Final
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.

Resources Analyzed:
Physical Resources:
- Air Quality
- Sediments and Water Quality

Biological Resources:
- Vegetation
- Invertebrates
- Habitats
- Fishes
- Marine Mammals
- Reptiles
- Birds and Bats

Human Resources:
- Cultural Resources
- Socioeconomic Resources
- Public Health and Safety

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 and bats (Sections 3.3 through 3.9). Following the biological resource sections are human resource sections: cultural resources, socioeconomic resources, and public health and safety (Sections 3.10, 3.11, and 3.12).

3.0.1 Navy Compiled and Generated Data

While preparing this document, the United States (U.S.) Department of the Navy (Navy) used the best available data, science, and information accepted by the relevant and 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 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 data that supports analysis of marine mammal occurrence, distribution, abundance, and habitat use preferences in and around ocean areas in the Atlantic and Pacific where the Navy conducts training and testing. More recently, the priority has begun to shift towards assessing the potential response of individual species to training and testing activities. Data collected through the monitoring program serves to inform the analysis of impacts on marine mammals with respect to species distribution, habitat use, and potential responses to training and testing activities. Monitoring is performed using various methods, including visual surveys from surface vessels and aircraft, passive acoustics, and tagging. Additional information on the program is available on the U.S. Navy Marine Species Monitoring Program website, https://www.navymarinespeciesmonitoring.us/, which serves as a public online portal for information on the background, history, and progress of the program and also provides access to reports, documentation, data, and updates on current monitoring projects and initiatives.

The two other Navy programs previously mentioned invest in research on the potential effects of sound on marine species and develop scientific information and analytic tools that support preparation of environmental impact statements (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 and other marine species, including physiological, behavioral, ecological, and population-level effects.[1] 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 Navy's Quantitative Analysis to Determine Impacts to Sea Turtles and Marine Mammals

If proposed Navy activities introduce sound or explosive energy into the marine environment, an analysis of potential impacts on marine species is conducted. Data on the density of animals (number of animals per unit area) of each species and stock is needed, along with criteria and thresholds defining the levels of sound and energy that may cause certain types of impacts. The Navy's acoustic effects model takes the density and the criteria and thresholds as inputs and analyzes Navy training and testing activities. Finally, mitigation and animal avoidance behaviors are considered to determine the number of impacts that could occur. The inputs and process are described below. A detailed explanation of this analysis is provided in the technical report titled *Quantifying Acoustic Impacts on Marine Mammals and Sea*

[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.

Turtles: Methods and Analytical Approach for Phase III Training and Testing (U.S. Department of the Navy, 2018b).

3.0.1.2.1 Marine Species Density Database

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

There is no single source of density data for every area of the world, species, and season because of the fiscal limitations, resources, effort involved in providing survey coverage to sufficiently estimate density, and practical limitations. Therefore, to characterize marine species density for large areas, such as the 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 hierarchal approach to ensure that the most accurate estimates were selected. The highest tier included peer-reviewed published studies of density estimates from spatial models since these provide spatially-explicit density estimates with relatively low uncertainty. Other preferred sources included peer reviewed published studies of density estimates derived from systematic line-transect survey data, the method typically used for the NMFS marine mammal stock assessment reports. In the absence of survey data, information on species occurrence and known or inferred habitat associations have been used to predict densities using model-based approaches including Relative Environmental Suitability models. Because these estimates inherently include a high degree of uncertainty, they were considered the least preferred data source. In cases where a preferred data source was not available, density estimates were selected based on expert opinion from scientists.

The resulting Geographic Information System database includes seasonal density values for every marine mammal and sea turtle species present within the Study Area. This database is described in the technical report titled U.S. Navy Marine Species Density Database Phase III for the Atlantic Fleet Training and Testing Study Area (U.S. Department of the Navy, 2017b), hereafter referred to as the Density Technical Report. These data are used as an input into the Navy Acoustic Effects Model.

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

1. Spatial density models are preferred and used when available because they provide an estimate with the least amount of uncertainty by deriving estimates for divided segments of the sampling area. These models (see Becker et al., 2016; Forney et al., 2015) predict spatial variability of animal presence as a function of habitat variables (e.g., sea surface temperature, seafloor depth,

etc.). This model is developed for areas, species, and, when available, specific timeframes (months or seasons) with sufficient survey data.

2. Stratified design-based density estimates use line-transect survey data with the sampling area divided (stratified) into sub-regions, and a density is predicted for each sub-region (Barlow, 2016; Becker et al., 2016; Bradford et al., 2017; Campbell et al., 2015; Jefferson et al., 2014). While geographically stratified density estimates provide a better indication of a species' distribution within the Study Area, the uncertainty is typically high because each sub-region estimate is based on a smaller stratified segment of the overall survey effort.
3. Design-based density estimations use line-transect survey data from land and aerial surveys designed to cover a specific geographic area (see Carretta et al., 2015). These estimates use the same survey data as stratified design-based estimates, but are not segmented into sub-regions and instead provide one estimate for a large surveyed area.
4. Although relative environmental suitability models provide estimates for areas of the oceans that have not been surveyed using information on species occurrence and inferred habitat associations and have been used in past density databases, these models were not used in the current quantitative analysis.

When interpreting the results of the quantitative analysis, as described in the Density Technical Report, it is important to consider that "each model is limited to the variables and assumptions considered by the original data source provider. No mathematical model representation of any biological population is perfect, and with regards to marine mammal biodiversity, any single model will not completely explain the results" (U.S. Department of the Navy, 2017b). These factors and others described in the Density Technical Report should be considered when examining the estimated impact numbers in comparison to current population abundance information for any given species or stock.

3.0.1.2.2 Developing Acoustic and Explosive Criteria and Thresholds

Information about the numerical sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed to analyze potential impacts to marine species. Revised Phase III criteria and thresholds for quantitative modeling of impacts use the best available existing data from scientific journals, technical reports, and monitoring reports to develop thresholds and functions for estimating impacts on marine species. Working with NMFS, the Navy has developed updated criteria for marine mammals and sea turtles. Criteria for estimating impacts on marine fishes are also used in this analysis, which largely follow 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 (U.S. Department of the Navy, 2012c), recent and emerging science has necessitated an update to these criteria and thresholds for assessing potential impacts on marine mammals and sea turtles. A detailed description of the Phase III acoustic and explosive criteria and threshold development is included in the supporting technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III) (U.S. Department of the Navy, 2017a)* and details are provided in each resource section. A series of behavioral studies, largely funded by the U.S. Navy, has led to a new understanding of how some species of marine mammals react to military sonar. This resulted in developing new behavioral response functions for estimating alterations in behavior. Additional information on auditory weighting functions has also emerged [e.g.,Mulsow et al. (2015)] leading to 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 were largely adopted by NMFS for species within their purview (National Marine Fisheries Service, 2016)).

The Navy also uses criteria for estimating effects to fishes and the ranges to which those effects are likely to occur. A working group of experts generated a technical report that provides numerical criteria and relative likelihood of effects to fish within different hearing groups (i.e., fishes with no swim bladder versus fishes with a swim bladder involved in hearing) (Popper et al., 2014). Where applicable, thresholds and relative risk factors presented in the technical report were used to assist in the analysis of effects to fishes from Navy activities. Details on criteria used to estimate impacts on marine fishes are contained within the appropriate stressor section (e.g., sonar and other transducers, explosives) within Section 3.6 (Fishes). This panel of experts also estimated parametric criteria for the effects of sea turtle exposure to sources located at 'near,' 'intermediate,' and 'far' distances, assigning 'low,' 'medium,' and 'high' probability to specific categories of behavioral impacts (Popper et al., 2014).

3.0.1.2.3 The Navy's Acoustic Effects Model

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

The model accounts for environmental variability of sound propagation in both distance and depth when computing the received sound level on the animats. The model conducts a statistical analysis based on multiple model runs to compute the estimated effects on animals. The number of animats that exceed the received threshold for an effect is tallied to provide an estimate of the number of marine mammals or sea turtles that could be affected.

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

- Naval activities are modeled as though they would occur regardless of proximity to marine mammals or sea turtles (i.e., mitigation is not modeled) and without any avoidance of the activity by the animal. The final step of the quantitative analysis of acoustic effects is to consider the implementation of mitigation. For sonar and other transducers, the possibility that marine mammals or sea turtles would avoid continued or repeated sound exposures is also considered.
- Many explosions from munitions such as bombs and missiles actually occur upon impact with above-water targets and at the water's surface. However, for this analysis, sources such as these were modeled as exploding underwater. This overestimates the amount of explosive and acoustic energy entering the water.

The model estimates the impacts caused by individual training and testing activities. During any individual modeled event, impacts on individual animats are considered over 24-hour periods. The animats do not represent actual animals, but rather allow for a statistical analysis of the number of instances that marine mammals or sea turtles may be exposed to sound levels resulting in an effect. Therefore, the model estimates the number of instances in which an effect threshold was exceeded over the course of a year, but does not estimate the number of individual marine mammals or sea turtles that may be impacted over a year (i.e., some marine mammals or sea turtles could be impacted several times, while others would not experience any impact). A detailed explanation of the Navy's Acoustic Effects Model is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

3.0.1.2.4 Accounting for Mitigation

3.0.1.2.4.1 Sonar and Other Transducers

The Navy implements mitigation measures (described in Section 2.3.4, Mitigation Measures) during activities that use sonar and other transducers, including the power-down or shut-down (i.e., power-off) of sonar when a marine mammal is observed in the mitigation zone. The mitigation zones encompass the estimated ranges to injury (including permanent threshold shift [PTS]) for a given sonar exposure. Therefore, the impact analysis quantifies the potential for mitigation to reduce the risk of PTS. Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, some model-estimated PTS is considered mitigated to the level of temporary threshold shift (TTS). The quantitative analysis does not analyze the potential for mitigation to reduce TTS or behavioral effects, even though mitigation could also reduce the likelihood of these effects. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species that may be near or within the mitigation zone.

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

3.0.1.2.4.2 Explosions

The Navy implements mitigation measures (described in Section 5.3, Procedural Mitigation to be Implemented) during explosive activities, including delaying detonations when a marine mammal is observed in the mitigation zone. The mitigation zones encompass the estimated ranges to mortality for a given explosive. Therefore, the impact analysis quantifies the potential for mitigation to reduce the risk of mortality due to exposure to explosives. Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., gunnery exercise) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is determined by species-specific characteristics and the viewing platform. A detailed explanation of the analysis is provided in the technical report *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2018b).

In the quantitative analysis, consideration of mitigation measures means that, for activities where mitigation is feasible, model-estimated mortality is considered mitigated to the level of injury. The impact analysis does not analyze the potential for mitigation to reduce non-auditory injury, PTS, TTS or behavioral effects, even though mitigation would also reduce the likelihood of these effects. In practice, mitigation also protects all unobserved (below the surface) animals in the vicinity, including other species, in addition to the observed animal. However, the analysis assumes that only animals sighted at the water surface would be protected by the applied mitigation. The analysis, therefore, does not capture the protection afforded to all marine species that may be near or within the mitigation zone.

3.0.1.2.5 Marine Mammal Avoidance of Sonar and other Transducers

Because a marine mammal is assumed to initiate avoidance behavior (e.g., tens of meters for most species groups) after an initial startle reaction when exposed to relatively high received levels of sound, a marine mammal could reduce its cumulative sound energy exposure over a sonar event with multiple pings (i.e., sound exposures). This would reduce risk of both PTS and TTS, although the quantitative analysis conservatively only considers the potential to reduce instances of PTS by accounting for marine mammals swimming away to avoid repeated high-level sound exposures. All reductions in PTS impacts from likely avoidance behaviors are instead considered TTS impacts.

3.0.1.3 Aquatic Habitats Database

The AFTT and Hawaii-Southern California Training and Testing Aquatic Habitat Database was developed after the completion of the 2013 AFTT and Hawaii-Southern California Training and Testing 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 Hawaii-Southern California Training and Testing 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, 2018a).

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, with locations set so as 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.

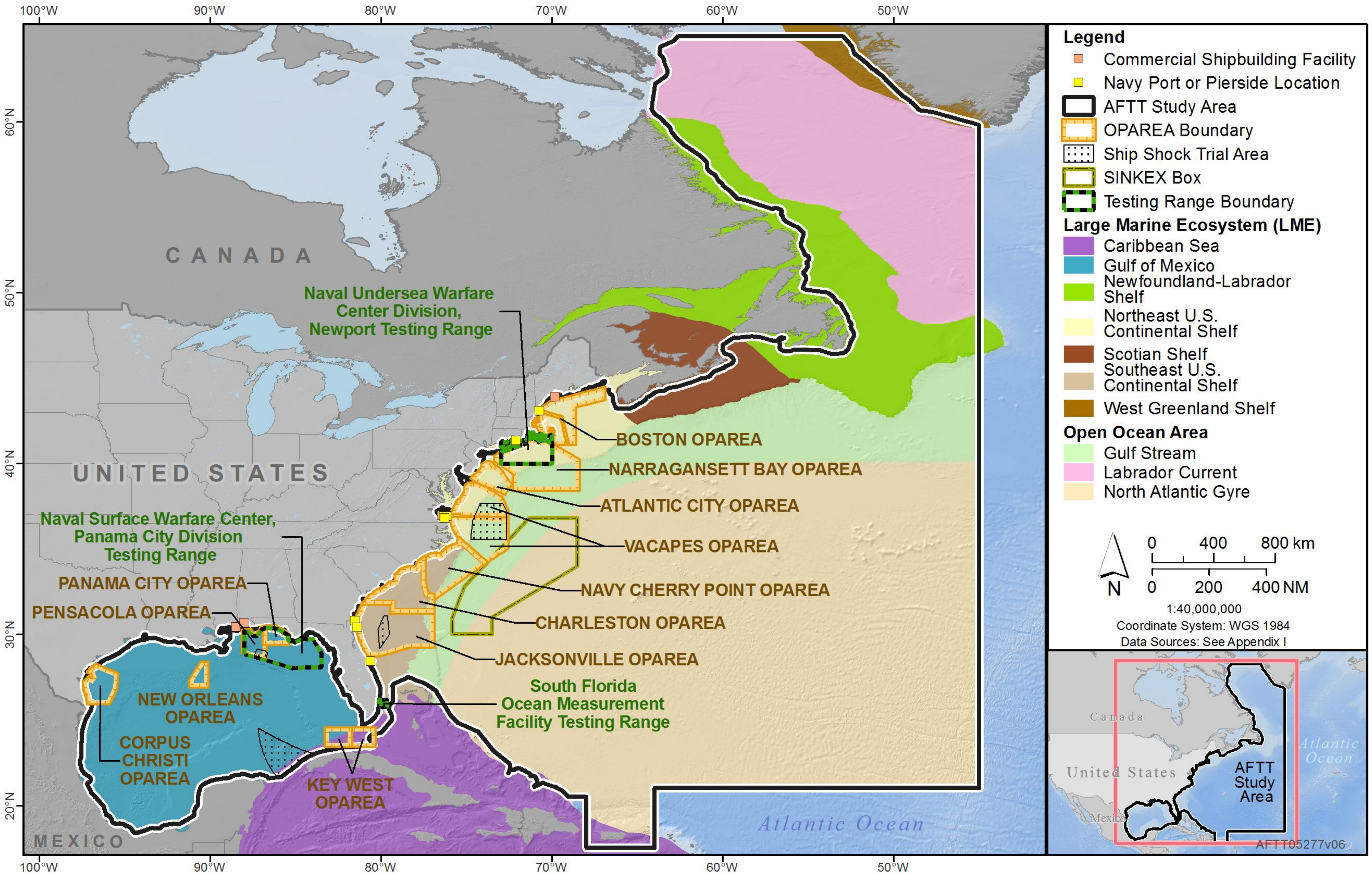
Biogeographic classifications organize and describe the patterns and distributions of organisms and the biological and physical processes that influence this distribution. These biogeographic classification systems and areas are described in Section 3.0.2.1 (Biogeographic Classifications).

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 (Sherman & Hempel, 2009). 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 (km^2) or greater, adjacent to the continents in coastal waters where primary productivity is generally higher than in open ocean areas" (Duda & Sherman, 2002). 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.



Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

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

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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 km^2 (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 Fylass 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 (m^2) 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 km^2 (Aquarone & Adams, 2009b).

This large marine ecosystem extends off the east coast of Canada within the Labrador Current (Aquarone & Adams, 2009b). 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 m^2 per year (Aquarone & Adams, 2009b).

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 km^2 (Aquarone & Adams, 2009a). This large marine ecosystem is located off the coast of the Canadian province of Nova Scotia and extends to the shelf break (Aquarone & Adams, 2009a). 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 m^2 per year (Aquarone & Adams, 2009a).

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.

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 km^2 (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 m^2 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 range complexes within 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 km^2 (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 m^2 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 range complexes within 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 km^2 (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 m^2 per year (Heileman & Rabalais, 2008). Other human uses in this large marine ecosystem include offshore 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 range complexes within 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 km^2. 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 m^2 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 range complexes within 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, 2009b; 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, 2004).

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 range complexes within 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 range complexes within 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 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.

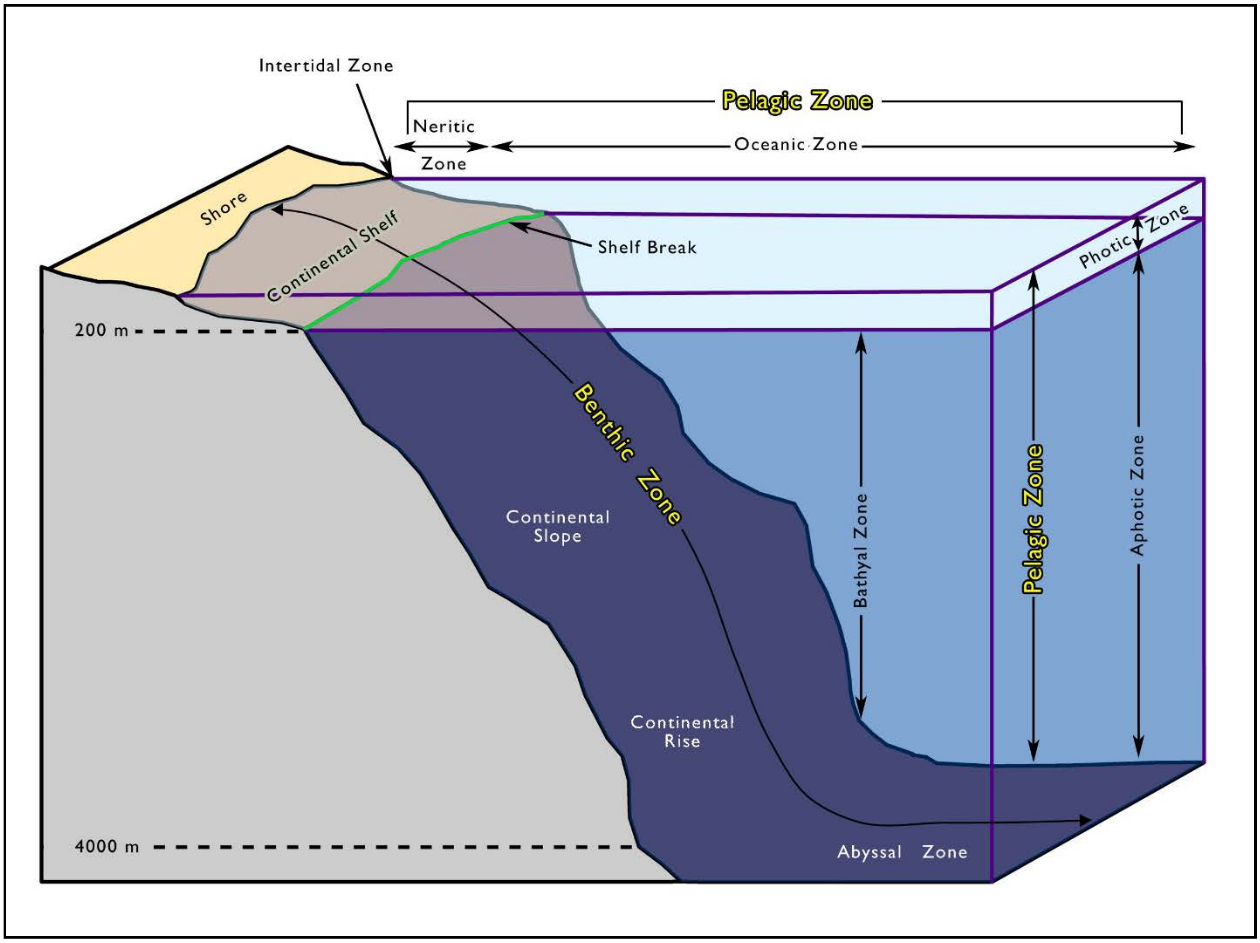
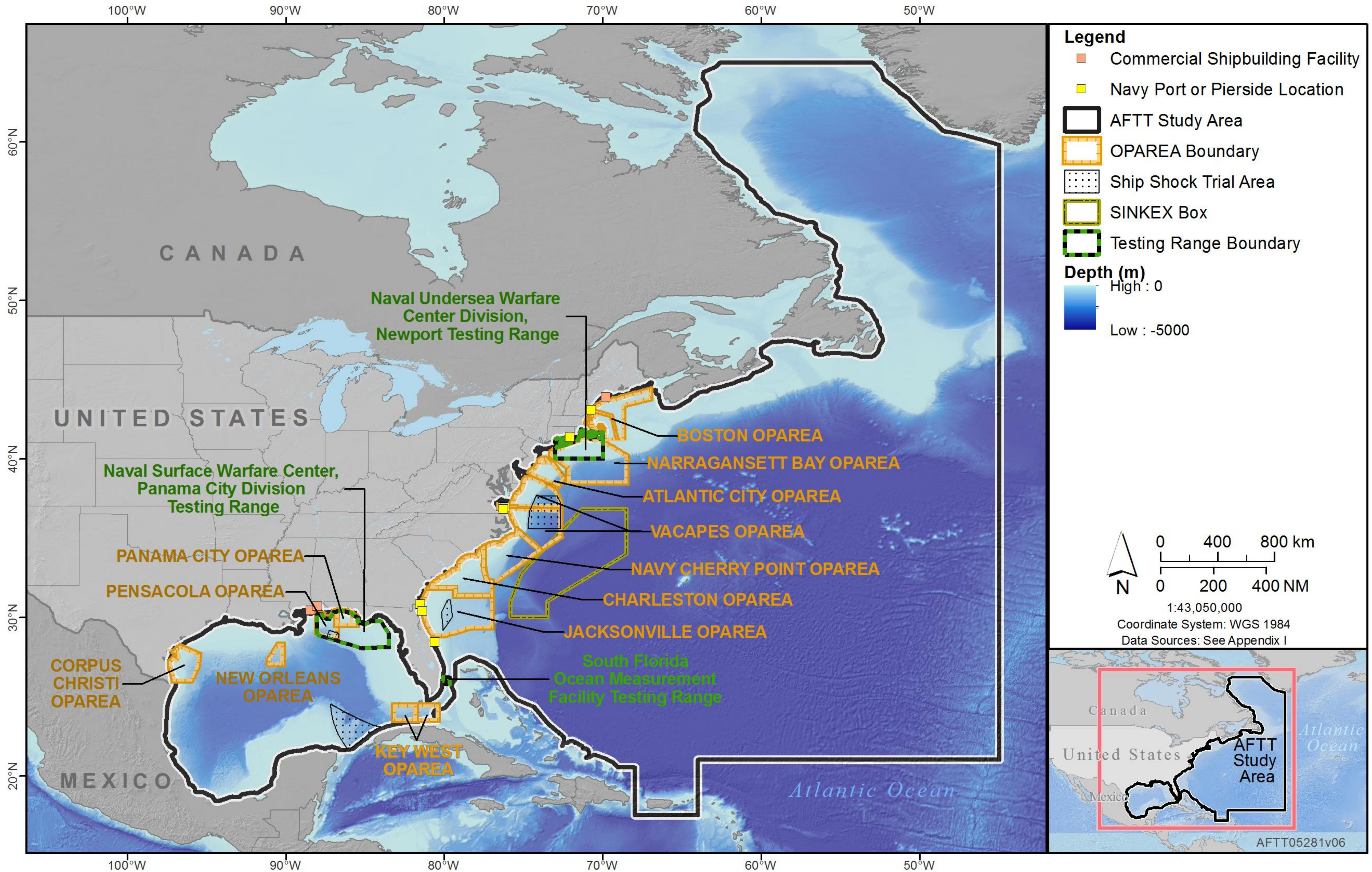


Figure 3.0-2: Three-Dimensional Representation of the Intertidal Zone (shoreline), Continental Margin, Abyssal Zone, and Water Column Zones

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).



Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 3.0-3: Bathymetry of the Entire Study Area

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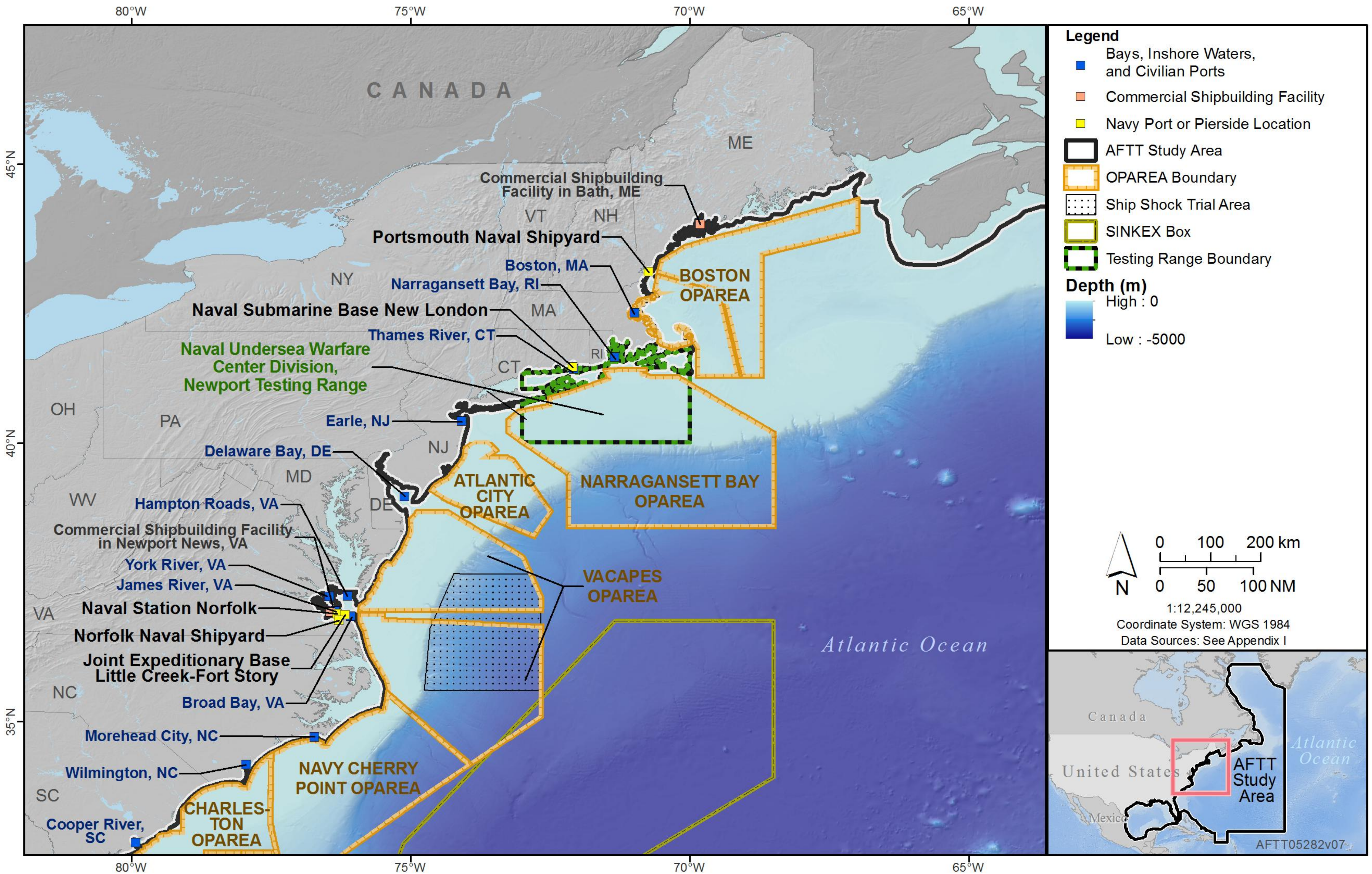

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

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

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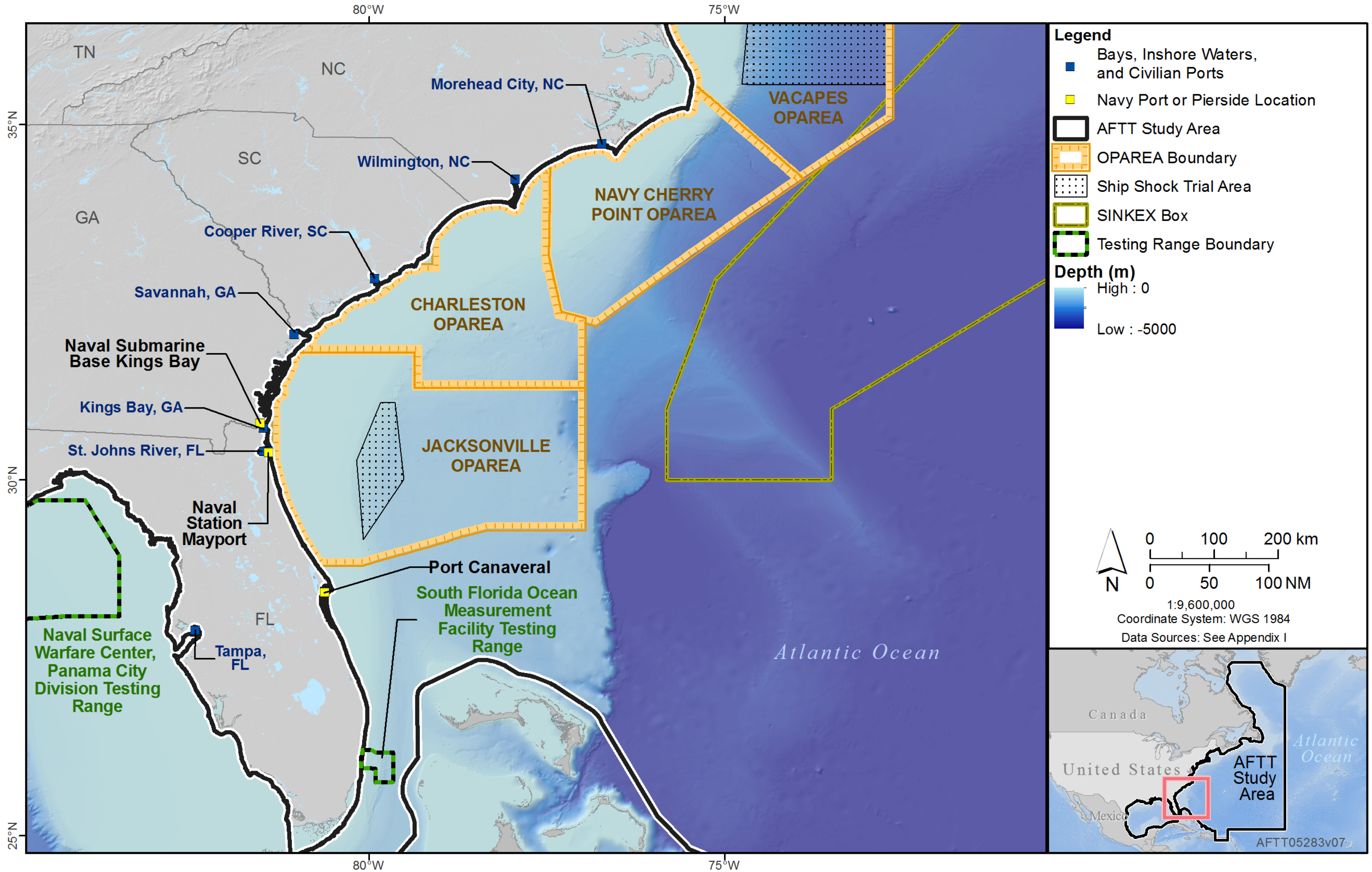

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 3.0-5: Bathymetry of the Southeast Portion of the Study Area

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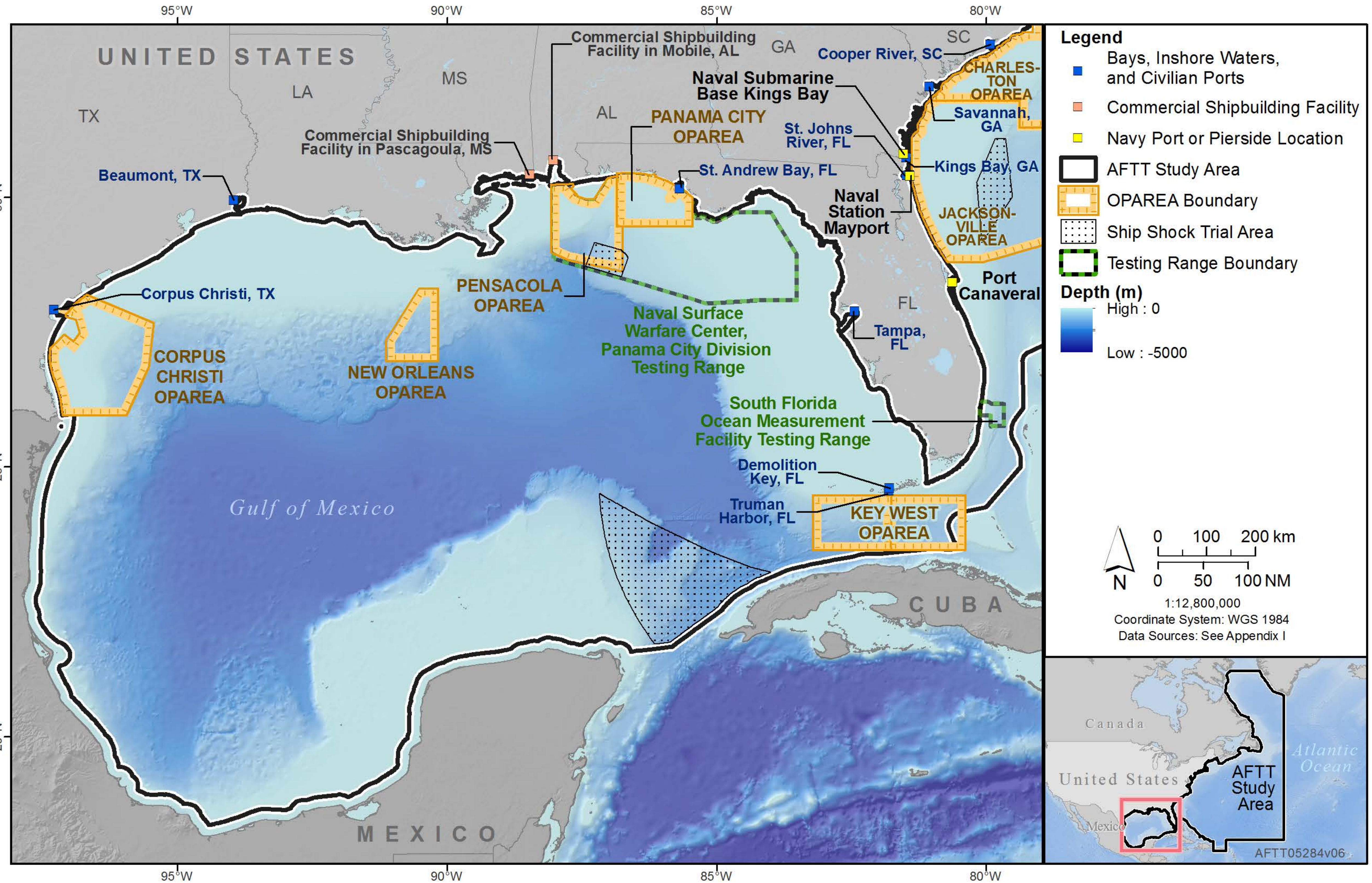

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area

Figure 3.0-6: Bathymetry of the Gulf of Mexico Portion of the Study Area

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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, 2009a). 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).

The Gulf of Maine is a semi-enclosed continental sea with an area of 89,000 km^2 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 km^2 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 (Aquarone, 2009). 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 (Minerals Management Service, 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 (Minerals Management Service, 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.

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

<table>
<tr><th>Component</th><th>Currents</th></tr>
<tr><td colspan="2">Northeast U.S. Continental Shelf Large Marine Ecosystem</td></tr>
<tr><td>Bath, ME</td><td rowspan="2">Riverine and tidal circulation patterns.</td></tr>
<tr><td>Portsmouth Naval Shipyard, Kittery, ME</td></tr>
<tr><td>Naval Undersea Warfare Center Division, Newport Testing Range</td><td>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.</td></tr>
<tr><td>Naval Submarine Base New London, Groton, CT</td><td rowspan="5">Riverine and tidal circulation patterns near mouth of estuary.
Subject to the influence of larger open oceanic currents and circulation systems.</td></tr>
<tr><td>Newport News, VA</td></tr>
<tr><td>Naval Station Norfolk, Norfolk, VA</td></tr>
<tr><td>Joint Expeditionary Base Little Creek—Fort Story, Virginia Beach, VA</td></tr>
<tr><td>Norfolk Naval Shipyard, Portsmouth, VA</td></tr>
<tr><td colspan="2">Southeast U.S. Continental Shelf Large Marine Ecosystem</td></tr>
<tr><td>Naval Submarine Base Kings Bay, Kings Bay, GA</td><td>Riverine and tidal circulation patterns in middle part of estuary.</td></tr>
<tr><td>Naval Station Mayport, Jacksonville, FL</td><td>Riverine and tidal circulation patterns in the mouth of estuary inlet.
Subject to the influence of larger open oceanic currents and circulation systems.</td></tr>
<tr><td>Port Canaveral, FL; South Florida Ocean Measurement Facility, FL</td><td>Tidal mixing within shallow dredged channel, plus wind driven circulation.</td></tr>
<tr><td colspan="2">Gulf of Mexico Large Marine Ecosystem</td></tr>
<tr><td>Pascagoula, MS; Naval Surface Warfare Center, Panama City Division, FL</td><td>Riverine and tidal circulation patterns in mouth of estuary/inlet. Offshore, near coastal areas subject to influence of larger open oceanic current/circulation.</td></tr>
</table>

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

Component	*Currents*
Gulf of Mexico Large Marine Ecosystem (continued)	
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

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 (Haug & Tiedemann, 1998).

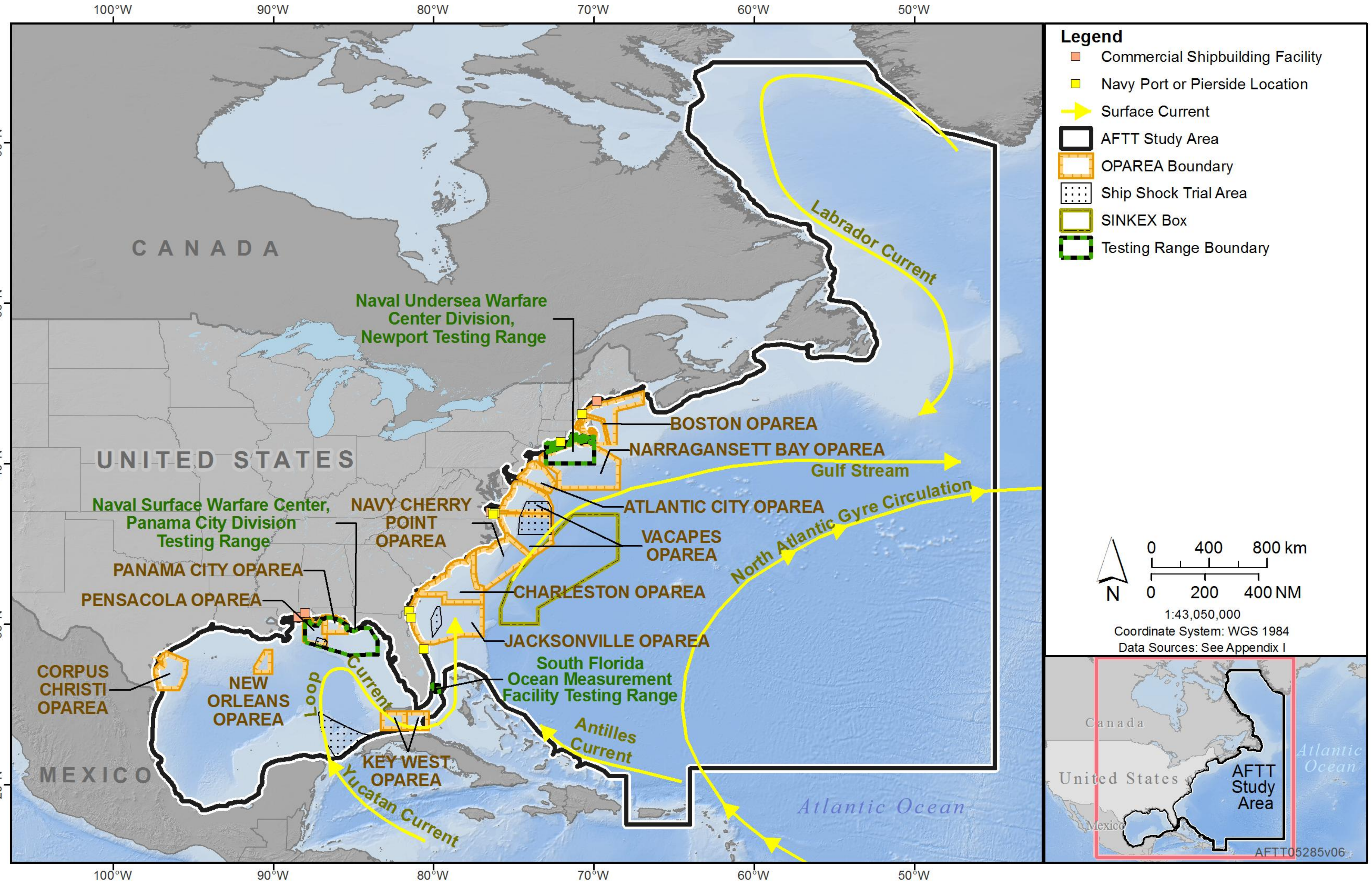
3.0.2.4 Ocean Fronts

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 (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.



Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

Figure 3.0-7: Major Currents in the Study Area

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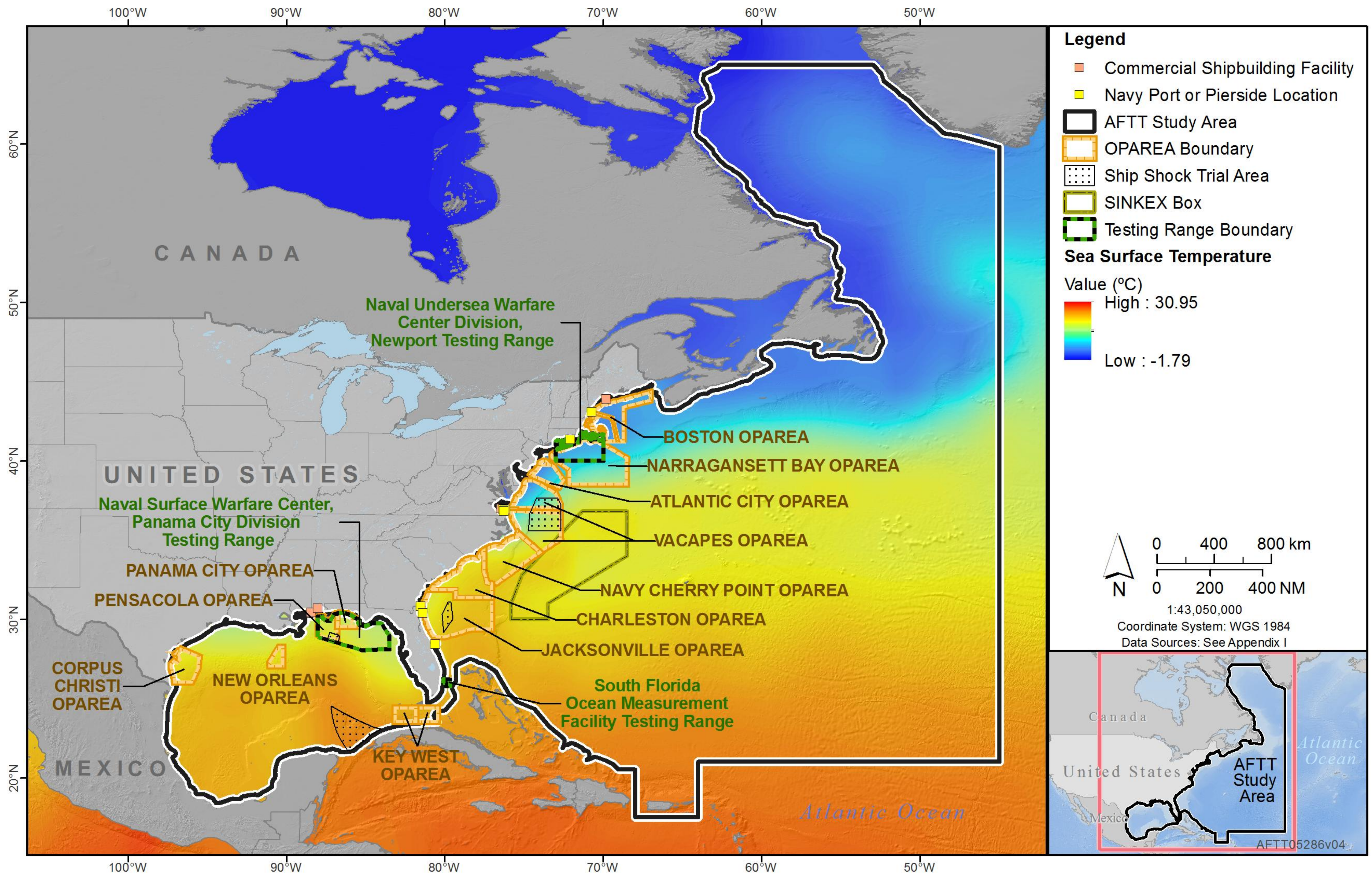

Notes: AFTT: Atlantic Fleet Training and Testing; OPAREA: Operating Area; SINKEX: Sinking Exercise; VACAPES: Virginia Capes

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

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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; Hamilton, 1990; Minerals Management Service, 2001). 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. Data sets used for analysis were considered across the full spectrum of Navy training and testing for the foreseeable future. For the purposes of analysis and presentation within this EIS/OEIS, data was organized and evaluated in one-year and five-year increments. 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).

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 and bats. Human resources evaluated include cultural resources, socioeconomic resources, 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 the Proposed Action's effects 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. 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. For example, some fixed-wing carrier-based aircraft may jettison fuel prior to an arrested landing to adjust their gross weight to a safe level. However, the fuel is jettisoned at altitudes and airspeeds that evaporate and atomize it before it reaches the water's surface (National Oceanic and Atmospheric Administration, 2016), resulting in no detectable impact to air or water quality.

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 3.0-14. 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 3.0-32), strike stressors (Table 3.0-36), entanglement stressors (Table 3.0-39), and ingestion stressors (Table 3.0-32). 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 3.0-24) 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 3.0-14).

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 (greater than 200 kilohertz [kHz]) Doppler sonars used for navigation, like those used on commercial and private vessels. The characteristics of these sonars and other transducers, such as source level, beam width, directivity, and frequency, depend on the purpose of the source. Higher frequencies can carry 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, 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, temporary minefields close to strategic ports and harbors, or at targets of opportunity such as navigation buoys. Kingfisher mode on vessels is most likely to be used when transiting to and from port. Sound sources used for imaging could be used throughout the Study Area.

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. Below, classes are further sorted by bins based on the frequency or bandwidth; source level; and, when warranted, the application in which the source would be used. Unless stated otherwise, a reference distance of 1 meter is used for sonar and other transducers.

- Frequency of the non-impulsive acoustic source:
  - Low-frequency sources operate below 1 kHz
  - Mid-frequency sources operate at and above 1 kHz, up to and including 10 kHz
  - High-frequency sources operate above 10 kHz, up to and including 100 kHz
  - Very high-frequency sources operate above 100 kHz but below 200 kHz
- Sound pressure level:
  - Greater than 160 dB re 1 µPa, but less than 180 dB re 1 µPa
  - Equal to 180 dB re 1 µPa and up to 200 dB re 1 µPa
  - Greater than 200 dB re 1 µPa
- Application in which the source would be used:
  - Sources with similar functions that have similar characteristics, such as pulse length (duration of each pulse), beam pattern, and duty cycle

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

Table 3.0-2 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	1,308	6,540	1,308	6,540
	LF4	LF sources equal to 180 dB and up to 200 dB	H	0	0	0	0	971	4,855	971	4,855
			C	0	0	0	0	20	100	20	100
	LF5	LF sources less than 180 dB	H	9	43	9	43	1,752	8,760	1,752	8,760
	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	3,337	16,684	3,337	16,684
	MF1K	Kingfisher mode associated with MF1 sonars	H	117	585	117	585	152	760	152	760
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)	H	2,078–2,097	10,428	2,116	10,580	1,257	6,271	1,257	6,271
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22)	H	591–611	2,994	630	3,150	370–803	2,624	761-803	3,847
	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	6,390	1,391	6,955
	MF8	Active sources (greater than 200 dB) not otherwise binned	H	0	0	0	0	348	1,740	348	1,740
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	H	0	0	0	0	7,395–7,562	37,173	7,561	37,172
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	H	870	4,348	870	4,348	5,690	28,450	5,690	28,450
	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	397	1,979	397	1,979
	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	1,864–2,056	9,704	2,056	10,280
			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	10,868	2,193	10,868
	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	20	100	20	100	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	3,028	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	4,756–5,606	25,480	6,106	30,530
	ASW3	MF towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	H	4,485–5,445	24,345	6,690	34,800	2,941–3,325	15,472	3,325	16,623
	ASW4	MF expendable active acoustic device countermeasures (e.g., MK 3)	C	425–431	2,137	437	2,185	3,493	17,057	3,493	17,057
	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	806–980	4,336	980	4,840
	TORP2	Heavyweight torpedo (e.g., MK-48)	C	80	400	80	400	344–408	1,848	408	2,040
	TORP3	Heavyweight torpedo (e.g., MK-48)	C	0	0	0	0	100	440	100	440
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
Acoustic Modems (M): Systems used to transmit data through the water	M3	MF acoustic modems (greater than 190 dB)	H	0	0	0	0	634	3,169	634	3,169

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

Source Class Category	Bin	Description	Unit	Training Alternative 1 Annual	Training Alternative 1 5-year Total	Training Alternative 2 Annual	Training Alternative 2 5-year Total	Testing Alternative 1 Annual	Testing Alternative 1 5-year Total	Testing Alternative 2 Annual	Testing Alternative 2 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	25,200	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	876–3,252	6,756	3,252	6,756

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

[1]H = hours; C = count (e.g., number of individual pings or individual sonobuoys).
[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]Formerly 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 µPa or less: Low-powered sources with source levels less than 160 dB re 1 µPa are typically hand-held sonars, range pingers, transponders, and acoustic communication devices. Assuming spherical spreading for a 160 dB re 1 µPa source, the sound will attenuate to less than 140 dB 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 µPa 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 are classified). Even if there is a possibility that some species may be exposed to and detect some of these sources, any response is expected to be short-term and inconsequential.

Table 3.0-3: Sonar and Transducers Qualitatively Analyzed

Source Class Category	*Bin*	*Characteristics*
Broadband Sound Sources (BB): Sources with wide frequency spectra	BB3	• Very-high-frequency • Very short pulse length
	BB8	• Small imploding source (lightbulb)
Doppler Sonar/Speed Logs (DS): High-frequency/very high-frequency navigation transducers	DS2–DS4	*Required for safe navigation.* • downward focused • narrow beam width • very short pulse lengths
Fathometers (FA): High-frequency sources used to determine water depth	FA1–FA4	*Required for safe navigation*. • downward focused directly below the vessel • narrow beam width (typically much less than 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)

Table 3.0-3: Sonar and Transducers Qualitatively Analyzed (continued)

Source Class Category	*Bin*	*Characteristics*
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)

3.0.3.3.1.2 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, Rhode Island. Table 3.0-4 shows the number of air gun shots proposed in the AFTT Study Area.

Table 3.0-4: 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.

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 µPa and 227 dB re 1 µPa, 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 sound exposure level (SEL) per shot.

For the specific applications and use of air guns in the AFTT Study Area, air guns were analyzed based on 1, 10, and 100 firings. Ten firings of an air gun was a conservative estimate of the number of firings that could occur over a single exposure duration at a single location. One hundred firings was based on pierside use of air guns.

3.0.3.3.1.3 Pile Driving

Impact pile driving and vibratory pile removal would occur during training for the construction of an Elevated Causeway System, a temporary pier that allows the offloading of ships in areas without a permanent port.

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 on average 35 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

Pile Size &Type	***Method***	***Average Sound Levels at 10 m (SEL per individual pile)***
24-in. Steel Pipe Pile	Impact[1]	192 dB re 1 µPa SPL peak 182 dB re 1 $\mu Pa^2 s$ SEL (single strike)
24-in. Steel Pipe Pile	Vibratory[2]	146 dB re 1 µPa SPL rms 145 dB re 1 $\mu Pa^2 s$ SEL (per second of duration)

[1] (Illingworth and Rodkin, 2017), [2] Illingworth and Rodkin (2015)
Notes: in. = inch, SEL = Sound Exposure Level, SPL = Sound Pressure Level, rms = root mean squared, dB re 1 µPa = 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 µPa at a range of 15 m (Illingworth and Rodkin, 2017). 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 µPa (94 dB re 20 µPa) within a range of 10 to 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. During training exercises, Elevated Causeway System construction is continued until personnel become proficient in the operation of the pile driving equipment and construction techniques. The size of the pier and number of piles used in an Elevated Causeway System training event is assumed to be no greater than 1,520 ft. long, requiring 119 supporting piles. 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 15 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 six 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

Method	*Piles Per 24-Hour Period*	*Time Per Pile*	*Total Estimated Time of Noise Per 24-Hour Period*
Pile Driving (Impact)	6	15 minutes	90 minutes
Pile Removal (Vibratory)	12	6 minutes	72 minutes

Pile driving for the Elevated Causeway System 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). 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.

3.0.3.3.1.4 Vessel Noise

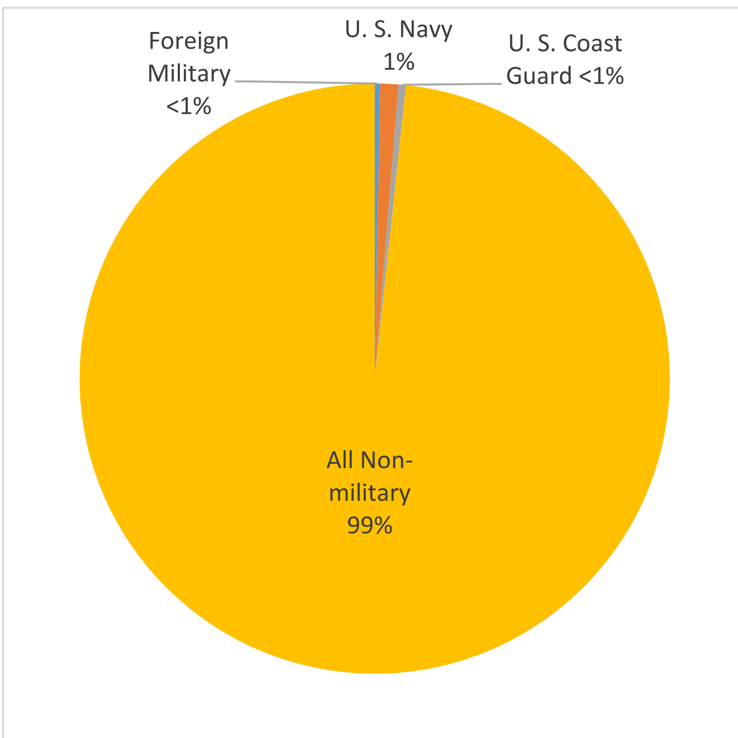
Vessel noise, in particular commercial shipping, is a major contributor to noise in the ocean and inshore waters. Frisk (2012) reported that between 1950 and 2007 ocean noise in the 25–50 Hz frequency range has increased 3.3 dB per decade, resulting in a cumulative increase of approximately 19 dB over 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. However, within the AFTT Study Area, 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 and Figure 3.0-9, Navy ships make up roughly 1 percent of the vessel presence in the AFTT Study Area (Mintz, 2016). In terms of anthropogenic noise, Navy ships are engineered to be as quiet as possible given ship class limitations, and would contribute a correspondingly smaller amount of shipping noise compared to more common commercial shipping and boating (Mintz, 2012; 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, Florida (Mintz, 2012), 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, Virginia, and Jacksonville, Florida (Mintz & Parker, 2006).

Table 3.0-7: Interpolated Ship-Hours from 2011 to 2015 Positional Records in the Study Area

Ship Category	***AFTT***
U.S. Navy	525,000
U.S. Coast Guard	337,000
Foreign Military	107,000
Nonmilitary	70,478,000

Note: Interpolated SeaLink data from 2011 through 2015 which represents an unknown fraction of actual vessel traffic. This data represents a relative traffic level, not absolute ship presence (Mintz, 2016)



Source: Mintz (2016)

Figure 3.0-9: AFTT Surface Ship Traffic By Percent Ship-Hours 2011-2015 (Mintz, 2016)

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 inshore 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). Anti-submarine warfare surface combatants (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 vessels are much quieter than Navy oil tankers, for example, which have a smaller presence but contribute substantially more broadband noise (Mintz & Filadelfo, 2011). A variety of smaller craft that vary in size and speed, such as service vessels for routine operations and opposition forces used during training and testing events, would be operating within the Study Area.

Studies to determine traffic patterns of Navy and non-Navy vessels in the Study Area were conducted by the Center for Naval Analysis (Mintz & Parker, 2006; Mintz & Filadelfo, 2011; Mintz, 2012). The most recent analysis covered the period 2011-2015 (Mintz, 2016) and included U.S. Navy surface ship traffic and non-military vessels such as cargo vessels, bulk carriers, commercial fishing vessels, oil tankers, passenger vessels, tugs, and research vessels. Caveats to this analysis include that only vessels over 65 ft. in length are reported so smaller Navy vessels and civilian craft are not included, and vessel position records are much more frequent for Navy vessels than for commercial vessels. Therefore, the Navy is likely overrepresented in the data and the reported fraction of total energy is likely the upper limit of its contribution (Mintz & Filadelfo, 2011; Mintz, 2012).

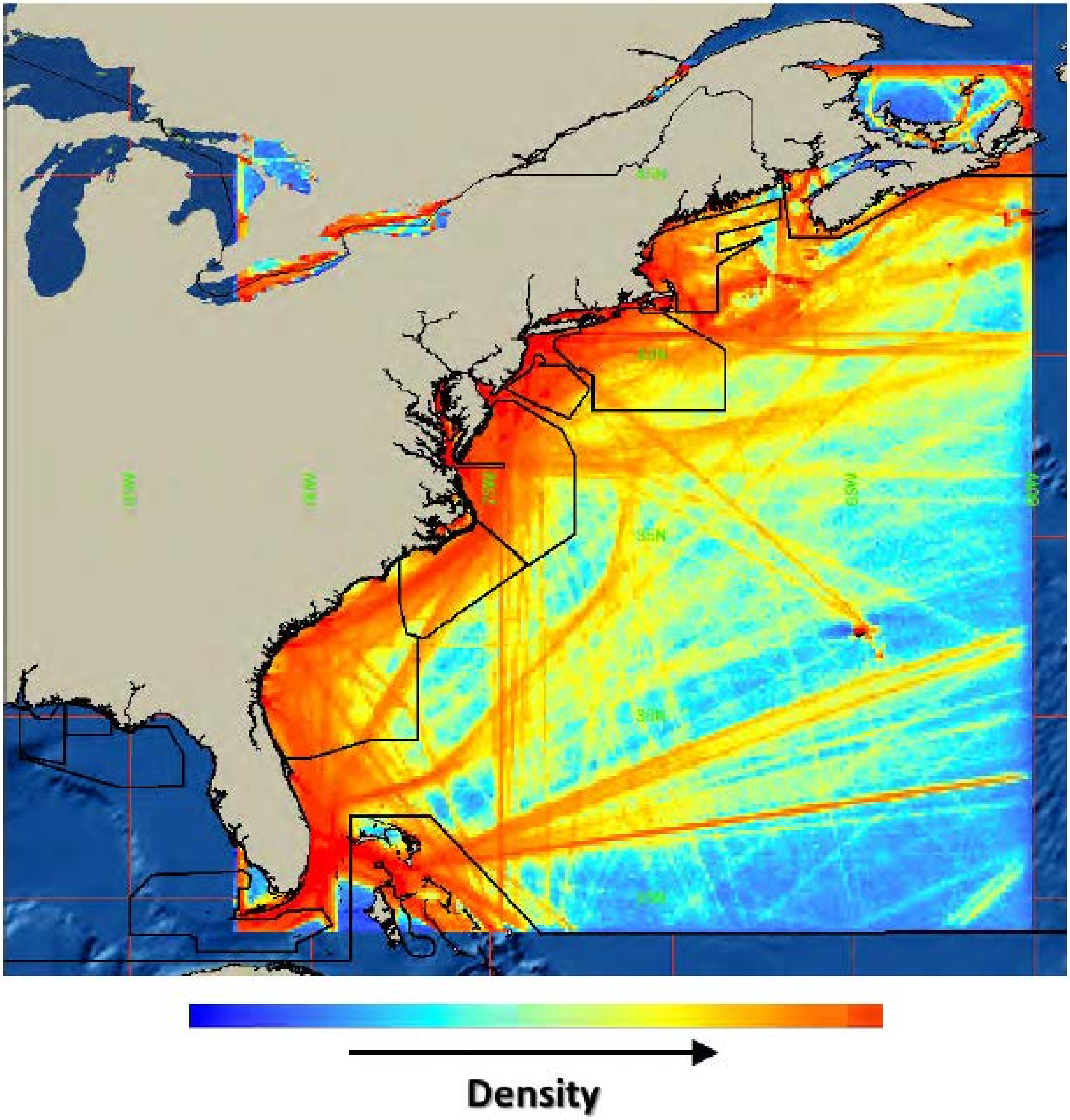
During training and testing, speeds of most large naval vessels (greater than 60 ft.) generally range from 10 to 15 knots to limit fuel consumption; however, ships will, on occasion, operate at higher speeds within their specific operational capabilities. Mintz (2016) reported median speeds for U.S. Navy vessel and various commercial ship classes (Table 3.0-8) in the AFTT Study Area from 2011-2015. 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). The average acoustic signature for a Navy vessel is 163 dB re 1 µPa, while the average acoustic signature for a commercial vessel is 175 dB re 1 µPa (Mintz & Filadelfo, 2011). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies (approximately around the one-third octave band centered at 100 Hz) (Mintz & Filadelfo, 2011; Richardson et al., 1995; Urick, 1983). Ship types also have unique acoustic signatures characterized by differences in dominant frequencies. Bulk carrier noise is predominantly near 100 Hz while container ship and tanker noise is predominantly below 40 Hz (McKenna et al., 2012). Small craft will emit higher-frequency noise (between 1 kHz and 50 kHz) than larger ships (below 1 kHz). Sound produced by vessels will typically increase with speed.

Table 3.0-8: Median Surface Ship Speeds for the AFTT Study Area 2011–2015

Ship Class	*Median Ship Speed (knots)*
U.S. Navy Aircraft Carrier	14.6
U.S. Navy Cruiser or Destroyer	11.0-11.4
U.S. Navy Amphibious Assault Ship	11.8-14.1
Commercial Cargo Ship	11.8
Commercial Tanker	10.9
Passenger Ship	10.1

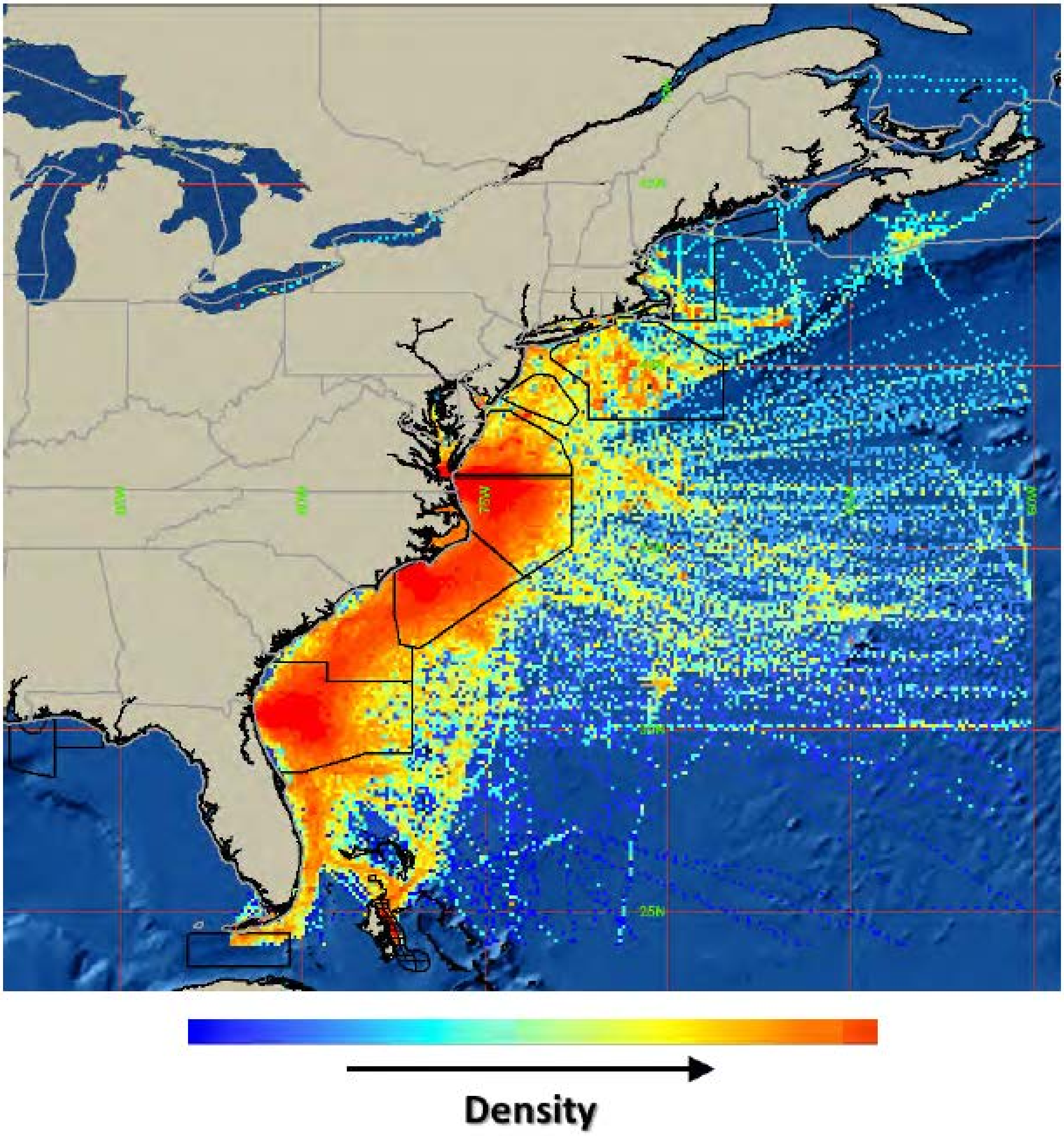
Source: Mintz (2016)

Figure 3.0-10 and Figure 3.0-11 show the geographic distribution of commercial and Navy shipping in the AFTT Study Area derived from the analysis in Mintz (2016). Mintz (2016) shows the geographic distribution of highest Navy surface ship activity within the range complexes south of Hampton Roads, with clear concentrations in and out of Hampton Roads, Virginia and Naval Station Mayport, Florida. Figure 3.0-10 highlights the commercial routes along the East Coast of the U.S. and around the Bahamas. Also seen are great circle routes in the Atlantic Ocean.



Source: Mintz (2016)

Figure 3.0-10: Relative Distribution of Commercial Vessel Traffic



Source: Mintz (2016)

Figure 3.0-11: Relative Distribution of U.S. Navy Vessel Traffic

3.0.3.3.1.5 Aircraft Noise

Fixed-wing, tiltrotor, and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area, contributing both airborne and underwater sound to the ocean environment. Sounds in air are often measured using A-weighting, which adjusts received sound levels based on human hearing abilities (see Appendix 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. The majority of aircraft noise would be generated at air stations, which are outside the Study Area. Takeoffs and landings occur at established airfields as well as on vessels across the Study Area. Takeoffs and landings from Navy vessels could startle marine mammals; however, these events only produce in-water noise at any given location for a brief period as the aircraft climbs to cruising altitude. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Table 3.0-9 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 3.0-9: Representative Aircraft Sound Characteristics

Noise Source	*Sound Pressure Level*
In-Water Noise Level	
F/A-18 Subsonic at 1,000 ft. (300 m) Altitude	152 dB re 1 µPa at 2 m below water surface[1]
F/A-18 Subsonic at 10,000 ft. (3,000 m) Altitude	128 dB re 1 µPa at 2 m below water surface[1]
H-60 Helicopter Hovering at 82 ft. (25 m) Altitude	Approximately 125 dB re 1 µPa at 1 m below water surface[2*]
Airborne Noise Level	
F/A-18C/D Under Military Power	143 dBA re 20 µPa at 13 m from source[3]
F/A-18C/D Under Afterburner	146 dBA re 20 µPa at 13 m from source[3]
F35-A Under Military Power	145 dBA re 20 µPa at 13 m from source[3]
F-35-A Under Afterburner	148 dBA re 20 µPa at 13 m from source[3]
H-60 Helicopter Hovering at 82 ft. (25 m) Altitude	113 dBA re 20 µPa[2]
F-35A Takeoff Through 1,000 ft. (300 m) Altitude	119 dBA re 20 $\mu Pa^2 s$[4**](per second of duration)
EA-18G Takeoff Through 1,622 ft. (500 m) Altitude	115 dBA re 20 $\mu Pa^2 s$ [5**](per second of duration)

[1]Eller and Cavanagh (2000)
[2]Bousman and Kufeld (2005)
[3]U.S. Naval Research Advisory Committee (2009)
[4]U.S. Department of the Air Force (2016)
[5]U.S. Department of the Navy (2012a)
*estimate based on in-air level
**average sound exposure level
Notes: dB re 1 µPa = decibel(s) referenced to 1 micropascal, dBA re 20 µPa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s), ft. = feet

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 3.0-9.

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, 2016). 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 μPa 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, 2016). 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 (U.S. Department of the Air Force, 2000). These results are shown in Table 3.0-10.

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).

Table 3.0-10: Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight

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

[1] Equivalent to SEL for a plane wave.
* Mach number equals aircraft speed divided by the speed of sound.
Notes: SPL = sound pressure level, dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 1 µPa²-s = decibel(s) referenced to 1 micropascal squared seconds, m = meter(s)

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 in warning areas or special use airspace for safety reasons. Small- and medium-caliber weapons firing could occur throughout the Study Area in identified training areas.

Examples of some types of weapons noise are shown in Table 3.0-11. Examples of launch noise are provided in the table. Noise produced by other weapons and devices are described further below.

Table 3.0-11: Examples of Weapons Noise

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

[1]Yagla and Stiegler (2003)
[2]U.S. Department of the Army (1999)
[3]U.S. Department of the Navy (2013)
Notes: dB re 1 µPa = decibel(s) referenced to 1 micropascal, dB re 20 µPa = decibel(s) referenced to 20 micropascals, dBA re 20 µPa = A-weighted decibel(s) referenced to 20 micropascals, m = meter(s)

Muzzle Blast from Naval Gunfire

Firing a gun produces a muzzle blast in air that propagates away from the gun with strongest directivity in the direction of fire (Figure 3.0-12). 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 µPa SPL peak for the atmospheric conditions of the test (U.S. Department of the Navy, 1981). Measurements were obtained for additional distances and angles off the firing line but were specific to the atmospheric conditions present during the testing.

As the pressure from the muzzle blast from a ship-mounted large-caliber gun propagates in air toward the water surface, the pressure can be both reflected from the water surface and transmitted into the water. As explained in Appendix 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 µPa, measured 5 ft. below the surface) was obtained when the gun was fired at the lowest angle, placing the blast closest to the water surface (Yagla & Stiegler, 2003). The unweighted 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 µPa^2-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 (U.S. Department of the Navy, 1981). Exposure to the bow shock wave is very brief.

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

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

Launch Noise

Missiles can be rocket or jet propelled and launches typically occur far offshore or in special use airspace such as warning areas, air traffic control assigned airspace, and restricted areas. 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 3.0-11.

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

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

3.0.3.3.2 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. Section 5.3.3 (Explosive Stressors) outlines the procedural mitigation measures for explosive stressors to reduce potential impacts on biological resources.

In order to better organize and facilitate the analysis of Navy training and testing activities using explosives that could detonate in water or at the water surface, explosive classification bins were developed. The use of explosive classification bins provides the same benefits as described for acoustic source classification bins in Section 3.0.3.3.1 (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 3.0-12. 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 3.0-12, the Navy uses some very small impulsive sources (less than 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 effects conclusions 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 3.0-12: 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	7,700	38,500	7,700	38,500	17,840–26,840	116,200	26,840	134,200
E2	> 0.25–0.5	Medium-caliber projectile	210–214	1,062	214	1,062	0	0	0	0
E3	> 0.5–2.5	Large-caliber projectile	4,592	22,960	4,592	22,960	3,054–3,422	16,206	3,422	17,110
E4	> 2.5–5	Mine neutralization charge	127–133	653	133	653	746–800	3,784	810	4,050
E5	> 5–10	5 in. projectile	1,436	7,180	1,436	7,180	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	22	110	22	110	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).

3.0.3.3.2.2 Explosions in Air

Explosions in air include detonations of projectiles and missiles during surface-to-air gunnery and air-to-air missile exercises conducted during air warfare. These explosions typically occur far above the water surface in special use airspace. Some typical types of explosive munitions that would be detonated in air during Navy activities are shown in Table 3.0-13. Various missiles, rockets, and medium- and large-caliber projectiles may be explosive or non-explosive, depending on the objective of the training or testing activity in which they are used. Quantities of explosive and non-explosive missiles, rockets, and projectiles proposed for use during Navy training and testing are provided in Appendix F (Military Expended Materials and Direct Strike Impact Analyses).

Table 3.0-13: Typical Air Explosive Munitions During Navy Activities

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

[1] Mission Design Series and popular name shown for missiles. [2] Most 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 Missile; 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 3.0-12), 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., U.S. Department of the Navy (1975)]. In air, the propagation of impulsive noise from an explosion is highly influenced by atmospheric conditions, including temperature and wind. While basic estimation methods do not consider the unique environmental conditions that may be present on a given day, they allow for approximation of explosive energy propagation under neutral atmospheric conditions. Explosions that occur during air warfare would typically be at a sufficient altitude that a large portion of the sound refracts upward due to cooling temperatures with increased altitude.

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

3.0.3.3.3 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 3.0-14 shows the number and location of proposed activities, primarily mine sweeping, that include the use of in-water electromagnetic devices.

Table 3.0-14: 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	1,203	1,203	6,015	6,015
Navy Cherry Point Range Complex	2,823	2,283	14,115	14,115
Jacksonville Range Complex	350	350	1,750	1,750
Gulf of Mexico Range Complex	104	104	480	480
Inshore Waters (Table 3.0-15)	60	60	180	180
Total	**4,540**	**4,000**	**22,540**	**22,540**
Testing				
Virginia Capes Range Complex	294	294	1,360	1,360
Navy Cherry Point Range Complex	2	2	12	12
Jacksonville Range Complex	92	92	462	462
Gulf of Mexico Range Complex	40	40	200	200
SFOMF	3	3	15	15
NSWC Panama City Testing Range	3	3	15	15
Inshore Waters (Table 3.0-15)	100	100	500	500
Total	**534**	**534**	**2,564**	**2,564**

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

Table 3.0-15 shows where within the inshore 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 3.0-15: Number and Location of Activities in Inshore 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	12
Earle, NJ	4	4	12	12
Delaware Bay, DE	4	4	12	12
Hampton Roads, VA	8	8	24	24
Morehead City, NC	4	4	12	12
Wilmington, NC	4	4	12	12
Savannah, GA	4	4	12	12
Kings Bay, GA	4	4	12	12
Mayport, FL	4	4	12	12
Port Canaveral, FL	4	4	12	12
Tampa, FL	4	4	12	12
Beaumont, TX	8	8	24	24
Corpus Christi, TX	4	4	12	12
Total	**60**	**60**	**180**	**180**
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 microteslas[2]. 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.

3.0.3.3.3.2 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 3.0-18 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.

3.0.3.3.3.3 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 (U.S. Department of the Navy, 2010). The assessment determined that the maximum potential for laser exposure is at the ocean's surface, where laser intensity is greatest (U.S. Department of the Navy, 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 to sustain damage. U.S. Department of the Navy (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 3.0-16 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.

Table 3.0-16: Number and Location of 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	26	26
Virginia Capes Range Complex	116	116	565	565
Navy Cherry Point Range Complex	8	8	26	26
Jacksonville Range Complex	8	8	26	26
Key West Range Complex	8	8	26	26
Gulf of Mexico Range Complex	8	8	26	26
NUWC Newport Testing Range	8	8	26	26
SFOMF	8	8	26	26
NSWC Panama City Testing Range	8	8	26	26
Total	**180**	**180**	**773**	**773**

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

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 3.0-17 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 at http://www.navy.mil/navydata/fact.asp, provide the latest information on the quantity and specifications of the vessels operated by the Navy.

Table 3.0-17: Representative Vessel Types, Lengths, and Speeds

Type	*Example(s)*	*Length*	*Typical Operating Speed*
Aircraft Carrier	Aircraft Carrier (CVN)	>1,000 ft.	10–15 knots
Surface Combatant	Cruisers (CG), Destroyers (DDG), 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

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 10–15 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 or greater, 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-offs 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 inshore waters.

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 inshore 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 inshore 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 (2012) 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 3.0-18 shows the number and location of proposed activities that include the use of vessels in the Study Area. Each activity included in Table 3.0-18 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 3.0-19 shows the number and location of proposed activities that include the use of vessels in the inshore waters of the Study Area. Each activity included in Table 3.0-19 could involve one or more vessels.

Table 3.0-18: 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	411	416	2,055	2,080
Virginia Capes Range Complex	12,412	12,632	62,019	63,158
Navy Cherry Point Range Complex	6,754	6,809	33,693	34,043
Jacksonville Range Complex	10,841	11,281	54,112	56,405
Key West Range Complex	131	131	655	655
Gulf of Mexico Range Complex	771	807	3,855	4,035
Other AFTT Areas	691	709	3,435	3,525
Inshore Waters (see Table 3.0-19)	4,197	4,197	20,935	20,935
Total	**36,208**	**36,982**	**180,579**	**184,836**
Testing				
Northeast Range Complexes	1,088	1,094	4,877	5,458
Virginia Capes Range Complex	1,784	1,786	7,388	8,786
Navy Cherry Point Range Complex	791	793	3,947	3,963
Jacksonville Range Complex	1,298	1,308	6,096	6,360
Key West Range Complex	398	398	1,732	1,936
Gulf of Mexico Range Complex	618	618	2,979	3,026
NUWC Newport Testing Range	767	767	3,803	3,830
SFOMF	198	198	992	992
NSWC Panama City Testing Range	406	406	2,003	2,003
Inshore Waters (see Table 3.0-19)	216	216	1,078	1,078
Total	**7,564**	**7,584**	**34,895**	**37,432**

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

Table 3.0-19: Number and Location of Activities in Inshore Waters Including Vessels

Activity Area	Maximum Annual # of Activities		5-Year # of Activities	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Training				
Boston, MA	2	2	6	6
Groton, CT	235	235	1,175	1,175
Narragansett, RI	198	198	990	990
Earle, NJ	2	2	6	6
Delaware Bay, DE	2	2	6	6
James River & Tributaries, VA	830	830	4,200	4,200
York River, VA	129	129	645	645
Lower Chesapeake Bay, VA	1,697	1,697	8,485	8,485
Hampton Roads, VA	4	4	12	12
Norfolk, VA	515	515	2,575	2,575
Morehead City, NC	2	2	6	6
Wilmington, NC	2	2	6	6
Cooper River, SC	120	120	600	600
Savannah, GA	2	2	6	6
Kings Bay, GA	7	7	31	31
Mayport, FL	343	343	1,711	1,711
St. Johns River, FL	2	2	10	10
Port Canaveral, FL	47	47	231	231
Tampa, FL	2	2	6	6
St. Andrew Bay, FL	50	50	250	250
Beaumont, TX	4	4	12	12
Corpus Christi, TX	2	2	6	6
Total	**4,197**	**4,197**	**20,975**	**20,975**
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	61	61	301	301
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	**216**	**216**	**1,078**	**1,078**

As stated earlier, activities that include vessel movements in the inshore 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 craft are provided in Table 3.0-20.

Table 3.0-20: Number of High Speed Vessel Hours for Small Craft Associated with Training Activities in Inshore 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 River & 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 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.

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 3.0-21 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 3.0-22 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 3.0-21: Representative Types, Sizes, and Speeds of In-Water Devices

Type	*Example(s)*	*Length*	*Typical Operating Speed*
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 3.0-22: Number and Location of Activities Including In-Water Devices

Activity Area	*Maximum Annual # of Activities*		*5-Year # of Activities*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Training				
Northeast Range Complexes	135	139	671	695
Virginia Capes Range Complex	7,316	7,556	36,538	37,780
Navy Cherry Point Range Complex	2,027	2,091	10,053	10,455
Jacksonville Range Complex	5,097	5,621	25,356	28,385
Key West Range Complex	32	32	160	160
Gulf of Mexico Range Complex	724	768	3,616	3,840
NSWC Panama City Testing Range	328	328	1,640	1,640
Other AFTT Areas	362	362	1,800	1,800
Inshore Waters (see Table 3.0-23)	1,217	1,217	6,335	6,335
Total	**17,238**	**18,114**	**86,169**	**91,090**
Testing				
Northeast Range Complexes	450	451	1,774	2,240
Virginia Capes Range Complex	1,266	1,266	5,084	6,332
Navy Cherry Point Range Complex	137	138	679	687
Jacksonville Range Complex	800	801	3,681	3,931
Key West Range Complex	111	111	328	544
Gulf of Mexico Range Complex	322	322	1,521	1,607
NUWC Newport Testing Range	1,032	1,032	5,147	5,147

Table 3.0-22: 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	204	204	1,014	1,014
NSWC Panama City Testing Range	438	438	2,047	2,111
Total	**4,760**	**4,763**	**21,275**	**23,613**

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

Table 3.0-23: Number and Location of Activities in Inshore 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	7	7	21	21
Earle, NJ	7	7	21	21
Delaware Bay, DE	7	7	21	21
Lower Chesapeake Bay	852	852	4,260	4,260
Hampton Roads, VA	14	14	42	42
James River and Tributaries	108	108	1,000	1,000
York River	38	38	190	190
Morehead City, NC	7	7	21	21
Wilmington, NC	7	7	21	21
Savannah, GA	7	7	21	21
Kings Bay, GA	51	51	241	241
Mayport, FL	77	77	371	371
Port Canaveral, FL	7	7	21	21
Tampa, FL	7	7	21	21
Beaumont, TX	14	14	42	42
Corpus Christi, TX	7	7	21	21
Total	**1,217**	**1,217**	**6,335**	**6,335**

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 3.0-24, Table 3.0-25 and Table 3.0-26), (2) fragments from high-explosive munitions (Table 3.0-27 and Table 3.0-28), (3) expendable targets (Table 3.0-29, Table 3.0-30, and Table 3.0-31), and (4) expended materials other than munitions, such as sonobuoys or torpedo accessories (Table 3.0-32, Table 3.0-33, and Table 3.0-34). See Appendix F (Military Expended Materials and Direct Strike Impact Analyses) 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 3.0-24: 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*
Torpedoes [1]				
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	2,188	2,188	10,940	10,940
Navy Cherry Point Range Complex	596	596	2,980	2,980
Jacksonville Range Complex	1,360	1,360	6,800	6,800
Gulf of Mexico Range Complex	270	270	1,350	1,350
Total	**4,414**	**4,414**	**22,070**	**22,070**
Rockets				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	1,835	1,183	9,175	9,175
Navy Cherry Point Range Complex	304	304	1,520	1,520
Jacksonville Range Complex	2,095	2,095	10,474	10,474
Gulf of Mexico Range Complex	191	191	955	955
Total	**4,426**	**3,774**	**22,129**	**22,129**
Rockets (Flechette)				
Virginia Capes Range Complex	95	95	475	475
Jacksonville Range Complex	110	110	551	551
Total	**205**	**205**	**1,026**	**1,026**
Large-Caliber Projectiles				
Virginia Capes Range Complex	4,930	4,930	24,650	24,650
Navy Cherry Point Range Complex	1,234	1,234	6,170	6,170
Jacksonville Range Complex	2,534	2,534	12,670	12,670
Gulf of Mexico Range Complex	498	498	2,490	2,490
Other AFTT Areas	210	210	1,050	1,050
Total	**9,406**	**9,406**	**47,030**	**47,030**
Large-Caliber – Casings Only				
Navy Cherry Point Range Complex	1,040	1,040	2,800	2,800
Total	**1,040**	**1,040**	**2,800**	**2,800**

Table 3.0-24: Number and Location of Non-Explosive Practice Munitions Expended During Training Activities (continued)

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Medium-Caliber Projectiles				
Northeast Range Complexes	1,000	1,000	5,000	5,000
Virginia Capes Range Complex	658,561	658,561	3,292,805	3,292,805
Navy Cherry Point Range Complex	328,149	328,149	1,640,745	1,640,745
Jacksonville Range Complex	383,861	383,861	1,919,305	1,919,305
Key West Range Complex	28,000	28,000	140,000	140,000
Gulf of Mexico Range Complex	28,950	28,950	144,750	144,750
Other AFTT Areas	21,150	21,150	100,750	100,750
Total	**1,449,671**	**1,449,671**	**7,243,355**	**7,243,355**
Small-Caliber Projectiles				
Northeast Range Complexes	27,000	27,000	135,000	135,000
Virginia Capes Range Complex	2,262,000	2,262,000	11,310,000	11,310,000
Navy Cherry Point Range Complex	393,000	393,000	1,965,000	1,965,000
Jacksonville Range Complex	1,026,000	1,026,000	5,130,000	5,130,000
Gulf of Mexico Range Complex	83,000	83,000	415,000	415,000
Other AFTT Areas	100,000	100,000	500,000	500,000
Total	**3,891,000**	**3,891,000**	**19,455,000**	**19,455,000**
Small-Caliber – Casings Only				
Virginia Capes Range Complex	5,000	5,000	25,000	25,000
Jacksonville Range Complex	5,000	5,000	25,000	25,000
Inshore Waters (see Table 3.0-25)	202,140	202,140	1,010,700	1,010,700
Total	**212,140**	**212,140**	**1,060,700**	**1,060,700**
Kinetic Energy Round				
Virginia Capes Range Complex	32	32	160	160
Navy Cherry Point Range Complex	4	4	20	20
Jacksonville Range Complex	4	4	20	20
Gulf of Mexico Range Complex	4	4	20	20
Other AFTT Areas	4	4	20	20
Total	**48**	**48**	**240**	**240**

[1] Non-explosive torpedoes are recovered after use.
Notes: AFTT = Atlantic Fleet Training and Testing

Table 3.0-25: Number and Location of Non-Explosive Practice Munitions Expended During Training Activities in Inshore Waters

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Small-Caliber – Casings Only				
Narragansett, RI	8,320	8,320	41,600	41,600
James River & Tributaries	97,920	97,920	489,600	489,600
Lower Chesapeake Bay	78,000	78,000	390,000	390,000
Cooper River, SC	5,100	5,100	25,500	25,500
Port Canaveral, FL	12,800	12,800	64,000	64,000
Total	**202,140**	**202,140**	**1,010,700**	**1,010,700**

Table 3.0-26: Number and Location of Non-Explosive Practice Munitions Expended During Testing Activities

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Torpedoes [1]				
Northeast Range Complexes	146	146	661	709
Virginia Capes Range Complex	375	375	1,571	1,862
Navy Cherry Point Range Complex	118	118	591	591
Jacksonville Range Complex	369	369	1,673	1,790
Key West Range Complex	2	2	11	11
Gulf of Mexico Range Complex	132	132	611	659
NUWC Newport Testing Range	315	315	1,575	1,575
SFOMF	6	6	29	29
NSWC Panama City Testing Range	180	180	900	900
Total	**1,643**	**1,643**	**7,622**	**8,126**
Bombs				
Virginia Capes Range Complex	916	916	4,580	4,580
Jacksonville Range Complex	12	12	60	60
Total	**928**	**928**	**4,460**	**4,460**
Rockets				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	759	759	3,713	3,727
Jacksonville Range Complex	407	407	1,950	2,034
Gulf of Mexico Range Complex	1	1	5	5
Total	**1,168**	**1,168**	**5,673**	**5,771**
Rockets (Flechette)				
Virginia Capes Range Complex	249	249	1,215	1,243
Jacksonville Range Complex	136	136	648	676
Total	**385**	**385**	**1,863**	**1,919**

Table 3.0-26: 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*
Missiles				
Northeast Range Complexes	25	25	122	122
Virginia Capes Range Complex	1,633	1,633	3,962	3,994
Navy Cherry Point Range Complex	25	25	122	122
Jacksonville Range Complex	594	594	814	822
Key West Range Complex	32	32	157	157
Gulf of Mexico Range Complex	42	42	207	207
Total	**2,351**	**2,351**	**5,384**	**5,424**
Kinetic Energy Rounds				
Northeast Range Complexes	33,503	33,503	167,504	167,504
Virginia Capes Range Complex	35,003	35,003	167,504	167,504
Navy Cherry Point Range Complex	35,003	35,003	167,504	167,504
Jacksonville Range Complex	35,003	35,003	167,504	167,504
Key West Range Complex	35,003	35,003	167,504	167,504
Gulf of Mexico Range Complex	35,003	35,003	167,504	167,504
NUWC Newport Testing Range	4	4	4	4
SFOMF	4	4	4	4
NSWC Panama City Testing Range	4	4	4	4
Total	**208,530**	**208,530**	**1,005,036**	**1,005,036**
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	234,665	234,665	1,155,325	1,173,325
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	**549,865**	**549,865**	**2,695,325**	**2,749,325**

Table 3.0-26: 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*
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 3.0-27: 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	306
Navy Cherry Point Range Complex	1	1	5	5
Jacksonville Range Complex	2	2	6	6
Gulf of Mexico Range Complex	22	22	106	106
Total	**87**	**87**	**423**	**423**
Grenades				
Northeast Range Complexes	56	56	280	280
Virginia Capes Range Complex	4,070	4,070	20,350	20,350
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	**4,210**	**4,210**	**21,050**	**21,050**
Bombs				
Virginia Capes Range Complex	88	88	500	500
Jacksonville Range Complex	56	56	280	280
Gulf of Mexico Range Complex	4	4	20	20

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

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
SINKEX Area	12	12	60	60
Total	**160**	**160**	**860**	**860**
Rockets				
Virginia Capes Range Complex	1,748	1,748	8,740	8,740
Navy Cherry Point Range Complex	76	76	380	380
Jacksonville Range Complex	1,824	1,824	9,120	9,120
Gulf of Mexico Range Complex	190	190	950	950
Total	**3,838**	**3,838**	**19,190**	**19,190**
Missiles				
Northeast Range Complexes	2	2	10	10
Virginia Capes Range Complex	199	199	995	995
Navy Cherry Point Range Complex	187	187	935	935
Jacksonville Range Complex	192	192	960	960
Key West Range Complex	8	8	40	40
Gulf of Mexico Range Complex	2	2	10	10
SINKEX Area	4	4	20	20
Total	**594**	**594**	**2,970**	**2,970**
Large-Caliber Projectiles				
Virginia Capes Range Complex	762	762	3,180	3,180
Navy Cherry Point Range Complex	210	210	1,050	1,050
Jacksonville Range Complex	642	642	3,210	3,210
Gulf of Mexico Range Complex	114	114	570	570
Other AFTT Areas	114	114	570	570
SINKEX Area	200	200	1,000	1,000
Total	**2,042**	**2,042**	**9,580**	**9,580**
Medium-Caliber Projectiles				
Virginia Capes Range Complex	46,100	46,100	230,500	230,500
Navy Cherry Point Range Complex	20,000	20,000	100,000	100,000
Jacksonville Range Complex	45,600	45,600	228,000	228,000
Gulf of Mexico Range Complex	6,000	6,000	30,000	30,000
Other AFTT Areas	400	400	2,000	2,000
Total	**118,100**	**118,100**	**590,500**	**590,500**

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

Table 3.0-28: Number and Location of Explosives that May Result in Fragments Used During Testing Activities

Activity Area	Maximum Annual # of Munitions		5-Year # of Munitions	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
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	7	7	29	29
NSWC Panama City Testing Range	12	12	60	60
Total	**46**	**46**	**194**	**194**
Explosive Sonobuoys				
Key West Range Complex	36	36	180	180
Total	**36**	**36**	**180**	**180**
AMNS 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	4	4	20	20
Total	**4**	**4**	**20**	**20**
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	222	222	1,033	1,110
Jacksonville Range Complex	70	70	327	350
Gulf of Mexico Range Complex	12	12	30	60
Total	**314**	**314**	**1,440**	**1,570**
Buoys				
Northeast Range Complexes	736	736	3,680	3,680
Virginia Capes Range Complex	368	368	1,840	1,840
Navy Cherry Point Range Complex	152	152	760	760
Jacksonville Range Complex	152	152	760	760
Key West Range Complex	202	202	1,010	1,010
Gulf of Mexico Range Complex	368	368	1,840	1,840
Total	**1,978**	**1,978**	**9,890**	**9,890**

Table 3.0-28: Number and Location of Explosives that May Result in Fragments Used During Testing Activities (continued)

Activity Area	*Maximum Annual # of Munitions*		*5-Year # of Munitions*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Anti-Torpedo Countermeasures				
Northeast Range Complexes	78	78	330	378
Virginia Capes Range Complex	96	96	432	480
Navy Cherry Point Range Complex	36	36	180	180
Jacksonville Range Complex	104	104	448	496
Gulf of Mexico Range Complex	72	72	312	360
Total	**386**	**386**	**1,702**	**1,894**
Mines				
Virginia Capes Range Complex	2	7	10	35
NSWC Panama City Testing Range	4	9	20	45
Total	**6**	**16**	**30**	**80**
Large-Caliber Projectiles				
Northeast Range Complexes	1,632	1,632	8160	8160
Virginia Capes Range Complex	4,763	4,763	23,815	23,815
Navy Cherry Point Range Complex	1,632	1,632	8,160	8,160
Jacksonville Range Complex	7,876	7,876	39,380	39,380
Key West Range Complex	2,332	2,332	11,660	11,660
Gulf of Mexico Range Complex	2,243	2,243	12,115	12,115
NSWC Panama City Testing Range	280	280	500	500
Total	**20,758**	**20,758**	**103,790**	**103,790**
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: NSWC = Naval Surface Warfare Center

Table 3.0-29: Number and Location of Targets Expended During Training Activities

Activity Area	*Maximum Annual # of Targets*		*5-Year # of Targets*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Air Targets (Decoy)				
Northeast Range Complexes	2	2	10	10
Virginia Capes Range Complex	81	81	405	405
Navy Cherry Point Range Complex	52	52	260	260
Jacksonville Range Complex	61	61	305	305
Key West Range Complex	9	9	47	47
Gulf of Mexico Range Complex	2	2	10	10
Total	**207**	**207**	**1,037**	**1,037**
Air Targets (Drone)				
Northeast Range Complexes	0	0	2	2
Virginia Capes Range Complex	18	18	92	92
Navy Cherry Point Range Complex	28	28	138	138
Jacksonville Range Complex	7	7	34	34
Gulf of Mexico Range Complex	0	0	2	2
Key West Range Complex	2	2	8	8
Total	**55**	**55**	**276**	**276**
Surface Targets (Mobile)				
Virginia Capes Range Complex	70	70	348	348
Navy Cherry Point Range Complex	23	23	114	114
Jacksonville Range Complex	78	78	388	388
Gulf of Mexico Range Complex	3	3	12	12
Total	**174**	**174**	**862**	**862**
Surface Targets (Stationary)				
Northeast Range Complexes	20	20	100	100
Virginia Capes Range Complex	4,512	4,512	22,560	22,560
Navy Cherry Point Range Complex	1,298	1,298	6,490	6,490
Jacksonville Range Complex	3,013	3,013	15,065	15,065
Gulf of Mexico Range Complex	334	334	1,670	1,670
Other AFTT Areas	200	200	980	980
Total	**9,377**	**9,377**	**46,865**	**46,865**
Subsurface Targets (Mobile)				
Northeast Range Complexes	82	84	408	420
Virginia Capes Range Complex	304	414	1,520	2,070
Navy Cherry Point Range Complex	98	125	488	625
Jacksonville Range Complex	1,057	1,272	5,303	6,362
Gulf of Mexico Range Complex	3	5	13	25
Other AFTT Areas	134	134	670	670
Total	**1,678**	**2,034**	**8,402**	**10,172**

Table 3.0-29: Number and Location of Targets Expended During Training Activities (continued)

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Mine Shapes				
Virginia Capes Range Complex	221	221	1,105	1,105
Navy Cherry Point Range Complex	78	78	390	390
Jacksonville Range Complex	78	78	390	390
Key West Range Complex	2	2	8	8
Gulf of Mexico Range Complex	93	93	466	466
Inshore Waters (see Table 3.0-30)	2	2	8	8
Total	**474**	**474**	**2,367**	**2,367**
Ship Hulks				
SINKEX Area	1	1	5	5
Total	**1**	**1**	**5**	**5**

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

Table 3.0-30: Number and Location of Targets Expended During Training Activities in Inshore Waters

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Mine Shapes				
Lower Chesapeake Bay	2	2	8	8
Total	**2**	**2**	**8**	**8**

Table 3.0-31: Number and Location of Targets Expended During Testing Activities

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Air Targets (Drones)				
Northeast Range Complexes	6	6	28	28
Virginia Capes Range Complex	200	200	976	976
Navy Cherry Point Range Complex	8	8	8	8
Jacksonville Range Complex	62	62	286	286
Key West Range Complex	6	6	6	6
Gulf of Mexico Range Complex	16	16	56	56
NUWC Newport Testing Range	6	6	6	6
SFOMF	6	6	6	6
NSWC Panama City Testing Range	6	6	6	6
Total	**316**	**316**	**1,378**	**1,378**
Air Targets (Decoy)				
Virginia Capes Range Complex	5	5	22	22
Jacksonville Range Complex	2	2	6	6
Total	**7**	**7**	**28**	**28**

Table 3.0-31: Number and Location of Targets Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Surface Targets (Mobile)				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	153	153	763	764
Jacksonville Range Complex	19	19	96	96
Key West Range Complex	2	2	11	11
Gulf of Mexico Range Complex	2	2	11	11
NUWC Newport Testing Range	450	450	2,250	2,250
Total	**627**	**627**	**3,136**	**3,137**
Surface Targets (Stationary)				
Northeast Range Complexes	172	172	858	858
Virginia Capes Range Complex	832	832	4,015	4,160
Navy Cherry Point Range Complex	172	172	858	858
Jacksonville Range Complex	545	545	2,576	2,727
Key West Range Complex	178	178	890	890
Gulf of Mexico Range Complex	248	248	1,212	1,242
NUWC Newport Testing Range	484	484	2,421	2,421
SFOMF	56	56	282	282
Total	**2,687**	**2,687**	**13,112**	**13,438**
Sub-Surface Targets (Mobile)				
Northeast Range Complexes	54	55	198	272
Virginia Capes Range Complex	57	58	237	290
Navy Cherry Point Range Complex	7	8	32	40
Jacksonville Range Complex	184	184	867	917
Key West Range Complex	3	3	15	15
Gulf of Mexico Range Complex	208	208	983	1,040
NUWC Newport Testing Range	516	516	2,581	2,581
SFOMF	95	95	475	475
Total	**1,124**	**1,127**	**5,388**	**5,630**
Sub-Surface Targets (Stationary)				
Northeast Range Complexes	2,228	2,228	10,896	11,142
Virginia Capes Range Complex	1,142	1,142	5,260	5,709
Navy Cherry Point Range Complex	81	81	407	407
Jacksonville Range Complex	320	320	1,564	1,600
Key West Range Complex	32	32	38	134
Gulf of Mexico Range Complex	960	960	4,795	4,801
NUWC Newport Testing Range	374	374	1,868	1,868
SFOMF	84	84	419	419
Total	**5,221**	**5,221**	**25,247**	**26,080**

Table 3.0-31: Number and Location of Targets Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Mine Shapes				
Virginia Capes Range Complex	127	127	536	636
Jacksonville Range Complex	122	122	610	610
Gulf of Mexico Range Complex	232	232	1,158	1,158
SFOMF	40	40	200	200
NSWC Panama City Testing Range	370	370	1,815	1,850
Total	**891**	**891**	**4,319**	**4,454**

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 Expended During Training Activities

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Acoustic Countermeasures				
Northeast Range Complexes	84	84	420	420
Virginia Capes Range Complex	51	51	255	255
Navy Cherry Point Range Complex	24	24	120	120
Jacksonville Range Complex	184	184	902	920
Gulf of Mexico Range Complex	0	6	0	30
Other AFTT Areas	88	88	440	440
Total	**431**	**437**	**2,137**	**2,185**
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
Inshore Waters (see Table 3.0.33)	20,400	20,400	102,000	102,000
Total	**114,540**	**114,540**	**572,700**	**572,700**
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**

Table 3.0-32: Number and Location of Other Military Materials Expended During Training Activities (continued)

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
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
Inshore Waters (see Table 3.0.33)	20,400	20,400	102,000	102,000
Total	**238,652**	**238,652**	**1,193,260**	**1,193,260**
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
Inshore Waters (see Table 3.0-33)	20,400	20,400	102,000	102,000
Total	**114,684**	**114,684**	**573,420**	**573,420**
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
Inshore Waters (see Table 3.0-33)	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	306
Navy Cherry Point Range Complex	1	1	5	5
Jacksonville Range Complex	2	2	6	6
Gulf of Mexico Range Complex	22	22	106	106
Total	**87**	**87**	**423**	**423**

Table 3.0-32: Number and Location of Other Military Materials Expended During Training Activities (continued)

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Expendable Bathythermographs				
Northeast Range Complexes	142	142	708	708
Virginia Capes Range Complex	414	439	2,065	2,193
Navy Cherry Point Range Complex	108	113	535	563
Jacksonville Range Complex	1,353	1,391	6,402	6,953
Gulf of Mexico Range Complex	5	128	25	640
Other AFTT Areas	154	154	770	770
Total	**2,176**	**2,367**	**10,505**	**11,827**
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
SINKEX	1	1	5	5
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				
Virginia Capes Range Complex	1,022	1,022	5,110	5,110
Navy Cherry Point Range Complex	332	332	1,660	1,660
Jacksonville Range Complex	1,060	1,060	5,300	5,300
Key West Range Complex	30	30	150	150
Gulf of Mexico Range Complex	53	53	265	265
Other AFTT Areas	24	24	120	120
Inshore Waters (see Table 3.0-33)	1,106	1,106	5,530	5,530
Total	**3,627**	**3,627**	**18,135**	**18,135**
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**

Table 3.0-32: Number and Location of Other Military Materials Expended During Training Activities (continued)

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Non-Explosive Sonobuoy				
Northeast Range Complexes	2,882	2,882	14,410	14,410
Virginia Capes Range Complex	7,484	7,484	37,204	37,420
Navy Cherry Point Range Complex	2,542	2,542	12,332	12,710
Jacksonville Range Complex	27,237	27,237	134,673	136,185
Gulf of Mexico Range Complex	0	702	0	3,510
Other AFTT Areas	432	432	2,160	2,160
Total	**40,577**	**41,279**	**200,779**	**206,395**
Decelerators/Parachutes - Small				
Northeast Range Complexes	2,882	2,882	14,410	14,410
Virginia Capes Range Complex	7,497	7,497	37,244	37,460
Navy Cherry Point Range Complex	2,542	2,542	12,332	12,710
Jacksonville Range Complex	27,265	27,265	134,813	136,325
Gulf of Mexico Range Complex	0	702	0	3,510
Other AFTT Areas	432	432	2,160	2,160
Total	**40,618**	**41,320**	**200,959**	**206,575**
Decelerators/Parachutes - Medium				
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**
Decelerators/Parachutes - Large				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	30	30	150	150
Gulf of Mexico Range Complex	1	1	5	5
Jacksonville Range Complex	1	1	5	5
Total	**33**	**33**	**165**	**165**
Decelerators/Parachutes – Extra Large				
Virginia Capes Range Complex	5	5	25	25
Total	**5**	**5**	**25**	**25**
Sabot-Kinetic Energy Round				
Virginia Capes Range Complex	32	32	160	160
Navy Cherry Point Range Complex	4	4	20	20
Jacksonville Range Complex	4	4	20	20
Gulf of Mexico Range Complex	4	4	20	20
Other AFTT Areas	4	4	20	20
Total	**48**	**48**	**240**	**240**

Table 3.0-32: Number and Location of Other Military Materials Expended During Training Activities (continued)

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
JATO Bottles				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	35	35	175	175
Jacksonville Range Complex	1	1	5	5
Gulf of Mexico Range Complex	1	1	5	5
Total	**38**	**38**	**190**	**190**

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; JATO = Jet Assisted Take-Off

Table 3.0-33: Number and Location of Other Military Materials Expended During Training Activities in Inshore Waters

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Marine Markers				
Narragansett, RI	64	64	320	320
James River and Tributaries	728	728	3,640	3,640
York River	20	20	100	100
Lower Chesapeake Bay	230	230	1,150	1,150
Port Canaveral, FL	64	64	320	320
Total	**1,106**	**1,106**	**5,530**	**5,530**
Flares				
James River & Tributaries	20,400	20,400	102,000	102,000
Total	**20,400**	**20,400**	**102,000**	**102,000**
Flare O-Ring				
James River & Tributaries	20,400	20,400	102,000	102,000
Total	**20,400**	**20,400**	**102,000**	**102,000**
Compression Pad or Plastic Piston				
James River & Tributaries	20,400	20,400	102,000	102,000
Total	**20,400**	**20,400**	**102,000**	**102,000**
Endcap – Chaff and Flare				
James River & Tributaries	20,400	20,400	102,000	102,000
Total	**20,400**	**20,400**	**102,000**	**102,000**

Table 3.0-34: Number and Location of Other Military Materials Expended During Testing Activities

Activity Area	*Maximum Annual # of Materials*		*5-Year # of Materials*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Acoustic Countermeasures				
Northeast Range Complexes	843	843	4,018	4,018
Virginia Capes Range Complex	1,163	1,163	5,814	5,814
Navy Cherry Point Range Complex	708	708	3,540	3,540
Jacksonville Range Complex	1,508	1,508	7,145	7,145
Gulf of Mexico Range Complex	697	697	3,484	3,484
NUWC Newport Testing Range	64	64	320	320
SFOMF	17	17	84	84
Total	**5,000**	**5,000**	**24,405**	**24,405**
Anchors (Other)				
Northeast Range Complexes	685	685	3,425	3,425
Virginia Capes Range Complex	343	343	1,713	1,713
Jacksonville Range Complex	20	20	100	100
Gulf of Mexico Range Complex	338	338	1,688	1,688
NUWC Newport Testing Range	70	70	350	350
SFOMF	654	654	3,270	3,270
Total	**2,110**	**2,110**	**10,546**	**10,546**
Anchors (Mine)				
Virginia Capes Range Complex	2	7	10	35
NSWC Panama City Testing Range	4	9	20	45
Total	**6**	**16**	**30**	**80**
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**

Table 3.0-34: Number and Location of Other Military Materials Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Chaff – Ship Cartridge				
Northeast Range Complexes	144	144	720	720
Virginia Capes Range Complex	1,019	1,019	4,955	4,955
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**	**10,235**	**10,235**
Canister-Miscellaneous				
Northeast Range Complexes	240	240	1,200	1,200
Virginia Capes Range Complex	240	240	1,200	1,200
Total	**480**	**480**	**2,400**	**2,400**
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**
Fiber Optic Canister				
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**

Table 3.0-34: Number and Location of Other Military Materials Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Expendable Bathythermographs				
Northeast Range Complexes	21,104	21,104	105,516	105,516
Virginia Capes Range Complex	9,740	9,740	48,697	48,697
Navy Cherry Point Range Complex	277	277	1,385	1,385
Jacksonville Range Complex	561	561	2,775	2,805
Key West Range Complex	10	10	50	50
Gulf of Mexico Range Complex	9,813	9,813	49,063	49,063
SFOMF	4	4	20	20
Total	**41,509**	**41,509**	**207,506**	**207,536**
Heavyweight Torpedo Accessories				
Northeast Range Complexes	98	98	421	469
Virginia Capes Range Complex	128	128	591	639
Navy Cherry Point Range Complex	42	42	210	210
Jacksonville Range Complex	134	134	579	627
Key West Range Complex	2	2	10	10
Gulf of Mexico Range Complex	84	84	371	419
NUWC Newport Testing Range	20	20	100	100
SFOMF	6	6	29	29
Total	**514**	**514**	**2,311**	**2,503**
Lightweight Torpedo Accessories				
Northeast Range Complexes	54	54	267	267
Virginia Capes Range Complex	225	225	867	1,110
Navy Cherry Point Range Complex	50	50	247	247
Jacksonville Range Complex	213	213	981	981
Key West Range Complex	2	2	7	7
Gulf of Mexico Range Complex	54	54	267	267
NUWC Newport Testing Range	20	20	100	100
NSWC Panama City Testing Range	192	192	960	960
Total	**810**	**810**	**3,696**	**3,939**
Non-Explosive Sonobuoy				
Northeast Range Complexes	3,596	3,715	15,911	18,375
Virginia Capes Range Complex	5,505	5,548	24,329	27,740
Navy Cherry Point Range Complex	2,144	2,187	10,606	10,935
Jacksonville Range Complex	5,847	6,062	29,845	29,910
Key West Range Complex	3,007	3,007	14,807	15,036
Gulf of Mexico Range Complex	2,027	2,027	9,550	10,135
NUWC Newport Testing Range	1,200	1,200	6,000	6,000
SFOMF	32	32	160	160

Table 3.0-34: Number and Location of Other Military Materials Expended During Testing Activities (continued)

Activity Area	Maximum Annual # of Materials		5-Year # of Materials	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
NSWC Panama City Testing Range	192	192	960	960
Total	**23,550**	**23,970**	**112,168**	**119,251**
Decelerators/Parachutes – Small				
Northeast Range Complexes	3,637	3,756	16,116	18,580
Virginia Capes Range Complex	5,711	5,754	25,108	28,762
Navy Cherry Point Range Complex	2,185	2,228	10,811	11,140
Jacksonville Range Complex	6,037	6,252	28,718	30,852
Key West Range Complex	3,008	3,008	14,812	15,310
Gulf of Mexico Range Complex	2,068	2,068	9,755	10,340
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	**24,070**	**24,490**	**112,440**	**122,104**
Decelerators/Parachutes - Large				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	14	14	70	70
Jacksonville Range Complex	1	1	5	5
Gulf of Mexico Range Complex	1	1	5	5
Total	**17**	**17**	**85**	**85**
Sabot – Kinetic Energy Round				
Northeast Range Complexes	33,503	33,503	167,054	167,054
Virginia Capes Range Complex	33,503	33,503	167,054	167,054
Navy Cherry Point Range Complex	33,503	33,503	167,054	167,054
Jacksonville Range Complex	33,503	33,503	167,054	167,054
Key West Range Complex	33,503	33,503	167,054	167,054
Gulf of Mexico Range Complex	33,503	33,503	167,054	167,054
NUWC Newport Testing Range	4	4	4	4
SFOMF	4	4	4	4
NSWC Panama City Testing Range	4	4	4	4
Total	**201,030**	**201,030**	**1,002,336**	**1,002,336**
JATO Bottles				
Northeast Range Complexes	1	1	5	5
Virginia Capes Range Complex	14	14	70	70
Jacksonville Range Complex	1	1	5	5
Gulf of Mexico Range Complex	1	1	5	5
Total	**17**	**17**	**85**	**85**

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; JATO = Jet Assisted Take-Off

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) and cultural resources.

Table 3.0-35 and Table 3.0-36 show the number and location of proposed activities that include the use of seafloor devices.

Table 3.0-35: 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	3,176	3,176	15,978	15,978
Navy Cherry Point Range Complex	662	662	3,260	3,260
Jacksonville Range Complex	665	665	3,321	3,321
Key West Range Complex	23	23	115	115
Gulf of Mexico Range Complex	383	383	1,911	1,911
NSWC Panama City Testing Range	244	244	1,220	1,220
Inshore Waters (see Table 3.0-36)	523	523	2,635	2,635
Total	**5,676**	**5,676**	**28,440**	**28,440**
Testing				
Northeast Range Complexes	11	11	55	55
Virginia Capes Range Complex	159	169	665	843
Navy Cherry Point Range Complex	10	10	50	50
Jacksonville Range Complex	33	33	149	149
Key West Range Complex	1	1	3	3
Gulf of Mexico Range Complex	50	50	247	247
NUWC Newport Testing Range	322	322	1,608	1,608
SFOMF	100	100	498	498
NSWC Panama City Testing Range	344	354	1,600	1,742
Total	**1,030**	**1,050**	**4,875**	**5,195**

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

Table 3.0-36: Number and Location of Activities in Inshore Waters Including Seafloor Devices

Activity Area	*Maximum Annual # of Activities*		*5-Year # of Activities*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Training				
Boston, MA	1	1	3	3
Earle, NJ	1	1	3	3
Delaware Bay, DE	1	1	3	3
Hampton Roads, VA	2	2	6	6
Lower Chesapeake Bay, VA	308	308	1,540	1,540
James River & Tributaries, VA	75	75	425	425
York River, VA	19	19	95	95
Morehead City, NC	1	1	3	3
Wilmington, NC	1	1	3	3
Savannah, GA	1	1	3	3
Kings Bay, GA	23	23	113	113
Mayport, FL	1	1	3	3
Port Canaveral, FL	1	1	3	3
Truman Harbor, FL	42	42	210	210
Demolition Key	42	42	210	210
Tampa, FL	1	1	3	3
Beaumont, TX	2	2	6	6
Corpus Christi, TX	1	1	3	3
Total	**523**	**523**	**2,635**	**2,635**

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) tiltrotor 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 tiltrotor 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 MQ-25 Stingray Carrier Based Unmanned Aerial System. Aircraft strikes are only applicable to birds and bats. Table 3.0-37 and Table 3.0-38 show the number and location of proposed activities that include the use of aircraft.

Table 3.0-37: 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	22,111	22,111	110,541	110,553
Navy Cherry Point Range Complex	36,031	36,031	180,134	180,155
Jacksonville Range Complex	38,101	38,101	190,470	190,503
Key West Range Complex	26,346	26,346	131,730	131,730
Gulf of Mexico Range Complex	1,088	1,099	5,438	5,493
NSWC Panama City Testing Range	244	244	1,220	1,220
Other AFTT Areas	48	48	240	240
Inshore Waters (see Table 3.0-38)	3,634	3,634	15,520	15,520
Total	**127,695**	**127,706**	**635,753**	**635,874**
Testing				
Northeast Range Complexes	756	759	3,492	3,792
Virginia Capes Range Complex	4,595	4,601	21,807	22,862
Navy Cherry Point Range Complex	639	640	3,189	3,197
Jacksonville Range Complex	921	926	4,318	4,563
Key West Range Complex	253	253	1,132	1,258
Gulf of Mexico Range Complex	192	192	858	925
NUWC Newport Testing Range	49	49	239	239
SFOMF	35	35	170	170
NSWC Panama City Testing Range	229	234	1,045	1,162
Inshore Waters (see Table 3.0-38)	4	4	4	4
Total	**7,673**	**7,693**	**36,254**	**38,172**

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

Table 3.0-38: Number and Location of Activities in Inshore 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	3
Earle, NJ	1	1	3	3
Delaware Bay, DE	1	1	3	3
Hampton Roads, VA	2	2	6	6
Lower Chesapeake Bay	1,624	1,624	5,500	5,500
James River & Tributaries	1,282	1,282	6,410	6,410
York River	4	4	20	20

Table 3.0-38: Number and Location of Activities in Inshore 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	3
Wilmington, NC	1	1	3	3
Savannah, GA	1	1	3	3
Kings Bay, GA	481	481	2,403	2,403
Mayport, FL	36	36	178	178
St. Johns River, FL	144	144	720	720
Port Canaveral, FL	1	1	3	3
Tampa, FL	1	1	3	3
St. Andrew Bay, FL	50	50	250	250
Beaumont, TX	2	2	6	6
Corpus Christi, TX	1	1	3	3
Total	**3,634**	**3,634**	**15,520**	**15,520**
Testing				
Little Creek, VA	2	2	2	2
Norfolk, VA	2	2	2	2
Total	**4**	**4**	**4**	**4**

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. 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. Arresting gear cables are not an entanglement concern due to their heavy weight and thickness. These cables weigh approximately 450 lb., reach 110 ft. in length, and are several inches thick. Therefore, they do not loop and are not able to wrap around an animal or appendage and will not be discussed further in this document.

3.0.3.3.5.1 Wires and Cables

Fiber Optic Cables

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

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 40.4 lb. and can be broken by hand (Swope & McDonald, 2013), 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.” However, it has a somewhat higher breaking strength than the monofilament used in the body of most commercial gillnets (typically 31 lb. or less). The 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, keeping 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 3.0-39 and Table 3.0-40 show the number and location of wires and cables expended during proposed training and testing activities.

Table 3.0-39: 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	62	62	306	306
Navy Cherry Point Range Complex	9	9	45	45
Jacksonville Range Complex	2	2	6	6
Gulf of Mexico Range Complex	22	22	106	106
Total	**95**	**95**	**463**	**463**
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	2,882	2,882	14,410	14,410
Virginia Capes Range Complex	7,484	7,484	37,204	37,420
Navy Cherry Point Range Complex	2,542	2,542	12,332	12,710
Jacksonville Range Complex	27,237	27,237	134,673	136,185
Gulf of Mexico Range Complex	0	702	0	3,510
Other AFTT Areas	432	432	2,160	2,160
Total	**40,577**	**41,279**	**200,779**	**206,395**
Expendable Bathythermograph Wires				
Northeast Range Complexes	142	142	708	708
Virginia Capes Range Complex	414	439	2,065	2,193
Navy Cherry Point Range Complex	108	113	535	563
Jacksonville Range Complex	1,353	1,391	6,402	6,953
Gulf of Mexico Range Complex	5	128	25	640
Other AFTT Areas	154	154	770	770
Total	**2,176**	**2,367**	**10,505**	**11,827**

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 3.0-40: Number and Location of Wires and Cables Expended During Testing 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	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**
Guidance Wires				
Northeast Range Complexes	98	98	421	469
Virginia Capes Range Complex	128	128	591	639
Navy Cherry Point Range Complex	42	42	210	210
Jacksonville Range Complex	134	134	579	627
Key West Range Complex	2	2	10	10
Gulf of Mexico Range Complex	84	84	371	419
NUWC Newport Testing Range	20	20	100	100
SFOMF	6	6	29	29
Total	**514**	**514**	**2,311**	**2,503**
Sonobuoy Wires				
Northeast Range Complexes	3,596	3,715	15,911	18,375
Virginia Capes Range Complex	5,505	5,548	24,329	27,740
Navy Cherry Point Range Complex	2,144	2,187	10,606	10,935
Jacksonville Range Complex	5,847	6,062	27,845	29,910
Key West Range Complex	3,007	3,007	14,807	15,305
Gulf of Mexico Range Complex	2,027	2,027	9,550	10,135
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	**23,550**	**23,970**	**110,168**	**119,520**
Expendable Bathythermograph Wires				
Northeast Range Complexes	21,104	21,104	105,516	105,516
Virginia Capes Range Complex	9,740	9,740	48,667	48,697
Navy Cherry Point Range Complex	277	277	1,385	1,385
Jacksonville Range Complex	561	561	2,775	2,805
Key West Range Complex	10	10	50	50
Gulf of Mexico Range Complex	9,813	9,813	49,063	49,063
SFOMF	4	4	20	20
Total	**41,509**	**41,509**	**207,476**	**207,536**

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

Decelerators/parachutes used during training and testing activities are classified into four different categories based on size: small, medium, large, and extra-large (Table 3.0-41). Aircraft-launched sonobuoys and lightweight torpedoes (such as the MK 46 and MK 54) use nylon decelerators/parachutes ranging in size from 18 to 48 in. in diameter (small). The majority of the decelerators/parachutes in the small size category are smaller (18 in.) cross shape decelerators/parachutes associated with sonobuoys (Figure 3.0-13). Illumination flares use large decelerators/parachutes, up to approximately 19 ft. in diameter. Both small- and medium-sized decelerators/parachutes are made of cloth and nylon, many with weights attached to their short attachment lines to speed their sinking. At water impact, the decelerator/parachute assembly is expended and sinks away from the unit. The decelerator/parachute assembly may remain at the surface for 5–15 seconds before the decelerator/parachute and its housing sink to the seafloor, where the fabric becomes flattened (Environmental Sciences Group, 2005). Once settled on the bottom the canopy may temporarily billow if bottom currents are present.

Table 3.0-41: Size Categories for Decelerators/Parachutes Expended During Training and Testing Activities

Size Category	*Diameter (ft.)*	*Associated Activity*
Small	1.5–6	Air-launched sonobuoys, lightweight torpedoes, and drones (drag parachute)
Medium	19	Illumination flares
Large	30–50	drones (main parachute)
Extra-large	82	drones (main parachute)

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

Aerial targets (drones) use large (between 30 and 50 ft. in diameter) and extra-large (80 ft. in diameter) decelerators/parachutes (Figure 3.0-14). Large and extra-large decelerators/parachutes are also made of cloth and nylon, with suspension lines of varying lengths (large: 40–70 ft. in length [with up to 28 lines per decelerator/parachute]; extra-large: 82 ft. in length [with up to 64 lines per decelerator/parachute]). Some aerial targets also use a small drag parachute (6 ft. in diameter) to slow their forward momentum prior to deploying the larger primary decelerator/parachute. Unlike the small- and medium-sized decelerators/parachutes, drone decelerators/parachutes do not have weights attached and may remain at the surface or suspended in the water column for some time prior to eventual settlement on the seafloor.

Figure 3.0-14: Aerial Target (Drone) with Parachute Deployed

Table 3.0-32 and Table 3.0-34 show the number and location of decelerator/parachutes expended during proposed training and testing activities.

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. Biodegradable polymers degrade to smaller compounds as a result of microorganisms and enzymes. The biodegradable polymers that the Navy uses are designed to temporarily interact with the propeller(s) of a target craft rendering it ineffective. Some of the polymer constituents would dissolve within two hours of immersion. Based on the constituents of the biodegradable polymer the Navy proposes to use, it is anticipated that the material will break down into small pieces within a few days to weeks. This will break down further and dissolve into the water column within weeks to a few months. 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. At the end of dispersion, the remaining materials are generally separated fibers with lengths on the order of 54 micrometers.

Biodegradable polymers will be used only during proposed testing activities, not during training activities. Table 3.0-42 shows the number and location of proposed testing activities that use biodegradable polymer.

Table 3.0-42: Number and Location of Activities Including Biodegradable Polymers During Testing

Activity Area	*Maximum Annual # of Activities*		*5-Year # of Activities*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
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 3.0-24, Table 3.0-25, and Table 3.0-26 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 3.0-27 and Table 3.0-28 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 3.0-43 and Table 3.0-44 show the number and location of targets used during proposed training and testing activities that may result in fragments.

Table 3.0-43: 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	2	2	12	12
Virginia Capes Range Complex	99	99	497	497
Navy Cherry Point Range Complex	80	80	398	398
Jacksonville Range Complex	68	68	339	339
Key West Range Complex	11	11	55	55

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

Activity Area	*Maximum Annual # of Targets*		*5-Year # of Targets*	
	Alternative 1	*Alternative 2*	*Alternative 1*	*Alternative 2*
Gulf of Mexico Range Complex	2	2	12	12
Total	**262**	**262**	**1,313**	**1,313**
Surface Targets				
Northeast Range Complexes	20	20	100	100
Virginia Capes Range Complex	4,582	4,582	22,908	22,908
Navy Cherry Point Range Complex	1,321	1,321	6,604	6,604
Jacksonville Range Complex	3,091	3,091	15,453	15,453
Gulf of Mexico Range Complex	336	336	1,682	1,682
Other AFTT Areas	200	200	980	980
Total	**9,550**	**9,550**	**47,727**	**47,727**
Mine Shapes				
Virginia Capes Range Complex	221	221	1,105	1,105
Navy Cherry Point Range Complex	78	78	390	390
Jacksonville Range Complex	78	78	390	390
Key West Range Complex	2	2	8	8
Gulf of Mexico Range Complex	93	93	466	466
Total	**472**	**472**	**2,359**	**2,359**

Notes: AFTT = Atlantic Fleet Training and Testing

Table 3.0-44: 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	14	14	69	69
Virginia Capes Range Complex	583	583	2,916	2,916
Navy Cherry Point Range Complex	6	6	29	29
Jacksonville Range Complex	168	168	842	842
Key West Range Complex	13	13	63	63
Gulf of Mexico Range Complex	25	25	125	125
Total	**809**	**809**	**4,044**	**4,044**
Surface Targets				
Northeast Range Complexes	173	173	863	863
Virginia Capes Range Complex	984	984	4,778	4,924
Navy Cherry Point Range Complex	172	172	858	858
Jacksonville Range Complex	545	545	2,673	2,824
Key West Range Complex	180	180	900	900

Table 3.0-44: Number and Location of Targets Expended During Testing Activities That May Result in Fragments (continued)

Activity Area	Maximum Annual # of Targets		5-Year # of Targets	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Gulf of Mexico Range Complex	250	259	1,222	1,252
NUWC Newport Testing Range	934	934	4,671	4,671
SFOMF	56	56	282	282
Total	**3,294**	**3,303**	**16,247**	**16,574**
Mine Shapes				
Virginia Capes Range Complex	127	127	536	636
Jacksonville Range Complex	122	122	610	610
Gulf of Mexico Range Complex	232	232	1,158	1,158
SFOMF	40	40	200	200
NSWC Panama City Testing Range	370	370	1,815	1,850
Total	**891**	**891**	**4,319**	**4,454**

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 masks the position of the ship or aircraft. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (U.S. Air Force, 1997). Chaff is released or dispensed in cartridges or projectiles that contain millions of fibers. When deployed, a diffuse cloud of fibers is formed that is undetectable to the human eye. Chaff is a very light material, similar to fine human hair. It can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (Arfsten et al., 2002; U.S. 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; U.S. Air Force, 1997; U.S. Department of the Navy, 1999). Nonetheless, some marine animal species within the Study Area could be exposed to chaff through direct body contact, inhalation, and ingestion. Chemical alteration of water and sediment from decomposing chaff fibers is not expected to occur. Based on the dispersion characteristics of chaff, it is likely that marine animals would occasionally come in direct contact with chaff fibers while either at the water's surface or while submerged, but such contact would be inconsequential. Because of the flexibility and softness of chaff, external contact would not be expected to impact most wildlife (U.S. Air Force, 1997) and the fibers would quickly wash off shortly after contact. Given the properties of chaff, skin irritation is not expected to be a problem (U.S. Air Force, 1997). The potential exists for marine animals to inhale chaff fibers if they are at the surface while chaff is airborne. Arfsten et al. (2002), (U.S. Department of the Navy, 1999), and U.S. Air Force (1997) reviewed the potential impacts of chaff inhalation on humans, livestock, and other animals and concluded that the fibers are too large to be inhaled into the lungs. The fibers were predicted to be deposited in the nose, mouth, or trachea and either swallowed or expelled.

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

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

Table 3.0-32 and Table 3.0-34 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. Air Force, 1997).

Table 3.0-32, Table 3.0-33, and Table 3.0-34 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-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 3.0-32 and Table 3.0-34 show the number and location of small-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). This analysis 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 (NM^2) of benthic habitat, a second stressor disturbed 0.5 NM^2, and all other stressors did not disturb benthic habitat, then the total benthic habitat disturbed would be 0.75 NM^2. For stressors with identical but not quantifiable assessment endpoints, available scientific knowledge, best professional judgment, and the general assumptions outlined above were used to evaluate potential additive impacts.
- For stressors with differing impacts and assessment endpoints, the potential for additive, synergistic, and antagonistic effects were evaluated based on available scientific knowledge, professional judgment, and the general assumptions outlined above.

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 can result from individually minor but collectively significant actions taking place over a period of time (40 Code of Federal Regulations part 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 3.1.1.3 (Approach to Analysis), 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 Section 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 bats, 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 3.0-15 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 is based on the characteristics of the acoustic stimuli and the characteristics of the animal (species, susceptibility, life history stage, size, and past experiences). Very high exposure levels close to explosives have the potential to cause injury. High-level, long-duration, or repetitive exposures may potentially cause some hearing loss. All perceived sounds may lead to behavioral responses, physiological stress, and masking. Many sounds, including sounds that are not detectable by the animal, could have no effect (Box A4).

3.0.3.6.1.1 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.

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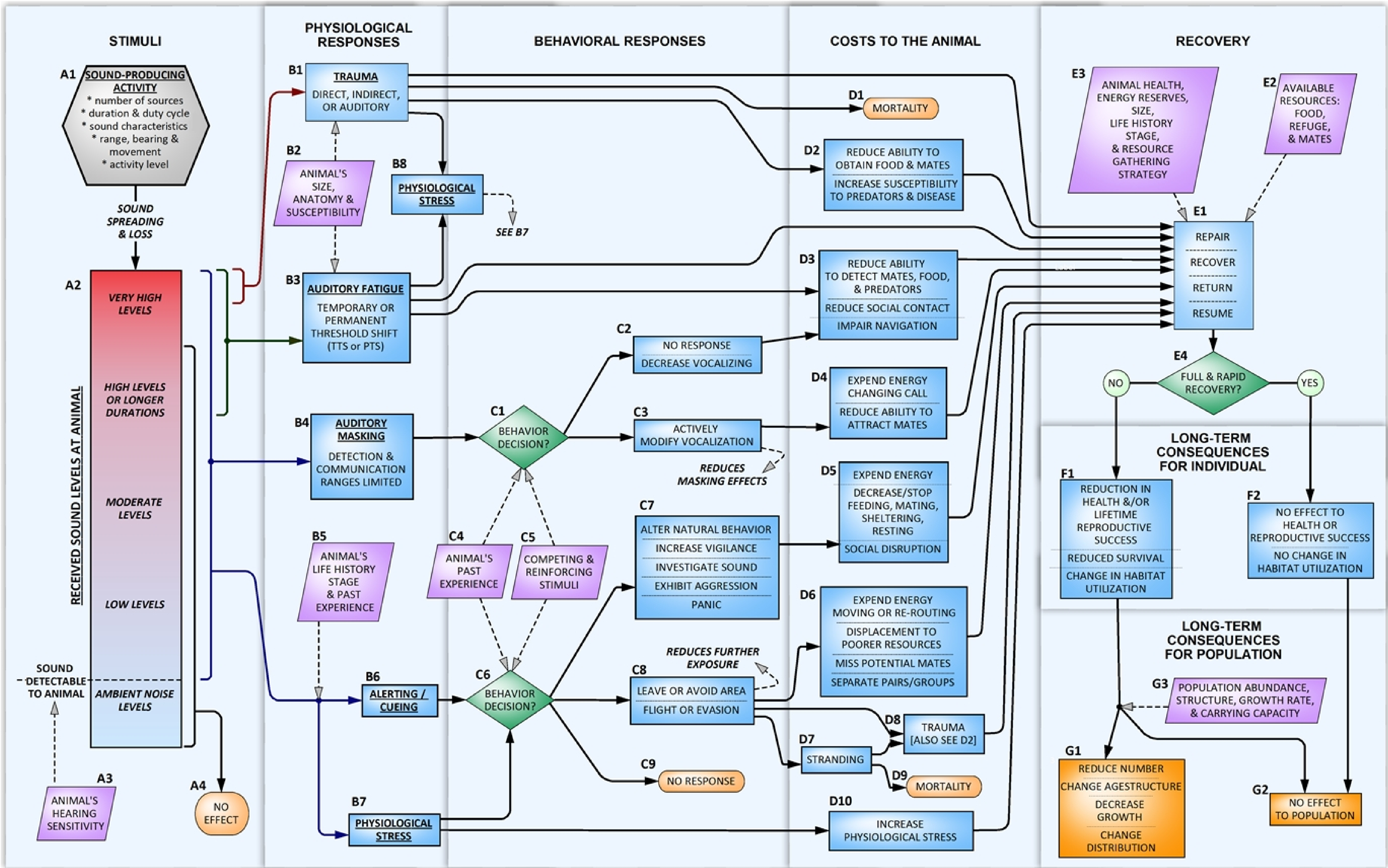

Figure 3.0-15: Flow Chart of the Evaluation Process of Sound-Producing Activities

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

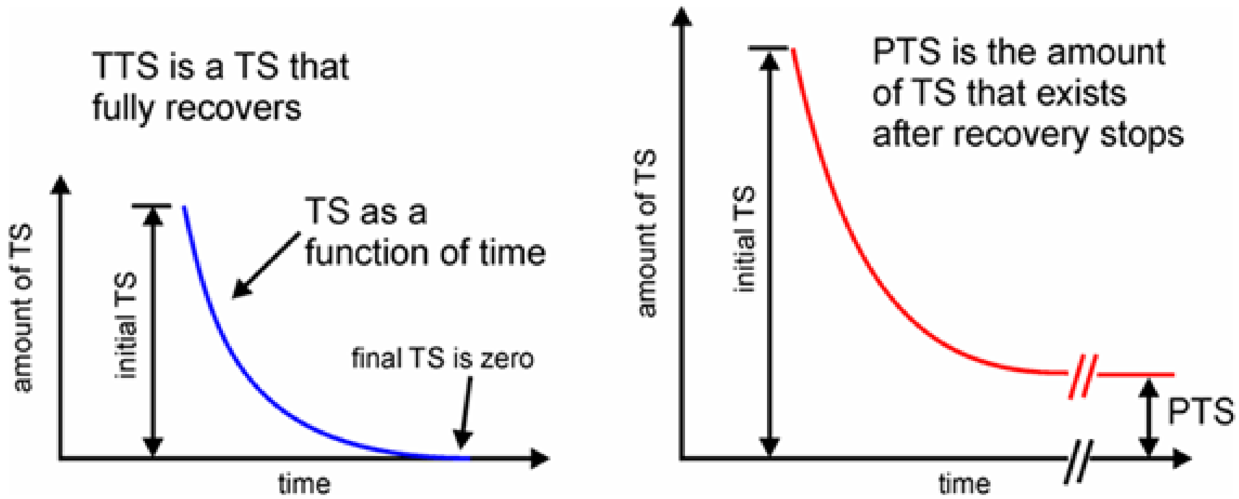
Vascular and tissue bubble formation resulting from sound exposure is a hypothesized mechanism of injury to breath-holding marine animals. Bubble formation and growth due to direct sound exposure have been hypothesized (Crum & Mao, 1996; Crum et al., 2005); however, the experimental laboratory conditions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

Injury could increase the animal's physiological stress (Box B8), which feeds into the stress response (Box B7) and also increases the likelihood or severity of a behavioral response. Injury may reduce an animal's ability to secure food by reducing its mobility or the efficiency of its sensory systems, making the injured individual less attractive to potential mates, increasing an individual's chances of contracting diseases 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 PTS, or TTS. If the threshold shift eventually returns to zero (the animal's hearing returns to pre-exposure value), the threshold shift is a TTS. If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 3.0-16 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 3.0-16: 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 may 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 Bureau of Ocean Energy Management (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 (U.S. Department of the Navy, 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 (Bruderer et al., 1999; Manville, 2016; Wiltschko et al., 2011; Wiltschko & Wiltschko, 2005).

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 (Bureau of Ocean Energy Management, 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 Bureau of Ocean Energy Management (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, explosives 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 NM^2 of benthic habitat, a second stressor disturbed 0.5 NM^2, and all other stressors did not disturb benthic habitat, then the total benthic habitat disturbed would be 0.75 NM^2. For stressors with identical but not quantifiable assessment endpoints, 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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