determine which designated training and testing areas (or portions of these areas) occur within this large marine ecosystem, refer to Figure 3.0-1, and for more information on the types of activities that will occur in an ecosystem, refer to Tables 2.3-1 through 2.3-5. Approximately 2 percent of the Study Area is located in the Southeast U.S. Continental Shelf Large Marine Ecosystem.

3.0.2.1.6 Gulf of Mexico Large Marine Ecosystem

The Gulf of Mexico Large Marine Ecosystem (Figure 3.0-1) encompasses an area of more than 1,500,000 km² (Heileman & Rabalais, 2008). This large marine ecosystem is a semi-enclosed sea that borders the United States, Mexico, and Cuba. This area includes the Florida Keys and Flower Garden Banks National Marine Sanctuaries. For additional details on marine protected areas and national marine sanctuaries, see Section 6.1.2 (Marine Protected Areas).

Oceanic influences in this large marine ecosystem are the Loop Current, Campeche Bank Coastal Front, Campeche Bank Shelf-Slope Front, Inner Shelf Front, Louisiana-Texas Shelf Front, and West Florida Shelf Front. Important structural features of this ecosystem include the extensive continental shelf, numerous estuaries, and a large amount of freshwater input from the Mississippi River (Sherman & Hempel, 2009). The Gulf of Mexico Large Marine Ecosystem supplies an important ecosystem service by providing resources for commercial fisheries (e.g., Gulf menhaden, king mackerel, red grouper, brown shrimp, white shrimp, and pink shrimp). This large marine ecosystem has a moderately high average primary productivity of less than 300 g of carbon per m² per year (Heileman & Rabalais, 2008). Other human uses in this large marine ecosystem include off-shore oil and gas exploration.

A large number of Navy training and testing activities occur in the Gulf of Mexico Large Marine Ecosystem. To determine which designated training and testing areas (or portions of these areas) occur within this large marine ecosystem, refer to Figure 3.0-1, and for more information on the types of activities that will occur in an ecosystem, refer to Tables 2.3-1 through 2.3-5. Approximately 13 percent of the Study Area is located in the Gulf of Mexico Large Marine Ecosystem.

3.0.2.1.7 Caribbean Sea Large Marine Ecosystem

The Caribbean Sea Large Marine Ecosystem (Figure 3.0-1) encompasses an area of approximately 3,300,000 km². This large marine ecosystem is bordered by the southern part of Florida, Central and South America, and the Antilles (Heileman & Mahon, 2008). Oceanic influences in this area are the Loop Current, North Equatorial Current, and Windward Passage Front. Important structural features of this ecosystem include coral reefs, sea mounts, and major input of freshwater from large rivers (Sherman & Hempel, 2009). The Caribbean Sea Large Marine Ecosystem supplies an important ecosystem service by providing resources for commercial fisheries (e.g., king mackerel, Spanish mackerel, dolphinfish, spiny lobster, queen conch, and shrimp). The Caribbean Sea Large Marine Ecosystem includes important breeding areas for sea turtles, as discussed in Section 3.8 (Reptiles). This region has a moderate primary productivity of 150–300 g of carbon per m² per year (Heileman & Mahon, 2008).

To determine which designated training and testing areas (or portions of these areas) occur within the portion of the Caribbean Sea Large Marine Ecosystem that falls within the Study Area, refer to Figure 3.0-1, and for more information on the types of activities that will occur in an ecosystem, refer to Tables 2.3-1 through 2.3-5. Approximately 1 percent of the Study Area is located in the Caribbean Sea Large Marine Ecosystem.

3.0.2.1.8 Labrador Current Open Ocean Area

The Labrador Current Open Ocean Area (Figure 3.0-1) lies between Labrador (Canada) and Greenland and is characterized by the cold water of the Labrador Current that flows north to south from the Arctic Ocean, down along the eastern coast of Canada (Reverdin et al., 2003). The Labrador Current then joins the Gulf Stream Current to form the North Atlantic Current (Gould, 1985; Reverdin et al., 2003). The Labrador Current has an average width of 26–50 nautical miles (NM), with typical velocities of 0.3–0.5

meters (m) per second, and flows to a maximum depth of 150 m (Halkin & Rossby, 1985; Reverdin et al., 2003; Tomczak & Godfrey, 2003).

The Arctic influence, combined with the southward-flowing current, results in an abundance of icebergs in this open ocean area, particularly during the spring and early summer months (Reverdin et al., 2003; Schmitz & McCartney, 1993; Tomczak & Godfrey, 2003). The cold-water Labrador Current influences the species assemblages found within this open ocean area (Valiela, 1995). However, farther south where this cold water current combines with the warm waters of the Gulf Stream (offshore of the Newfoundland-Labrador Shelf, Scotian Shelf, and Northeast U.S. Continental Shelf Large Marine Ecosystems), the species assemblage reflects both warm- and cold-water organisms (Aquarone, 2009; Aquarone & Adams, 2009a; Valiela, 1995). The Labrador Current Open Ocean Area is an important feeding and migration area for the Gulf of Maine Atlantic salmon (Fay et al., 2006).

No specifically designated training or testing areas fall within the Labrador Current Open Ocean Area; however, training or testing may occasionally occur in this area during transit. See Chapter 2 (Description of Proposed Action and Alternatives) for locations of activities within and outside of designated training and testing ranges. Approximately 10 percent of the Study Area is located in the Labrador Current Open Ocean Area.

3.0.2.1.9 Gulf Stream Open Ocean Area

The major western boundary current of the North Atlantic, the Gulf Stream, characterizes the Gulf Stream Open Ocean Area (Figure 3.0-1). The Gulf Stream forms where the Loop Current in the Gulf of Mexico (Reverdin et al., 2003) and the Florida Current (Atkinson et al., 1984) combine in the Atlantic Ocean. The Gulf Stream begins where the Florida Current ceases to follow the continental shelf, flowing northeast along the southeastern United States from Cape Canaveral, Florida, to Cape Hatteras, North Carolina (Atkinson & Targett, 1983). As the Gulf Stream moves away from Cape Hatteras it flows northeast toward Europe (Garrison, 1998).

The Gulf Stream has a maximum width of 200 kilometers (km), with typical velocities exceeding 1.0 m per second, and flows to a maximum depth of 200 m (Halkin & Rossby, 1985; Reverdin et al., 2003; Tomczak & Godfrey, 2003). The Gulf Stream flows over the shelf break south of 32 degrees (°) North (N) at water depths less than 800 m (Atkinson et al., 1984; Halkin & Rossby, 1985). North of 32° N, the Gulf Stream is displaced 54 NM offshore, at which point it abruptly turns east near the Charleston Bump (a deep-water outcropping) (Reverdin et al., 2003). From there, the Gulf Stream continues northeast, joining the Labrador Current to form the Slope Jet Current at 41° N–42° N. This branch of the Gulf Stream, along with the Labrador and Slope Jet Current, continues northeast as the North Atlantic Current (Gould, 1985; Reverdin et al., 2003).

The Gulf Stream is an important migratory corridor for many different marine species, including marine mammals, sea turtles, and fishes. The influence of the warm waters of the Gulf Stream also provides passive dispersal of tropical species from southern portions of the Study Area into the northern portions of the Study Area.

A large proportion of Navy training and testing activities occur in this open ocean area. To determine which designated training and testing areas (or portions of these areas) occur within the Gulf Stream Open Ocean Area, refer to Figure 3.0-1, and for more information on the types of activities that will occur in an ecosystem, refer to Tables 2.3-1 through 2.3-5. Approximately 11 percent of the Study Area is located in the Gulf Stream Open Ocean Area.

3.0.2.1.10 North Atlantic Gyre Open Ocean Area

North Atlantic Ocean circulation is driven by the anticyclonic (clockwise) motion of the North Atlantic Subtropical Gyre (Figure 3.0-1). The North Atlantic Gyre Open Ocean Area occurs from 10° N to 40° N and is delimited by the westward-flowing Canary Current, North Equatorial Current, the Caribbean Current, Loop Current in the Gulf of Mexico, Florida Current, Gulf Stream (Talwani et al., 1971), and the eastward-flowing North Atlantic Current (Schmitz & McCartney, 1993). The North Atlantic Subtropical Gyre is transected by the eastward-flowing Azores Current (Juliano & Alves, 2007). Only the northwestern portion of the North Atlantic Gyre is located in the Study Area. The North Atlantic Gyre, like all large subtropical gyres in the ocean, has extremely low rates of primary productivity (Valiela, 1995). The observed low productivity is caused by a persistent thermocline (a layer of water that separates warm water from cold deep water) that prevents the vertical mixing of water. This thermocline results in dilute (nutrient-poor) surface waters in the gyre, which limits the growth of phytoplankton throughout the year (Valiela, 1995). The Sargasso Sea is a unique feature contained within this gyre, and despite the nutrient limitations of the area, is characterized by dense mats of floating Sargassum, a type of marine vegetation (seaweed) that provides important cover habitat for a variety of marine organisms (see Section 3.3, Vegetation, for more details).

To determine which designated training and testing areas (or portions of these areas) occur within the North Atlantic Gyre Open Ocean Area, refer to Figure 3.0-1 and for more information on the types of activities that will occur in an ecosystem, refer to Tables 2.3-1 through 2.3-5. Although approximately 50 percent of the Study Area is located in the North Atlantic Gyre Open Ocean Area, the majority of Navy training and testing activities do not occur here.

3.0.2.2 Bathymetry

The discussion of bathymetry (water depth) includes a general overview of the Study Area followed by more detailed sections organized by biogeographic classification area. Bathymetry describes the surface features of the seafloor, and it is an important factor in understanding the potential impacts of Navy training and testing activities on the seafloor, the propagation of underwater sound, and species diversity.

The contour of the ocean floor as it descends from the shoreline has an important influence on the distribution of organisms, as well as the structure and function of marine ecosystems (Madden et al., 2009). The continental shelf and slope make up the continental margin of oceans. The typical zonation of oceans is shown in Figure 3.0-2.

The continental shelf gently slopes seaward hundreds of miles (mi.) from shore from the low tide line to a maximum depth of 200 m (Tomczak & Godfrey, 2003; United Nations Educational Scientific and Cultural Organization, 2009). The continental slope is steep; it begins seaward of the shelf break and extends to a depth of approximately 3,000 m. The continental rise extends from the continental slope to a depth of approximately 4,000 m. The abyssal zone, a relatively flat or gently sloping ocean floor, continues from the continental rise to depths of up to approximately 6,500 m. The abyssal zones of the Atlantic Ocean reach depths greater than 6,000 m. Bathymetry of the entire Study Area is shown in Figure 3.0-3 through Figure 3.0-6.

Bathymetric features associated with the continental margin and the deep seafloor of the Study Area include canyons, seamounts (underwater mountains), trenches, ridges, and plateaus. The continental shelf of the northwest Atlantic ranges in width from 5 to 17 NM at its narrowest point off the coast of

North Carolina to 215 NM at its widest point off the coast of Newfoundland (Blanton et al., 2003; Slatt, 1984).

Several bathymetric features are located in the Northeast U.S. Continental Shelf, the Scotian Shelf, and the Newfoundland-Labrador Shelf Large Marine Ecosystems. The Grand Banks are a group of shallow underwater plateaus on the eastern extent of the continental shelf in 25–100 m of water. South of the Grand Banks is the Newfoundland Rise, which at 41° N, 50° West (W) is the northernmost extent of the New England Seamount Chain (Reverdin et al., 2003). This chain includes more than 30 volcanic seamounts that extend south to Bermuda.

The Scotian Shelf is bordered by the Canadian province of Nova Scotia and extends offshore to the shelf break, more than 200 NM from the coast (Aquarone & Adams, 2009b). The continental shelf is relatively shallow, with an average depth of 90 m. However, in some areas it rapidly drops to depths greater than 3,000 m. Sable Island, located 160 NM southeast of Halifax, is surrounded by shallow banks (25–100 m).

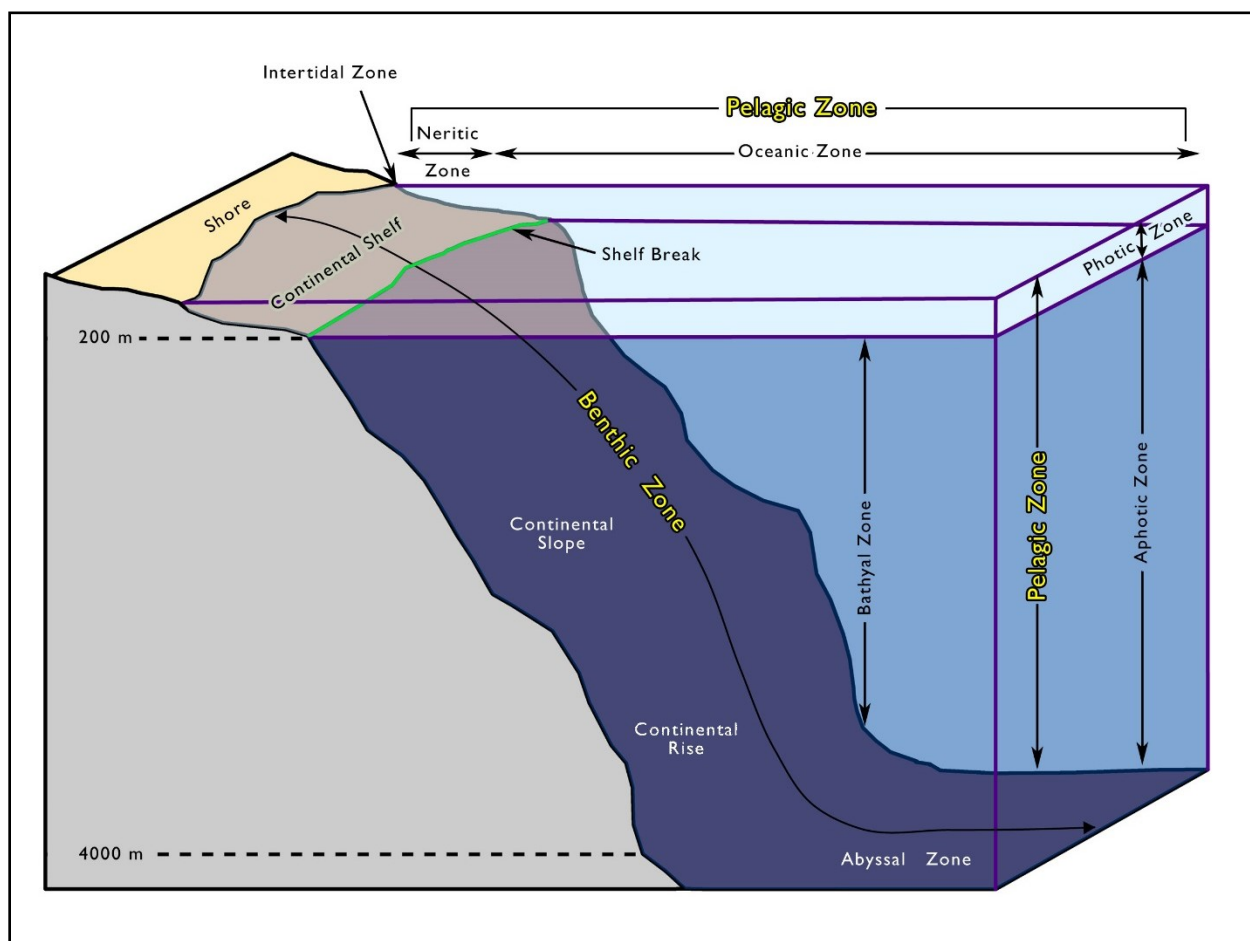


Figure 3.0-2: Three-Dimensional Representation of the Intertidal Zone (shoreline), Continental Margin, Abyssal Zone, and Water Column Zones

The Gulf of Maine is a semi-enclosed continental sea with an area of 89,000 km² and average depth of 150 m (Ballard & Uchupi, 1974). It is characterized by rocky shorelines of exposed bedrock from previous glacial scouring. Inland of the Gulf of Maine is the Bay of Fundy. It covers 16,500 km² with an average

depth of 50 m (Wade et al., 1996). The Bay of Fundy and Gulf of Maine are known for having extreme tidal ranges as great as 15 m (Wade et al., 1996).

The Southeast U.S. Continental Shelf Large Marine Ecosystem includes the coastal area from southern Florida to Cape Hatteras, North Carolina (Shepard, 2005). It includes the topographic feature known as the Blake Plateau, which has water depths of 500–1,100 m (Popenoe & Manheim, 2001). The Blake Plateau is bounded by the continental shelf on the west, Cape Hatteras on the north, the Bahama Banks on the south, and the abyssal plain on the east (Gorsline, 1963; Popenoe & Manheim, 2001). The Charleston Bump, a rocky, high-relief outcrop, occurs on the Blake Plateau between latitude 31° N and 32° N, and between longitude 77.5° W and 79.5° W (Popenoe & Manheim, 2001). The continental shelf in this area has a smooth surface and a low gradient (3° or less), while the continental slope reaches depths of 1,400 m (Knebel, 1984). Portions of the continental slope in this area are associated with deep-water coral communities at depths of 70–1,000 m (Reed & Ross, 2005). At the boundary between the Northeast U.S. Continental Shelf and the Southeast U.S. Continental Shelf, the continental slope is divided by Hatteras Canyon, the most southerly canyon along the continental margin of the U.S. east coast. Offshore of Hatteras Canyon, the continental slope is steep and reaches 5,000 m (Rowe, 1971). Other notable features are large sand shoals that extend from the barrier islands off North Carolina (Hunt et al., 1977; Oertel, 1985).

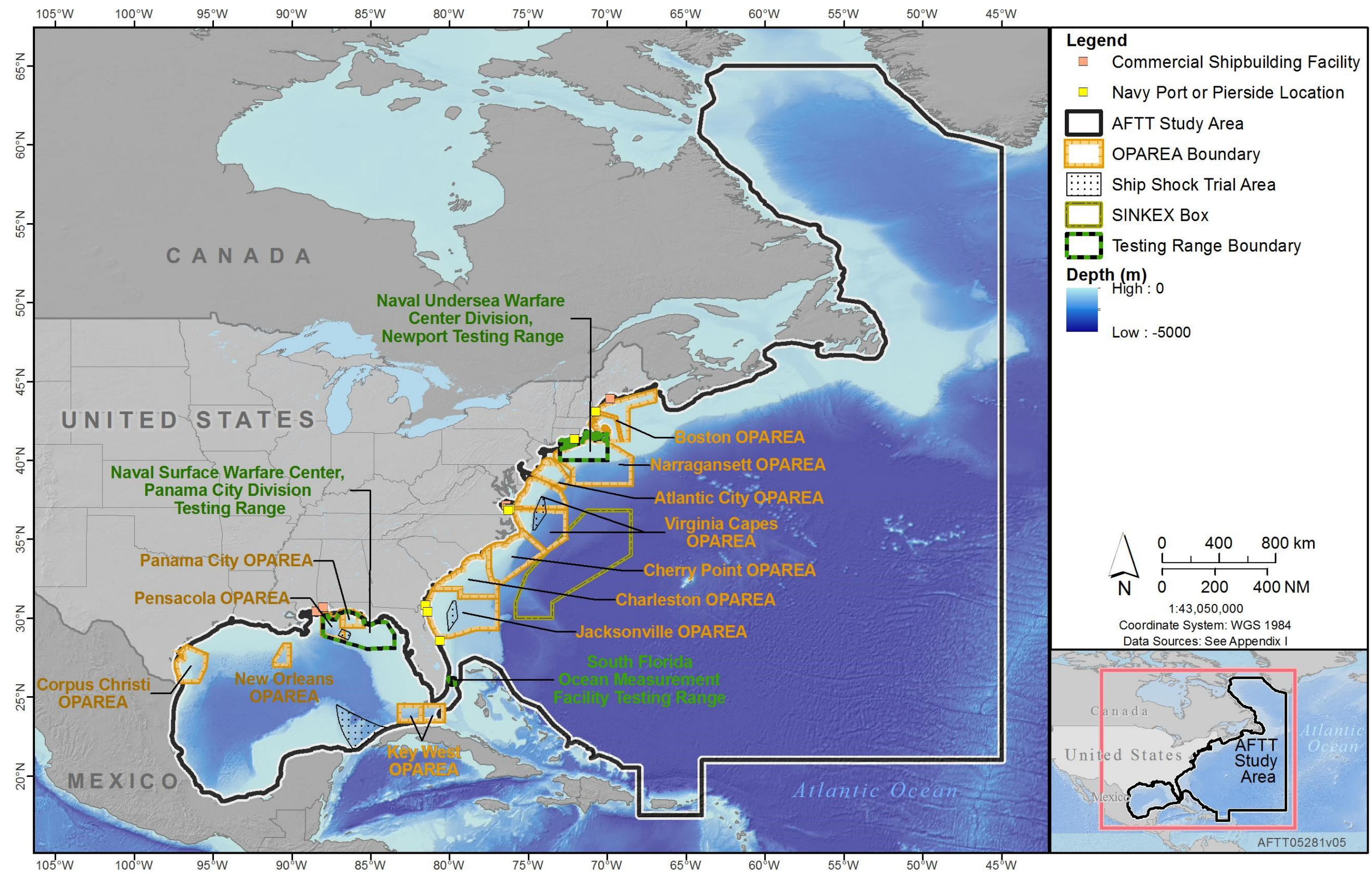
The average depth of the Gulf of Mexico is 1,615 m, with a maximum depth of 3,850 m (Pequegnat et al., 1990). Dominant features of the Gulf of Mexico include the Sigsbee Escarpment (steep slope) and the Alaminos and Keathley Canyons, which divide the escarpment into western and eastern portions (Roberts et al., 2005). The eastern Gulf of Mexico is dominated by the Florida Escarpment, which is divided by a series of submarine canyons and contains more than 90 basins (Rowe & Kennicutt, 2002). The western portion is underlain by the Louann Salt Formation, which creates faults and diapirs (salt domes) often associated with hydrocarbon seeps along the faults. Dominant features in the southern portion of the Gulf of Mexico are the Campeche Escarpment and the Mexican Ridge, which consists of a series of valleys and ridges (Escobar-Briones et al., 2008).

3.0.2.3 Currents, Circulation Patterns, and Water Masses

To analyze the impact of Navy training and testing activities on marine resources (e.g., vegetation and animals) it is important to know where the resources occur in the Study Area. Some of the major factors that influence the distribution of marine resources are currents, circulation patterns, and water masses.

Prevailing winds and the Coriolis effect (the deflection of objects caused by the rotation of the earth) cause surface waters to move in a gyre, or circular fashion, in ocean basins. In the North Atlantic Ocean, this gyre system is composed of the Gulf Stream, North Atlantic, Canary, and Equatorial Currents. In the Gulf of Mexico, the Florida Current is a strong, east-northeast-flowing current that connects the Loop Current to the Gulf Stream at the entrance to the Florida Straits (Figure 3.0-7).

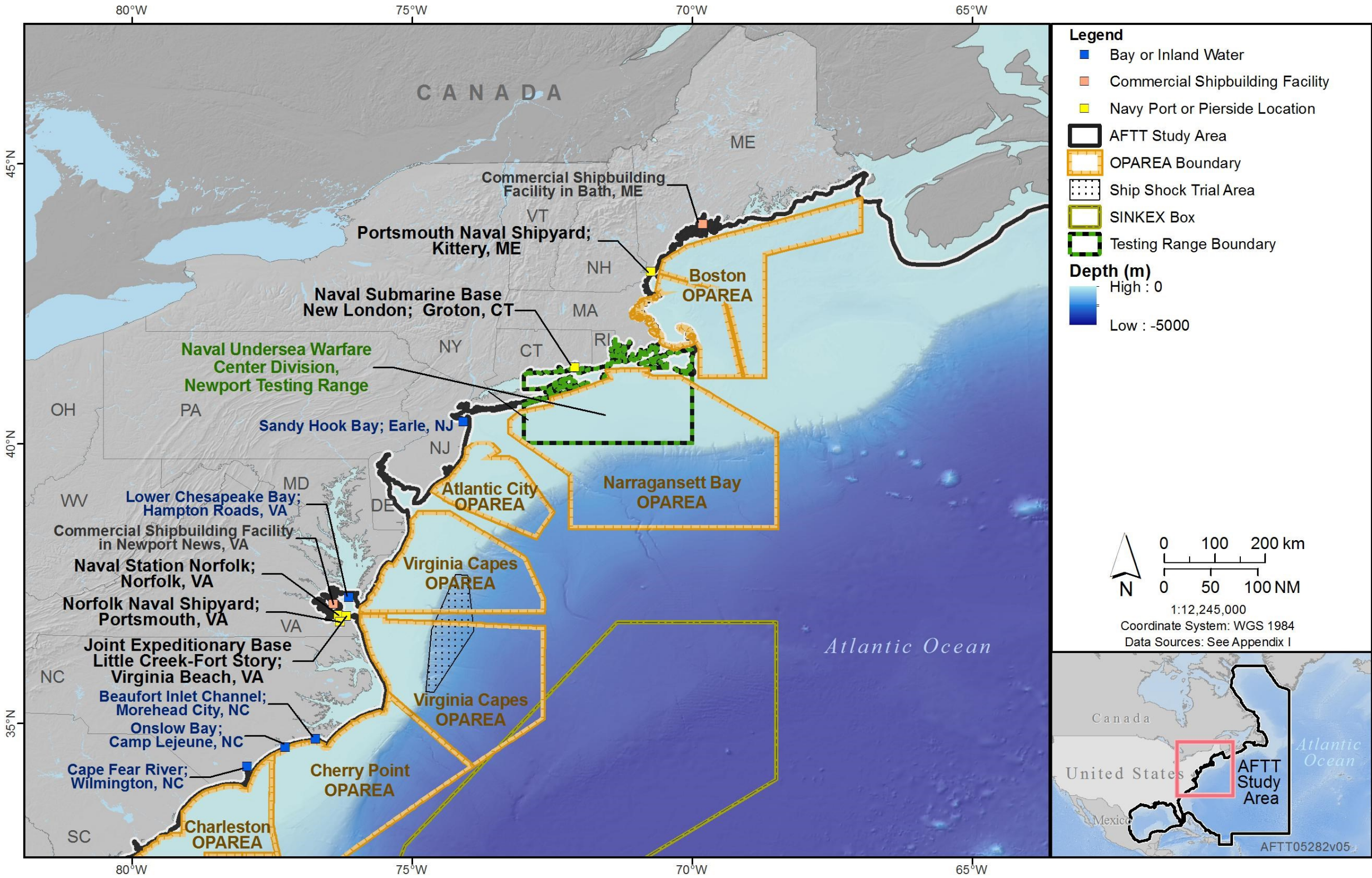
Surface currents are horizontal movements of water primarily driven by the drag of the wind over the sea surface. Wind-driven circulation affects the upper 100 m of the water column and therefore drives the circulation over continental shelves (Hunter et al., 2007). Surface currents of the Atlantic Ocean have an annual average mean velocity of 0.5 m per second and include equatorial currents, circumpolar currents, eastern boundary currents, and western boundary currents (Juliano & Alves, 2007). Refer to Figure 3.0-7 and Table 3.0-1 for a depiction and description of the major surface currents in the Study Area.



Notes: AFTT = Atlantic Fleet Training and Testing, OPAREA = Operating Area

Figure 3.0-3: Bathymetry of the Entire Study Area

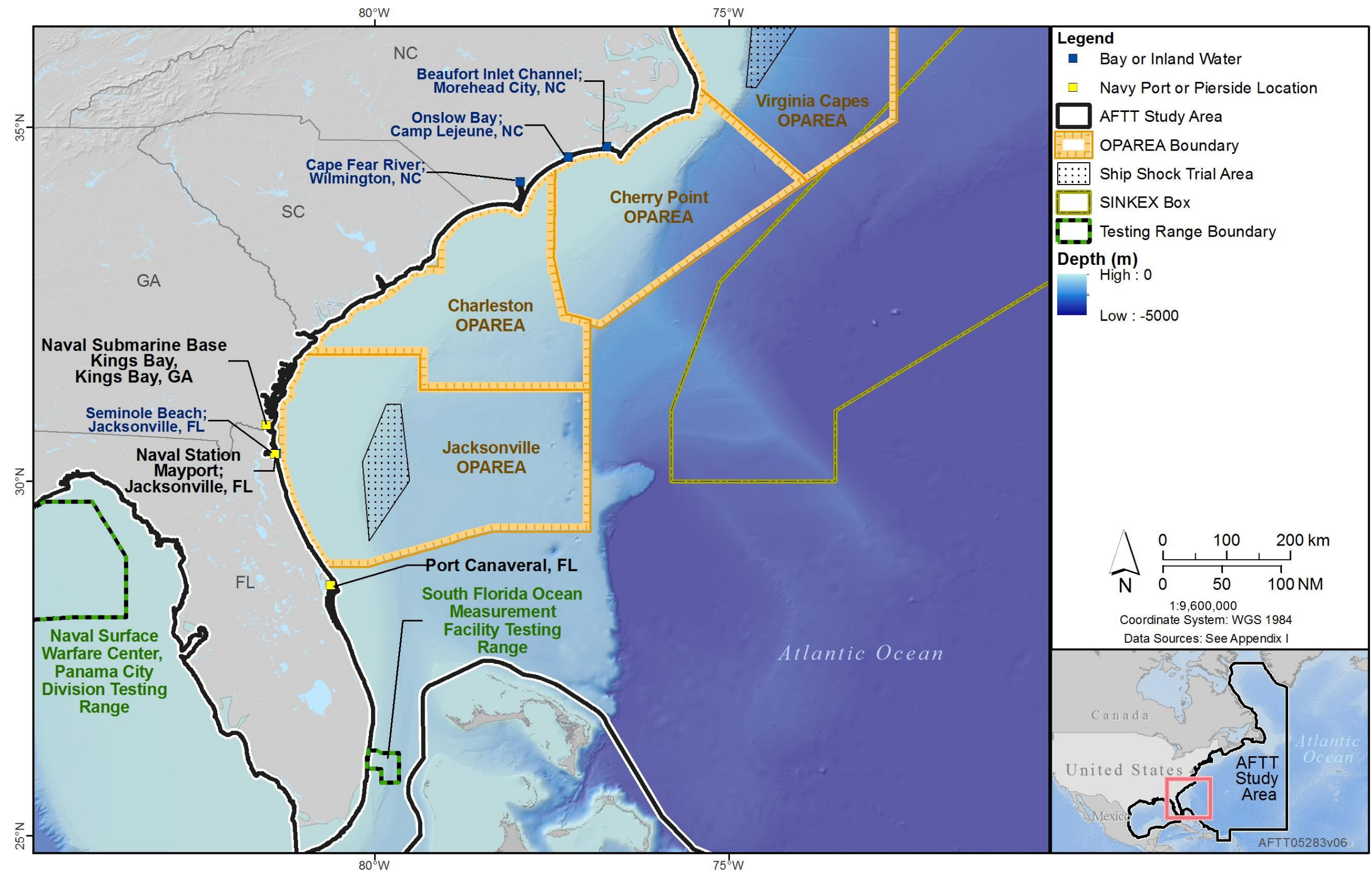
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Notes: AFTT = Atlantic Fleet Training and Testing, OPAREA = Operating Area, SINKEX = Sinking Exercise

Figure 3.0-4: Bathymetry of the Northeast Portion of the Study Area

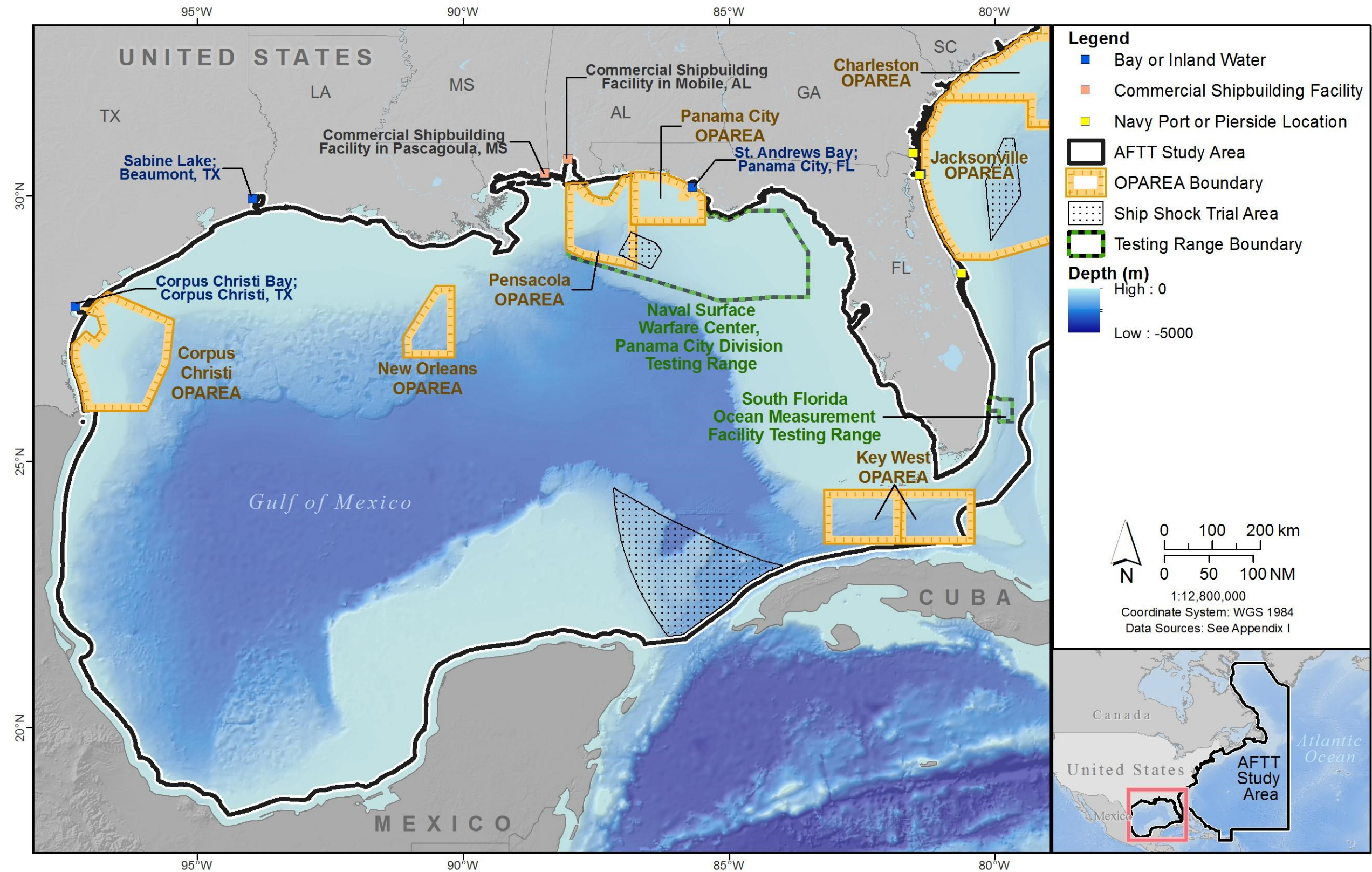
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Notes: AFTT = Atlantic Fleet Training and Testing, OPAREA = Operating Area, SINKEX = Sinking Exercise

Figure 3.0-5: Bathymetry of the Southeast and Caribbean Portions of the Study Area

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Notes: AFTT = Atlantic Fleet Training and Testing, OPAREA = Operating Area

Figure 3.0-6: Bathymetry of the Gulf of Mexico and Caribbean Sea Portions of the Study Area

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Eastern boundary currents are relatively shallow, broad, and slow-moving and travel toward the equator along the eastern boundaries of ocean basins. Western boundary currents are narrow, deep, and swift and are a result of the trade winds and the westerlies. In general, eastern boundary currents carry cold waters from higher latitudes to lower latitudes, and western boundary currents carry warm waters from lower latitudes to higher latitudes (Reverdin et al., 2003).

In the northern hemisphere, including the Study Area, the influence of the westerlies and the northeasterly trade winds on North Atlantic currents produce the eastward-flowing Subtropical Counter Current (Tomczak & Godfrey, 2003). Subpolar gyres are also present in the North Atlantic as a result of the polar easterlies and the westerlies. In the North Atlantic, subpolar gyres rotate counterclockwise (Tomczak & Godfrey, 2003).

The western continental margin of any ocean basin is the location of intense boundary currents; the Gulf Stream Current is the western boundary current found in the North Atlantic Ocean (Figure 3.0-7). The Gulf Stream Current is part of a larger current system called the Gulf Stream System that also includes the Loop Current in the Gulf of Mexico, the Florida Current in the Florida Straits, and the North Atlantic Current in the central North Atlantic Ocean. The Gulf Stream Current is a powerful surface current, carrying warm water into the cooler North Atlantic just south of the Northeast Range Complexes (Pickard & Emery, 1990; Verity et al., 1993). In general, the Gulf Stream flows roughly parallel to the coastline from the Florida Straits to Cape Hatteras, where it is deflected away from the North American continent and flows northeastward.

The temperature and salinity of water determines its density; density differences cause water masses to move both vertically and horizontally in relation to one another. Cold, salty, dense water at the surface will sink, and warm, less saline water will rise. Density differences also drive the horizontal circulation of deep-water masses throughout ocean basins.

Thermohaline circulation—also called the ocean conveyor belt or meridional overturning—is the continuous horizontal circulation of water masses throughout the ocean. This cycle begins when dense waters sink and deep-water masses form. Deep-water masses form in the North Atlantic and Southern oceans (Dickson & Brown, 1994). North Atlantic Deep Water is formed in the Norwegian Sea between Iceland and Greenland. North Atlantic Deep Water is carried by the Deep Western Boundary Current along the western continental slope to join Antarctic Bottom Water (Dengler et al., 2004; Pickart, 1992). At the surface, waters are heated and freshwater inputs result in lower salinity. As a result of density differences and higher sea levels in the Pacific Ocean and Indian Ocean, these surface water masses return to the Antarctic Ocean and North Atlantic Ocean. In the North Atlantic, these surface waters undergo evaporative cooling, which increases their densities, resulting in the sinking and formation of the North Atlantic Deep Water (Huang & Tiedemann, 1998).

Table 3.0-1: Summary of Current Patterns in Areas Located Outside the Range Complexes

Component	Currents
Northeast U.S. Continental Shelf Large Marine Ecosystem	
Bath, ME	Riverine and tidal circulation patterns.
Portsmouth Naval Shipyard; Kittery, ME	
Naval Undersea Warfare Center Division, Newport Testing Range	Shallow water coastal currents generated by tidal action and wind. Currents are affected by open-ocean conditions as well as by tidal exchange and wind-generated currents in the estuaries.

**Table 3.0-1: Summary of Current Patterns in Areas Located Outside the Range Complexes
(continued)**

Component	Currents
Northeast U.S. Continental Shelf Large Marine Ecosystem (continued)	
Naval Submarine Base New London; Groton, CT	Riverine and tidal circulation patterns near mouth of estuary. Subject to the influence of larger open oceanic currents and circulation systems.
Newport News, VA	
Naval Station Norfolk; Norfolk, VA	
Joint Expeditionary Base Little Creek—Fort Story; Virginia Beach, VA	
Norfolk Naval Shipyard; Portsmouth, VA	
Southeast U.S. Continental Shelf Large Marine Ecosystem	
Naval Submarine Base Kings Bay; Kings Bay, GA	Riverine and tidal circulation patterns in middle part of estuary.
Naval Station Mayport, Jacksonville, FL	Riverine and tidal circulation patterns in the mouth of estuary inlet. Subject to the influence of larger open oceanic currents and circulation systems.
Port Canaveral, FL; South Florida Ocean Measurement Facility, FL	Tidal mixing within shallow dredged channel, plus wind driven circulation.
Gulf of Mexico Large Marine Ecosystem	
Pascagoula, MS; Naval Surface Warfare Center, Panama City Division, FL	Riverine and tidal circulation patterns in mouth of estuary/inlet. Offshore, near coastal areas subject to influence of larger open oceanic current/circulation.
Gulf of Mexico	The Louisiana coast current flows along the coast of the United States from the mouth of the Mississippi River to the western Gulf of Mexico. The Yucatan Current flows north, east, and west as it enters the Gulf of Mexico from the Caribbean Sea. The Loop Current originates as part of the Yucatan Current, and spins in a clockwise direction and connects with the Florida Current from west to east through the Florida Straits. Warm and cold core eddy rings develop in the western half of the Gulf of Mexico between the Loop Current and the Texas/Mexico coast. Cold-core eddy rings develop off the Florida Current in the eastern Gulf.
Caribbean Sea Large Marine Ecosystem	
Other AFTT Areas (Outside the Range Complexes)	The Antilles Current flows southeast to northwest along the northern edge of the Turks and Caicos Islands and Bahama Islands. The Labrador Current flows south from Labrador Bay.
Labrador Current Open Ocean Area	
Other AFTT Areas (Outside the Range Complexes)	Labrador surface current and West Greenland surface current move water in a counter clockwise direction around the outer edges of the Labrador Sea. West Labrador surface current also moves water farther to the north. Portions of the deep North Atlantic Current return cold, denser water back to the south, away from the Labrador Sea.

Source: Stewart, (2008)

Notes: AFTT = Atlantic Fleet Training and Testing, CT = Connecticut, FL = Florida, GA = Georgia, ME = Maine, MS = Mississippi, VA = Virginia

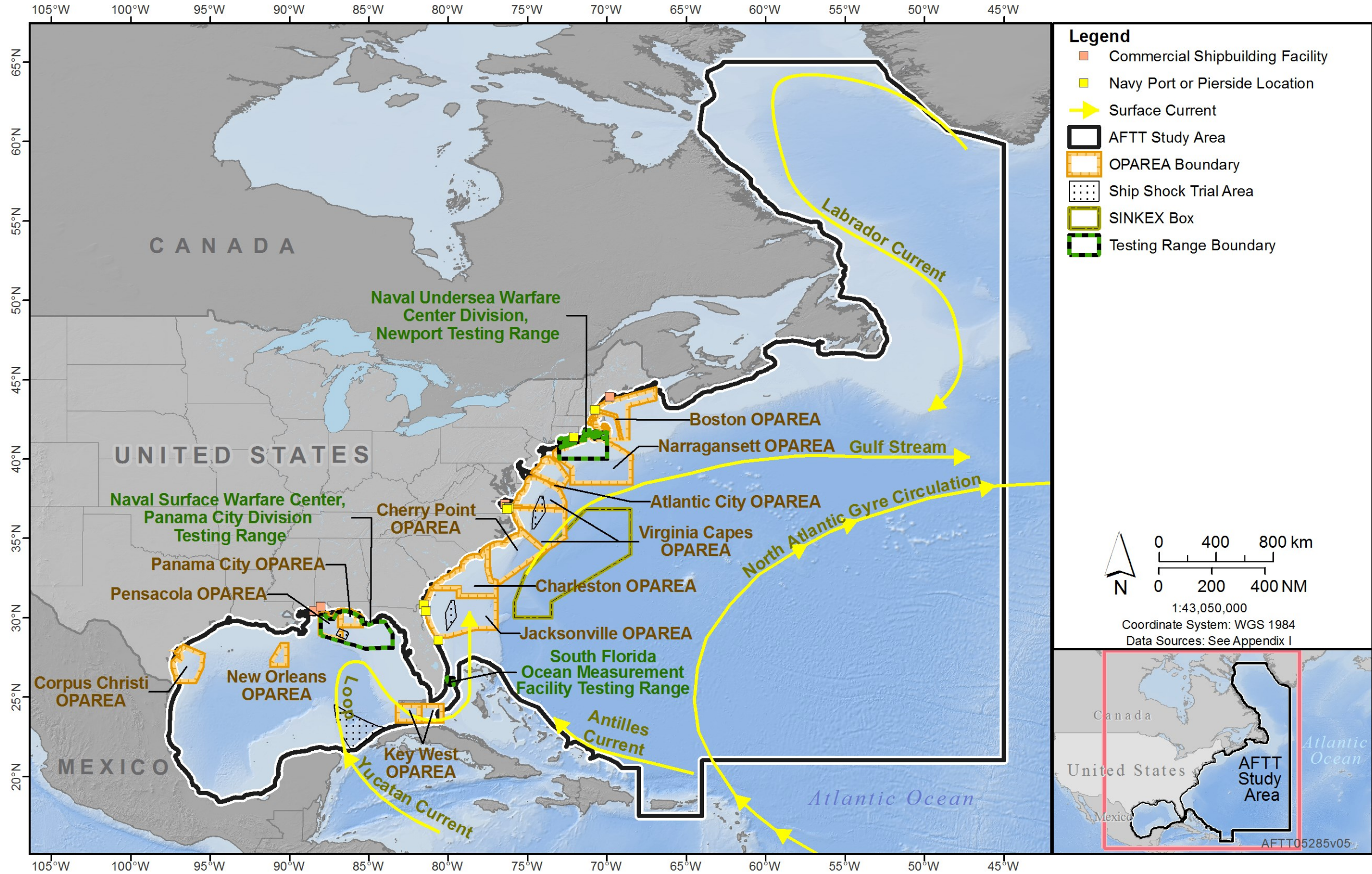


Figure 3.0-7: Major Currents in the Study Area

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3.0.2.4 Ocean Fronts

Ocean fronts are characterized by increased productivity and biomass (e.g., marine vegetation and animals) (Bost et al., 2009). Fronts are the boundaries between two water masses with distinct temperatures or densities and are characterized by rapid changes in specific water properties over short distances.

The Study Area is influenced by the Mid-Atlantic Bight (a curve in the coastline) shelf break front, the Gulf Stream front, and the Loop Current and Florida Current. As the Gulf Stream Current moves east from Cape Hatteras, North Carolina, it carries warm equatorial waters into the cooler Atlantic Ocean. Cold water flowing north to south from coastal areas of the northeastern United States (as shown in Figure 3.0-7) converges with the warmer waters of the Gulf Stream off Cape Hatteras, creating a frontal system. These fronts can be depicted on maps that show the drastic changes in sea surface temperatures between water masses. Figure 3.0-8 shows the influence of ocean fronts on the sea surface temperatures of the Study Area.

The front formed at the intersection of the continental shelf and slope extends from the Mid-Atlantic Bight into New England waters. This front is biologically important and persists year-round. Phytoplankton (microscopic drifting plants) production is enhanced at this frontal boundary, often with twice the concentration of phytoplankton found in adjacent waters (Ryan et al., 1999).

North of Cape Hatteras, the Gulf Stream meanders in a wave-like fashion and becomes unstable. These instabilities in current flow lead to the pinching off of relatively warm or cool waters as either warm- or cold-core mesoscale eddies (Mann & Lazier, 1996). Mesoscale eddies are large (54–108 NM wide) rotating water currents that separate from the main current. They cause cold, deep waters to rise to the surface (upwelling) or conversely, warm, surface waters to sink (downwelling), and consequently influence primary production (Sangrà et al., 2009) and facilitate the transfer of energy to higher trophic levels (Rice et al., 2015; Thompson et al., 2012). Warm-core eddies rotate clockwise (anticyclonic) and bring warm water and associated plankton (drifting organisms), including ichthyoplankton (fish eggs and larvae), to the colder areas of the northeast shelf. Cold-core eddies rotate counterclockwise (cyclonic) and deliver cold, nutrient-rich waters and plankton to the surface of the ocean. These types of mesoscale eddies form around the Gulf Stream and influence the sea surface temperature.

Warm- and cold-core eddy rings develop in the western half of the Gulf of Mexico between the Loop Current and the Texas and Mexico coast. These eddies travel westward and southward in the Gulf (Elliot, 1982; Gallaway et al., 2001; Hamilton, 1990). The Loop Current and associated eddies are responsible for circulation in the deepest portions of the Gulf of Mexico (Hamilton, 1990). Frontal eddies occur along the East Florida Shelf (Fiechter & Mooers, 2003; Lee et al., 1992) when warm Florida Current front waters meander seaward beyond the shelf break, allowing colder slope waters to upwell onto the East Florida Shelf.

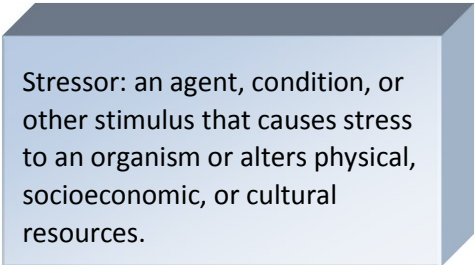
3.0.2.5 Abiotic Substrate

In the marine and estuarine environments of the AFTT Study Area there are a variety of types of surfaces, or substrates, on which organisms live. Nonliving (abiotic) substrates can be categorized based on the grain size of unconsolidated material: “Soft” (e.g., sand, mud), “Intermediate” (e.g., cobble, gravel), and “Hard” (e.g., bedrock, boulders, artificial structures).

3.0.3 OVERALL APPROACH TO ANALYSIS

The Navy's overall approach to analysis in this EIS/OEIS is consistent with the approach used in previous analyses and included the following general steps:

- identifying resources and stressors for analysis,
- analyzing resource-specific impacts for individual stressors,
- analyzing resource-specific impacts for multiple stressors,
- examining potential marine species population-level impacts,
- analyzing cumulative effects, and
- analyzing mitigations to reduce identified potential impacts.



Stressor: an agent, condition, or other stimulus that causes stress to an organism or alters physical, socioeconomic, or cultural resources.

Navy training and testing activities in the Proposed Action may produce one or more stimuli that cause stress on a resource. Each proposed Navy activity was examined to determine its potential stressors. 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. Not all stressors affect every resource, nor do all proposed Navy activities produce all stressors. Since the activities proposed in this EIS/OEIS are similar to current activities analyzed previously, the stressors considered are also similar.

The potential direct, indirect, and cumulative impacts of the Proposed Action were analyzed based on these potential stressors being present with the resource. Direct impacts are caused by the action and occur at the same time and place. Indirect impacts result when a direct impact on one resource induces an impact on another resource (referred to as a secondary stressor). Indirect impacts would be reasonably foreseeable because of a functional relationship between the directly impacted resource and the secondarily impacted resource. For example, a significant change in water quality could secondarily impact those resources that rely on water quality, such as marine animals and public health and safety. Cumulative effects or impacts are the incremental impacts of the action added to other past, present, and reasonably foreseeable future actions.

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 (Chapter 4, Cumulative Impacts). Mitigation measures are discussed in detail in Chapter 5 (Mitigation), and regulatory considerations are discussed in Chapter 6 (Regulatory Considerations).

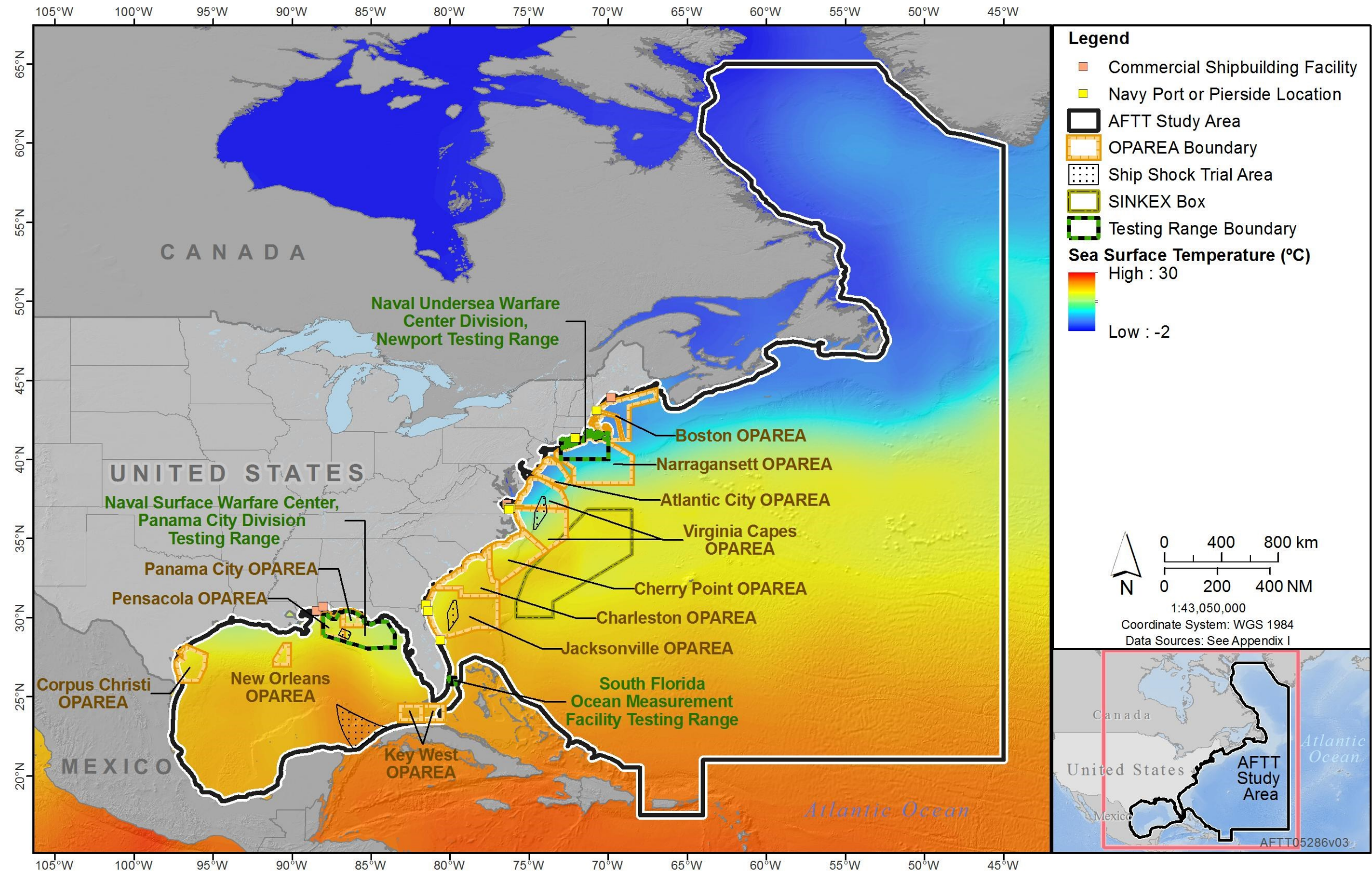


Figure 3.0-8: Average Sea Surface Temperature in the Study Area (2011–2015)

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In this sequential approach, the initial analyses were used to develop each subsequent step so the analysis focused 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.

3.0.3.1 Resources and Issues Evaluated

Physical resources evaluated include air quality, sediments, and water quality. Biological resources (including threatened and endangered species) evaluated include vegetation, invertebrates, habitats, fishes, marine mammals, reptiles, and birds. Human resources evaluated include cultural resources, socioeconomics, and public health and safety.

3.0.3.2 Resources and Issues Eliminated from Further Consideration

This AFTT EIS/OEIS analyzes only in-water activities and activities occurring over water. Therefore, some resource areas are not analyzed. Resources and issues considered but not carried forward for further consideration include land use, demographics, environmental justice, and children's health and safety. Land use was eliminated from further consideration because the offshore activities in the Proposed Action are not connected to land use issues and no new actions are being proposed that would include relevant land use. Demographics were eliminated from further consideration because implementing the Proposed Action would result in activities that occur at sea away from human populations, and would not result in a change in the demographics within the Study Area or within the counties of the coastal states that abut the Study Area. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, was eliminated as an issue for further consideration because all of the proposed activities occur in the ocean and in harbors and bays, where there are no human residences present. Also, the proposed activities do not impact access to food sources. Therefore, there are no disproportionately high and adverse human health or environmental impacts from the Proposed Action on minority populations or low-income populations. Similarly, Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, was eliminated as an issue for further consideration because all of the proposed activities occur in the ocean, where there are no child populations present. Therefore, the Proposed Action would not lead to disproportionate risks to children that result from environmental health risks or safety risks.

3.0.3.3 Identifying Stressors for Analysis

The proposed training and testing activities were evaluated to identify specific components that could act as stressors by having direct or indirect impacts on the environment. This analysis includes identifying the spatial variation of the identified stressors. Matrices were prepared to identify associations between stressors, resources, and the spatial relationships of those stressors, resources, and activities within the Study Area under the Proposed Action. Each stressor includes a description of activities that may generate the stressor. Additional information on these activities and resources is also provided in Appendix B (Activity Stressor Matrices). Stressors for physical resources (air quality, sediments and water quality) and human resources (cultural resources, socioeconomics, 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 public comment received during 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 the EIS/OEIS.

In subsequent sections, tables are provided in which the annual number of activities that could involve a particular stressor are totaled by alternative and by location, within the categories of training and testing. For example, see Table 3.0-13 (Annual Activities Including Electromagnetic Devices). It is important to note that the various tables are not exclusive of each other, and that the stressors from a single named activity from Chapter 2 (Description of Proposed Action and Alternatives) could show up on several tables. For example, the activity Anti-Submarine Warfare Tracking Exercise – Helicopter could include acoustic stressors that would appear on Table 3.0-2, physical disturbance stressors (Table 3.0-31), strike stressors (Table 3.0-36), entanglement stressors (Table 3.0-38, and ingestion stressors (Table 3.0-31). Also, activities are not always conducted independently of each other. For example, there are instances where a training activity could occur on a vessel while another training activity or a testing activity is being conducted on the same vessel simultaneously. Finally, note that some of the tables that follow in this section count individual items expended (see Table 3.0-23) while others count the annual number of activities in which that stressor could occur at least once during the conduct of that activity (see Table 3.0-13).

3.0.3.3.1 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 impacts on resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). Explanations of the terminology and metrics used when describing sound in this EIS/OEIS are in Appendix D (Acoustic and Explosive Concepts).

Acoustic stressors include acoustic signals emitted into the water for a specific purpose (e.g., by active sonars and air guns), as well as incidental sources of broadband sound produced as a byproduct of vessel movement; aircraft transits; pile driving and removal; and use of weapons or other deployed objects. Explosives also produce broadband sound but are characterized separately from other acoustic sources due to their unique hazardous characteristics (see Section 3.0.3.3.2, Explosive Stressors). Characteristics of each of these sound sources are described in the following sections.

In order to better organize and facilitate the analysis of approximately 300 individual sources of underwater sound deliberately employed by the Navy including sonars, other transducers (devices that convert energy from one form to another—in this case, to sound waves), air guns, and explosives, a series of source classifications, or source bins, were developed. The source classification bins do not include the broadband sounds produced incidental to pile driving; vessel and aircraft transits; and weapons firing.

The use of source classification bins provides the following benefits:

- provides the ability for new sensors or munitions to be covered under existing authorizations, as long as those sources fall within the parameters of a “bin”;
- improves efficiency of source utilization data collection and reporting requirements anticipated under the MMPA authorizations;
- ensures a conservative approach to all impact estimates, as all sources within a given class are modeled as the most impactful source (highest source level, longest duty cycle, or largest net explosive weight) within that bin;

- allows analyses to be conducted in a more efficient manner, without any compromise of analytical results; and
- provides a framework to support the reallocation of source usage (hours/explosives) between different source bins, as long as the total numbers of takes remain within the overall analyzed and authorized limits. This flexibility is required to support evolving Navy training and testing requirements, which are linked to real world events.

3.0.3.3.1.1 Sonar and Other Transducers

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

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

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

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

Anti-Submarine Warfare

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

Most anti-submarine warfare sonars are mid-frequency (1–10 kHz) because mid-frequency sound balances sufficient resolution to identify targets with distance over which threats can be identified. However, some sources may use higher or lower frequencies. Duty cycles can vary widely, from rarely used to continuously active. For example, a submarine’s mission revolves around its stealth; therefore, submarine sonar is used infrequently because its use would also reveal a submarine’s location. Anti-submarine warfare sonars can be wide-angle in a search mode or highly directional in a track mode.

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

Mine Warfare, Small Object Detection, and Imaging

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

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

Navigation and Safety

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

Communication

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

Classification of Sonar and Other Transducers

Sonars and other transducers are grouped into classes that share an attribute, such as frequency range or purpose of use. Classes are further sorted by bins based on the frequency or bandwidth; source level; and, when warranted, the application in which the source would be used, as follows:

- frequency of the non-impulsive acoustic source
 - low-frequency sources operate below 1 kHz
 - mid-frequency sources operate at and above 1 kHz, up to and including 10 kHz
 - high-frequency sources operate above 10 kHz, up to and including 100 kHz

- very high-frequency sources operate above 100 kHz but below 200 kHz
- sound pressure level
 - greater than 160 dB re 1 μ Pa, but less than 180 dB re 1 μ Pa
 - equal to 180 dB re 1 μ Pa and up to 200 dB re 1 μ Pa
 - greater than 200 dB re 1 μ Pa
- application in which the source would be used.
 - sources with similar functions that have similar characteristics, such as pulse length (duration of each pulse), beam pattern, and duty cycle

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

Table 3.0-2 shows the bin use that could occur in any year under each action alternative for training and testing activities. A range of annual bin use indicates that use of that bin is anticipated to vary annually, consistent with the variation in the number of annual activities described in Chapter 2 (Description of Proposed Action and Alternatives). The five-year total for both action alternatives takes that variability into account.

Table 3.0-2: Sonar and Transducer Sources Quantitatively Analyzed

Source Class Category	Bin	Description	Unit ¹	Training				Testing			
				Alternative 1		Alternative 2		Alternative 1		Alternative 2	
				Annual ²	5-year Total	Annual ²	5-year Total	Annual ²	5-year Total	1-year	5-year Total
Low-Frequency (LF): Sources that produce signals less than 1 kHz	LF3	LF sources greater than 200 dB	H	0	0	0	0	1,188	5,940	1,188	5,940
	LF4	LF sources equal to 180 dB and up to 200 dB	H	0	0	0	0	641	3,205	641	3,205
			C	0	0	0	0	20	100	20	100
	LF5	LF sources less than 180 dB	H	0	0	0	0	1,632	8,160	1,632	8,160
	LF6	LF sources greater than 200 dB with long pulse lengths	H	145–175	784	204	1,020	40	200	40	200
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)	H	5,005–5,605	26,224	7,081	35,404	3,417	17,084	3,417	17,084
	MF1K	Kingfisher mode associated with MF1 sonars	H	58	290	58	290	152	760	152	760
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	C	49,188–49,227	246,017	49,265	246,321	20,681	103,405	20,681	103,405
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22)	H	591–611	2,994	630	3,150	412–803	2,792	803	4,015
	MF5	Active acoustic sonobuoys (e.g., DICASS)	C	6,708–6,836	33,796	6,964	34,820	5,070–6,182	27,412	6,382	31,908

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

Source Class Category	Bin	Description	Unit	Training				Testing			
				Alternative 1		Alternative 2		Alternative 1		Alternative 2	
				Annual	5-year Total	Annual	5-year Total	Annual	5-year Total	Annual	5-year Total
Mid-Frequency (MF): Tactical and non-tactical sources that produce signals between 1 and 10 kHz (continued)	MF6	Active underwater sound signal devices (e.g., MK 84)	C	0	0	0	0	1,256–1,341	6,450	1,391	6,955
	MF8	Active sources (greater than 200 dB) not otherwise binned	H	0	0	0	0	228	1,140	228	1,140
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	0	0	0	0	9,765–9,932	49,023	9,765–9,932	49,023
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	H	0	0	0	0	6,530	32,651	6,530	32,651
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%	H	873–1,001	4,621	1,399	6,995	1,424	7,120	1,424	7,120
	MF12	Towed array surface ship sonars with an active duty cycle greater than 80%	H	367–397	1,894	596	2,980	1,388	6,940	1,388	6,940
	MF14	Oceanographic MF sonar	H	0	0	0	0	1,440	7,200	1,440	7,200

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

Source Class Category	Bin	Description	Unit	Training				Testing			
				Alternative 1		Alternative 2		Alternative 1		Alternative 2	
				Annual	5-year Total	Annual	5-year Total	Annual	5-year Total	Annual	5-year Total
High-Frequency (HF): Tactical and non-tactical sources that produce signals between 10 and 100 kHz	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	1,928–1,932	9,646	1,935	9,672	582	2,908	582	2,908
	HF3	Other hull-mounted submarine sonars (classified)	H	0	0	0	0	31	154	31	154
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)	H	5,411–6,371	29,935	6,371	31,855	30,772–30,828	117,916	30,828	118,140
	HF5	Active sources (greater than 200 dB) not otherwise binned	H	0	0	0	0	2,824	14,120	2,824	14,120
			C	0	0	0	0	40	200	40	200
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	0	0	0	0	2,193	10,964	2,193	10,964
	HF7	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	H	0	0	0	0	1,224	6,120	1,224	6,120
	HF8	Hull-mounted surface ship sonars (e.g., AN/SQS-61)	H	18	90	18	90	2,084	10,419	2,084	10,419

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

Source Class Category	Bin	Description	Unit	Training				Testing			
				Alternative 1		Alternative 2		Alternative 1		Alternative 2	
				Annual	5-year Total	Annual	5-year Total	Annual	5-year Total	Annual	5-year Total
Very High Frequency Sonars (VHF): Non-tactical sources that produce signals between 100 and 200 kHz	VHF1	Very high frequency sources greater than 200 dB	H	0	0	0	0	12	60	12	60
Anti-Submarine Warfare (ASW): Tactical sources (e.g., active sonobuoys and acoustic countermeasures systems) used during ASW training and testing activities	ASW1	MF systems operating above 200 dB	H	582–641	3,208	1,040	5,200	820	4,100	820	4,100
	ASW2	MF Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)	C	1,476–1,556	7,540	1,636	8,180	4,636–5,486	24,880	5,986	29,930
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	H	4,485–5,445	24,345	6,690	34,800	4,941	24,704	4,941	24,704
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)	C	426–432	2,138	438	2,186	3,723	18,615	3,723	18,615
	ASW5 ³	MF sonobuoys with high duty cycles	H	572–652	3,020	732	3,660	608–628	3,080	708	3,540

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

Source Class Category	Bin	Description	Unit	Training				Testing			
				Alternative 1		Alternative 2		Alternative 1		Alternative 2	
				Annual	5-year Total	Annual	5-year Total	Annual	5-year Total	Annual	5-year Total
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK-46, MK-54, or Anti-Torpedo Torpedo)	C	57	285	57	285	1,228–1,352	6,448	1,332	6,660
	TORP2	Heavyweight torpedo (e.g., MK-48)	C	80	400	80	400	934	4,670	934	4,670
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars used for ship navigation and safety	FLS2	HF sources with short pulse lengths, narrow beam widths, and focused beam patterns	H	0	0	0	0	1,224	6,120	1,224	6,120
	FLS3	VHF sources with short pulse lengths, narrow beam widths, and focused beam patterns	H	0	0	0	0	0	0	0	0
Acoustic Modems (M): Systems used to transmit data through the water	M3	MF acoustic modems (greater than 190 dB)	H	0	0	0	0	1,269	6,344	1,269	6,344

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

Source Class Category	Bin	Description	Unit	Training				Testing			
				Alternative 1		Alternative 2		Alternative 1		Alternative 2	
				Annual	5-year Total	Annual	5-year Total	Annual	5-year Total	Annual	5-year Total
Swimmer Detection Sonars (SD): Systems used to detect divers and submerged swimmers	SD1–SD2	HF and VHF sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security	H	0	0	0	0	176	880	176	880
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	MF SAS systems	H	0	0	0	0	960	4,800	960	4,800
	SAS2	HF SAS systems	H	0–8,400	25,200	8,400	42,000	3,512	17,560	3,512	17,560
	SAS3	VHF SAS systems	H	0	0	0	0	960	4,800	960	4,800
	SAS4	MF to HF broadband mine countermeasure sonar	H	0	0	0	0	960	4,800	960	4,800
Broadband Sound Sources (BB): Sonar systems with large frequency spectra, used for various purposes	BB1	MF to HF mine countermeasure sonar	H	0	0	0	0	960	4,800	960	4,800
	BB2	HF to VHF mine countermeasure sonar	H	0	0	0	0	960	4,800	960	4,800
	BB4	LF to MF oceanographic source	H	0	0	0	0	516–2,892	4,956	516–2,892	4,956

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

Source Class Category	Bin	Description	Unit	Training				Testing			
				Alternative 1		Alternative 2		Alternative 1		Alternative 2	
				Annual	5-year Total	Annual	5-year Total	Annual	5-year Total	Annual	5-year Total
Broadband Sound Sources (BB) (continued): Sonar systems with large frequency spectra, used for various purposes	BB5	LF to MF oceanographic source	H	0	0	0	0	672	3,360	672	3,360
	BB6	HF oceanographic source	H	0	0	0	0	672	3,360	672	3,360
	BB7	LF oceanographic source	C	0	0	0	0	120	600	120	600

¹H = hours; C = count (e.g., number of individual pings or individual sonobuoys).

²Expected annual use may vary per bin because the number of events may vary from year to year, as described in Chapter 2, Description of Proposed Action and Alternatives.

³Formerly ASW2 (H) in Phase II.

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

- Transmit primarily above 200 kHz: Sources above 200 kHz are above the hearing range of the most sensitive marine mammals and far above the hearing range of any other animals in the Study Area.
- Source levels of 160 dB re 1 μ Pa or less: Low-powered sources with source levels less than 160 dB re 1 μ Pa are typically hand-held sonars, range pingers, transponders, and acoustic communication devices. Assuming spherical spreading for a 160 dB re 1 μ Pa source, the sound will attenuate to less than 140 dB within 10 m and less than 120 dB within 100 m of the source. Ranges would be even shorter for a source less than 160 dB re 1 μ Pa source level.
- Acoustic source classes listed in Table 3.0-3: Sources with operational characteristics, such as short pulse length, narrow beam width, downward-directed beam, and low energy release, or manner of system operation, which exclude the possibility of any significant impact to a protected species (actual source parameters listed in the classified bin list). Even if there is a possibility that some species may be exposed to and detect some of these sources, any response is expected to be short-term and inconsequential.

3.0.3.3.1.2 Air Guns

Air guns are essentially stainless steel tubes charged with high-pressure air via a compressor. An impulsive sound is generated when the air is almost instantaneously released into the surrounding water. Small air guns with capacities up to 60 cubic inches would be used during testing activities in various offshore areas in the AFTT Study Area, as well as near shore at Newport, RI. Table 3.0-3 shows the number of air guns shots proposed in the AFTT Study Area.

Generated impulses would have short durations, typically a few hundred milliseconds, with dominant frequencies below 1 kHz. The root-mean-square sound pressure level (SPL) and peak pressure (SPL peak) at a distance 1 m from the air gun would be approximately 215 dB re 1 μ Pa and 227 dB re 1 μ Pa, respectively, if operated at the full capacity of 60 cubic inches. The size of the air gun chamber can be adjusted, which would result in lower SPLs and SEL per shot.

Table 3.0-3: Training and Testing Air Gun Sources Quantitatively Analyzed in the Study Area

Source Class Category	Bin	Unit ¹	Training				Testing			
			Alternative 1		Alternative 2		Alternative 1		Alternative 2	
			Annual	5-year Total	Annual	5-year Total	Annual	5-year Total	Annual	5-year Total
Air Guns (AG): Small underwater air guns	AG	C	0	0	0	0	604	3,020	604	3,020

¹ C = count. One count (C) of AG is equivalent to 100 air gun firings.

Table 3.0-4: Sonar and Transducers Qualitatively Analyzed

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

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

3.0.3.3.1.3 Pile Driving

Impact pile driving and vibratory pile removal would occur during construction of an Elevated Causeway System, a temporary pier that allows the offloading of ships in areas without a permanent port. Construction of the elevated causeway could occur in sandy shallow water coastal areas at Joint

Expeditionary Base Little Creek-Fort Story in the Virginia Capes Range Complex or Marine Corps Base Camp Lejeune in the Navy Cherry Point Range Complex.

Installing piles for elevated causeways would involve the use of an impact hammer mechanism with both it and the pile held in place by a crane. The hammer rests on the pile, and the assemblage is then placed in position vertically on the beach or, when offshore, positioned with the pile in the water and resting on the seafloor. When the pile driving starts, the hammer part of the mechanism is raised up and allowed to fall, transferring energy to the top of the pile. The pile is thereby driven into the sediment by a repeated series of these hammer blows. Each blow results in an impulsive sound emanating from the length of the pile into the water column as well as from the bottom of the pile through the sediment. Because the impact wave travels through the steel pile at speeds faster than the speed of sound in water, a steep-fronted acoustic shock wave is formed in the water (Reinhall & Dahl, 2011) (note this shock wave has very low peak pressure compared to a shock wave from an explosive). An impact pile driver generally operates in the range of 36–50 blows per minute.

Pile removal involves the use of vibratory extraction, during which the vibratory hammer is suspended from the crane and attached to the top of a pile. The pile is then vibrated by hydraulic motors rotating eccentric weights in the mechanism, causing a rapid up and down vibration in the pile. This vibration causes the sediment particles in contact with the pile to lose frictional grip on the pile. The crane slowly lifts up on the vibratory driver and pile until the pile is free of the sediment. Vibratory removal creates continuous non-impulsive noise at low source levels for a short duration.

The source levels of the noise produced by impact pile driving and vibratory pile removal from an actual elevated causeway pile driving and removal are shown in Table 3.0-5.

Table 3.0-5: Elevated Causeway System Pile Driving and Removal Underwater Sound Levels

<i>Pile Size & Type</i>	<i>Method</i>	<i>Average Sound Levels at 10 m (SEL per individual pile)</i>
24-in. Steel Pipe Pile	Impact ¹	192 dB re 1 μ Pa SPL peak 182 dB re 1 μ Pa ² s SEL (single strike)
24-in. Steel Pipe Pile	Vibratory ²	146 dB re 1 μ Pa SPL rms 145 dB re 1 μ Pa ² s SEL (per second of duration)

¹ Illingworth and Rodkin (2016), ² Illingworth and Rodkin (2015)

Notes: in. = inch, SEL = Sound Exposure Level, SPL = Sound Pressure Level, rms = root mean squared, dB re 1 μ Pa = decibels referenced to 1 micropascal

In addition to underwater noise, the installation and removal of piles also results in airborne noise in the environment. Impact pile driving creates in-air impulsive sound about 100 dBA re 20 μ Pa at a range of 15 m (Illingworth and Rodkin, 2016). During vibratory extraction, the three aspects that generate airborne noise are the crane, the power plant, and the vibratory extractor. The average sound level recorded in air during vibratory extraction was about 85 dBA re 20 μ Pa (94 dB re 20 μ Pa) within a range of 10-15 m (Illingworth and Rodkin, 2015).

The length of the pier, and therefore the number of piles required, would be determined by the distance from shore to the appropriate water depth for ship off-loading. Construction of the Elevated Causeway System would involve intermittent impact pile driving over approximately 20 days. Crews work 24 hours a day and would drive approximately six piles in that period. Each pile takes about 10 minutes to drive with time taken between piles to reposition the driver. When training events that use the Elevated Causeway System are complete, the structure would be removed using vibratory methods over

approximately 10 days. Crews would remove about 12 piles per 24-hour period, each taking about three minutes to remove. Table 3.0-6 summarizes the pile driving and pile removal activities that would occur during a 24-hour period.

Table 3.0-6: Summary of Pile Driving and Removal Activities per 24-Hour Period

<i>Method</i>	<i>Piles Per 24-Hour Period</i>	<i>Time Per Pile</i>	<i>Total Estimated Time of Noise Per 24-Hour Period</i>
Pile Driving (Impact)	6	10 minutes	60 minutes
Pile Removal (Vibratory)	12	3 minutes	36 minutes

Pile driving for elevated causeway system training would occur in shallower water, and sound could be transmitted on direct paths through the water, be reflected at the water surface or bottom, or travel through bottom substrate. Soft substrates such as sand bottom at the proposed elevated causeway system locations would absorb or attenuate the sound more readily than hard substrates (rock), which may reflect the acoustic wave. Most acoustic energy would be concentrated below 1,000 hertz (Hz) (Hildebrand, 2009).

3.0.3.3.1.4 Vessel Noise

Vessel noise, in particular commercial shipping, is a major contributor to noise in the ocean and intensively used inland waters. Frisk (2012) reported that between 1950 and 2007 ocean noise in the 25–50 Hz frequency range has increased 3.3 dB per decade, resulting in a cumulative increase of approximately 19 dB over a baseline of 52 dB. The increase in noise is associated with an increase in commercial shipping, which correlates with global economic growth (Frisk, 2012).

Naval vessels (including ships and small craft) would produce low-frequency, broadband underwater sound, though the exact level of noise produced varies by vessel type. Navy vessels represent a small amount of overall vessel traffic and an even smaller amount of overall vessel traffic noise. As shown in Table 3.0-7, Navy ships make up roughly 1 percent of the vessel presence in the AFTT Study Area. Navy ship traffic is more concentrated around the homeports of Norfolk, VA and Jacksonville, FL. The Navy contributes 1 percent of radiated broadband noise in the Virginia Capes and Jacksonville Range Complexes (Mintz & Filadelfo, 2011). However, since Navy ships are quieter (Mintz, 2012a; Mintz & Filadelfo, 2011), they are most likely contributing less than 1 percent of the overall total vessel broadband noise in the entire AFTT study area.

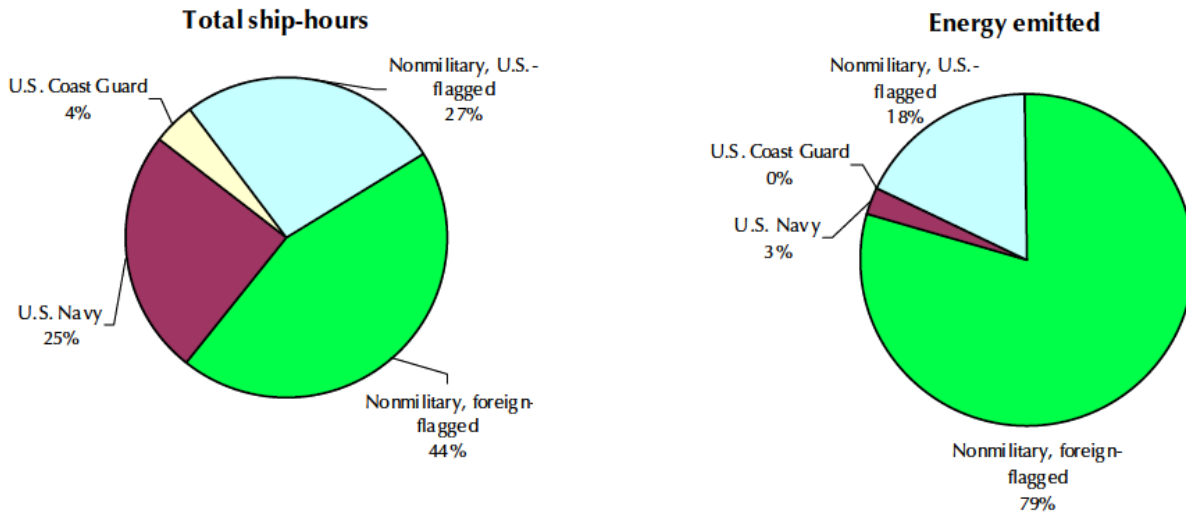
Table 3.0-7: Estimated Vessel Presence (Hours) in Study Area

<i>Ship Category</i>	<i>AFTT</i>
Non-military	9,970,244
Military	72,094

Notes: Ship-hours were calculated from representative data to assess the relative contribution. The totals given represent a relative fraction of actual vessel presence (Mintz, 2012a).

Figure 3.0-9 shows a comparison of ship hours to energy emitted during a Composite Training Unit Exercise, a major training exercise, an event during which Navy vessel traffic would be higher than usual in the Study Area (Mintz & Filadelfo, 2011). Although this data was gathered for a Composite Training Unit Exercise conducted in the Southern California Range Complex, it shows how the Navy contribution

to overall vessel noise changes during a major training exercise. Even during this period of greater than typical Navy vessel use, the Navy contribution to overall vessel noise in the Study Area is low.



Source: Mintz & Filadelfo, 2011

Figure 3.0-9: Traffic and Broadband Radiated Noise During a Composite Training Unit Exercise in the Southern California Range Complex

Studies to determine traffic patterns of Navy and non-Navy vessels in the Study Area were conducted by the Center for Naval Analysis (Mintz, 2012a; Mintz & Filadelfo, 2011; Mintz & Parker, 2006). SeaLink data from 2009 for U.S. Navy and non-military vessels was used, which included Navy surface vessels, cargo vessels, bulk carriers, commercial fishing vessels, oil tankers, passenger vessels, tugs, and research vessels. SeaLink data includes only vessels over 65 ft. in length so smaller navy vessels and pleasure craft are not included, and vessel position records in SeaLink are much more frequent for Navy vessels than for commercial vessels. Therefore, the Navy is likely overrepresented in the data and the reported fraction of total energy is likely the upper limit of its contribution (Mintz, 2012a; Mintz & Filadelfo, 2011).

Exposure to vessel noise would be greatest in the areas of highest vessel traffic. Within the Study Area, commercial traffic is heaviest along the U. S. East Coast and the northern coast of the Gulf of Mexico and follows distinct overseas routes and across the Gulf of Mexico. Navy traffic in the Study Area is concentrated along the U.S. East Coast between the mouth of the Chesapeake Bay and Jacksonville, FL (Mintz, 2012a), although vessels would be used during many training and testing activities proposed throughout the Study Area. Noise exposure due to naval vessels would be greatest near naval port facilities, especially around and between the ports of Norfolk, VA, and Jacksonville, FL (Mintz & Parker, 2006).

Radiated noise from ships varies depending on the nature, size, and speed of the ship. Due to the large number of variables that determine the sound level radiated from vessels, this source will be analyzed qualitatively. The quietest Navy warships radiate much less broadband noise than a typical fishing vessel, while the loudest Navy ships during travel are almost on par with large oil tankers (Mintz & Filadelfo, 2011). For comparison, McKenna et al. (2012) determined that container ships produced broadband source levels around 188 dB re 1 μ Pa and a typical fishing vessel radiates noise at a source level of about 158 dB re 1 μ Pa (Mintz & Filadelfo, 2011; Richardson et al., 1995; Urick, 1983). The

average acoustic signature for a Navy vessel is 163 dB re 1 μ Pa, while the average acoustic signature for a commercial vessel is 175 dB re 1 μ Pa (Mintz & Filadelfo, 2011). 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 around the one-third octave band centered at 100 Hz) (Mintz & Filadelfo, 2011; Richardson et al., 1995; Urick, 1983). Ship types also have unique acoustic signatures characterized by differences in dominant frequencies. Bulk carrier noise is predominantly near 100 Hz while container ship and tanker noise is predominantly below 40 Hz (McKenna et al., 2012). Small craft types will emit higher-frequency noise (between 1 kHz and 50 kHz) than larger ships (below 1 kHz). Sound produced by vessels will typically increase with speed. During training, speeds of most large naval vessels (greater than 60 ft.) generally range from 10 to 15 knots for fuel consumption; however, ships will, on occasion, operate at higher speeds within their specific operational capabilities.

Anti-submarine warfare platforms (such as guided missile destroyers and cruisers) 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 & Filadelfo, 2011). A variety of smaller craft that vary in size and speed, such as service vessels for routine operations and opposition forces used during training events, would be operating within the Study Area.

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 weeks within a given area. Activities involving vessel movements occur intermittently and are variable in duration. 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 a small percentage compared to the large amounts of commercial and recreational vessel traffic in these areas (Mintz & Filadelfo, 2011), as shown in the hours of vessel presence (Table 3.0-7) and the relative distribution of vessel traffic (Figure 3.0-10 and Figure 3.0-11).

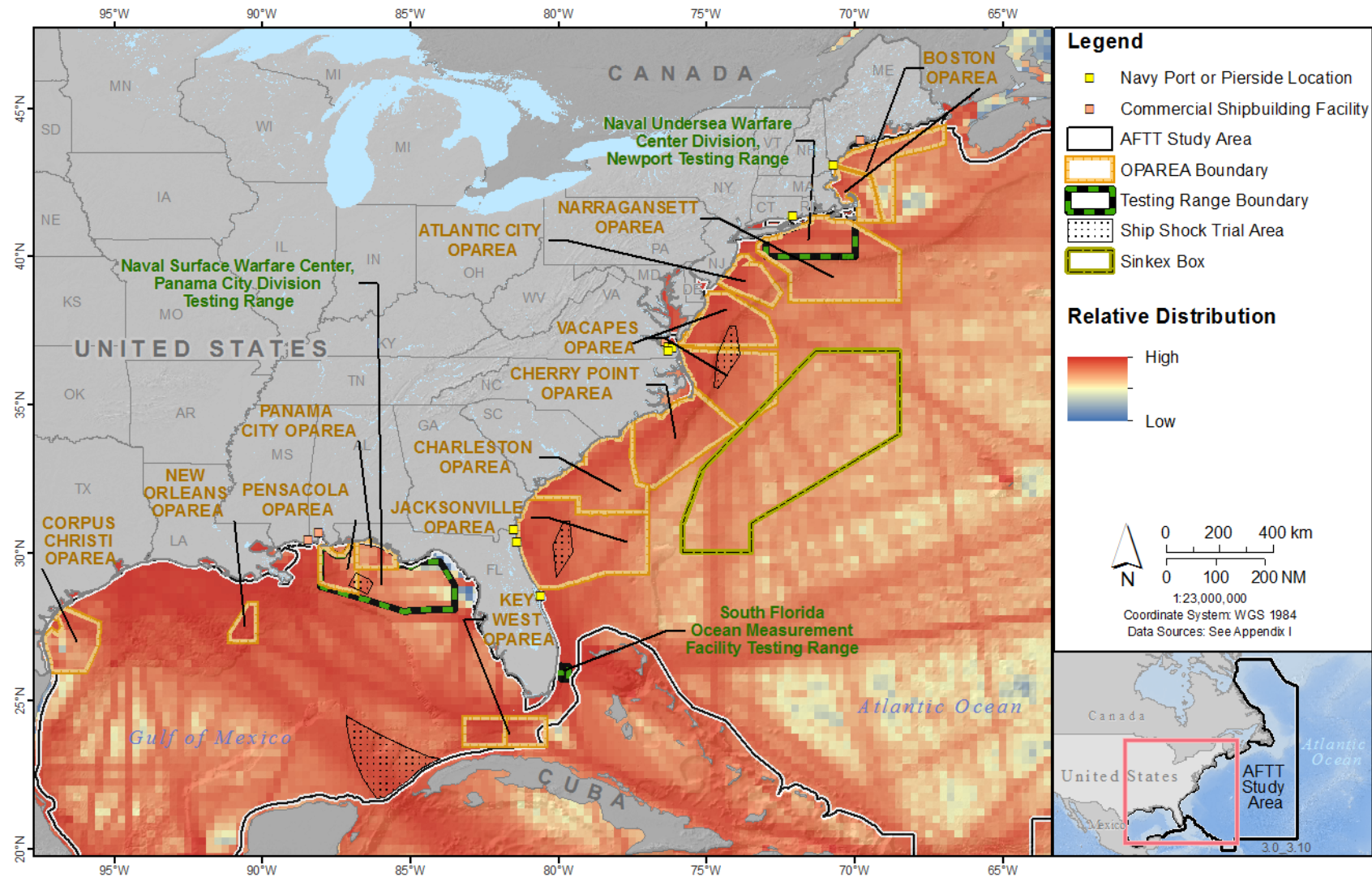


Figure 3.0-10: Relative Distribution of Commercial Vessel Traffic in Atlantic Fleet Training and Testing Study Areas

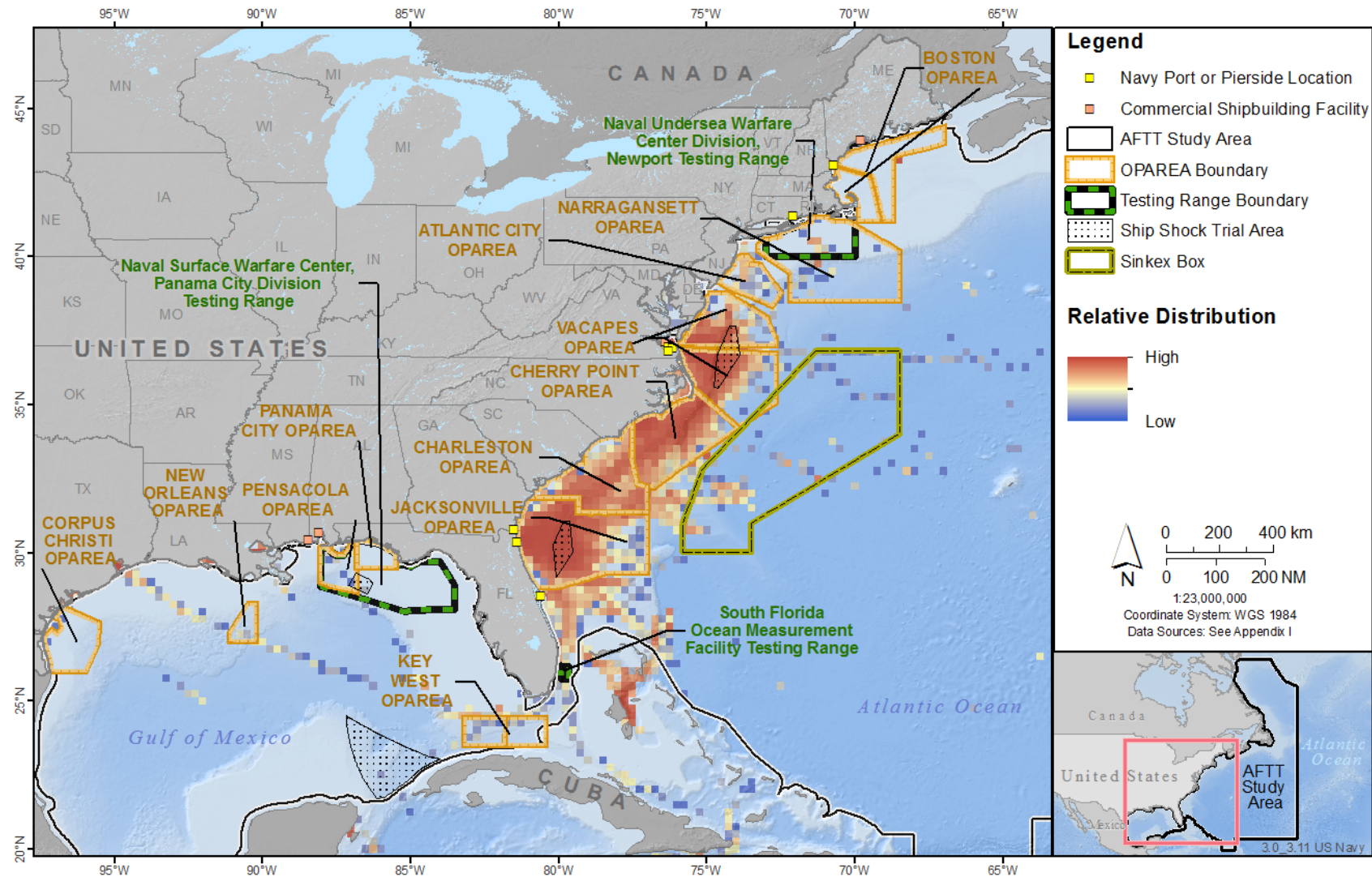


Figure 3.0-11: Relative Distribution of U.S. Navy Vessel Traffic in Atlantic Fleet Training and Testing Study Areas

3.0.3.3.1.5 Aircraft Overflight Noise

Fixed-wing, tiltrotor, and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area, contributing both airborne and underwater sound to the ocean environment. Sounds in air are often measured using A-weighting, which adjusts received sound levels based on human hearing abilities (see Appendix D, Acoustic and Explosive Concepts). Aircraft used in training and testing generally have turboprop or jet engines. Motors, propellers, and rotors produce the most noise, with some noise contributed by aerodynamic turbulence. Aircraft sounds have more energy at lower frequencies. Aircraft may transit to or from vessels at sea throughout the Study Area from established airfields on land. Most aircraft noise would be produced around air stations outside the Study Area. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Table 3.0-8 provides source levels for some typical aircraft used during training and testing in the Study Area and depicts comparable airborne source levels for the F-35A, EA-18G, and F/A-18C/D during takeoff.

Table 3.0-8: Representative Aircraft Sound Characteristics

Noise Source	Sound Pressure Level
In-Water Noise Level	
F/A-18 Subsonic at 1,000 ft. (300 m) Altitude	152 dB re 1 μ Pa at 2 m below water surface ¹
F/A-18 Subsonic at 10,000 ft. (3,000 m) Altitude	128 dB re 1 μ Pa at 2 m below water surface ¹
H-60 Helicopter Hovering at 82 ft. (25 m) Altitude	Approximately 125 dB re 1 μ Pa at 1 m below water surface ^{2*}
Airborne Noise Level	
F/A-18C/D Under Military Power	143 dBA re 20 μ Pa at 13 m from source ³
F/A-18C/D Under Afterburner	146 dBA re 20 μ Pa at 13 m from source ³
F35-A Under Military Power	145 dBA re 20 μ Pa at 13 m from source ³
F-35-A Under Afterburner	148 dBA re 20 μ Pa at 13 m from source ³
H-60 Helicopter Hovering at 82 ft. (25 m) Altitude	113 dBA re 20 μ Pa ²
F-35A Takeoff Through 1,000 ft. (300 m) Altitude	119 dBA re 20 μ Pa ^{2s4**} (per second of duration)
EA-18G Takeoff Through 1,622 ft. (500 m) Altitude	115 dBA re 20 μ Pa ^{2s5**} (per second of duration)

Sources: ¹Eller and Cavanagh (2000), ²Bousman and Kufeld (2005), ³U.S. Naval Research Advisory Committee (2009), ⁴U.S. Department of the Air Force (2016), ⁵U.S. Department of the Navy (2012a)

*estimate based on in-air level

**average sound exposure level

Notes: dB re 1 μ Pa = decibel(s) referenced to 1 micropascal, dBA re 20 μ Pa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s), ft. = feet

Underwater Transmission of Aircraft Noise

Sound generated in air is transmitted to water primarily in a narrow area directly below the source (Appendix D, Acoustic and Explosive Concepts). A sound wave propagating from any source must enter the water at an angle of incidence of about 13° or less from the vertical for the wave to continue propagating under the water's surface. At greater angles of incidence, the water surface acts as an effective reflector of the sound wave and allows very little penetration of the wave below the water (Urick, 1983). Water depth and bottom conditions strongly influence how the sound from airborne

sources propagates underwater. At lower altitudes, sound levels reaching the water surface would be higher, but the transmission area would be smaller. As the sound source gains altitude, sound reaching the water surface diminishes, but the possible transmission area increases. Estimates of underwater sound pressure level are provided for representative aircraft in Table 3.0-8.

Noise generated by fixed-wing aircraft is transient in nature and extremely variable in intensity. Most fixed-wing aircraft sorties (a flight mission made by an individual aircraft) would occur above 3,000 ft. Air combat maneuver altitudes generally range from 5,000 to 30,000 ft., 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 from most air combat maneuver overflights are expected to be less than 85 A-weighted decibels (based on an F/A-18 aircraft flying at an altitude of 5,000 ft. and at a subsonic airspeed [400 knots] (U.S. Department of the Navy, 2009b). 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 and is estimated to be 125 dB re 1 μ Pa at 1 m below water surface for a UH-60 hovering at 82 ft. (25 m) altitude (Bousman & Kufeld, 2005).

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

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 not intentionally generated below 30,000 ft. unless over water and more than 30 NM from inhabited coastal areas or islands. Although deviation from these guidelines may be authorized for tactical missions that require supersonic flight, phases of formal training requiring supersonic speeds, research and test flights that require supersonic speeds, and for flight demonstration purposes when authorized by the Chief of Naval Operations (U.S. Department of the Navy, 2009a). A supersonic test track parallel to the Eastern Shore of the Delmarva Peninsula has historically been used by the U.S. Navy and is regularly used for F/A-18 and F-35 sorties. Due to the proximity of the supersonic test track to the Eastern Shore of the Delmarva Peninsula, sonic booms may occur closer to shore within the test track.

Several factors that influence sonic booms include weight, size, and shape of aircraft or vehicle; altitude; flight paths; and atmospheric conditions. A larger and heavier aircraft must displace more air and create more lift to sustain flight, compared with small, light aircraft. Therefore, larger aircraft create sonic booms that are stronger than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the stronger the shock waves (U.S. Department of the Navy & Department of Defense, 2007). Aircraft maneuvers that result in changes to acceleration, flight path angle, or heading can also affect

the strength of a boom. In general, an increase in flight path angle (lifting the aircraft's nose) will diffuse a boom while a decrease (lowering the aircraft's nose) will focus it. In addition, acceleration will focus a boom while deceleration will weaken it. Any change in horizontal direction will focus a boom, causing two or more wave fronts that originated from the aircraft at different times to coincide exactly (U.S. Department of the Navy, 2001). Atmospheric conditions such as wind speed and direction, and air temperature and pressure can also influence the sound propagation of a sonic boom.

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

In air, the energy from a sonic boom is concentrated in the frequency range from 0.1 to 100 Hz. The underwater sound field due to transmitted sonic boom waveforms is primarily composed of low-frequency components (Sparrow, 2002), and frequencies greater than 20 Hz have been found to be difficult to observe at depths greater than 33 ft. (10 m) (Sohn et al., 2000). F/A-18 Hornet supersonic flight was modeled to obtain peak sound pressure levels and energy flux density at the water surface and at depth (Laney & Cavanagh, 2000). These results are shown in Table 3.0-9.

Table 3.0-9: Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight

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

¹ Equivalent to SEL for a plane wave.

* Mach number equals aircraft speed divided by the speed of sound.

Notes: SPL = sound pressure level, dB re 1 μ Pa = decibel(s) referenced to 1 micropascal, dB re 1 μ Pa²-s = decibel(s) referenced to 1 micropascal squared seconds, m = meter(s)

3.0.3.3.1.6 Weapon Noise

The Navy trains and tests using a variety of weapons, as described in Appendix A (Navy Activity Descriptions). Depending on the weapon, incidental (unintentional) noise may be produced at launch or firing; while in flight; or upon impact. Other devices intentionally produce noise to serve as a non-lethal deterrent. Not all weapons utilize explosives, either by design or because they are non-explosive practice munitions. Noise produced by explosives, both in air and water, are discussed in Section 3.0.3.3.2 (Explosive Stressors).

Noise associated with large caliber weapons firing and the impact of non-explosive practice munitions or kinetic weapons would typically occur at locations greater than 12 NM from shore for safety reasons. Small- and medium-caliber weapons firing could occur throughout the Study Area.

Examples of some types of weapons noise are shown in Table 3.0-10. Examples of launch noise are provided in the table. Noise produced by other weapons and devices are described further below.

Table 3.0-10: Examples of Weapons Noise

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

Sources: ¹Yagla and Stiegler (2003); ²U.S. Department of the Army (1999); ³U.S. Department of the Navy (2013).

Notes: dB re 1 μ Pa = decibel(s) referenced to 1 micropascal, dB re 20 μ Pa = decibel(s) referenced to 20 micropascals, dBA re 20 μ Pa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s)

Muzzle Blast from Naval Gunfire

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

As the pressure from the muzzle blast from a ship-mounted large caliber gun propagates in air toward the water surface, the pressure can be both reflected from the water surface and transmitted into the water. As explained in Appendix D (Acoustic and Explosive Concepts), most sound enters the water in a

narrow cone beneath the sound source (within about 13–14° of vertical), with most sound outside of this cone being totally reflected from the water surface. In-water sound levels were measured during the muzzle blast of a 5 in. large caliber naval gun. The highest possible sound level in the water (average peak SPL of 200 dB re 1 μ Pa, measured 5 ft. below the surface) was obtained when the gun was fired at the lowest angle, placing the blast closest to the water surface (Yagla & Stiegler, 2003). The unweighted sound exposure level would be expected to be 15–20 dB lower than the peak pressure, making the highest possible sound exposure level in the water about 180–185 dB re 1 μ Pa²-s directly below the muzzle blast. Other gunfire arrangements, such as with smaller-caliber weapons or greater angles of fire, would result in less sound entering the water. The sound entering the water would have the strongest directivity directly downward beneath the gun blast, with lower sound pressures at increasing angles of incidence until the angle of incidence is reached where no sound enters the water.



Source: (Yagla & Stiegler, 2003)

Figure 3.0-12: Gun Blast and Projectile from a 5-in./54 Navy Gun

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

Supersonic Projectile Bow Shock Wave

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

Projectiles from a 5 in./54 gun would travel at approximately 2,600 ft./sec, and the associated bow shock wave is subjectively described as a “crack” noise (Pater, 1981). Measurements of a 5 in. projectile shock wave ranged from 140 to 147 dB re 20 μ Pa SPL peak taken at the ground surface at 0.59 NM distance from the firing location and 10° off the line of fire for safety (approximately 190 m from the shell’s trajectory) (Pater, 1981).

Hyperkinetic projectiles may travel up to and exceed approximately six times the speed of sound in air, or about 6,500 ft./second (U.S. Department of the Navy, 2014). For a hyperkinetic projectile sized similar to the 5-in. shell, peak pressures would be expected to be several dB higher than those described for the 5-in. projectile above, following the model in Pater (1981).

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

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. Examples of launch noise sound levels are shown in Table 3.0-10.

Impact Noise (non-explosive)

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

Long Range Acoustic Device

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

3.0.3.3.2 Explosive Stressors

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

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

3.0.3.3.2.1 Explosions in Water

Explosive detonations during training and testing activities are associated with high-explosive munitions, including, but not limited to, bombs, missiles, rockets, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Explosive detonations during training and testing involving the use of high-explosive munitions, including bombs, missiles, and naval gun shells, could occur in the air or near the water's surface. Explosive detonations associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could be detonated in the water column or on the ocean bottom. Most detonations would occur in waters greater than 200 ft. in depth, and greater than 3 NM from shore, although mine warfare, demolition, and some testing detonations would occur in shallow water close to shore.

In order to better organize and facilitate the analysis of explosives used by the Navy during training and testing that could detonate in water or at the water surface, explosive classification bins were developed. The use of explosive classification bins provides the same benefits as described for acoustic source classification bins in Section 3.0.3.3.1 (Acoustic Stressors).

Explosives detonated in water are binned by net explosive weight. The bins of explosives that are proposed for use in the Study Area are shown in Table 3.0-11. This table shows the number of in-water explosive items that could be used in any year under each action alternative for training and testing activities. A range of annual bin use indicates that use of that bin is anticipated to vary annually, consistent with the variation in the number of annual activities described in Chapter 2 (Description of Proposed Action and Alternatives). The five-year total for both action alternatives takes any annual variability into account.

In addition to the explosives quantitatively analyzed for impacts to protected species shown in Table 3.0-11, the Navy uses some very small impulsive sources (<0.1 pound [lb.] net explosive weight), categorized in bin E0, that are not anticipated to result in takes of protected species. Quantitative modeling in multiple locations has validated that these sources have a very small zone of influence. These E0 charges, therefore, are categorized as *de minimis* sources and are qualitatively analyzed to determine the appropriate determinations under NEPA in the appropriate resource impact analyses, as well as under the MMPA and the ESA.

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

Table 3.0-11: Explosive Sources Quantitatively Analyzed that Could Be Used Underwater or at the Water Surface

Bin	Net Explosive Weight ¹ (lb.)	Example Explosive Source	Training				Testing			
			Alternative 1		Alternative 2		Alternative 1		Alternative 2	
			Annual ²	5-year Total	Annual ²	5-year Total	Annual ²	5-year Total	Annual ²	5-year Total
E1	0.1–0.25	Medium-caliber projectile	10,340	51,700	10,340	51,700	17,840–26,840	116,200	26,840	134,200
E2	> 0.25–0.5	Medium-caliber projectile	210–214	1,062	214	1,070	0	0	0	0
E3	> 0.5–2.5	Large-caliber projectile	3,286	16,430	3,286	16,430	2,814–3,182	15,006	3,182	15,910
E4	> 2.5–5	Mine neutralization charge	127–133	653	133	665	746–800	3,784	810	4,050
E5	> 5–10	5 in. projectile	4,140	20,700	4,140	20,700	1,325	6,625	1,325	6,625
E6	> 10–20	Hellfire missile	602	3,010	602	3,010	28–48	200	48	240
E7	> 20–60	Demo block/ shaped charge	4	20	4	20	0	0	0	0
E8	> 60–100	Lightweight torpedo	48	240	48	240	33	165	33	165
E9	> 100–250	500 lb. bomb	66	330	66	330	4	20	4	20
E10	> 250–500	Harpoon missile	90	450	90	450	68–98	400	98	490
E11	> 500–650	650 lb. mine	1	5	1	5	10	50	20	100
E12	> 650–1,000	2,000 lb. bomb	18	90	18	90	0	0	0	0
E14 ³	> 1,741–3,625	Line charge	0	0	0	0	4	20	4	20
E16 ⁴	> 7,250–14,500	Littoral Combat Ship full ship shock trial	0	0	0	0	0–12	12	0–12	12
E17 ⁴	> 14,500–58,000	Aircraft carrier full ship shock trial	0	0	0	0	0–4	4	0–4	4

¹ Net Explosive Weight refers to the equivalent amount of trinitrotoluene (TNT) the actual weight of a munition may be larger due to other components.

² Expected annual use may vary per bin because the number of events may vary from year to year, as described in Chapter 2, Description of Proposed Action and Alternatives.

³ E14 is not modeled for protected species impacts in water because most energy is lost into the air or to the bottom substrate due to detonation in very shallow water.

⁴ Shock trials consist of four explosions each. In any given year there could be 0-3 small ship shock trials (E16) and 0-1 large ship shock trials (E17). Over a 5-year period, there could be three small ship shock trials (E16) and one large ship shock trial (E17).

3.0.3.3.2 Explosions in Air

Explosions in air include detonations of projectiles and missiles during surface-to-air gunnery and air-to-air missile exercises conducted during air warfare. These explosions typically occur far above the water surface. Some typical types of explosive munitions that would be detonated in air during Navy activities are shown in Table 3.0-12. Various missiles, rockets, and medium and large projectiles may be explosive or non-explosive, depending on the objective of the training or testing activity in which they are used. Quantities of explosive and non-explosive missiles, rockets, and projectiles proposed for use during Navy training and testing are provided in Appendix F (Military Expended Material and Direct Strike Impact Analyses).

Table 3.0-12: Typical Air Explosive Munitions During Navy Activities

<i>Weapon Type¹</i>	<i>Net Explosive Weight (lb.)</i>	<i>Typical Altitude of Detonation (ft.)</i>
Surface-to-Air Missile		
RIM-66 SM-2 Standard Missile	80	> 15,000
RIM-116 Rolling Airframe Missile	39	< 3,000
RIM-7 Sea Sparrow	36	> 15,000 (can be used on low targets)
FIM-92 Stinger	7	< 3,000
Air-to-Air Missile		
AIM-9 Sidewinder	38	> 15,000
AIM-7 Sparrow	36	> 15,000
AIM-120 AMRAAM	17	> 15,000
Air-to-Surface Missile		
AGM-88 HARM	45	< 100
Projectile - Large Caliber²		
5"54 HE-ET	7	< 100
5"54 Other	8	< 3,000

¹ Mission Design Series and popular name shown for missiles. ² Most medium and large caliber projectiles used during Navy training and testing activities do not contain high explosives.

AMRAAM = Advanced Medium-Range Air-to-Air Missile; HARM = High-Speed Anti-Radiation; HE-ET = High Explosive- Electronic Time

Bombs and projectiles that detonate at or near the water surface, which are considered for underwater impacts (see Table 3.0-11), would also release some explosive energy into the air. Appendix A (Navy Activity Descriptions) describes where activities with these stressors typically occur.

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

Missiles, rockets, projectiles, and other cased weapons will produce casing fragments upon detonation. These fragments may be of variable size and are ejected at supersonic speed from the detonation. The

casing fragments will be ejected at velocities much greater than debris from any target due to the proximity of the casing to the explosive material. Unlike detonations on land targets, in-air detonations during Navy training and testing would not result in other propelled materials such as crater debris.

3.0.3.3.3 Energy Stressors

This section describes the characteristics of energy introduced through naval training and testing activities and the relative magnitude and location of these activities to provide the basis for analysis of potential impacts on resources from in-water electromagnetic devices, in-air electromagnetic devices, and lasers .

3.0.3.3.3.1 In-Water Electromagnetic Devices

Electromagnetic energy emitted into the water from magnetic influence mine neutralization systems is considered in this document. Table 3.0-13 shows the number and location of proposed activities, primarily mine sweeping, that include the use of in-water electromagnetic devices.

Table 3.0-13: Number and Location of Activities Including In-Water Electromagnetic Devices

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Virginia Capes Range Complex	890	890	4,450	4,450
Navy Cherry Point Range Complex	193	193	965	965
Jacksonville Range Complex	165	165	825	825
Gulf of Mexico Range Complex	104	104	520	520
Inland Waters (Table 3.0-14)	68	68	204	340
Total	1,420	1,420	6,964	7,100
Testing				
Virginia Capes Range Complex	184	184	920	920
Navy Cherry Point Range Complex	12	12	60	60
Jacksonville Range Complex	102	102	510	510
Gulf of Mexico Range Complex	40	40	200	200
NUWC Newport Testing Range	660	660	3,300	3,300
SFOMF	3	3	15	15
NSWC Panama City Testing Range	3	3	15	15
Inland Waters (Table 3.0-14)	100	100	500	500
Total	1,104	1,104	5,520	5,520

Notes: NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility;
NSWC = Naval Surface Warfare Center

Table 3.0-14 shows where within the inland waters the activities would occur.

In-water electromagnetic energy devices 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.” A mine neutralization device could be towed through the water by a surface vessel or remotely operated vehicle, 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.

Table 3.0-14: Number and Location of Activities in Inland Waters Including In-Water Electromagnetic Devices

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Boston, MA	4	4	12	20
Earle, NJ	4	4	12	20
Wilmington, DE	4	4	12	20
Delaware Bay, DE	4	4	12	20
Hampton Roads, VA	8	8	24	40
Morehead City, NC	8	8	24	40
Savannah, GA	4	4	12	20
Kings Bay, GA	4	4	12	20
Mayport, FL	4	4	12	20
Port Canaveral, FL	8	8	24	40
Tampa, FL	4	4	12	20
Beaumont, TX	8	8	24	40
Corpus Christi, TX	4	4	12	20
Total	68	68	204	340
Testing				
Little Creek, VA	100	100	500	500
Total	100	100	500	500

Generally, voltage used to power these systems is around 30 volts. Since saltwater is an excellent conductor, just 35 volts (capped at 55 volts) is required to generate the current. These are considered safe levels for marine species due to the low electric charge relative to salt water.

The static magnetic field generated by the mine neutralization devices is of relatively minute strength. Typically, the maximum magnetic field generated would be approximately 2,300 microteslas². This level of electromagnetic density is very low compared to magnetic fields generated by other everyday items. The magnetic field generated is between the levels of a refrigerator magnet (15,000–20,000 microteslas) and a standard household can opener (up to 400 microteslas at 4 in.). The strength of the electromagnetic field decreases quickly away from the cable. The magnetic field generated is very weak, comparable to the earth's natural field (U.S. Department of the Navy, 2005).

The kinetic energy weapon (commonly referred to as the rail gun) will be tested and eventually used in training events aboard surface vessels, firing non-explosive projectiles at land- or 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 two minutes, and fires in less than one second; therefore, the release of any electromagnetic energy would occur over a very short period. Also, the system is shielded so as not to affect shipboard controls and systems. The amount of electromagnetic energy

² The microtesla is a unit of measurement of magnetic flux density, or "magnetic induction."

released from this system is low and contained on the surface vessel. Therefore, this device is not expected to result in any electromagnetic impacts and will not be further analyzed for biological resources in this document.

3.0.3.3.2 In-Air Electromagnetic Devices

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

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

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

It is assumed that most Navy platforms associated with the Proposed Action will be transmitting from a variety of in-air electromagnetic devices at all times that they are underway, with very limited exceptions. Most of these transmissions (e.g., for routine surveillance, communications, and navigation) will be at low power. High-power settings are used for a small number of activities including ballistic missile defense training, missile and rocket testing, radar and other system testing, and signature analysis operations. The number of Navy vessels or aircraft in the Study Area at any given time varies and is dependent on local training or testing requirements. Therefore, in-air electromagnetic energy as part of the Proposed Action would be widely dispersed throughout the Study Area, but more concentrated in portions of the Study Area near ports, naval installations, and range complexes. Table 3.0-17 and Table 3.0-36 show the annual number and location of activities involving vessels and aircraft, which provide a proxy for level of in-air electromagnetic device use for the purposes of this EIS/OEIS.

3.0.3.3.3 Lasers

The devices discussed here include lasers that 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 measure the distance to a target, to guide weapons, to aid in communication, and to detect or classify mines. High-energy lasers are used as weapons to create critical failures on air and surface targets.

Low-Energy Lasers

Within the category of low-energy lasers, the highest potential level of exposure would be from an underwater laser or 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 species. However, an animal's eye would have to be exposed to a direct laser beam for at least ten 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 further analyzed in this document for biological resources.

High-Energy Lasers

High-energy laser weapons training and testing involves the use of up to 30 kilowatts of directed energy as a weapon against small surface vessels and airborne targets. High-energy lasers would be employed from surface ships and are designed to create small but critical failures in potential targets. The high-energy laser is expected to be used at short ranges. Table 3.0-15 shows the number and location of proposed activities that include the use of high-energy lasers. Marine life at or near the ocean surface and birds could be susceptible to injury by high-energy lasers.

3.0.3.3.4 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 magnitude and location of these activities to provide the basis for analyzing the potential physical disturbance and strike impacts on resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences).

3.0.3.3.4.1 Vessels and In-Water Devices

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 15 ft. to over 1,000 ft. Table 3.0-16 provides examples of the types of vessels, length, and speeds used in both testing and training activities. The U.S. Navy Fact Files, available on the Internet, provide the latest information on the quantity and specifications of the vessels operated by the Navy.

Table 3.0-15: Activities Including High-Energy Lasers

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Virginia Capes Range Complex	4	4	20	20
Jacksonville Range Complex	4	4	20	20
Total	8	8	40	40
Testing				
Northeast Range Complexes	8	8	40	40
Virginia Capes Range Complex	116	116	580	580
Navy Cherry Point Range Complex	8	8	40	40
Jacksonville Range Complex	8	8	40	40
Key West Range Complex	8	8	40	40
Gulf of Mexico Range Complex	8	8	40	40
NUWC Newport Testing Range	8	8	40	40
SFOMF	8	8	40	40
NSWC Panama City Testing Range	8	8	40	40
Total	180	180	900	900

Notes: NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility;
NSWC = Naval Surface Warfare Center

Navy ships transit at speeds that are optimal for fuel conservation or to meet operational requirements. Large Navy ships (greater than 18 m in length) generally operate at average speeds of between 10 and 15 knots, and submarines generally operate at speeds in the range of 8–13 knots. Small craft (for purposes of this discussion, less than 50 ft. in length), which are all support craft, have much more variable speeds (0–50+ knots, dependent on the mission). While these speeds are considered averages and representative of most events, some vessels need to operate outside of these parameters during certain situations. For example, to produce the required relative wind speed over the flight deck for take-off and landings, an aircraft carrier vessel group engaged in flight operations must adjust its speed through the water accordingly. Also, 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 idling or moving slowly ahead to maintain steerage. There are a few specific offshore events, including high-speed tests of newly constructed vessels, where vessels would operate at higher speeds. High speed movements of smaller craft during inshore operations could occur more frequently.

The number of Navy vessels in the Study Area at any given time varies and is dependent on local training or testing requirements. Activities range from involving one or two vessels to several vessels operating over various time frames and locations. For the purposes of this analysis, vessel movements are discussed in two categories; (1) those activities that occur in the offshore component of the Study Area and (2) those activities that occur in inland waters.

Table 3.0-16: Representative Vessel Types, Lengths, and Speeds

<i>Type</i>	<i>Example(s)</i>	<i>Length</i>	<i>Typical Operating Speed</i>
Aircraft Carrier	Aircraft Carrier (CVN)	>1000 ft.	10–15 knots
Surface Combatant	Cruisers (CG), Destroyers (DDG), Frigates (FF), Littoral Combat Ships (LCS)	300–700 ft.	10–15 knots
Amphibious Warfare Ship	Amphibious Assault Ship (LHA, LHD), Amphibious Transport Dock (LPD), Dock Landing Ship (LSD)	300–900 ft.	10–15 knots
Combat Logistics Force Ships	Fast Combat Support Ship (T-AOE), Dry Cargo/Ammunition Ship (T-AKE), Fleet Replenishment Oilers (T-AO)	600–750 ft.	8–12 knots
Support Craft/Other	Amphibious Assault Vehicle (AAV); Combat Rubber Raiding Craft (CRRC); Landing Craft, Mechanized (LCM); Landing Craft, Utility (LCU); Submarine Tenders (AS); Yard Patrol Craft (YP)	15–140 ft.	0–20 knots
Support Craft/Other—Specialized High Speed	High Speed Ferry/Catamaran; Patrol Combatants (PC); Rigid Hull Inflatable Boat (RHIB); Expeditionary Fast Transport (EPF); Landing Craft, Air Cushion (LCAC)	33–320 ft.	0–50+ knots
Submarines	Fleet Ballistic Missile Submarines (SSBN), Attack Submarines (SSN), Guided Missile Submarines (SSGN)	300–600 ft.	8–13 knots

Notes: > = greater than, m = meters

Activities that occur in the offshore component of the Study Area may last from a few hours to a few weeks. Vessels associated with those activities would be widely dispersed in the offshore waters, but more concentrated in portions of the Study Area in close proximity to ports, naval installations, range complexes, and testing ranges. In contrast, activities that occur in inland waters can last from a few hours to up to 12 hours of daily movement per vessel per activity, and can involve speeds greater than 10 knots. The vessels operating within the inland waters are generally smaller than those in the offshore waters and are considered small craft (less than 50 ft.).

In an attempt to determine traffic patterns for Navy and non-Navy vessels, the Center for Naval Analysis (Mintz & Parker, 2006) conducted a review of historic data for commercial vessels, coastal shipping patterns, and Navy vessels. Commercial and non-Navy traffic, which included cargo vessels, bulk carriers, passenger vessels, and oil tankers (all over 20 m in length), was heaviest near the major shipping ports from the Gulf of Maine to southern Florida, as well as in specific international shipping lanes. Compared to coastal vessel activity, there was relatively little concentration of vessels in the other portions of the Study Area (Mintz & Parker, 2006). Navy traffic was heaviest just offshore of Norfolk, Virginia, and Jacksonville, Florida, as well as along the coastal waters between the two ports.

Data collected for 2009 vessel traffic were analyzed by Mintz (2012b) and Mintz and Filadelfo (2011) and indicated that within the AFTT Study Area, large Navy vessels accounted for less than 1 percent of the total large vessel traffic (from estimated vessel hours using positional data) in that area. In the Virginia Capes and Jacksonville Range Complexes where Navy vessel activity is concentrated, the Navy vessels accounted for 7 and 9 percent (respectively) of the total large vessel traffic. Barco et al. (2009) found that large military vessels (at least 65 ft. in length) were approximately 18 percent of the total large vessels transiting (inbound and outbound) the Chesapeake Bay channel, an area of highly concentrated

Navy activity because of the proximity of Naval Station Norfolk. Based on the large number of commercial and recreational boats in the Hampton Roads area, military vessels would probably comprise an even smaller proportion of total vessels, if smaller vessels (less than 65 ft. in length) were factored into these analyses.

Table 3.0-17 shows the number and location of proposed activities that include the use of vessels in the Study Area. Each activity included in Table 3.0-17 could involve one or more vessels. As described above in Section 3.0.3.3 (Identifying Stressors for Analysis), activities are not always conducted independently of each other, as there are instances when a training activity could occur on a vessel while another training activity or a testing activity is being conducted on the same vessel simultaneously. The location and hours of Navy vessel usage for testing and training activities are most dependent upon the locations of Navy ports, piers, and established at-sea testing and training areas. Table 3.0-18 shows the number and location of proposed activities that include the use of vessels in the inland waters of the Study Area. Each activity included in Table 3.0-18 could involve one or more vessels. With the exception of the establishment of the Undersea Warfare Training Range in the offshore waters off the coast of Florida, these established training and testing areas have not appreciably changed in several decades and are not expected to change in the foreseeable future.

Table 3.0-17: Number and Location of Activities Including Vessels

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Northeast Range Complexes	373	375	1,153	1,165
Virginia Capes Range Complex	10,821	10,931	50,753	51,315
Navy Cherry Point Range Complex	6,590	6,617	32,919	33,080
Jacksonville Range Complex	8,956	9,176	44,038	45,180
Key West Range Complex	141	141	705	705
Gulf of Mexico Range Complex	642	658	3,208	3,290
Other AFTT Areas	503	521	2,515	2,605
Inland Waters (see Table 3.0-18)	3,189	3,189	16,505	15,537
Total	31,215	31,608	151,796	152,986
Testing				
Northeast Range Complexes	945	948	4,449	4,737
Virginia Capes Range Complex	1,345	1,346	5,915	6,612
Navy Cherry Point Range Complex	755	756	3,768	3,776
Jacksonville Range Complex	1,060	1,065	5,109	5,239
Key West Range Complex	351	351	1,646	1,748
Gulf of Mexico Range Complex	426	426	2,089	2,110
NUWC Newport Testing Range	697	697	3,479	3,479
SFOMF	149	149	742	742
NSWC Panama City Testing Range	404	404	1,992	1,992
Inland Waters (see Table 3.0-18)	166	166	828	728
Total	6,298	6,308	30,017	31,163

Table 3.0-18: Number and Location of Activities in Inland Waters Including Vessels

<i>Activity Area</i>	<i>Maximum Annual # of Activities</i>		<i>5-Year # of Activities</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Training				
Boston, MA	1	1	3	5
Groton, CT	235	235	1,175	1,175
Narragansett, RI	198	198	990	990
Earle, NJ	1	1	3	5
Wilmington, DE	1	1	3	5
Delaware Bay, DE	1	1	3	5
James Rivers & Tributaries, VA	705	705	3,525	3,525
York River, VA	125	125	625	625
Lower Chesapeake Bay, VA	1,017	1,017	5,085	5,085
Hampton Roads, VA	2	2	6	10
Norfolk, VA	406	406	2,620	2,620
Morehead City, NC	1	1	3	5
Cooper River, SC	60	60	300	300
Savannah, GA	1	1	3	5
Kings Bay, GA	6	6	28	30
Mayport, FL	327	327	1,633	1,635
St. Johns River, FL	2	2	10	10
Port Canaveral, FL	46	46	228	230
Tampa, FL	1	1	3	5
St. Andrew's Bay, FL	50	50	250	252
Beaumont, TX	2	2	6	10
Corpus Christi, TX	1	1	3	5
Total	3,189	3,189	16,505	16,537
Testing				
Bath, ME	11	11	55	55
Portsmouth, NH	26	26	130	130
Newport, RI	4	4	20	20
Groton, CT	9	9	47	47
Little Creek, VA	11	11	51	51
Norfolk, VA	64	64	318	318
Kings Bay, GA	4	4	20	20
Mayport, FL	27	27	135	135
Port Canaveral, FL	3	3	17	17
Pascagoula, MS	7	7	35	35
Total	166	166	828	828

As stated earlier, activities that include vessel movements in the inland waters of the Study Area occur on a more regular basis than the offshore activities, and often involve the vessels traveling at speeds greater than 10 knots, and generally in more confined waterways than activities occurring in the offshore waters. In order to analyze this stressor appropriately, the number of hours of high speed vessel movement for small crafts are provided in Table 3.0-19.

Table 3.0-19: Number of High Speed Vessel Hours for Small Crafts Associated with Training Activities in Inland Waters of the Study Area

Activity Area	Maximum Annual # of Hours		5-Year # of Hours	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Narragansett, RI	9,502	9,502	47,510	47,510
James Rivers & Tributaries	18,108	18,108	90,540	90,540
York River	6,590	6,590	32,950	32,950
Lower Chesapeake Bay	39,325	39,325	196,625	196,625
Cooper River, SC	12,651	12,651	63,255	63,255
Mayport, FL	510	510	2,550	2,550
St. Johns River	482	482	2,410	2,410
Port Canaveral, FL	4,352	4,352	21,760	21,760
St. Andrew's Bay	56	56	280	280
Total	91,576	91,576	457,880	457,880

While the estimates provided in the above tables represent the average distribution of events, actual locations and hours of Navy vessel usage are dependent upon requirements, deployment schedules, annual budgets, and other unpredictable factors. Consequently, vessel use can be highly variable. Multiple activities usually occur from the same vessel, particularly in offshore waters, so increases in the number of activities do not necessarily result in increases in vessel use or transit. The manner in which the Navy uses vessels to accomplish its training and testing activities is likely to remain consistent with the range of variability observed over the last decade. Consequently, even with the addition of Undersea Warfare Training Range off the coast of Florida, the Navy is not proposing appreciable changes in the levels, frequency, or locations where vessels have been used over the last decade.

In-Water Devices

In-water devices as discussed in this analysis include unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles, unmanned underwater vehicles, motorized autonomous targets, and towed devices. These devices are self-propelled and unmanned or towed through the water from a variety of platforms, including helicopters, unmanned underwater vehicles, and surface ships. In-water devices are generally smaller than most Navy vessels, ranging from several inches to about 50 ft. See Table 3.0-20 for a range of in-water devices used. These devices can operate anywhere from the water surface to the benthic zone. Most 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 underwater vehicles) or are closely monitored by observers manning the towing platform who ensure the towed in-water device does not run into objects in the water. Because of their size and potential operating speed, unmanned surface vehicles are the in-water devices that operate in a manner with the most potential to strike living marine resources. Table 3.0-21 shows the number and location of

proposed activities that include the use of in-water devices. For a list of activities by name that include the use of in-water devices, see Appendix B (Activity Stressor Matrices).

Table 3.0-20: Representative Types, Sizes, and Speeds of In-Water Devices

<i>Type</i>	<i>Example(s)</i>	<i>Length</i>	<i>Typical Operating Speed</i>
Towed Device	Minehunting Sonar Systems; Improved Surface Tow Target; Towed Sonar System; MK-103, MK-104 and MK-105 Minesweeping Systems; Organic Airborne and Surface Influence Sweep	< 33 ft.	10–40 knots
Unmanned Surface Vehicle	MK-33 Seaborne Power Target Drone Boat, QST-35A Seaborne Powered Target, Ship Deployable Seaborne Target, Small Waterplane Area Twin Hull, Unmanned Influence Sweep System	< 50 ft.	Variable, up to 50+ knots
Unmanned Underwater Vehicle	Acoustic Mine Targeting System, Airborne Mine Neutralization System, AN/AQS Systems, Archerfish Common Neutralizer, Crawlers, CURV 21, Deep Drone 8000, Deep Submergence Rescue Vehicle, Gliders, Expendable Mobile Anti-Submarine Warfare Training Targets, Magnum Remotely Operated Vehicle, Manned Portables, MK 30 Anti-Submarine Warfare Targets, Remote Multi-Mission Vehicle, Remote Minehunting System, Large Displacement Unmanned Underwater Vehicle	< 60 ft.	1–15 knots
Torpedoes	Light-weight and Heavy-weight Torpedoes	< 33 ft.	20–30 knots

Table 3.0-21: Number and Location of Activities Including In-Water Devices

<i>Activity Area</i>	<i>Maximum Annual # of Activities</i>		<i>5-Year # of Activities</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Training				
Northeast Range Complexes	9	11	43	55
Virginia Capes Range Complex	3,809	3,939	19,009	19,695
Navy Cherry Point Range Complex	819	856	4,021	4,280
Jacksonville Range Complex	1,357	1,717	6,677	8,585
Gulf of Mexico Range Complex	385	423	1,923	2,115
NSWC Panama City Testing Range	328	328	1,640	1,640
Other AFTT Areas	110	110	550	550
Inland Waters (see Table 3.0-22)	777	777	3,615	3,886
Total	6,894	7,461	37,478	40,806
Testing				
Northeast Range Complexes	185	185	928	928
Virginia Capes Range Complex	316	316	1,337	1,580
Navy Cherry Point Range Complex	48	48	237	237
Jacksonville Range Complex	549	549	2,612	2,612
Key West Range Complex	1	1	8	8
Gulf of Mexico Range Complex	318	318	1,588	1,588
NUWC Newport Testing Range	1,771	1,771	8,825	8,825

Table 3.0-21: Number and Location of Activities Including In-Water Devices (continued)

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Testing				
SFOMF	619	619	3,455	3,455
NSWC Panama City Testing Range	1,563	1,563	7,704	7,704
Total	5,370	5,370	26,694	26,937

Notes: NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility;
NSWC = Naval Surface Warfare Center

Table 3.0-22: Number and Location of Activities in Inland Waters Including In-Water Devices

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Boston, MA	9	9	27	45
Earle, NJ	9	9	27	45
Wilmington, DE	9	9	27	45
Delaware Bay, DE	9	9	27	45
Lower Chesapeake Bay	426	426	2,130	2,130
Hampton Roads, VA	18	18	54	90
James River and Tributaries	90	90	450	450
York River	19	19	95	95
Morehead City, NC	9	9	27	45
Savannah, GA	9	9	27	45
Kings Bay, GA	31	31	137	156
Mayport, FL	44	44	202	220
Port Canaveral, FL	9	9	27	45
Tampa, FL	9	9	27	45
St. Andrew's Bay	50	50	250	250
Beaumont, TX	18	18	54	90
Corpus Christi, TX	9	9	27	45
Total	777	777	3,615	3,886

3.0.3.3.4.2 Military Expended Materials

Military expended materials that may cause physical disturbance or strike include: (1) all sizes of non-explosive practice munitions (Table 3.0-23, Table 3.0-24 and Table 3.0-25), (2) fragments from high-explosive munitions (Table 3.0-26 and Table 3.0-27), (3) expendable targets (Table 3.0-28, Table 3.0-29, and Table 3.0-30), and (4) expended materials other than munitions, such as sonobuoys or torpedo accessories (Table 3.0-31 and

Table 3.0-32). See Appendix F (Military Expended Materials and Direct Strike Calculations) for more information on the type and quantities of military expended materials proposed to be used.

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 as an alteration of the bottom substrate and associated organisms (e.g., invertebrates and vegetation).

Table 3.0-23: Number and Location of Non-Explosive Practice Munitions Expended During Training Activities

Activity Area	Maximum Annual # of Munitions		5-Year # of Munitions	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Torpedoes¹				
Northeast Range Complexes	24	24	120	120
Virginia Capes Range Complex	21	21	105	105
Jacksonville Range Complex	92	92	460	460
Total	137	137	685	685
Bombs				
Virginia Capes Range Complex	2,248	2,248	11,240	11,240
Navy Cherry Point Range Complex	596	596	2,980	2,980
Jacksonville Range Complex	1,366	1,366	6,830	6,830
Gulf of Mexico Range Complex	270	270	1,350	1,350
Total	4,480	4,480	22,400	22,400
Rockets				
Virginia Capes Range Complex	2,708	2,708	13,538	13,538
Navy Cherry Point Range Complex	289	289	1,444	1,444
Jacksonville Range Complex	2,997	2,997	14,982	14,982
Gulf of Mexico Range Complex	289	289	1,444	1,444
Total	6,283	6,283	31,408	31,408
Rockets (Flechette)				
Virginia Capes Range Complex	143	143	712	712
Navy Cherry Point Range Complex	15	15	76	76
Jacksonville Range Complex	157	157	788	788
Gulf of Mexico Range Complex	15	15	76	76
Total	330	330	1,652	1,652
Large Caliber Projectiles				
Virginia Capes Range Complex	3,802	3,802	19,010	19,010
Navy Cherry Point Range Complex	1,134	1,134	5,670	5,670
Jacksonville Range Complex	1,388	1,388	6,940	6,940
Gulf of Mexico Range Complex	638	638	3,190	3,190
Other AFTT Areas	196	196	980	980
Total	7,158	7,158	35,790	35,790
Large Caliber – Casings Only				
Navy Cherry Point Range Complex	960	960	4,800	4,800
Total	960	960	4,800	4,800

Table 3.0-23: Number and Location of Non-Explosive Practice Munitions Expended During Training Activities (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Munitions</i>		<i>5-Year # of Munitions</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Medium Caliber Projectiles				
Northeast Range Complexes	1,000	1,000	5,000	5,000
Virginia Capes Range Complex	800,769	800,769	4,003,845	4,003,845
Navy Cherry Point Range Complex	358,574	358,574	1,792,870	1,792,870
Jacksonville Range Complex	439,234	439,234	2,196,170	2,196,170
Key West Range Complex	56,000	56,000	280,000	280,000
Gulf of Mexico Range Complex	32,000	32,000	160,000	160,000
Other AFTT Areas	21,251	21,251	106,250	106,250
Total	1,708,828	1,708,828	8,544,135	8,544,135
Small Caliber Projectiles				
Northeast Range Complexes	36,600	36,600	135,000	135,000
Virginia Capes Range Complex	3,806,350	3,806,350	19,031,750	19,031,750
Navy Cherry Point Range Complex	833,675	833,675	4,168,375	4,168,375
Jacksonville Range Complex	1,436,275	1,436,275	7,181,375	7,181,375
Gulf of Mexico Range Complex	237,500	237,500	1,187,500	1,187,500
Other AFTT Areas	200,000	200,000	1,000,000	1,000,000
Total	6,550,400	6,550,400	32,704,000	32,704,000
Small Caliber – Casings Only				
Virginia Capes Range Complex	3,400	3,400	17,000	17,000
Jacksonville Range Complex	1,000	1,000	5,000	5,000
Inland Waters (see Table 3.0-24)	157,020	157,020	781,100	781,100
Total	161,420	161,420	803,100	803,100

¹ Non-explosive torpedoes are recovered after use.

Notes: AFTT = Atlantic Fleet Training and Testing

Table 3.0-24: Number and Location of Non-Explosive Practice Munitions Expended During Training Activities in Inland Waters

<i>Activity Area</i>	<i>Maximum Annual # of Munitions</i>		<i>5-Year # of Munitions</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Narragansett, RI	8,320	8,320	41,600	41,600
James Rivers & Tributaries	102,000	102,000	510,000	510,000
Lower Chesapeake Bay	28,800	28,800	140,000	140,000
Cooper River, SC	5,100	5,100	25,500	25,500
Port Canaveral, FL	12,800	12,800	64,000	64,000
Total	157,020	157,020	781,100	781,100

Table 3.0-25: Number and Location of Non-Explosive Practice Munitions Expended During Testing Activities

<i>Activity Area</i>	<i>Maximum Annual # of Munitions</i>		<i>5-Year # of Munitions</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Airborne Mine Neutralization System Neutralizer				
Virginia Capes Range Complex	180	195	740	975
Jacksonville Range Complex	50	50	250	250
Gulf of Mexico Range Complex	100	100	500	500
NSWC Panama City Testing Range	84	99	364	495
Total	414	444	1,854	2,220
Torpedoes ¹				
Northeast Range Complexes	240	240	1,192	1,192
Virginia Capes Range Complex	465	465	2,074	2,317
Navy Cherry Point Range Complex	128	128	642	642
Jacksonville Range Complex	571	571	2,778	2,847
Key West Range Complex	4	4	12	12
Gulf of Mexico Range Complex	236	236	1,172	1,172
NUWC Newport Testing Range	120	120	600	600
SFOMF	34	34	170	170
NSWC Panama City Testing Range	240	240	1,200	1,200
Total	2,038	2,038	9,840	10,152
Bombs				
Virginia Capes Range Complex	964	964	4,820	4,820
Jacksonville Range Complex	12	12	60	60
Total	976	976	4,880	4,880
Rockets				
Virginia Capes Range Complex	746	746	3,644	3,728
Jacksonville Range Complex	406	406	1,945	2,029
Total	1,152	1,152	5,589	5,757
Rockets (Flechette)				
Virginia Capes Range Complex	248	248	1,215	1,243
Jacksonville Range Complex	135	135	648	676
Total	383	383	1,863	1,919
Missiles				
Northeast Range Complexes	24	24	120	120
Virginia Capes Range Complex	899	899	4,463	4,495
Navy Cherry Point Range Complex	24	24	120	120
Jacksonville Range Complex	136	136	672	680
Key West Range Complex	31	31	155	155
Gulf of Mexico Range Complex	24	24	120	120
Total	1,138	1,138	5,650	5,690

Table 3.0-25: Number and Location of Non-Explosive Practice Munitions Expended During Testing Activities (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Munitions</i>		<i>5-Year # of Munitions</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Kinetic Energy Rounds				
Northeast Range Complexes	35,003	35,003	175,017	175,017
Virginia Capes Range Complex	35,003	35,003	175,017	175,017
Navy Cherry Point Range Complex	35,003	35,003	175,017	175,017
Jacksonville Range Complex	35,003	35,003	175,017	175,017
Key West Range Complex	35,003	35,003	175,017	175,017
Gulf of Mexico Range Complex	35,003	35,003	175,017	175,017
NUWC Newport Testing Range	4	4	17	17
SFOMF	4	4	17	17
NSWC Panama City Testing Range	4	4	17	17
Total	210,030	210,030	1,050,153	1,050,153
Large Caliber Projectiles				
Northeast Range Complexes	1,761	1,761	8,805	8,805
Virginia Capes Range Complex	8,147	8,147	40,735	40,735
Navy Cherry Point Range Complex	1,440	1,440	7,200	7,200
Jacksonville Range Complex	14,524	14,524	72,620	72,620
Key West Range Complex	3,190	3,190	15,950	15,950
Gulf of Mexico Range Complex	2,774	2,774	13,870	13,870
NSWC Panama City Testing Range	280	280	1,400	1,400
Total	32,116	32,116	160,580	160,580
Medium Caliber Projectiles				
Northeast Range Complexes	9,060	9,060	45,300	45,300
Virginia Capes Range Complex	239,660	239,660	1,180,300	1,198,300
Navy Cherry Point Range Complex	8,160	8,160	40,800	40,800
Jacksonville Range Complex	237,360	237,360	1,150,800	1,186,800
Key West Range Complex	32,660	32,660	163,300	163,300
Gulf of Mexico Range Complex	22,860	22,860	114,300	114,300
NSWC Panama City Testing Range	5,100	5,100	25,500	25,500
Total	554,860	554,860	2,720,300	2,774,300

Table 3.0-25: Number and Location of Non-Explosive Practice Munitions Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Munitions		5-Year # of Munitions	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Kinetic Energy Rounds				
Small Caliber Projectiles				
Northeast Range Complexes	4,800	4,800	24,000	24,000
Virginia Capes Range Complex	77,800	77,800	389,000	389,000
Navy Cherry Point Range Complex	4,800	4,800	24,000	24,000
Jacksonville Range Complex	4,800	4,800	24,000	24,000
Key West Range Complex	4,800	4,800	24,000	24,000
Gulf of Mexico Range Complex	17,800	17,800	89,000	89,000
NSWC Panama City Testing Range	7,000	7,000	35,000	35,000
Total	121,800	121,800	609,000	609,000

¹ Non-explosive torpedoes are recovered after use.

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center

Table 3.0-26: Number and Location of Explosives that May Result in Fragments Used During Training Activities

Activity Area	Maximum Annual # of Munitions		5-Year # of Munitions	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Torpedoes				
SINKEX Area	1	1	5	5
Total	1	1	5	5
Neutralizers				
Virginia Capes Range Complex	62	62	306	310
Navy Cherry Point Range Complex	1	1	5	5
Jacksonville Range Complex	2	2	6	10
Gulf of Mexico Range Complex	22	22	106	110
Total	87	87	423	435
Grenades				
Northeast Range Complexes	56	56	280	280
Virginia Capes Range Complex	70	70	350	350
Navy Cherry Point Range Complex	28	28	140	140
Jacksonville Range Complex	28	28	140	140
Gulf of Mexico Range Complex	28	28	140	140
Total	210	210	1,050	1,050
Bombs				
Virginia Capes Range Complex	76	76	380	380
Jacksonville Range Complex	50	50	250	250
Gulf of Mexico Range Complex	4	4	20	20

Table 3.0-26: Number and Location of Explosives that May Result in Fragments Used During Training Activities (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Munitions</i>		<i>5-Year # of Munitions</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
SINKEX Area	12	12	60	60
Total	142	142	710	710
Rockets				
Virginia Capes Range Complex	1,254	1,254	6,270	6,270
Navy Cherry Point Range Complex	76	76	380	380
Jacksonville Range Complex	1,330	1,330	6,650	6,650
Gulf of Mexico Range Complex	76	76	380	380
Total	2,736	2,736	13,680	13,680
Missiles				
Northeast Range Complexes	4	4	20	20
Virginia Capes Range Complex	155	155	775	775
Navy Cherry Point Range Complex	106	106	530	530
Jacksonville Range Complex	136	136	680	680
Key West Range Complex	8	8	40	40
Gulf of Mexico Range Complex	8	8	40	40
SINKEX Area	4	4	20	20
Total	421	421	2,105	2,105
Large Caliber Projectiles				
Virginia Capes Range Complex	2,998	2,998	14,990	14,990
Navy Cherry Point Range Complex	756	756	3,780	3,780
Jacksonville Range Complex	1,160	1,160	5,800	5,800
Gulf of Mexico Range Complex	260	260	1,300	1,300
Other AFTT Areas	96	96	480	480
SINKEX Area	200	200	1,000	1,000
Total	5,470	5,470	27,350	27,350
Medium Caliber Projectiles				
Virginia Capes Range Complex	65,312	65,312	326,560	326,560
Navy Cherry Point Range Complex	23,200	23,200	116,000	116,000
Jacksonville Range Complex	58,952	58,952	294,760	294,760
Gulf of Mexico Range Complex	6,250	6,250	31,250	31,250
Other AFTT Areas	1,350	1,350	6,750	6,750
Total	155,064	155,064	775,320	775,320

Notes: AFTT = Atlantic Fleet Training and Testing; SINKEX = Sinking Exercise

Table 3.0-27: Number and Location of Explosives that May Result in Fragments Used During Testing Activities

<i>Activity Area</i>	<i>Maximum Annual # of Munitions</i>		<i>5-Year # of Munitions</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Torpedoes				
Northeast Range Complexes	7	7	29	29
Virginia Capes Range Complex	7	7	29	29
Navy Cherry Point Range Complex	3	3	9	9
Jacksonville Range Complex	7	7	29	29
Key West Range Complex	3	3	9	9
Gulf of Mexico Range Complex	3	3	29	29
NSWC Panama City Testing Range	12	12	60	60
Total	42	42	194	194
Explosive Sonobuoys				
Key West Range Complex	72	72	360	360
Total	72	72	360	360
Neutralizers				
Virginia Capes Range Complex	250	255	1,090	1,275
Jacksonville Range Complex	50	50	250	250
Gulf of Mexico Range Complex	100	100	500	500
NSWC Panama City Testing Range	328	333	1,584	1,665
Total	728	738	3,424	3,690
Bombs				
Virginia Capes Range Complex	2	2	10	10
Total	2	2	10	10
Rockets				
Virginia Capes Range Complex	206	206	830	1,030
Jacksonville Range Complex	200	200	800	1,000
Total	406	406	1,630	2,030
Missiles				
Northeast Range Complexes	10	10	50	50
Virginia Capes Range Complex	176	176	830	880
Jacksonville Range Complex	70	70	327	350
Gulf of Mexico Range Complex	12	12	30	60
Total	268	268	1,237	1,340
Buoys				
Northeast Range Complexes	710	725	3,268	3,622
Virginia Capes Range Complex	576	581	2,517	2,902
Navy Cherry Point Range Complex	337	342	1,667	1,707
Jacksonville Range Complex	399	424	1,992	2,117
Key West Range Complex	706	706	3,497	3,527
Gulf of Mexico Range Complex	352	352	1,682	1,757
Total	3,080	3,130	14,623	15,632

Table 3.0-27: Number and Location of Explosives that May Result in Fragments Used During Testing Activities (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Munitions</i>		<i>5-Year # of Munitions</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Anti-Torpedo Countermeasures				
Northeast Range Complexes	142	142	710	710
Virginia Capes Range Complex	160	160	800	800
Navy Cherry Point Range Complex	42	42	210	210
Jacksonville Range Complex	156	156	780	780
Gulf of Mexico Range Complex	142	142	710	710
Total	642	642	3,210	3,210
Mines				
Virginia Capes Range Complex	10	15	50	75
Jacksonville Range Complex	8	8	40	40
Gulf of Mexico Range Complex	16	16	80	80
NSWC Panama City Testing Range	4	9	20	45
Total	38	48	190	240
Large Caliber Projectiles				
Northeast Range Complexes	132	132	660	660
Virginia Capes Range Complex	3,263	3,263	16,315	16,315
Navy Cherry Point Range Complex	132	132	660	660
Jacksonville Range Complex	6,376	6,376	31,880	31,880
Key West Range Complex	832	832	4,160	4,160
Gulf of Mexico Range Complex	923	923	4,615	4,615
NSWC Panama City Testing Range	100	100	500	500
Total	11,758	11,758	58,790	58,790
Medium Caliber Projectiles				
Northeast Range Complexes	3,860	3,860	19,300	19,300
Virginia Capes Range Complex	17,270	17,270	80,350	86,350
Navy Cherry Point Range Complex	3,360	3,360	16,800	16,800
Jacksonville Range Complex	14,860	14,860	62,300	74,300
Key West Range Complex	3,360	3,360	16,800	16,800
Gulf of Mexico Range Complex	3,360	3,360	16,800	16,800
Total	46,070	46,070	212,350	230,350

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center

Table 3.0-28: Number and Location of Targets Used or Expended During Training Activities

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Air Targets				
Northeast Range Complexes	4	4	20	20
Virginia Capes Range Complex	78	78	390	390
Navy Cherry Point Range Complex	85	85	425	425
Jacksonville Range Complex	65	65	325	325
Key West Range Complex	8	8	40	40
Gulf of Mexico Range Complex	8	8	40	40
Total	248	248	1,240	1,240
Surface Targets ¹				
Northeast Range Complexes	2	2	10	10
Virginia Capes Range Complex	1,215	1,215	6,075	6,075
Navy Cherry Point Range Complex	598	598	2,990	2,990
Jacksonville Range Complex	775	775	3,875	3,875
Gulf of Mexico Range Complex	51	51	255	255
Other AFTT Areas	3	3	15	15
Total	2,644	2,644	13,220	13,220
Surface Targets (Stationary)				
Virginia Capes Range Complex	4	4	20	20
Total	4	4	20	20
Subsurface Targets (Mobile)¹				
Northeast Range Complexes	100	102	498	510
Virginia Capes Range Complex	291	401	1,455	2,005
Navy Cherry Point Range Complex	81	108	403	540
Jacksonville Range Complex	1,108	1,328	5,540	6,640
Gulf of Mexico Range Complex	3	5	13	25
Other AFTT Areas	179	179	891	891
Total	1,762	2,123	8,800	10,611
Mine Shapes ¹				
Virginia Capes Range Complex	292	292	1,456	1,460
Navy Cherry Point Range Complex	24	24	120	120
Jacksonville Range Complex	60	60	292	300
Key West Range Complex	8	8	40	40
Gulf of Mexico Range Complex	60	60	292	300
Inland Waters (see Table 3.0-29)	68	68	204	340
Total	504	504	2,404	2,560
Ship Hulks				
SINKEX Area	1	1	5	5
Total	1	1	5	5

¹ Many of these items are recovered after use.

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

Table 3.0-29: Number and Location of Targets Used or Expended During Training Activities in Inland Waters

<i>Activity Area</i>	<i>Maximum Annual # of Targets</i>		<i>5-Year # of Targets</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Mine Shapes				
Boston, MA	4	4	12	20
Earle, NJ	4	4	12	20
Delaware Bay, DE	4	4	12	20
Hampton Roads, VA	8	8	24	40
Morehead City, NC	8	8	24	40
Wilmington, NC	4	4	12	20
Savannah, GA	4	4	12	20
Kings Bay, GA	4	4	12	20
Mayport, FL	4	4	12	20
Port Canaveral, FL	8	8	24	40
Tampa, FL	4	4	12	20
Beaumont, TX	8	8	24	40
Corpus Christi, TX	4	4	12	20
Total	68	68	204	340

Table 3.0-30: Number and Location of Targets Used or Expended During Testing Activities

<i>Activity Area</i>	<i>Maximum Annual # of Targets</i>		<i>5-Year # of Targets</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Aerial Drones¹				
Northeast Range Complexes	6	6	28	28
Virginia Capes Range Complex	480	480	2,397	2,398
Navy Cherry Point Range Complex	6	6	28	28
Jacksonville Range Complex	174	174	868	868
Key West Range Complex	6	6	28	28
Gulf of Mexico Range Complex	6	6	28	28
NUWC Newport Testing Range	6	6	28	28
SFOMF	6	6	28	28
NSWC Panama City Testing Range	6	6	28	28
Total	696	696	3,461	3,462
Air Target ¹				
Northeast Range Complexes	60	60	300	300
Virginia Capes Range Complex	60	60	300	300
Navy Cherry Point Range Complex	60	60	300	300
Jacksonville Range Complex	60	60	300	300
Key West Range Complex	60	60	300	300
Gulf of Mexico Range Complex	70	70	350	350
Total	370	370	1,850	1,850

**Table 3.0-30: Number and Location of Targets Used or Expended During Testing Activities
(continued)**

<i>Activity Area</i>	<i>Maximum Annual # of Targets</i>		<i>5-Year # of Targets</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Surface Targets¹				
Northeast Range Complexes	111	111	552	552
Virginia Capes Range Complex	400	400	1,904	1,907
Navy Cherry Point Range Complex	111	111	552	552
Jacksonville Range Complex	228	228	1,038	1,137
Key West Range Complex	111	111	552	552
Gulf of Mexico Range Complex	121	121	572	602
NUWC Newport Testing Range	13	13	62	62
SFOMF	13	13	62	62
NSWC Panama City Testing Range	13	13	62	62
Total	1,121	1,121	5,356	5,578
Surface Targets (Mobile)¹				
Northeast Range Complexes	1	1	4	4
Virginia Capes Range Complex	1	1	4	4
Navy Cherry Point Range Complex	1	1	4	4
Jacksonville Range Complex	1	1	4	4
Key West Range Complex	1	1	4	4
Gulf of Mexico Range Complex	1	1	4	4
Total	6	6	24	24
Surface Targets (Stationary)¹				
Northeast Range Complexes	61	61	305	305
Virginia Capes Range Complex	61	61	305	305
Navy Cherry Point Range Complex	61	61	305	305
Jacksonville Range Complex	61	61	305	305
Key West Range Complex	61	61	305	305
Gulf of Mexico Range Complex	61	61	305	305
Total	366	366	1,830	1,830
Sub-Surface Targets (Mobile)¹				
Northeast Range Complexes	100	100	500	500
Virginia Capes Range Complex	105	105	525	525
Jacksonville Range Complex	265	265	1,325	1,325
Gulf of Mexico Range Complex	100	100	500	500
NUWC Newport Testing Range	240	240	1,200	1,200
Total	810	810	4,050	4,050

**Table 3.0-30: Number and Location of Targets Used or Expended During Testing Activities
(continued)**

<i>Activity Area</i>	<i>Maximum Annual # of Targets</i>		<i>5-Year # of Targets</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Mine Shapes ¹				
Northeast Range Complexes	5,600	5,600	28,000	28,000
Virginia Capes Range Complex	3,172	3,172	12,860	12,860
Jacksonville Range Complex	1,595	1,595	7,975	7,975
Gulf of Mexico Range Complex	2,755	2,755	13,772	13,772
NUWC Newport Testing Range	342	342	1,710	1,710
SFOMF	885	885	4,423	4,423
NSWC Panama City Testing Range	4,309	4,309	21,545	21,545
Total	18,658	18,658	90,285	90,285

¹ Most of these items are recovered after use.

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

Table 3.0-31: Number and Location of Other Military Materials Used or Expended During Training Activities

<i>Activity Area</i>	<i>Maximum Annual # of Materials</i>		<i>5-Year # of Materials</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Acoustic Countermeasures				
Northeast Range Complexes	84	84	420	420
Virginia Capes Range Complex	41	41	205	205
Navy Cherry Point Range Complex	14	14	70	70
Jacksonville Range Complex	164	164	802	820
Gulf of Mexico Range Complex	0	6	0	30
Other AFTT Areas	89	89	441	441
Total	392	398	1,938	1,986
Concrete Slugs				
Virginia Capes Range Complex	14	14	70	70
Navy Cherry Point Range Complex	1	1	5	5
Jacksonville Range Complex	1	1	5	5
Key West Range Complex	6	6	30	30
Gulf of Mexico Range Complex	1	1	5	5
Inland Waters (see Table 3.0-32)	6	6	30	30
Total	29	29	145	145

Table 3.0-31: Number and Location of Other Military Materials Used or Expended During Training Activities (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Materials</i>		<i>5-Year # of Materials</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Compression Pad/Piston				
Virginia Capes Range Complex	1,000	1,000	5,000	5,000
Navy Cherry Point Range Complex	22,300	22,300	111,500	111,500
Jacksonville Range Complex	38,000	38,000	190,000	190,000
Key West Range Complex	31,000	31,000	155,000	155,000
Gulf of Mexico Range Complex	1,840	1,840	9,200	9,200
Total	94,140	94,140	470,700	470,700
Chaff – Air Cartridge				
Virginia Capes Range Complex	2,080	2,080	10,400	10,400
Navy Cherry Point Range Complex	25,760	25,760	128,800	128,800
Jacksonville Range Complex	47,840	47,840	239,200	239,200
Key West Range Complex	4,800	4,800	240,000	240,000
Gulf of Mexico Range Complex	288	288	1,440	1,440
Total	80,768	80,768	619,840	619,840
Chaff – Ship Cartridge				
Virginia Capes Range Complex	264	264	1,320	1,320
Navy Cherry Point Range Complex	480	480	2,400	2,400
Jacksonville Range Complex	516	516	2,580	2,580
Gulf of Mexico Range Complex	120	120	600	600
Total	1,380	1,380	6,900	6,900
Endcaps – Chaff & Flare				
Virginia Capes Range Complex	3,120	3,120	15,600	15,600
Navy Cherry Point Range Complex	48,108	48,108	240,540	240,540
Jacksonville Range Complex	85,888	85,888	429,440	429,440
Key West Range Complex	79,008	79,008	395,040	395,040
Gulf of Mexico Range Complex	2,128	2,128	10,640	10,640
Total	218,252	218,252	1,091,260	1,091,260
Flares				
Virginia Capes Range Complex	1,040	1,040	5,200	5,200
Navy Cherry Point Range Complex	22,348	22,348	111,740	111,740
Jacksonville Range Complex	38,048	38,048	190,240	190,240
Key West Range Complex	31,008	31,008	155,040	155,040
Gulf of Mexico Range Complex	1,840	1,840	9,200	9,200
Inland Waters (see Table 3.0-32)	20,400	20,400	102,000	102,000
Total	114,684	114,684	573,420	573,420

Table 3.0-31: Number and Location of Other Military Materials Used or Expended During Training Activities (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Materials</i>		<i>5-Year # of Materials</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Flare O-Rings				
Virginia Capes Range Complex	1,040	1,040	5,200	5,200
Navy Cherry Point Range Complex	22,348	22,348	111,740	111,740
Jacksonville Range Complex	38,048	38,048	190,240	190,240
Key West Range Complex	31,008	31,008	155,040	155,040
Gulf of Mexico Range Complex	1,840	1,840	9,200	9,200
Inland Waters (see Table 3.0-32)	20,400	20,400	102,000	102,000
Total	114,684	114,684	573,420	573,420
Fiber Optic Canister				
Virginia Capes Range Complex	62	62	306	210
Navy Cherry Point Range Complex	1	1	5	5
Jacksonville Range Complex	2	2	6	10
Gulf of Mexico Range Complex	22	22	106	110
Total	87	87	423	335
Expendable Bathythermographs				
Northeast Range Complexes	139	142	695	708
Virginia Capes Range Complex	329	439	1,640	2,193
Navy Cherry Point Range Complex	85	113	422	563
Jacksonville Range Complex	1,171	1,391	5,490	6,953
Gulf of Mexico Range Complex	3	128	13	640
Other AFTT Areas	154	154	771	771
Total	1,880	2,365	9,031	11,828
Heavyweight Torpedo Accessories				
Northeast Range Complexes	24	24	120	120
Virginia Capes Range Complex	8	8	40	40
Jacksonville Range Complex	48	48	240	240
Total	81	81	405	405
Lightweight Torpedo Accessories				
Virginia Capes Range Complex	13	13	65	65
Jacksonville Range Complex	44	44	220	220
Total	57	57	285	285
Marine Markers				
Northeast Range Complexes	192	192	960	960
Virginia Capes Range Complex	10,196	10,196	50,980	50,980
Navy Cherry Point Range Complex	332	332	1,660	1,660
Jacksonville Range Complex	1,263	1,263	6,315	6,315
Gulf of Mexico Range Complex	303	303	1,515	1,515

Table 3.0-31: Number and Location of Other Military Materials Used or Expended During Training Activities (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Materials</i>		<i>5-Year # of Materials</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Other AFTT Areas	24	24	120	120
Inland Waters (see Table 3.0-32)	805	805	4,025	4,025
Total	13,115	13,115	65,575	65,575
Non-Explosive Buoy				
Virginia Capes Range Complex	24	34	114	170
Navy Cherry Point Range Complex	17	22	73	110
Jacksonville Range Complex	116	186	550	930
Gulf of Mexico Range Complex	0	16	0	80
Total	157	258	737	1,290
Non-Explosive Sonobuoy				
Northeast Range Complexes	3,132	3,132	15,660	15,660
Virginia Capes Range Complex	8,394	8,394	41,787	41,970
Navy Cherry Point Range Complex	2,987	2,987	14,542	14,935
Jacksonville Range Complex	30,504	30,504	150,741	152,520
Gulf of Mexico Range Complex	0	785	0	3,925
Other AFTT Areas	496	496	2,480	2,480
Total	45,513	46,298	225,210	231,490
Decelerators/Parachutes - Small				
Northeast Range Complexes	3,128	3,128	15,640	15,640
Virginia Capes Range Complex	8,218	8,218	40,907	41,090
Navy Cherry Point Range Complex	2,959	2,959	14,402	14,795
Jacksonville Range Complex	30,328	30,328	149,861	151,640
Gulf of Mexico Range Complex	0	785	0	3,925
Other AFTT Areas	480	480	2,400	2,400
Total	45,113	45,898	223,210	229,490
Decelerators/Parachutes - Medium				
Virginia Capes Range Complex	8	8	40	40
Jacksonville Range Complex	28	28	140	140
Total	36	36	180	180
Parachutes - Large				
Virginia Capes Range Complex	40	40	200	200
Navy Cherry Point Range Complex	48	48	240	240
Jacksonville Range Complex	48	48	240	240
Key West Range Complex	8	8	40	40
Total	144	144	720	720

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

Table 3.0-32: Number and Location of Other Military Materials Used or Expended During Training Activities in Inland Waters

<i>Activity Area</i>	<i>Maximum Annual # of Materials</i>		<i>5-Year # of Materials</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Concrete Slugs				
Lower Chesapeake Bay	6	6	30	30
Total	6	6	30	30
Flares				
James River & Tributaries	20,400	20,400	102,000	102,000
Total	20,400	20,400	102,000	102,000
Marine Markers				
Narragansett, RI	65	65	325	325
James River & Tributaries	660	660	3,300	3,300
York River	20	20	100	100
Port Canaveral, FL	60	60	300	300
Total	805	805	4,025	4,025

Table 3.0-33: Number and Location of Other Military Materials Used or Expended During Testing Activities

<i>Activity Area</i>	<i>Maximum Annual # of Materials</i>		<i>5-Year # of Materials</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Acoustic Countermeasures				
Northeast Range Complexes	842	842	4,210	4,210
Virginia Capes Range Complex	1,038	1,038	5,190	5,190
Navy Cherry Point Range Complex	764	764	3,820	3,820
Jacksonville Range Complex	1,331	1,331	6,651	6,651
Gulf of Mexico Range Complex	836	836	4,180	4,180
NUWC Newport Testing Range	64	64	320	320
SFOMF	100	100	500	500
Total	4,975	4,975	24,871	24,871
Anchors				
Northeast Range Complexes	3,600	3,600	18,000	18,000
Virginia Capes Range Complex	1,800	1,800	9,000	9,000
Jacksonville Range Complex	101	101	501	501
Gulf of Mexico Range Complex	1,923	1,923	9,614	9,614
NUWC Newport Testing Range	206	206	1,026	1,026
SFOMF	87	87	433	433
Total	7,717	7,717	38,574	38,574

Table 3.0-33: Number and Location of Other Military Materials Used or Expended During Testing Activities (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Materials</i>		<i>5-Year # of Materials</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Concrete Slugs				
Northeast Range Complexes	38	38	190	190
Gulf of Mexico Range Complex	38	38	190	190
Total	76	76	380	380
Compression Pad/Piston				
Virginia Capes Range Complex	20,195	20,195	100,975	100,975
Gulf of Mexico Range Complex	600	600	3,000	3,000
Total	20,795	20,795	103,975	103,975
Chaff – Air Cartridge				
Virginia Capes Range Complex	20,595	20,595	102,975	102,975
Jacksonville Range Complex	400	400	2,000	2,000
Gulf of Mexico Range Complex	1,200	1,200	6,000	6,000
Total	22,195	22,195	110,975	110,975
Chaff – Ship Cartridge				
Northeast Range Complexes	144	144	720	720
Virginia Capes Range Complex	1,019	1,019	5,095	5,095
Navy Cherry Point Range Complex	144	144	720	720
Jacksonville Range Complex	480	480	2,400	2,400
Key West Range Complex	144	144	720	720
Gulf of Mexico Range Complex	144	144	720	720
Total	2,075	2,075	10,375	10,375
Endcaps – Chaff & Flare				
Virginia Capes Range Complex	40,790	40,790	203,950	203,950
Jacksonville Range Complex	400	400	2,000	2,000
Gulf of Mexico Range Complex	1,800	1,800	9,000	9,000
Total	42,990	42,990	214,950	214,950
Endcaps and Pistons (Non Chaff & Flare)				
NUWC Newport Testing Range	379	379	1,895	1,895
Total	379	379	1,895	1,895
Flares				
Virginia Capes Range Complex	20,195	20,195	100,975	100,975
Gulf of Mexico Range Complex	600	600	3,000	3,000
Total	20,795	20,795	103,975	103,975
Flare O-Rings				
Virginia Capes Range Complex	20,195	20,195	100,975	100,975
Gulf of Mexico Range Complex	600	600	3,000	3,000
Total	20,795	20,795	103,975	103,975

Table 3.0-33: Number and Location of Other Military Materials Used or Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Fiber Optic Canister				
Virginia Capes Range Complex	430	430	1,830	2,250
Jacksonville Range Complex	100	100	500	500
Gulf of Mexico Range Complex	200	200	1,000	1,000
NSWC Panama City Testing Range	412	432	1,948	2,160
Total	1,142	1,162	5,278	5,910
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Expendable Bathythermographs				
Northeast Range Complexes	1,835	1,835	7,171	7,171
Virginia Capes Range Complex	1,019	1,019	5,065	5,095
Navy Cherry Point Range Complex	315	315	1,575	1,575
Jacksonville Range Complex	637	637	3,155	3,185
Key West Range Complex	10	10	50	50
Gulf of Mexico Range Complex	978	978	4,890	4,890
SFOMF	4	4	20	20
Total	4,798	4,798	23,926	23,986
Heavyweight Torpedo Accessories				
Northeast Range Complexes	190	190	950	950
Virginia Capes Range Complex	220	220	1,100	1,100
Navy Cherry Point Range Complex	52	52	260	260
Jacksonville Range Complex	234	234	1,170	1,170
Key West Range Complex	2	2	10	10
Gulf of Mexico Range Complex	186	186	930	930
NUWC Newport Testing Range	60	60	300	300
SFOMF	34	34	170	170
Total	978	978	4,890	4,890
Lightweight Torpedo Accessories				
Northeast Range Complexes	196	196	977	977
Virginia Capes Range Complex	409	409	1,799	2,042
Navy Cherry Point Range Complex	120	120	597	597
Jacksonville Range Complex	497	497	2,413	2,482
Key West Range Complex	2	2	7	7
Gulf of Mexico Range Complex	196	196	977	977
NUWC Newport Testing Range	60	60	300	300
NSWC Panama City Testing Range	252	252	1,260	1,260
Total	1,732	1,732	8,330	8,330
Non-Explosive Sonobuoy				
Northeast Range Complexes	9,190	9,410	42,949	47,049

Table 3.0-33: Number and Location of Other Military Materials Used or Expended During Testing Activities (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Materials</i>		<i>5-Year # of Materials</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Virginia Capes Range Complex	8,678	8,758	39,659	40,039
Navy Cherry Point Range Complex	2,558	2,638	12,579	13,189
Jacksonville Range Complex	6,344	6,744	30,669	33,719
Key West Range Complex	3,906	3,906	19,109	19,529
Gulf of Mexico Range Complex	4,646	4,646	22,149	23,229
NUWC Newport Testing Range	1,200	1,200	6,000	6,000
SFOMF	32	32	160	160
NSWC Panama City Testing Range	192	192	960	960
Total	36,746	37,526	174,234	187,624
Decelerators/Parachutes – Small				
Northeast Range Complexes	9,190	9,410	42,949	47,049
Virginia Capes Range Complex	8,678	8,758	39,659	40,039
Navy Cherry Point Range Complex	2,558	2,638	12,579	13,189
Jacksonville Range Complex	6,344	6,744	30,669	33,719
Key West Range Complex	3,978	3,978	19,469	19,889
Gulf of Mexico Range Complex	4,646	4,646	22,149	23,229
NUWC Newport Testing Range	1,200	1,200	6,000	6,000
SFOMF	32	32	160	160
NSWC Panama City Testing Range	192	192	960	960
Total	36,818	37,598	174,594	187,984
Decelerators/Parachutes - Medium				
Northeast Range Complexes	33	33	165	165
Virginia Capes Range Complex	196	196	737	980
Navy Cherry Point Range Complex	33	33	165	165
Jacksonville Range Complex	224	224	1,051	1,120
Key West Range Complex	1	1	5	5
Gulf of Mexico Range Complex	33	33	165	165
Total	520	520	2,288	2,288
Sabots				
Northeast Range Complexes	35,003	35,003	175,017	175,017
Virginia Capes Range Complex	35,003	35,003	175,017	175,017
Navy Cherry Point Range Complex	35,003	35,003	175,017	175,017
Jacksonville Range Complex	35,003	35,003	175,017	175,017
Key West Range Complex	35,003	35,003	175,017	175,017
Gulf of Mexico Range Complex	35,003	35,003	175,017	175,017
NUWC Newport Testing Range	383	383	1,912	1,912
Total	210,409	210,409	1,052,048	1,052,048

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

3.0.3.3.4.3 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, recoverable 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 when in place, however during the deployment process, they may pose a physical disturbance or strike risk. The effect of devices on the bottom will be discussed as an alteration of the bottom substrate and associated living resources (e.g., invertebrates and vegetation).

Table 3.0-34 shows the number and location of proposed activities that include the use of seafloor devices.

Table 3.0-34: Number and Location of Activities Including Seafloor Devices

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Virginia Capes Range Complex	7,052	7,052	35,256	35,256
Navy Cherry Point Range Complex	1,365	1,365	6,825	6,825
Jacksonville Range Complex	1,374	1,374	6,860	6,870
Key West Range Complex	37	37	185	185
Gulf of Mexico Range Complex	759	759	3,785	3,795
NSWC Panama City Testing Range	488	488	2,440	2,440
Inland Waters (see Table 3.0-35)	1,052	1,052	5,200	5,260
Total	12,127	12,127	60,551	60,631
Testing				
Northeast Range Complexes	28	28	138	138
Virginia Capes Range Complex	312	317	1,338	1,571
Navy Cherry Point Range Complex	29	29	143	143
Jacksonville Range Complex	83	83	383	383
Key West Range Complex	1	1	3	3
Gulf of Mexico Range Complex	75	75	376	376
NUWC Newport Testing Range	590	590	2,942	2,942
SFOMF	213	213	1,063	1,063
NSWC Panama City Testing Range	534	539	2,499	2,644
Other AFTT Areas	2	2	10	10
Inland Waters (see Table 3.0-35)	2	2	10	10
Total	1,869	1,879	8,905	9,283

Notes: NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility;
NSWC = Naval Surface Warfare Center

Table 3.0-35: Number and Location of Activities in Inland Waters Including Seafloor Devices

<i>Activity Area</i>	<i>Maximum Annual # of Activities</i>		<i>5-Year # of Activities</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Training				
Boston, MA	2	2	6	10
Narragansett, RI	185	185	925	925
Earle, NJ	2	2	6	10
Wilmington, DE	2	2	6	10
Delaware Bay, DE	2	2	6	10
Hampton Roads, VA	4	4	12	20
Lower Chesapeake Bay	490	490	2,450	2,450
James Rivers & Tributaries	198	198	990	990
York River	45	45	225	225
Morehead City, NC	2	2	6	10
Cooper River, SC	60	60	300	300
Savannah, GA	2	2	6	10
Kings Bay, GA	2	2	6	10
Mayport, FL	46	46	226	230
Port Canaveral, FL	2	2	6	10
Tampa, FL	2	2	6	10
Beaumont, TX	4	4	12	20
Corpus Christi, TX	2	2	6	10
Total	1,052	1,052	5,200	5,260
Testing				
Little Creek, VA	1	1	5	5
Norfolk, VA	1	1	5	5
Total	2	2	10	10

3.0.3.3.4.4 Aircraft

Aircraft involved in Navy training and testing activities are separated into three categories: (1) fixed-wing aircraft, (2) rotary-wing aircraft, (3) tilt-rotor aircraft, and (4) unmanned aerial systems. Fixed-wing aircraft include, but are not limited to, planes such as F-35, P-8, F/A-18, and E/A-18G. Rotary-wing aircraft are also referred to as helicopters (e.g., MH-60), and tilt-rotor aircraft include the MV-22. Unmanned aerial systems include a variety of platforms, including but not limited to, the Small Tactical Unmanned Aerial System – Tier II, Triton unmanned aerial system, Fire Scout Vertical Take-off and Landing Unmanned Aerial System, and the Unmanned Combat Air System. Aircraft strikes are only applicable to birds. Table 3.0-36 shows the number and location of proposed activities that include the use of aircraft.

Table 3.0-36: Number and Location of Activities Including Aircraft

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Northeast Range Complexes	92	92	460	460
Virginia Capes Range Complex	16,586	16,583	80,957	80,965
Navy Cherry Point Range Complex	17,008	17,008	85,023	85,035
Jacksonville Range Complex	19,115	19,115	95,555	95,575
Key West Range Complex	29,908	29,908	149,540	149,540
Gulf of Mexico Range Complex	752	758	3,758	3,790
NSWC Panama City Testing Range	244	244	1,220	1,220
Other AFTT Areas	24	24	120	120
Inland Waters (see Table 3.0-37)	1,501	1,501	7,485	7,515
Total	85,230	85,233	424,118	424,220
Testing				
Northeast Range Complexes	738	741	3,403	3,703
Virginia Capes Range Complex	3,343	3,349	15,568	16,623
Navy Cherry Point Range Complex	608	609	3,035	3,043
Jacksonville Range Complex	871	876	4,069	4,314
Key West Range Complex	240	240	1,072	1,198
Gulf of Mexico Range Complex	139	139	610	677
NUWC Newport Testing Range	18	18	86	86
SFOMF	34	34	170	170
NSWC Panama City Testing Range	227	232	1,041	1,158
Inland Waters (see Table 3.0-37)	4	4	16	16
Total	5,995	6,010	28,029	29,830

Notes: NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility;
NSWC = Naval Surface Warfare Center

Table 3.0-37: Number and Location of Activities in Inland Waters Including Aircraft

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Boston, MA	1	1	3	5
Earle, NJ	1	1	3	5
Wilmington, DE	1	1	3	5
Delaware Bay, DE	1	1	3	5
Hampton Roads, VA	2	2	6	10
Lower Chesapeake Bay	68	68	340	340
James Rivers & Tributaries	720	720	3,660	3,660
York River	4	4	20	20

**Table 3.0-37: Number and Location of Activities in Inland Waters Including Aircraft
(continued)**

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Morehead City, NC	1	1	3	5
Savannah, GA	1	1	3	5
Kings Bay, GA	481	481	2,403	2,405
Mayport, FL	165	165	773	775
Port Canaveral, FL	1	1	3	5
Tampa, FL	1	1	3	5
St. Andrews Bay, FL	50	50	250	250
Beaumont, TX	2	2	6	10
Corpus Christi, TX	1	1	3	5
Total	1,501	1,501	7,485	7,515
Testing				
Little Creek, VA	2	2	8	8
Norfolk, VA	2	2	8	8
Total	4	4	16	16

3.0.3.3.5 Entanglement Stressors

This section describes the entanglement stressors introduced into the water through naval training and testing, the relative magnitude and location of these activities, and provides the basis for analysis of potential impacts on 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 (e.g., size and rigidity) for their potential to entangle marine animals. For a constituent of military expended materials to entangle a marine animal, the item must be flexible enough to wrap around the animal or appendages, or trapped in the jaw, baleen, etc. This analysis includes the potential impacts from three types of military expended materials: (1) wires and cables, (2) decelerators/parachutes, and (3) biodegradable polymer. Unlike typical fishing nets and lines, the Navy's equipment, other than biodegradable polymer, 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.

3.0.3.3.5.1 Wires and Cables

Fiber Optic Cables

Fiber optic cables are expended during Navy training and testing associated with remotely operated mine neutralization activities. The length of the cable varies (up to about 3,000 m). The physical properties of the fiber optic cable would not allow the cable to loop before it breaks. Fiber optic cables are somewhat flexible, durable, and abrasion or chemical-resistant. The physical characteristics of the fiber optic material render the cable easily broken when kinked, twisted, or bent sharply. 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 seafloor.

Guidance Wires

Guidance wires are used during heavy-weight torpedo firings to help the firing platform control and steer the torpedo. They trail behind the torpedo as it moves through the water. Finally, the guidance wire is released from both the firing platform and the torpedo 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 lb. and can be broken by hand (Environmental Sciences Group, 2005) which minimizes the potential for entanglement of marine animals (National Marine Fisheries Service, 2008), contrasting with the rope or lines associated with commercial fishing towed gear (trawls), stationary gear (traps), or entanglement gear (gillnets) that use lines with substantially higher (up to 500–2,000 lb.) breaking strength as their “weak links.” The relatively low breaking strength and resistance to looping and coiling suggest that torpedo guidance wire does not have a high entanglement potential compared to other entanglement hazards (Swope & McDonald, 2013). Torpedo guidance wire sinks at a rate of 0.24 m per second (Swope & McDonald, 2013).

Sonobuoy Wire

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

Bathythermographs are similar to sonobuoys in that they consist of an antenna, a float unit, and a subsurface unit (to measure temperature of the water column in the case of the bathythermograph) that is connected to the float unit by a wire. The bathythermograph wire is similar to the sonobuoy wire described above.

Table 3.0-38 and Table 3.0-39 show the number and location of wires and cables expended during proposed training and testing activities.

Table 3.0-38: Number and Location of Wires and Cables Expended During Training Activities

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Fiber Optic Cables				
Virginia Capes Range Complex	762	762	3,806	3,810
Navy Cherry Point Range Complex	88	88	440	440
Jacksonville Range Complex	165	165	821	825
Gulf of Mexico Range Complex	154	154	766	770
Total	1,169	1,169	5,833	5,845

**Table 3.0-38: Number and Location of Wires and Cables Expended During Training Activities
(continued)**

<i>Activity Area</i>	<i>Maximum Annual # of Materials</i>		<i>5-Year # of Materials</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Guidance Wires				
Northeast Range Complexes	24	24	120	120
Virginia Capes Range Complex	8	8	40	40
Jacksonville Range Complex	48	48	240	240
SINKEX Area	1	1	5	5
Total	81	81	405	405
Sonobuoy Wires				
Northeast Range Complexes	3,128	3,128	15,640	15,640
Virginia Capes Range Complex	8,218	8,218	40,907	41,090
Navy Cherry Point Range Complex	2,959	2,959	14,402	14,795
Jacksonville Range Complex	30,328	30,328	149,861	151,640
Gulf of Mexico Range Complex	0	785	0	3,925
SINKEX Area	480	480	2,400	2,400
Total	45,113	45,898	223,210	229,490
Expendable Bathythermograph Wires				
Northeast Range Complexes	139	142	695	708
Virginia Capes Range Complex	329	439	1,640	2,193
Navy Cherry Point Range Complex	85	113	422	563
Jacksonville Range Complex	1,171	1,391	5,490	6,953
Gulf of Mexico Range Complex	3	128	13	640
Other AFTT Areas	155	155	771	771
Total	1,882	2,368	9,031	11,828

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

Table 3.0-39: Number and Location of Wires and Cables Expended During Testing Activities

<i>Activity Area</i>	<i>Maximum Annual # of Materials</i>		<i>5-Year # of Materials</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Fiber Optic Cables				
Virginia Capes Range Complex	430	450	1,830	2,250
Jacksonville Range Complex	100	100	500	500
Key West Range Complex	200	200	1,000	1,000
NSWC Panama City Testing Range	412	432	1,948	2,160
Total	1,142	1,182	5,278	5,910

**Table 3.0-39: Number and Location of Wires and Cables Expended During Testing Activities
(continued)**

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Guidance Wires				
Northeast Range Complexes	190	190	950	950
Virginia Capes Range Complex	220	220	1,100	1,100
Navy Cherry Point Range Complex	52	52	260	260
Jacksonville Range Complex	234	234	1,170	1,170
Key West Range Complex	2	2	10	10
Gulf of Mexico Range Complex	186	186	930	930
NUWC Newport Testing Range	60	60	300	300
SFOMF	34	34	170	170
Total	978	978	4,890	4,890
Sonobuoy Wires				
Northeast Range Complexes	9,290	9,410	42,949	47,049
Virginia Capes Range Complex	8,678	8,758	39,659	43,789
Navy Cherry Point Range Complex	2,558	2,638	12,579	13,189
Jacksonville Range Complex	6,344	6,744	30,669	33,719
Key West Range Complex	3,978	3,978	19,469	19,889
Gulf of Mexico Range Complex	4,646	4,646	22,149	23,229
NUWC Newport Testing Range	1,200	1,200	6,000	6,000
SFOMF	32	32	160	160
NSWC Panama City Testing Range	192	192	960	960
Total	36,918	37,598	174,594	187,984
Expendable Bathythermograph Wires				
Northeast Range Complexes	1,835	1,835	9,171	9,171
Virginia Capes Range Complex	1,019	1,019	5,065	5,095
Navy Cherry Point Range Complex	315	315	1,575	1,575
Jacksonville Range Complex	637	637	3,155	3,185
Key West Range Complex	10	10	50	50
Gulf of Mexico Range Complex	978	978	4,890	4,890
SFOMF	4	4	20	20
Total	4,798	4,798	23,926	23,986

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

3.0.3.3.5.2 Decelerators/Parachutes

Aircraft-launched sonobuoys and lightweight torpedoes (such as the MK 46 and MK 54) use nylon decelerators/parachutes ranging in size from 18 in. (small) to 48 in. (medium) in diameter. The majority are relatively small (18 in.) cruciform shape decelerators/parachutes associated with sonobuoys (Figure 3.0-13). Illumination flares and targets use large decelerators/parachutes, up to approximately 19 ft. in diameter. Decelerators/parachutes are made of cloth and nylon, many with weights attached to their

short attachment lines to speed their sinking. At water impact, the decelerator/parachute assembly is expended and sinks away from the unit. The decelerator/parachute assembly may remain at the surface for 5–15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Environmental Sciences Group, 2005). Once settled on the bottom the canopy may temporarily billow if bottom currents are present. Table 3.0-31 and Table 3.0-32.

Table 3.0-33 show the number and location of decelerator/parachutes expended during proposed training and testing activities.



Figure 3.0-13: Sonobuoy Launch Depicting the Relative Size of a Parachute

3.0.3.3.5.3 Biodegradable Polymer

Marine Vessel Stopping payloads are systems designed to deliver the appropriate measure(s) to affect a vessel's propulsion and associated control surfaces to significantly slow and potentially stop the advance of the vessel. Marine Vessel Stopping proposed activities include the use of biodegradable polymers designed to entangle the propellers of in-water vessels. A biodegradable polymer is a high molecular weight polymer that degrades to smaller compounds as a result of microorganisms and enzymes. The rate of biodegradation could vary from hours to years and the type of small molecules formed during degradation can range from complex to simple products, depending on whether the polymers are natural or synthetic (Karlsson & Albertsson, 1998). Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material will breakdown into small pieces within a few days to weeks. This will breakdown further and dissolve into the water column within weeks to a few months. The final products which are all environmentally benign will be dispersed quickly to undetectable concentrations. Degradation and dispersal timelines are influenced by water temperature, currents, and other oceanographic features. Overall, the longer the polymer remains in the water, the weaker it becomes making it more brittle and likely to break.

Biodegradable polymers will be used only during proposed testing activities, not during training activities. Table 3.0-40 shows the number and location of proposed testing activities that use biodegradable polymer.

Table 3.0-40: Activities Including Biodegradable Polymers During Testing Activities

<i>Activity Area</i>	<i>Maximum Annual # of Activities</i>		<i>5-Year # of Activities</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Biodegradable Polymer				
Virginia Capes Range Complex	30	30	150	150
Jacksonville Range Complex	30	30	150	150
Key West Range Complex	30	30	150	150
Gulf of Mexico Range Complex	30	30	150	150
NUWC Newport Testing Range	30	30	150	150
Total	150	150	750	750

Notes: NUWC = Naval Undersea Warfare Center

3.0.3.3.6 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 in order to provide the basis for analysis of potential impacts on 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 high-explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and decelerators/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 regarding ingestion.

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

3.0.3.3.6.1 Non-Explosive Practice Munitions

Only small- or medium-caliber projectiles and flechettes (small metal darts) from some non-explosive rockets 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. in diameter. Flechettes from some non-explosive rockets are approximately 2 in. in length. Each non-explosive flechette rocket contains approximately 1,180 individual flechettes that are released. These solid metal materials would quickly move through the water column and settle to the seafloor. Table 3.0-23 and Table 3.0-25 show the number and location of non-explosive practice munitions used during proposed training and testing activities.

3.0.3.3.6.2 Fragments from High-Explosive Munitions

Many different types of high-explosive munitions can result in fragments that are expended at sea during training and testing activities.

Types of high-explosive munitions that can result in fragments include torpedoes, neutralizers, grenades, projectiles, missiles, rockets, buoys, sonobuoys, anti-torpedo countermeasures, mines, 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; typical sizes of fragments are unknown. These solid metal materials would quickly sink through the water column and settle to the seafloor. Table 3.0-26 and Table 3.0-27 show the number and location of explosives used during training and testing activities that may result in fragments.

3.0.3.3.6.3 Military Expended Materials Other Than Munitions

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

Target-Related Materials

At-sea targets are usually remotely-operated airborne, surface, or subsurface traveling units, many of which are designed to be recovered for reuse. However, if they are used during activities that use high-explosives then they may result in fragments and ultimate loss of the target. Expendable targets that may result in fragments would include air-launched decoys, surface targets (e.g., marine markers, cardboard boxes, and 10 ft. 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. Only targets that may result in smaller fragments are included in the analyses of ingestion potential.

There are additional types of targets discussed previously, but only surface targets, air targets, ship hulks, and mine shapes would be expected to result in fragments when high-explosive munitions are used. Table 3.0-41 and Table 3.0-42 show the number and location of targets used during proposed training and testing activities that may result in fragments.

Table 3.0-41: Number and Location of Targets Expended During Training Activities That May Result in Fragments

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Air Targets				
Northeast Range Complexes	4	4	20	20
Virginia Capes Range Complex	78	78	390	390
Navy Cherry Point Range Complex	85	85	425	425
Jacksonville Range Complex	65	65	325	325
Key West Range Complex	8	8	40	40
Gulf of Mexico Range Complex	8	8	40	40
Total	248	248	1,240	1,240
Surface Targets				
Northeast Range Complexes	2	2	10	10

Table 3.0-41: Number and Location of Targets Expended During Training Activities That May Result in Fragments (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Targets</i>		<i>5-Year # of Targets</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Virginia Capes Range Complex	3,876	3,876	6,095	6,095
Navy Cherry Point Range Complex	598	598	2,990	2,990
Jacksonville Range Complex	775	775	3,875	3,875
Gulf of Mexico Range Complex	51	51	255	255
Other AFTT Areas	3	3	15	15
Total	5,305	5,305	13,240	13,240
Subsurface Targets				
Northeast Range Complexes	100	102	498	510
Virginia Capes Range Complex	291	401	1,455	2,055
Navy Cherry Point Range Complex	81	108	403	540
Jacksonville Range Complex	1,108	1,328	5,540	6,640
Gulf of Mexico Range Complex	3	5	12	25
Other AFTT Areas	178	178	891	891
Total	1,761	2,122	8,799	10,661
Mine Shapes				
Virginia Capes Range Complex	292	292	1,456	1,460
Navy Cherry Point Range Complex	24	24	120	120
Jacksonville Range Complex	60	60	292	300
Key West Range Complex	8	8	40	40
Gulf of Mexico Range Complex	60	60	292	300
Inland Waters (see Table 3.0-42)	60	60	204	340
Total	504	504	2,584	2,860

Notes: AFTT = Atlantic Fleet Training and Testing

Table 3.0-42: Number and Location of Targets Expended During Training Activities in Inland Waters That May Result in Fragments

<i>Activity Area</i>	<i>Maximum Annual # of Targets</i>		<i>5-Year # of Targets</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
Mine Shapes				
Boston, MA	4	4	12	20
Earle, NJ	4	4	12	20
Delaware Bay, DE	4	4	12	20
Hampton Roads, VA	8	8	24	40
Morehead City, NC	8	8	24	40
Wilmington, NC	4	4	12	20
Savannah, GA	4	4	12	20
Kings Bay, GA	4	4	12	20

Table 3.0-42: Number and Location of Targets Expended During Training Activities in Inland Waters That May Result in Fragments (continued)

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Mayport, FL	4	4	12	20
Port Canaveral, FL	8	8	24	40
Tampa, FL	4	4	12	20
Beaumont, TX	8	8	24	40
Corpus Christi, TX	4	4	12	20
Total	68	68	204	340

Table 3.0-43: Number and Location of Targets Expended During Testing Activities That May Result in Fragments

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Air Targets				
Northeast Range Complexes	60	60	300	300
Virginia Capes Range Complex	60	60	300	300
Navy Cherry Point Range Complex	60	60	300	300
Jacksonville Range Complex	60	60	300	300
Key West Range Complex	60	60	300	300
Gulf of Mexico Range Complex	70	70	350	350
Total	370	370	1,850	1,850
Air Targets – Drones				
Northeast Range Complexes	6	6	28	28
Virginia Capes Range Complex	480	480	2,398	2,398
Navy Cherry Point Range Complex	6	6	28	28
Jacksonville Range Complex	174	174	868	868
Key West Range Complex	6	6	28	28
Gulf of Mexico Range Complex	6	6	28	28
NUWC Newport Testing Range	6	6	28	28
SFOMF	6	6	28	28
NSWC Panama City Testing Range	6	6	28	28
Total	696	696	3,462	3,462
Surface Targets				
Northeast Range Complexes	174	174	861	861
Virginia Capes Range Complex	462	462	2,213	2,306
Navy Cherry Point Range Complex	171	171	861	861
Jacksonville Range Complex	290	290	1,317	1,445
Key West Range Complex	173	173	861	861
Gulf of Mexico Range Complex	121	121	881	911

Table 3.0-43: Number and Location of Targets Expended During Testing Activities That May Result in Fragments (continued)

<i>Activity Area</i>	<i>Maximum Annual # of Targets</i>		<i>5-Year # of Targets</i>	
	<i>Alternative 1</i>	<i>Alternative 2</i>	<i>Alternative 1</i>	<i>Alternative 2</i>
NUWC Newport Testing Range	253	253	62	62
SFOMF	13	13	62	62
NSWC Panama City Testing Range	13	13	62	62
Total	1,670	1,670	7,180	7,431
Subsurface Targets				
Northeast Range Complexes	100	100	500	500
Virginia Capes Range Complex	105	105	525	525
Jacksonville Range Complex	265	265	1,325	1,325
Gulf of Mexico Range Complex	100	100	500	500
NUWC Newport Testing Range	240	240	1,200	1,200
Total	810	810	4,050	4,050
Mine Shapes				
Northeast Range Complexes	5,600	5,600	28,000	28,000
Virginia Capes Range Complex	3,172	3,172	15,860	15,860
Jacksonville Range Complex	1,595	1,595	7,975	7,975
Gulf of Mexico Range Complex	2,755	2,755	13,772	13,772
NUWC Newport Testing Range	342	342	1,710	1,710
SFOMF	885	885	4,423	4,423
NSWC Panama City Testing Range	4,309	4,309	21,545	21,545
Total	18,658	18,658	93,285	93,285

Notes: AFTT = Atlantic Fleet Training and Testing; NUWC = Naval Undersea Warfare Center; SFOMF = South Florida Ocean Measurement Facility; NSWC = Naval Surface Warfare Center; SINKEX = Sinking Exercise

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. Department of the 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 (Arfsten et al., 2002; U.S. Department of the Air Force, 1997). Doppler radar has tracked chaff plumes containing approximately 900 g of chaff drifting 200 mi. from the point of release, with the plume covering greater than 400 mi.³ (Arfsten et al., 2002).

The chaff concentrations that marine animals could be exposed to following the 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 (Arfsten et al., 2002; Hullar et al., 1999; U.S. Department of the Air Force, 1997). 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. Department of the 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. Department of the Air Force, 1997). The potential exists for marine animals to inhale chaff fibers if they are at the surface while chaff is airborne. Arfsten et al. (2002), Hullar et al. (1999), and U.S. Department of the 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 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. Department of the 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).

Table 3.0-31 and Table 3.0-33 show the number and location of chaff cartridges, chaff canisters, and chaff components used during training and testing activities.

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. The flare device consists of a cylindrical cartridge approximately 1.4 in. in diameter and 5.8 in. in length. Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic compression pad or piston (0.45 to 4.1 g depending on flare type). The flare pads and pistons float in sea water.

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. Department of the Air Force, 1997).

Table 3.0-31 and Table 3.0-33 show the number and location of flares and flare components expended during training and testing activities.

Decelerators/Parachutes

Decelerators/parachutes are expended with the use of sonobuoys, lightweight torpedoes, and illumination flares. Only the small- and medium-size decelerators/parachutes expended with sonobuoys and lightweight torpedoes pose an ingestion risk to marine life. See Section 3.0.3.3.5.2 (Decelerators/Parachutes) above for a complete description.

Table 3.0-31 and Table 3.0-33 show the number and location of small- and medium-size decelerators/parachutes expended during proposed training and testing activities.

3.0.3.4 Resource-Specific Impacts Analysis for Individual Stressors

The direct and indirect impacts of each stressor are analyzed in each resource section for which there may be an impact. Quantitative methods were used to the extent possible, but data 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) 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, or injury.
- 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.

3.0.3.5 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 inform the 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 co-occur in time and space, 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 contributes to a combined overall adverse impact.

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, or 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 square nautical miles (NM²) of benthic habitat, a second stressor disturbed 0.5 NM², and all other stressors did not disturb benthic habitat, then the total benthic habitat disturbed would be 0.75 NM². 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.

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 Code of Federal Regulations section 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.

3.0.3.6 Biological Resource Methods

The analysis of impacts on biological resources focused on the likelihood of encountering the stressor, the primary stimulus, response, and recovery of individual organisms. Where appropriate, the potential of a biological resource to overlap with a stressor was analyzed with consideration given to the specific geographic area (large marine ecosystems, open ocean areas, range complexes, OPAREAs, and other training and testing areas) in which the overlap could occur. Additionally, the differential impacts of training versus testing activities that introduce stressors to the resource were considered.

For each of the non-biological resources considered in this EIS/OEIS, the methods are unique to each specific resource and are therefore described in each resource section. For Air Quality see Section 3.1.1.1 (Methods), for Sediments and Water Quality see Section 3.2.1.2 (Methods), for Cultural Resources see Section 3.10.1.3 (Methods), for Socioeconomics see Section 3.11.1 (Introduction and Methods), and for Public Health and Safety see the Methods discussion under 3.12.1 (Introduction).

3.0.3.6.1 Conceptual Framework for Assessing Effects from Acoustic and Explosive Activities

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

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

The categories of potential effects are:

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

Figure 3.0-14 is a flowchart that diagrams the process used to evaluate the potential effects to marine animals exposed to sound-producing activities. The shape and color of each box on the flowchart represent either a decision point in the analysis (green diamonds); specific processes such as responses, costs, or recovery (blue rectangles); external factors to consider (purple parallelograms); and final outcomes for the individual or population (orange ovals and rectangles). Each box is labeled for reference throughout the following sections. For simplicity, sound is used here to include not only sound waves but also blast waves generated from explosive sources. Box A1, the Sound-Producing Activity, is the source of this stimuli and therefore the starting point in the analysis.

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

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

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

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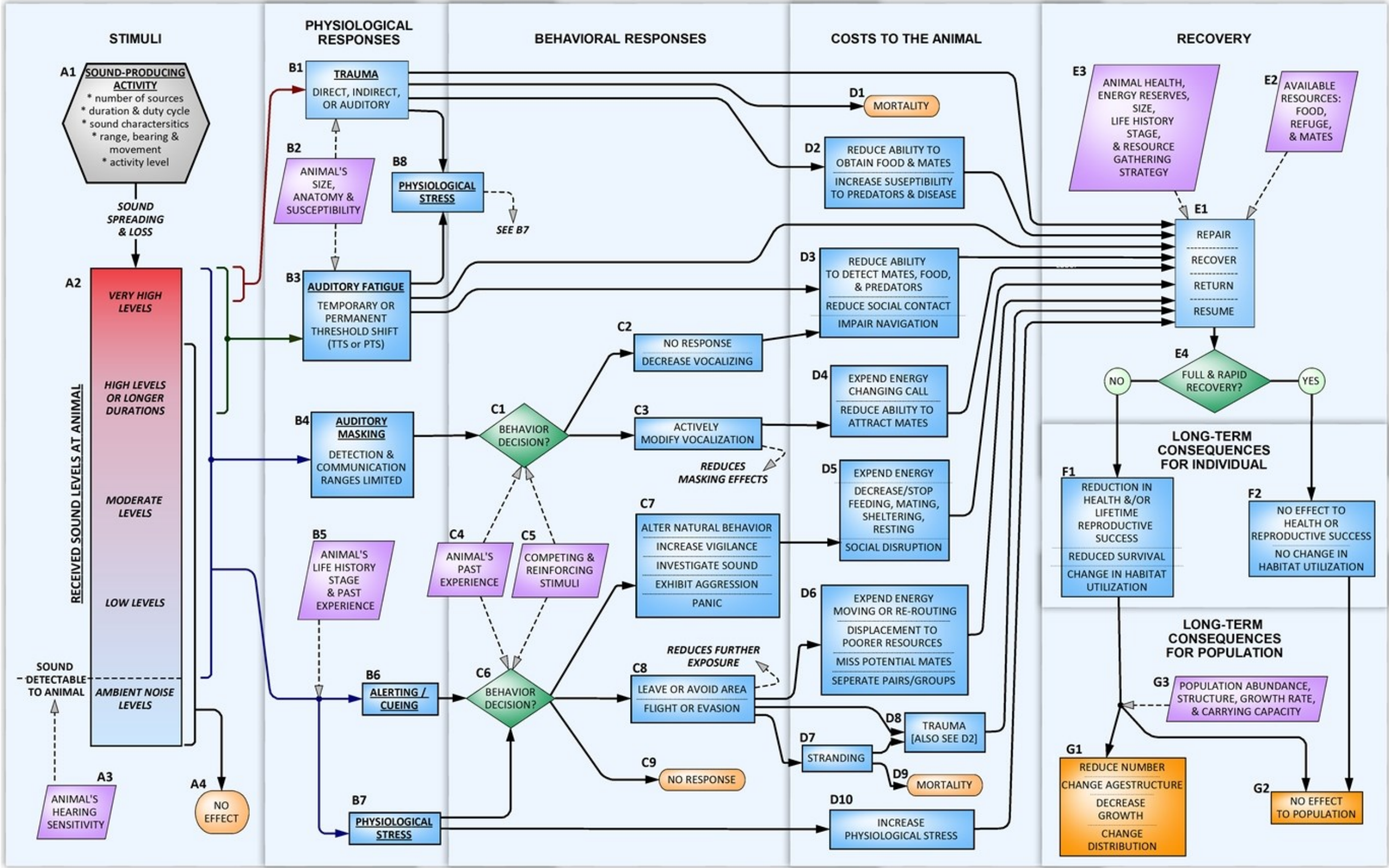


Figure 3.0-14: Flow Chart of the Evaluation Process of Sound-Producing Activities

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3.0.3.6.1.1 Injury

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

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

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

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

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

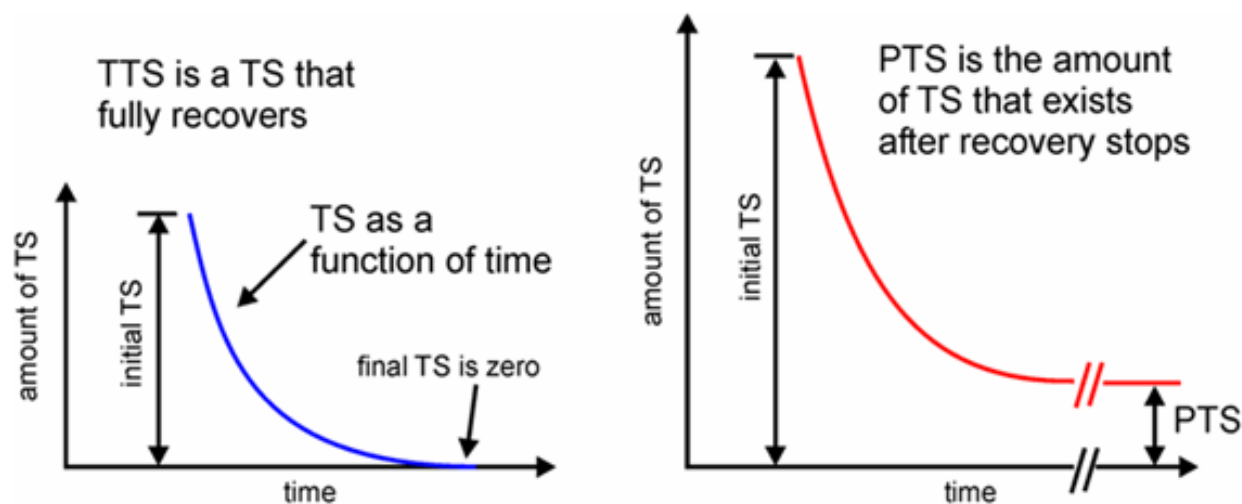
Injury could increase the animal's physiological stress (Box B8), which feeds into the stress response (Box B7) and also increases the likelihood or severity of a behavioral response. Injury may reduce an animal's ability to secure food by reducing its mobility or the efficiency of its sensory systems,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

Damaged tissues from mild to moderate injury may heal over time. The predicted recovery of direct injury is based on the severity of the injury, availability of resources, and characteristics of the animal. The animal may also need to recover from any potential costs due to a decrease in resource gathering

efficiency and any secondary effects from predators or disease. Severe injuries can lead to reduced survivorship (longevity), elevated stress levels, and prolonged alterations in behavior that can reduce an animal's lifetime reproductive success. An animal with decreased energy stores or a lingering injury may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring produced over its lifetime.

3.0.3.6.1.2 Hearing Loss

Hearing loss, also called a noise-induced threshold shift, is possibly the best studied type of effect from sound exposures to animals. Hearing loss manifests itself as loss in hearing sensitivity across part of an animal's hearing range, which is dependent upon the specifics of the noise exposure. Hearing loss may be either permanent threshold shift (PTS), or temporary threshold shift (TTS). If the threshold shift eventually returns to zero (the animal's hearing returns to pre-exposure value), the threshold shift is a TTS. If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 3.0-15 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.



Notes: PTS = Permanent Threshold Shift, TS = Threshold Shift, TTS = Temporary Threshold Shift

Figure 3.0-15: Two Hypothetical Threshold Shifts

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

The mechanisms responsible for hearing loss may consist of a variety of mechanical and biochemical processes in the inner ear, including physical damage or distortion of the tympanic membrane (not including tympanic membrane rupture which is considered auditory injury), physical damage or

distortion of the cochlear hair cells, hair cell death, changes in cochlear blood flow, and swelling of cochlear nerve terminals (Henderson et al., 2006; Kujawa & Liberman, 2009). Although the outer hair cells are the most prominent target for fatigue effects, severe noise exposures may also result in inner hair cell death and loss of auditory nerve fibers (Henderson et al., 2006).

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

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

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

3.0.3.6.1.3 Masking

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

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

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

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

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

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

3.0.3.6.1.4 Physiological Stress

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

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

The generalized stress response is characterized by a release of hormones (Reeder & Kramer, 2005) and other chemicals (e.g., stress markers) such as reactive oxidative compounds associated with noise-induced hearing loss (Henderson et al., 2006). Stress hormones include norepinephrine and epinephrine (i.e., the catecholamines), which produce elevations in the heart and respiration rate,

increase awareness, and increase the availability of glucose and lipid for energy. Other stress hormones are the glucocorticoid steroid hormones cortisol and aldosterone, which are classically used as an indicator of a stress response and to characterize the magnitude of the stress response (Hennessy et al., 1979).

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

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

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

3.0.3.6.1.5 Behavioral Reactions

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

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

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

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

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

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

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

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

3.0.3.6.1.6 Long-Term Consequences

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

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

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

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

3.0.3.6.2 Conceptual Framework for Assessing Effects from Energy-Producing Activities

3.0.3.6.2.1 Stimuli

Magnitude of the Energy Stressor

Regulations do not provide threshold criteria to determine the significance of the potential effects from activities that involve the use of varying electromagnetic frequencies or lasers. Many organisms, primarily marine vertebrates, have been studied to determine their thresholds for detecting electromagnetic fields, as reviewed by Normandeau et al. (2011); however, there are no data on predictable responses to exposure above or below detection thresholds. The types of electromagnetic fields discussed are those from mine neutralization activities (magnetic influence minesweeping). High-energy and low-energy lasers were considered for analysis. Low-energy lasers (e.g., targeting systems, detection systems, laser light detection and ranging) do not pose a risk to organisms (Swope, 2010) and therefore will not be discussed further. Radar was also considered for analysis, and also was determined not to pose a risk to biological resources.

Location of the Energy Stressor

Evaluation of potential energy exposure risks considered the spatial overlap of the resource occurrence and electromagnetic field and high-energy laser use. Wherever appropriate, specific geographic areas of potential impact were identified and the relative location of the resource with respect to the source was considered. For example, the greatest potential electromagnetic energy exposure is at the source, where intensity is greatest and the greatest potential for high energy laser exposure is at the ocean's surface, where high-energy laser intensity is greatest. All light energy, including laser light, entering the ocean becomes absorbed and scattered at a rate that is dependent on the frequency of the light. For most laser applications, the energy is rapidly reduced as the light penetrates the ocean.

Behavior of the Organism

Evaluation of potential energy exposure risk considered the behavior of the organism, especially where the organism lives and feeds (e.g., surface, water column, seafloor). The analysis for electromagnetic devices considered those species with the ability to perceive or detect electromagnetic signals. The analysis for high-energy lasers and radar particularly considered those species known to occur at or above the surface of the ocean.

3.0.3.6.2.2 Immediate Response and Costs to the Individual

Many different types of organisms (e.g., some invertebrates, fishes, sea turtles, birds, mammals) are sensitive to electromagnetic fields (Normandeau et al., 2011). An organism that encounters a disturbance in an electromagnetic field could respond by moving toward the source, moving away from it, or not responding at all. The types of electromagnetic devices used in the Proposed Action simulate the electromagnetic signature of a vessel passing through the water column, so the expected response would be similar to that of vessel movement. However, since there would be no actual strike potential, a physiological response would be unlikely in most cases. Recovery of an individual from encountering electromagnetic fields would be variable, but since the physiological response would likely be minimal, as reviewed by Normandeau et al. (2011), any recovery time would also be minimal.

Very little data are available to analyze potential impacts on organisms from exposure to high energy lasers. For all but the highest energy lasers, the greatest laser-related concern for marine species is damage to an organism's ability to see.

3.0.3.6.2.3 Long-Term Consequences to the Individual and Population

Long-term consequences are considered in terms of a resource's existing population level, growth and mortality rates, other stressors on the resource from the Proposed Action, cumulative impacts on the resource, and the ability of the population to recover from or adapt to impacts. Impacts of multiple or repeated stressors on individuals are cumulative.

3.0.3.6.3 Conceptual Framework for Assessing Effects from Physical Disturbance or Strike

3.0.3.6.3.1 Stimuli

Size and Weight of the Objects

To determine the likelihood of a strike and the potential impacts on an organism or habitat that would result from a physical strike, the size and weight of the striking object relative to the organism or habitat must be considered. For example, most small organisms and early life stages would simply be displaced by the movement generated by a large object moving through, or falling into, the water, whereas a

larger organism could potentially be struck by an object since it may not be displaced by the movement of the water. The weight of the object is also a factor that would determine the severity of a strike. A strike by a heavy object would be more severe than a strike by a low-weight object (e.g., a decelerator/parachute, flare end cap, or chaff canister).

Location and Speed of the Objects

Evaluation of potential physical disturbance or strike risk considered the spatial overlap of the resource occurrence and potential striking objects. Analysis of impacts from physical disturbance or strike stressors focuses on proposed activities that may cause an organism or habitat to be struck by an object moving through the air (e.g., aircraft), water (e.g., vessels, in-water devices, towed devices), or dropped into the water (e.g., non-explosive practice munitions and seafloor devices). The area of operation, vertical distribution, and density of these items also play central roles in the likelihood of impact. Wherever appropriate, specific geographic areas of potential impact are identified. Analysis of potential physical disturbance or strike risk also considered the speed of vessels as a measure of intensity. Some vessels move slowly, while others are capable of high speeds.

Buoyancy of the Objects

Evaluation of potential physical disturbance or strike risk in the ocean considered the buoyancy of targets or expended materials during operation, which will determine whether the object will be encountered at the surface, within the water column, or on the seafloor.

Behavior of the Organism

Evaluation of potential physical disturbance or strike risk considered where organisms occur and if they occur in the same geographic area and vertical distribution as those objects that pose strike risks.

3.0.3.6.3.2 Immediate Response and Costs to the Individual

Before being struck, some organisms would sense a pressure wave through the water and respond by remaining in place, moving away from the object, or moving toward it. An organism displaced a small distance by movements from an object falling into the water nearby would likely continue on with no response. However, others could be disturbed and may exhibit a generalized stress response. If the object actually hit the organism, direct injury in addition to stress may result. The function of the stress response in vertebrates is to rapidly raise the blood sugar level to prepare the organism to flee or fight. This generally adaptive physiological response can become a liability if the stressor persists and the organism cannot return to its baseline physiological state.

Most organisms would respond to sudden physical approach or contact by darting quickly away from the stimulus. Other species may respond by freezing in place or seeking refuge. In any case, the individual must stop whatever it was doing and divert its physiological and cognitive attention to responding to the stressor. The energy costs of reacting to a stressor depend on the specific situation, but in all cases the caloric requirements of stress reactions reduce the amount of energy available to the individual for other functions such as predator avoidance, reproduction, growth, and metabolism.

The ability of an organism to return to what it was doing following a physical strike (or near miss resulting in a stress response) is a function of fitness, genetic, and environmental factors. Some organisms are more tolerant of environmental or human-caused stressors than others and become acclimated more easily. Within a species, the rate at which an individual recovers from a physical disturbance or strike may be influenced by its age, sex, reproductive state, and general condition. An organism that has reacted to a sudden disturbance by swimming at burst speed would tire after some

time; its blood hormone and sugar levels may not return to normal for 24 hours. During the recovery period, the organism may not be able to attain burst speeds and could be more vulnerable to predators. If the individual were not able to regain a steady state following exposure to a physical stressor, it may suffer depressed immune function and even death.

3.0.3.6.3.3 Long-Term Consequences to the Population

Long-term consequences are considered in terms of a resource's existing population level, growth and mortality rates, other stressors on the resource from the Proposed Action, cumulative impacts on the resource, and the ability of the population to recover from or adapt to impacts. Impacts of multiple or repeated stressors on individuals are cumulative.

3.0.3.6.4 Conceptual Framework for Assessing Effects from Entanglement

3.0.3.6.4.1 Stimuli

Physical Properties of the Objects

For an organism to become entangled in military expended materials, the materials must have certain properties, such as the ability to form loops and a high breaking strength. Some items could have a relatively low breaking strength on their own, but that breaking strength could be increased if multiple loops were wrapped around an entangled organism.

Physical Features of the Resource

The physical makeup of the organism itself is also considered when evaluating the risk of entanglement. Some species, by their size or physical features, are more susceptible to entanglement than others. For example, more rigid bodies with protruding snouts (e.g., hammerhead shark) or large, rigid fins (e.g., humpback whale) would have an increased risk of entanglement when compared to species with smoother, streamlined bodies such as lamprey or eels.

Location of the Objects

Evaluation of potential entanglement risk considered the spatial overlap of the resource occurrence and military expended materials. Distribution and density of expended items play a central role in the likelihood of impact. Wherever appropriate, specific geographic areas of potential impact are identified.

Buoyancy of Objects

Evaluation of potential entanglement risk considered the buoyancy of military expended materials to determine whether the object will be encountered within the water column (including the surface) or on the seafloor. Less buoyant materials, such as torpedo guidance wires, sink rapidly to the seafloor. More buoyant materials include less dense items (e.g., decelerators/parachutes) that are weighted and would sink slowly to the seafloor and could be entrained in currents.

Behavior of the Organism

Evaluation of potential entanglement risk considered the general behavior of the organism, including where the organism typically occurs (e.g., surface, water column, seafloor). The analysis particularly considered those species known to become entangled in nonmilitary expended materials (e.g., "marine debris") such as fishing lines, nets, rope, and other derelict fishing gear that often entangle marine organisms.

3.0.3.6.4.2 Immediate Response and Costs to the Individual

The potential impacts of entanglement on a given organism depend on the species and size of the organism. Species that have protruding snouts, fins, or appendages are more likely to become entangled than smooth-bodied organisms. Also, items could get entangled by an organism's mouth, if caught on teeth or baleen, with the rest of the item trailing alongside the organism. Materials similar to fishing gear, which is designed to entangle an organism, would be expected to have a greater entanglement potential than other materials. An entangled organism would likely try to free itself of the entangling object and in the process may become even more entangled, possibly leading to a stress response. The net result of being entangled by an object could be disruption of the normal behavior, injury due to lacerations, and other sublethal or lethal impacts.

3.0.3.6.4.3 Long-Term Consequences to the Individual and Population

Consequences of entanglement could range from an organism successfully freeing itself from the object or remaining entangled indefinitely, possibly resulting in lacerations and other sublethal or lethal impacts. Stress responses or infection from lacerations could lead to latent mortality. The analysis will focus on reasonably foreseeable long-term consequences of the direct impact, particularly those that could impact the fitness of an individual. Changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success could have population-level impacts if enough individuals are impacted. This population-level impact would vary among species and taxonomic groups.

3.0.3.6.5 Conceptual Framework for Assessing Effects from Ingestion

3.0.3.6.5.1 Stimuli

Size of the Objects

To assess the ingestion risk from military expended materials, this analysis considered the size of the object relative to the animal's ability to swallow it. Some items are too large to be ingested (e.g., non-explosive practice bombs and most targets) and impacts from these items are not discussed further. However, these items may potentially break down into smaller ingestible pieces over time. Items that are of ingestible size when they are introduced into the environment and when they break down are carried forward for analysis within each resource section where applicable.

Location of the Objects

Evaluation of potential ingestion risk considered the spatial overlap of the resource occurrence and military expended materials. The distribution and density of expended items play a central role in the likelihood of impact. Wherever appropriate, specific geographic areas of potential impact were identified.

Buoyancy of the Objects

Evaluation of potential ingestion risk considered the buoyancy of military expended materials to determine whether the object will be encountered within the water column (including the surface) or on the seafloor. Less buoyant materials, such as solid metal materials (e.g., projectiles or munitions fragments), sink rapidly to the seafloor. More buoyant materials include less dense items (e.g., target fragments and decelerators/parachutes) that may be caught in currents and gyres or entangled in floating *Sargassum*. These materials can remain in the water column for an indefinite period of time before sinking. However, decelerators/parachutes are weighted and would generally sink, unless that sinking is suspended, in the scenario described here.

Feeding Behavior

Evaluation of potential ingestion risk considered the feeding behavior of the organism, including where (e.g., surface, water column, seafloor) and how (e.g., filter feeding) the organism feeds and what it feeds on. The analysis particularly considered those species known to ingest nonfood items (e.g., plastic or metal items).

3.0.3.6.5.2 Immediate Response and Costs to the Individual

Potential impacts of ingesting foreign objects on a given organism depend on the species and size of the organism. Species that normally eat spiny hard-bodied invertebrates would be expected to have tougher mouths and guts than those that normally feed on softer prey. Materials similar in size and shape to the normal diet of an organism may be more likely to be ingested without causing harm to the animal; however, some general assumptions were made. Relatively small objects with smooth edges, such as shells or small-caliber projectiles, might pass through the digestive tract without causing harm. A small sharp-edged item may cause the individual immediate physical distress by tearing or cutting the mouth, throat, or stomach. If the object is rigid and large (relative to the individual's mouth and throat), it may block the throat or obstruct digestive processes. An object may even be enclosed by a cyst in the gut lining. The net result of ingesting large foreign objects is disruption of the normal feeding behavior, which could be sublethal or lethal.

3.0.3.6.5.3 Long-Term Consequences to the Individual and Population

The consequences of ingesting nonfood items could be nutrient deficiency, bioaccumulation, uptake of toxic chemicals, compaction, and mortality. The analysis focused on reasonably foreseeable long-term consequences of the direct impact, particularly those that could impact the fitness of an individual. Changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success could have population-level impacts if enough individuals were impacted. This population-level impact would vary among species and taxonomic groups.

3.0.3.6.6 Conceptual Framework for Assessing Effects from Secondary Stressors

This conceptual framework describes the potential effects to marine species exposed to stressors indirectly through impacts on habitat and prey availability (e.g., sediment or water quality, and physical disturbance). Stressors from Navy training and testing activities could pose indirect impacts to marine biological resources via indirect effects to habitat or to prey. These include indirect impacts from (1) explosives, explosion byproducts and unexploded munitions, (2) metals, (3) chemicals, and (4) transmission of disease and parasites. The methods used to determine secondary stressors on marine resources are presented below. Once a category of primary stressor has been analyzed to determine how a marine biological resource is impacted, an analysis follows of how a secondary stressor is potentially impacting a marine resource. After the secondary stressors are identified, a determination on the significance of the secondary impact is made. The same criteria to determine the level of significance for primary impacts are used for secondary stressors. In addition, it is possible for a significant primary impact to produce a beneficial indirect impact. For example, sinking exercises could generate a significant impact to the seafloor and surrounding habitats, while causing a potential beneficial secondary impact by creating hard-bottom habitat for invertebrates, producing a food source for fishes, and creating structural refuges for other biological resources.

3.0.3.6.6.1 Secondary Stressors

Impacts on Habitat

Primary impacts defined in each marine resource section were used to develop a conceptual model to predict the potential secondary stressors on each habitat or 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., habitat alteration, changes in animal behavior or physiology, injury, mortality, or changes in human use), and the duration and intensity of the impacts of individual stressors. For example, a secondary stressor from a munitions strike could be habitat degradation. The primary impact or stressor is the actual strike on the habitat such as the seafloor, with the introduction of military expended materials, munitions, and fragments inducing further habitat degradation.

Secondary stressors can also induce additive impacts on habitats. These types of impacts are also determined by summing the individual stressors with identical and quantifiable assessment endpoints. For example, if one stressor disturbed 0.25 NM² of benthic habitat, a second stressor disturbed 0.5 NM², and all other stressors did not disturb benthic habitat, then the total benthic habitat disturbed would be 0.75 NM². For stressors with identical but not quantifiable assessment endpoints, potential additive impacts were qualitatively evaluated using available scientific knowledge and best professional judgment. Other habitat impacts such as underwater detonations were assessed by size of charge (net explosive weight), charge radius, height above the seafloor, substrate types in the area, and equations linking all these factors. The analysis also considered that impacts of underwater explosions vary with the bottom substrate type and that the secondary impacts would also be variable among substrate types.

Impacts on Prey Availability

Assessing the impacts of secondary stressors on prey availability falls into two main areas over different temporal scales: the cost to an individual over a relatively short amount of time (short-term) and the cost to an individual or population over a longer period of time (long-term).

3.0.3.6.6.2 Immediate Response and Costs to the Individual

After a primary impact was identified, an analysis of secondary stressors on that resource was initiated. This analysis examined whether indirect impacts would occur after the initial (primary) impact and at what temporal scale that secondary stressor would affect the resource (short-term or long-term). An assessment was then made as to whether the secondary stressor would impact an individual or a population. For example, an underwater explosion could impact a single resource such as a fish or multiple other species in the food web (e.g., prey species such as plankton). The analysis also took into consideration whether the primary impact affected more than an individual or single species. For example, a prey species that would be directly injured or killed by an explosive blast could draw in predators or scavengers from the surrounding waters that would feed on those organisms, and in turn could be more directly susceptible to being injured or killed by subsequent explosions. For purposes of this analysis, indirect impacts on a resource did not require trophic transfer (e.g., bioaccumulation) in order to be observed. It is important to note that the terms “indirect” and “secondary” describe how the impact may occur in an organism or its ecosystem and does not imply reduced severity of environmental consequences.

3.0.3.6.6.3 Long-Term Consequences to the Individual and Population

Long-term consequences of secondary stressors on an individual or population are often difficult to determine. Once a primary impact is identified, the severity of that impact helps to determine the temporal scale at which the secondary stressor can be measured. For most marine resources, the abundance of prey species near a detonation point would be diminished for a short period (weeks to months) before being repopulated by animals from adjacent waters. In some extreme cases, recovery of the habitat or prey resources could occur over a relatively long time frame (months to years). It is important to note that indirect impacts often differ among resources, spatial, and temporal scales.

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