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

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3.2 SEDIMENTS AND WATER QUALITY

SEDIMENTS AND WATER QUALILTY SYNOPSIS

The United States Department of the Navy (Navy) considered all potential stressors that sediments and water quality could potentially be exposed to from the Proposed Action. The following conclusions have been reached for the Preferred Alternative:

- Explosives and explosives byproducts: Impacts from explosives and explosives byproducts would be short term and local. Impacts from unconsumed explosives and constituent chemical compounds would be minimal and limited to the area adjacent to the munition. Explosives and constituent compounds could persist in the environment depending on the integrity of the undetonated munitions casing and the physical conditions on the seafloor where the munition resides. Chemical and physical changes to sediments and water quality, as measured by the concentrations of contaminants or other anthropogenic compounds, may be detectable and would be below applicable regulatory standards for determining effects on biological resources and habitats.
- Chemicals other than explosives: Impacts from other chemicals not associated with explosives would be both short term and long term depending on the chemical and the physical conditions on the seafloor where the source of the chemicals resides. Impacts would be minimal and localized to the immediate area surrounding the source of the chemical release.
- Metals: Impacts from metals would be minimal and long term and dependent on the metal and the physical conditions on the seafloor where the metal object (e.g., non-explosive munition) resides. Impacts would be localized to the area adjacent to the metal object. Concentrations of metal contaminants near the expended material or munition may be measurable and are likely to be similar to the concentrations of metals in sediments from nearby reference locations.
- Other materials: Impacts from other expended materials not associated with munitions would be both short term and long term depending on the material and the physical conditions (e.g., substrate, temperature, currents) on the seafloor where the material resides. Impacts would be localized to the immediate area surrounding the material. Chemical and physical changes to sediments and water quality, as measured by the concentrations of contaminants or other anthropogenic compounds near the expended material, are not likely to be detectable and would be similar to the concentrations of chemicals and material residue from nearby reference locations.

3.2.1 INTRODUCTION AND METHODS

3.2.1.1 Introduction

The following sections provide an overview of the characteristics of sediments and water quality in the Atlantic Fleet Training and Testing (AFTT) Study Area (Study Area), and describe, in general terms, the methods used to analyze potential impacts of the Proposed Action on these resources.

3.2.1.1.1 Sediments

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

3.2.1.1.1.1 Characteristics of Sediments

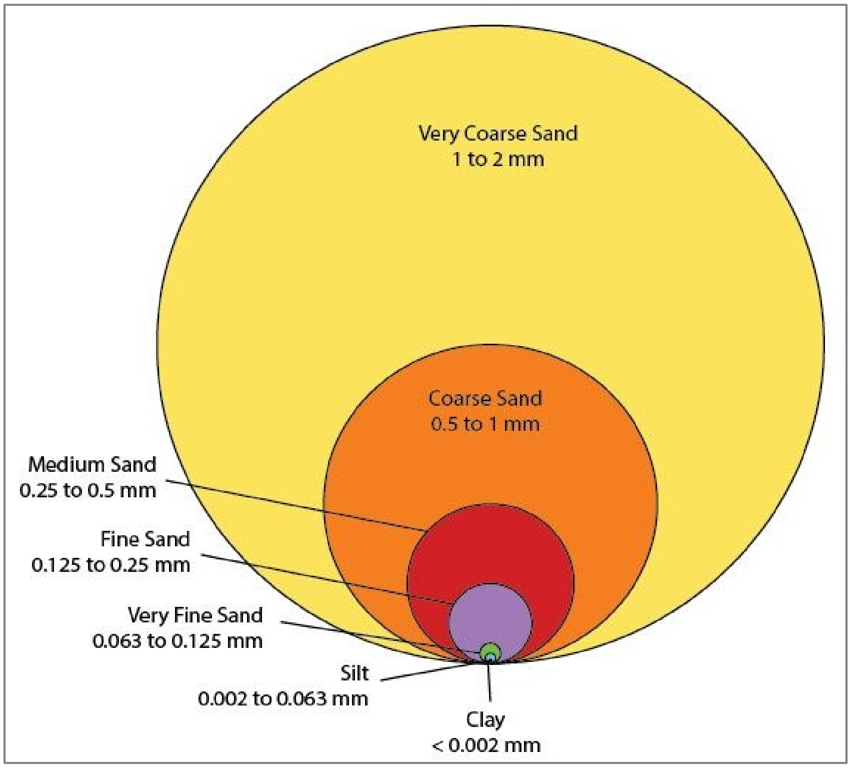


Figure 3.2-1: Sediment Particle Size Comparison

Sediments consist of solid fragments of organic and inorganic matter forming the bottom, or substrate, of bodies of water. Sediments in the marine environment (e.g., in ocean basins) are either terrigenous, meaning that they originate from land, or are biogenic (i.e., formed from the remains of marine organisms). Terrigenous sediments come from the weathering of rock and other land-based substrates and are transported by water, wind, and ice (glaciers) to the seafloor. Biogenic sediments are produced in the oceans by the skeletal remains of single-celled benthic and planktonic organisms (e.g., foraminiferans and diatoms). When an organism dies, its remains are deposited on the seafloor. The remains are composed primarily of either calcium carbonate (e.g., a shell) or silica, and mixed with clays, form either a calcareous or siliceous ooze (Chester, 2003). Sediments in the Atlantic Ocean are predominantly composed of calcareous oozes, and the Pacific Ocean has more siliceous oozes (Kennett, 1982). In addition to composition, sediments are also classified by size. Blott and Pye (2012) reviewed commonly used historical classification systems and offered a refined system that is adopted for describing sediments in this section. Sediments are grouped into five size classes: boulders, gravel, sand, silt, and clay. Sands range in size from 0.063 millimeter (mm) (very fine sands) to 2 mm (very coarse sands) (Figure 3.2-1). For comparison, the thickness of a nickel is approximately 2 mm. Sediment types smaller than sands are silts (0.002 to 0.063 mm in diameter) and clays (particles less than 0.002 mm in diameter). Sediments larger than sands are various types of gravel ranging in size from 2 mm (granules) to 64 mm (cobbles). Sediments greater than 64 mm in diameter are defined as boulders and range up to 2,048 mm (Blott & Pye, 2012; U.S. Department of Agriculture, 1993). Fine-grained silts and clays are often found mixed together in areas beyond the continental slope, such as on abyssal plains, and are referred to generally as mud (Kennett, 1982). Sediments in nearshore waters and on the continental shelf contain more sands that are primarily terrigenous, and sediments farther from shore in deep ocean basins are primarily biogenic. As organic and inorganic particles move downward through the water column and ultimately to the seafloor, many substances, including contaminants, that adhere to the particles and are otherwise scarce in the water column, become concentrated in bottom sediments (Chapman et al., 2003; Kszos et al., 2003).

3.2.1.1.1.2 Factors Affecting Marine Sediment Quality

The quality of sediments is influenced by their physical, chemical, and biological components; by where they are deposited; by the properties of seawater; and by other inputs and sources of contamination. Sediments tend to be dynamic, where factors affecting marine sediments often interact and influence each other. These factors are summarized below.

Physical characteristics and processes: At any given site, the texture and composition of sediments are important physical factors that influence the types of substances that are retained in the sediments, and subsequent biological and chemical processes. For example, clay-sized and smaller sediments and similarly sized organic particles tend to bind potential sediment contaminants and potentially limit their movement in the environment (U.S. Environmental Protection Agency, 2009). Conversely, fine-grained sediments are easily disturbed by currents and bottom-dwelling organisms, dredging, storms, and bottom trawling (Eggleton & Thomas, 2004; Hedges & Oades, 1997). Disturbance is also possible in deeper areas, where currents are minimal (Carmody et al., 1973), from mass wasting events such as underwater slides and debris flows (Coleman & Prior, 1988). If re-suspended, fine-grained sediments (and any substances bound to them) can be transported long distances.

Chemical characteristics and processes: The concentration of oxygen in sediments strongly influences sediment quality through its effect on the binding of materials to sediment particles. At the sediment surface, the level of oxygen is usually the same as that of the overlying water. Deeper sediment layers, however, are often low in oxygen (i.e., hypoxic) or have no oxygen (i.e., anoxic), and have a low oxidation-reduction potential, which predicts the stability of various compounds that regulate nutrient and metal availability in sediments. Certain substances combine in oxygen-rich environments and become less available for other chemical or biological reactions.

Biological characteristics and processes: Organic matter in sediments provides food for resident microbes. The metabolism of these microbes can change the chemical environment in sediments and thereby increase or decrease the mobility of various substances and influence the ability of sediments to retain and transform those substances (Mitsch et al., 2009; U.S. Environmental Protection Agency, 2008c). Bottom-dwelling animals often rework sediments in the process of feeding or burrowing. In this way, marine organisms influence the structure, texture, and composition of sediments, as well as, the horizontal and vertical distribution of substances in the sediment (Boudreau, 1998). Moving substances out of or into low or no-oxygen zones in the sediment may alter the form and availability of various substances. The metabolic processes of bacteria also influence sediment components directly. For example, sediment microbes may convert mercury to methyl mercury, increasing its toxicity (Mitchell & Gilmour, 2008). However, it is more common that biological processes breakdown contaminants and reduce toxicity in sediments (White et al., 1997).

Location: The quality of coastal and marine sediments is influenced substantially by inputs from adjacent watersheds (Turner & Rabalais, 2003). Proximity to watersheds with large cities or intensively farmed lands often increases the amount of both inorganic and organic contaminants that find their way into coastal and marine sediments. A wide variety of metals and organic substances, such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and pesticides—often referred to collectively as "persistent organic pollutants"—are discharged into coastal waters by urban, agricultural, and industrial point and non-point sources in the watershed (U.S. Environmental Protection Agency, 2008c). Location on the ocean floor also influences the distribution and concentration of various elements through local geology and volcanic activity (Demina & Galkin, 2009), as well as through landslides and debris flow events (Coleman & Prior, 1988).

Other Contributions to Sediments: While the greatest mass of sediments is carried into marine systems by rivers (U.S. Environmental Protection Agency, 2008c), wind and rain also deposit materials in coastal waters and contribute to the mass and quality of sediments. For example, approximately 80 percent of the mercury released by human activities comes from coal combustion, mining and smelting, and solid waste incineration (Agency for Toxic Substances and Disease Registry, 1999). These activities are generally considered to be the major sources of mercury in marine systems (Fitzgerald et al., 2007). Atmospheric deposition of lead is similar in that human activity is a major source of lead in sediments (Wu & Boyle, 1997).

3.2.1.1.2 Water Quality

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

3.2.1.1.2.1 Characteristics of Marine Waters

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

3.2.1.1.2.2 Influences of Marine Properties and Processes on Seawater Characteristics

Ocean currents and tides mix and redistribute seawater. In doing so, they alter surface water temperatures, transport and deposit sediment, and concentrate and dilute substances that are dissolved and suspended in the water. These processes operate to varying degrees from nearshore areas to the abyssal plain. Salinity also affects the density of seawater and, therefore, its movement relative to the sea surface (Libes, 2009). Upwelling brings cold, nutrient-rich waters from deeper areas, increasing the productivity of local surface waters (Mann & Lazier, 1996). Storms and hurricanes also cause strong mixing of marine waters (Li et al., 2008).

Temperature and pH influence the behavior of trace metals in seawater, such as the extent to which they dissolve in water (i.e., the metal's solubility) or their tendency to adsorb organic and inorganic particles. However, the degree of influence differs widely among metals (Byrne, 1996). The concentration of a given element may change with position in the water column. For example, some metals (e.g., cadmium) are present at low concentrations in surface waters and at higher concentrations at depth (Bruland, 1992), while others decline quickly with increasing depth below the surface (e.g., zinc and iron) (Nozaki, 1997). On the other hand, dissolved aluminum concentrations are highest at the surface, lowest at mid-depths, and increase again at depths below about 1,000 meters (Li et al., 2008).

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

Runoff from coastal watersheds influences local and regional coastal water conditions, especially large rivers. Influences include increased sediments and pollutants, and decreased salinity (Rabalais et al., 2002; Turner & Rabalais, 2003; Wiseman & Garvine, 1995). Coastal bays and large estuaries serve to filter river outflows and reduce total discharge of runoff to the ocean (Edwards et al., 2006; Mitsch et al., 2009). Depending on their structure and components, estuaries can directly or indirectly affect coastal water quality by recycling various compounds (e.g., excess nutrients), sequestering elements in more inert forms (e.g., trace metals), or altering them, such as the conversion of mercury to methyl mercury (Mitchell & Gilmour, 2008; Mitsch & Gosselink, 2007).

3.2.1.1.2.3 Coastal Water Quality

Most water quality problems in coastal waters of the United States are from degraded water clarity or increased concentrations of phosphates or chlorophyll-*a* (U.S. Environmental Protection Agency, 2012b). Water quality indicators measured are dissolved inorganic nitrogen, dissolved inorganic phosphorus, water clarity or turbidity, dissolved oxygen, and chlorophyll-*a*. Chlorophyll-*a* is an indicator of microscopic algae (phytoplankton) abundance used to judge nutrient availability (e.g., phosphates and nitrates). Excess phytoplankton blooms can decrease water clarity and, when phytoplankton die off following blooms, lower concentrations of dissolved oxygen. Most sources of these impacts arise from on-shore point and non-point sources of pollution. Point sources are direct water discharges from a single source, such as industrial or sewage treatment plants, while non-point sources are the result of many diffuse sources, such as runoff caused by rainfall.

3.2.1.2 Methods

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

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

3.2.1.2.1 State Standards and Guidelines

State jurisdiction regarding sediments and water quality extends from the low tide line to 3 nautical miles (NM) offshore for all states except Texas and the Gulf coast of Florida where state waters extend to 9 NM offshore. Waters under the jurisdiction of Puerto Rico also extend to 9 NM, and waters under the control of the United States (U.S.) Virgin Islands extend to 3 NM offshore. Creating state-level sediments and water quality standards and guidelines begins with each state establishing a use for the water, which is referred to as its "designated" use. Examples of such uses of marine waters include fishing, shellfish harvesting, and recreation. For this section, a water body is considered "impaired" if any one of its designated uses is not met. Once this use is designated, standards or guidelines are established to protect the water at the desired level of quality. Applicable state standards and guidelines specific to each stressor are detailed in Section 3.2.3 (Environmental Consequences).

3.2.1.2.2 Federal Standards and Guidelines

Federal jurisdiction regarding sediments and water quality extends from 3 to 200 NM along the Atlantic and Gulf coasts of the United States. However, as discussed in the prior paragraph, for Texas, Puerto Rico, and Florida's Gulf coast, federal jurisdiction begins at 9 NM from shore and extends seaward to 200 NM. These standards and guidelines are mainly the responsibility of the U.S. Environmental Protection Agency (USEPA), specifically ocean discharge provisions of the Clean Water Act (33 United States Code [U.S.C.] section 1343). Ocean discharges may not result in "unreasonable degradation of the marine environment." Specifically, disposal may not result in: (1) unacceptable negative effects on human health; (2) unacceptable negative effects on the marine ecosystem; (3) unacceptable negative persistent or permanent effects due to the particular volumes or concentrations of the dumped materials; and (4) unacceptable negative effects on the ocean for other uses as a result of direct environmental impact (40 Code of Federal Regulations [CFR] section 125.122). Applicable federal standards and guidelines specific to each stressor are detailed in Section 3.2.3 (Environmental Consequences). Proposed training and testing activities also occur beyond 200 NM. Even though Clean Water Act regulations may not apply, pertinent water quality standards are used as accepted scientific standards to assess potential impacts on sediments and water quality from the Proposed Action.

The International Convention for the Prevention of Pollution from Ships (Convention) addresses pollution generated by normal vessel operations. The Convention is incorporated into U.S. law as 33 U.S.C. sections 1901–1915. The Convention includes six annexes: Annex I, oil discharge; Annex II, hazardous liquid control; Annex III, hazardous material transport; Annex IV, sewage discharge; Annex V, plastic and garbage disposal; and Annex VI, air pollution. The Navy is required to comply with the Convention; however, the United States is not a party to Annex IV. The discharge of sewage by military vessels is regulated by Section 312(d) of the Clean Water Act. The Convention contains handling requirements and specifies where materials can be discharged at sea, but it does not contain standards related to sediments nor water quality.

The National Defense Authorization Act of 1996 amended Section 312 of the Clean Water Act, directing the USEPA and the Department of Defense to jointly establish the Uniform National Discharge Standards for discharges (other than sewage) incidental to the normal operation of military vessels. The Uniform National Discharge Standards program establishes national discharge standards for military vessels in U.S. coastal and inland waters extending seaward to 12 NM. Twenty-five types of discharges were identified as requiring some form of pollution control (e.g., a device or policy) to reduce or eliminate the potential for impacts. The discharges addressed in the program include, ballast water, deck runoff, and seawater used for cooling equipment. For a complete list of discharges refer to 40 CFR part 1700.4.

These national discharge standards reduce the environmental impacts associated with vessel discharges, stimulate the development of improved pollution control devices aboard vessels, and advance the development of environmentally sound military vessels. The U.S. Navy adheres to regulations outlined in the Uniform National Discharge Standards program, and, as such, the analysis of impacts in this Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) will be limited to potential impacts from training and testing activities including impacts from military expended materials, but not impacts from discharges addressed under the Convention or the Uniform National Discharge Standards program.

3.2.1.2.3 Intensity and Duration of Impact

The intensity or severity of impact is defined as follows (listed by increasing level of impact):

- Chemical, physical, or biological changes in sediment or water quality would not be detectable as a result of the use of military materials. The proposed activities would not violate water quality standards.
- Chemical, physical, or biological changes in sediment or water quality would be measurable, but total concentrations would not violate applicable standards, regulations, and guidelines. Sediment or water quality would be equivalent to existing conditions, and designated uses of the water body or substrate would not change.
- Chemical, physical, or biological changes in sediment or water quality would be measurable and readily apparent, but total concentrations would not violate applicable standards, regulations, and guidelines. Sediment or water quality would be altered compared to the historical baseline or desired conditions, and designated uses of the water body or substrate would be changed. Mitigation would be necessary and would likely be successful.
- Chemical, physical, or biological changes in sediment or water quality would be readily measurable, and some standards, regulations, and guidelines would be periodically approached, equaled, or exceeded as measured by total concentrations. Sediment or water quality would be frequently altered from the historical baseline or desired conditions, and designated uses of the water body or substrate would be changed. Mitigation measures would be necessary to limit or reduce impacts on sediment or water quality, although the efficacy of those measures would not be assured.

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

3.2.1.2.4 Measurement and Prediction

Many of the conditions discussed above often influence each other, so measuring and characterizing various substances in the marine environment is often difficult (Byrne, 1996; Ho et al., 2007). For instance, sediment contaminants may also change over time. Valette-Silver (1993) reviewed several studies that demonstrated the gradual increase in a variety of contaminants in coastal sediments that began as early as the 1800s, continued into the 1900s, peaked between the 1940s and 1970s, and declined thereafter (e.g., lead, dioxin, polychlorinated biphenyls). After their initial deposition, normal physical, chemical, and biological processes can re-suspend, transport, and redeposit sediments and associated substances in areas far removed from the source (Hameedi et al., 2002; U.S. Environmental Protection Agency, 2012b). The conditions noted above further complicate predictions of the impact of various substances on the marine environment.

3.2.1.2.5 Sources of Information

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

Because of the proximity of inshore and nearshore areas to humans, information on the condition of sediments and water quality in those areas tends to be relatively readily available. However, much less is known about deep ocean sediments and open ocean water quality. Since sediments and water quality in inshore and nearshore areas tends to be affected by various human social and economic activities, two general assumptions are used in this discussion: (1) sediments and water quality generally improve as distance from shore increases; and (2) sediments and water quality generally improve as depth increases.

3.2.1.2.6 Areas of Analysis

The locations where specific military expended materials would be used are discussed under each stressor in Section 3.2.3 (Environmental Consequences).

3.2.2 AFFECTED ENVIRONMENT

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

3.2.2.1 Sediments

The following subsections discuss sediments for each region in the Study Area. Note that sand and gravel harvested from offshore along the U.S. Atlantic coast and in the Gulf of Mexico are discussed as a socioeconomic resource in Section 3.11 (Socioeconomic Resources). Impacts on sediments discussed in Section 3.2.3 (Environmental Consequences) are also relevant to sand and gravel, but Section 3.11 (Socioeconomic Resources) analyzes the use of sand and gravel as a resource for purposes such as beach replenishment.

3.2.2.1.1 Sediment Descriptions in Geographic Regions of the Study Area

3.2.2.1.1.1 Sediments in the North Atlantic Region

The North Atlantic region consists of the West Greenland Shelf, the Newfoundland-Labrador Shelf, and the Scotian Shelf Large Marine Ecosystems, as well as the Labrador Current Open Ocean Area (see Figure 3.0-1 in Section 3.0, Introduction). The region includes the coasts and offshore marine areas southwest of Greenland, east and northeast of Newfoundland and Labrador, and surrounding Nova Scotia. Substrate in the North Atlantic region is comprised almost entirely of soft, unconsolidated sediments derived from terrestrial erosion of sedimentary rock. The most common types of sedimentary rock are sandstone and shale. The majority of sediments on the continental shelf were deposited by receding glaciers and weathered terrestrial rock (Kennett, 1982). Within the region, deposits of larger grain-sized gravel are found in the Gulf of Maine, whereas smaller grain-sized, quartz-rich sands dominate the remainder of the northeastern continental shelf (Churchill, 1989). Sediments in the North Atlantic region contain very little carbonate (less than 5 percent) (Chang et al., 2001; Kennett, 1982).

Although there are no designated range complexes in this region, the area may be used for Navy training and testing activities. See Figure 3.0-1 in Section 3.0 (Introduction) for range complexes within each large marine ecosystem.

Low population densities and low levels of coastal development in the North Atlantic region, limit the amount of pollution from land-based sources in the North Atlantic region (Aquarone & Adams, 2009a, 2009b; Aquarone et al., 2009). However, pollution is increasing from offshore oil and gas development activities (Aquarone & Adams, 2009a, 2009b), and metal pollution exists from prior mineral development activity and atmospheric deposition (Bindler et al., 2001; Larsen et al., 2001). Natural hydrocarbon seeps are located near Baffin Island to the north (Kvenvolden & Cooper, 2003).

3.2.2.1.1.2 Sediments in the Northeast and Mid-Atlantic Region

Section 3.5 (Habitats) provides a detailed discussion of substrate types within the Northeast and Mid-Atlantic Region, and is summarized here. Almost the entire continental shelf along the U.S. Atlantic coast is composed of sandy sediments. Sediments north of Cape Hatteras are dominated by quartz and feldspar from Precambrian and Paleozoic rocks that were mechanically weathered and deposited by glaciers and rivers. Silicon- and phosphorus-based sediments are locally abundant (Milliman et al., 1972). Sediment in deep areas beyond the continental shelf break is often dominated by biogenic calcareous ooze (i.e., calcium carbonate and clays) (Kennett, 1982). Nearshore areas off capes and at the mouths of bays, such as Chesapeake Bay and Delaware Bay, are influenced by longshore and cross-shelf currents as well as tidal fluctuations (McBride & Moslow, 1991; Murray & Thieler, 2004). Extensive estuaries on the Atlantic coast tend to trap much of the sediment delivered by rivers. Fine-grained sediments that reach the ocean are usually transported shoreward by tides or deposited on the continental slope and beyond.

In contrast to the surrounding areas, fine-grained, sandy clay and silt sediments occur on the continental shelf south of Nantucket Shoals and the coast of Martha’s Vineyard in an area known as the “Mud Patch” (Chang et al., 2001). This is the only area of its size on the eastern U.S. continental shelf where surface sediments contain up to 95 percent silt and clay and no rock fragments (Chang et al., 2001; Churchill, 1989).

Sediment Quality in the Northeast and Mid-Atlantic Region

States bordering the Northeast U.S. Continental Shelf Large Marine Ecosystem include Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, and northeast North Carolina (Figure 3.0-1 in Section 3.0, Introduction). Information regarding the current quality of sediment in nearshore areas of these states is provided below (Table 3.2-1). Except where otherwise indicated, information provided below, including the data used in the sediment quality map, was drawn from the U.S Environmental Protection Agency National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016).

In 2008, sediments in the northeast coastal region—Maine through Virginia—were rated 76 percent good, 11 percent fair, and 13 percent poor (no data were reported for 1 percent) in an evaluation of coastal conditions by the USEPA (U.S. Environmental Protection Agency, 2008a). Criteria used in the agency’s sediment quality index included sediment toxicity, sediment contaminants, and excess sediment carbon contained in organic compounds (total organic carbon). To receive a good rating, no individual samples in the region could be rated as poor, and the rating for sediment contaminants had to be good. A fair rating indicated that none of the individual samples were rated as poor, and the sediment contaminant index was fair. Sediments in an area were rated as poor if one or more samples were rated poor (U.S. Environmental Protection Agency, 2012b).

Areas that were rated poor in the Northeast and Mid-Atlantic Region were mostly adjacent to urbanized areas and areas of past industrial activity, and included Narragansett Bay, western Long Island Sound, New York-New Jersey Harbor, and the upper portions of Chesapeake Bay. Elevated levels of sediment contaminants, including metals (e.g., arsenic, chromium, mercury, nickel, silver, and zinc), polychlorinated biphenyl, and dichlorodiphenyltrichloroethane (DDT), were the primary reason for the poor ratings in these areas. Overall, in the 2008 assessment, the region rated fair for contaminants, but good for sediment toxicity (only 4 percent of sites rated poor), and good for total organic carbon in sediments (1 percent poor) (U.S. Environmental Protection Agency, 2012b).

In 2016, the USEPA published another national coastal condition assessment, updating the 2008 assessment with 2010 sampling results (U.S. Environmental Protection Agency, 2016). In comparison to the 2008 assessment, sediment quality in the Northeast and Mid-Atlantic Region has declined, with 60 percent of sediments rated good, 20 percent rated fair, and 9 percent rated poor (data were missing for 11 percent of sampling sites). While 80 percent of sediments were rated good for contaminants, only 58 percent were rated good for sediment toxicity, which was the primary reason for the decline in overall sediment quality.

The sediment toxicity index for marine and estuarine sediments is based on the survival rate of selected estuarine amphipods when the specimens are exposed to samples collected in the field. Sediment toxicity indicates how combinations of anthropogenic and natural chemicals might affect the survival of benthic organisms.

Table 3.2-1: Sediment Quality Criteria and Index, U.S. Atlantic Coast and Gulf of Mexico

Parameter	***Site Criteria***			***Regional Criteria***		
	Good	***Fair***	***Poor***	***Good***	***Fair***	***Poor***
Sediment Toxicity	Amphipod[1] survival rate ≥ 80%	n/a	Amphipod[1] survival rate < 80%	< 5% of coastal area in poor condition	n/a	≥ 5% of coastal area in poor condition
Sediment Contaminants	No ERM[2] concentration exceeded, and < 5 ERL[3] concentrations exceeded	No ERM[2] concentration exceeded and ≥ 5 ERL[3] concentrations exceeded	An ERM[2] concentration exceeded for one or more contaminants	< 5% of coastal area in poor condition	5–15% of coastal area in poor condition	> 15% of coastal area in poor condition
Excess Sediment TOC	TOC concentration < 2%	TOC concentration 2% to 5%	TOC concentration > 5%	< 20% of coastal area in poor condition	20–30% of coastal area in poor condition	> 30% of coastal area in poor condition

Table 3.2-1: Sediment Quality Criteria and Index, U.S. Atlantic Coast and Gulf of Mexico (continued)

Parameter	*Site Criteria*			*Regional Criteria*		
	Good	*Fair*	*Poor*	*Good*	*Fair*	*Poor*
Sediment Quality Index	No poor ratings, sediment contaminants criteria are rated “good”	No poor ratings, sediment contaminants criteria are rated “fair”	One or more individual criteria rated poor	< 5% of coastal area in poor condition, and > 50% in good condition	5–15% of coastal area in poor condition, and > 50% in combined fair and poor condition	> 15% of coastal area in poor condition

[1] Amphipods are small animals found in a wide variety of aquatic habitats. Because they are so widely distributed, they are often used as an indicator of toxicity in sediments and water bodies.

[2] ERM (effects range-median) is the level measured in the sediment below which adverse biological effects were measured 50 percent of the time.

[3] ERL (effects range-low) is the level measured in the sediment below which adverse biological effects were measured 10 percent of the time (Long et al., 1995).

Source: (U.S. Environmental Protection Agency, 2012b)

Notes: % = percent, ≥ = equal to or greater than, < = less than, > = greater than, n/a = not applicable, TOC = total organic carbon

The impact that anthropogenic activities can have over the long term is exemplified by changes observed in Long Island Sound, where development dates to colonial times. Mean concentrations of metals in Long Island Sound have increased substantially and steadily since pre-industrial levels (Table 3.2-2) (Varekamp et al., 2014). The concentrations of silver, cadmium, copper, and mercury showed the greatest increases (between 30 and 6.5 times over background levels); lead, arsenic, and zinc have increased between 2.4 and 3.6 times; and chromium, vanadium, nickel, and barium concentrations have remained close to background levels.

Table 3.2-2: Comparison of Mean Pre-Industrial and Post-Industrial Metal Concentrations in Sediments in Long Island Sound with Sediment Effects Thresholds

Metal	*Pre-Industrial Background Mean Concentration (µg/g)*	*Post-Industrial Mean Concentration (µg/g)*	*Mean Enrichment Factor*	*National Oceanic and Atmospheric Administration*	
				Effects Range-Low (ppm)	*Effects Range-Median (ppm)*
Cadmium	0.2	2	9.9	1.2	9.6
Chromium	59	78	1.3	81	370
Copper	8	117	14.6	34	270
Lead	23	83	3.6	46.7	218
Mercury	0.1	0.7	6.5	0.15	0.71
Nickel	25	26	1.0	20.9	51.6
Silver	0.05	1.5	29.8	1.0	3.7
Zinc	68	160	2.4	150	410
Arsenic	2.5	6	2.5	8.2	70
Vanadium	90	101	1.1	NA	NA

Table 3.2-2: Comparison of Mean Pre-Industrial and Post-Industrial Metal Concentrations in Sediments in Long Island Sound with Sediment Effects Thresholds (continued)

Metal	*Pre-Industrial Background Mean Concentration (µg/g)*	*Post-Industrial Mean Concentration (µg/g)*	*Mean Enrichment Factor*	*National Oceanic and Atmospheric Administration*	
				Effects Range-Low (ppm)	*Effects Range-Median (ppm)*
Barium	377	230	0.6	NA	NA

Effects range-low is the level measured in the sediment below which adverse biological effects were measured 10 percent of the time Long et al. (1995).
Effects range-median is the level measured in the sediment below which adverse biological effects were measured 50 percent of the time.
Enrichment Factor is the ratio of the postindustrial and preindustrial concentrations and is a measure of the change in concentration over time (e.g., the concentration of cadmium has increase 9.9 times since preindustrial levels)
Source: Varekamp et al. (2014)
Notes: µg /g = micrograms per gram, ppm = parts per million, NA = Not applicable

The distribution of metals within sediments in the sound varied widely, as did maximum concentrations, and was strongly correlated with fine-grained sediments rich in organic material. With the exception of arsenic, all post-industrial metal concentrations exceeded Effects Range-Low levels and were less than Effects Range-Median levels; the concentration of arsenic was less than the Effects Range-Low level; however, the authors note that there were fewer samples for arsenic available for analysis (Table 3.2-2). Increases in metal concentrations were closely linked to the industrialization of the region, and included many non-point source discharges, such as urban runoff, and point source discharges, such as effluent from waste water treatment facilities located along tributaries of the sound. Overall, concentrations of metal contaminants increased with proximity to New York City, lending additional support to the close association between industrialization and increased sediment contamination.

Polycyclic aromatic hydrocarbons and polychlorinated biphenyls, two widely dispersed contaminants found worldwide in marine sediments have been present in the Study Area for decades (Boehm & Requejo, 1986; Farrington & Takada, 2014; Farrington & Tripp, 1977; Lamoreaux & Brownawell, 1999). The source of most polycyclic aromatic hydrocarbons introduced into the environment (terrestrial and marine) is from the incomplete combustion of biofuels (Ravindra et al., 2008). Aromatic hydrocarbons can enter the marine environment through multiple means, including as urban runoff, effluent from outfalls serving densely populated urban regions, and as deposition from airborne particulate matter (Farrington & Takada, 2014). While there are natural sources of polycyclic aromatic hydrocarbons, such as wildfires and volcanic eruptions, the primary source of aromatic hydrocarbons in the marine environment is emissions from the anthropogenic combustion of fossil fuels, including oil and coal (Farrington & Takada, 2014; Ravindra et al., 2008).

Polychlorinated biphenyls are anthropogenic organic chemicals made up of carbon, hydrogen, and chlorine atoms, and were produced in the United States from 1929 until they were banned in 1979, because of growing concerns over their toxicity and links to a number of adverse health effects, including cancers, neurological disorders, reproductive effects, and immune system effects (Manta Trust, 2017). Even though the production of polychlorinated biphenyls has not occurred in the United States for decades, the chemicals are present in products manufactured prior to 1979 and still in use today (e.g., electrical transformers, cable insulation, paints, and plastics) as well as imported products from countries where polychlorinated biphenyls have not been banned for as long (or at all). The chemicals are resistant to breakdown in the environment, including in the marine environment, enabling them to persist in a variety forms far from where they originated (Farrington & Takada, 2014; Manta Trust, 2017).

Dichlorodiphenyltrichloroethane (DDT) is a pesticide that was widely used in the United States in the 1950s and 1960s until its production and use was banned in 1972 over concerns of adverse environmental effects (e.g., thinning of bird egg shells resulting in poor reproductive success in multiple species) (Sericano et al., 2014).

The concentration of aromatic hydrocarbons and polychlorinated biphenyls in sediments is positively correlated with total organic carbon content in sediments. Fine-grained sediments (silts and clays) have higher total organic carbon levels than sandy sediments, and areas dominated by fine-grained sediments, like the Mud Patch, tend to act as sinks for polycyclic aromatic hydrocarbons and other contaminants like polychlorinated biphenyls (Boehm & Requejo, 1986; Lamoreaux & Brownawell, 1999). Disturbance of seafloor sediments with high concentrations of these chemical contaminants can cause resuspension, increased bioavailability, and facilitate the widespread distribution of these contaminants. The use of equipment and products manufactured prior to 1979 with polychlorinated biphenyls can continue to introduce the contaminant into the environment.

Farrington and Takada (2014) provide a summary of four decades of research on persistent organic pollutants, including polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and dichlorodiphenyltrichloroethane (DDT). Concentrations of polycyclic aromatic hydrocarbons measured in benthic dwelling bivalves, so called sentinel organisms, exceeded the National Oceanic and Atmospheric Administration thresholds for environmental effects in multiple samples collected in the northeast and mid-Atlantic regions (Table 3.2-3). Although a number of sites have exceeded effects thresholds, (Farrington & Takada, 2014) the overwhelming trend is that concentrations of these three chemical contaminants is decreasing in bivalves, a proxy for sediments, along the entire U.S. coastline. Only one site in the Study Area, off the coast of North Carolina, is showing an increase in the concentration of polycyclic aromatic hydrocarbons, and no sites in the Study Area are showing an increase in concentrations of polychlorinated biphenyls. Concentrations of dichlorodiphenyltrichloroethane (DDT) are also decreasing in coastal areas along the U.S. coastline (as measured in bivalve bioassays) (Sericano et al., 2014); however, dichlorodiphenyltrichloroethane (DDT) is also resistant to breakdown in the environment, as are its breakdown products. Nevertheless, by 2050, the concentration of DDT and its breakdown products are expected to be at 10 percent of current levels (Sericano et al., 2014).

Table 3.2-3: Comparison of Polycyclic Aromatic Hydrocarbons, Polychlorinated Biphenyls and dichlorodiphenyltrichloroethane in Sediment Samples with Sediment Guidelines Developed by the National Oceanic and Atmospheric Administration

Sediment Contaminant	***Contaminant Concentration (ppb)***				***National Oceanic and Atmospheric Administration***	
	Northeast	***Mid-Atlantic***	***Southeast***	***Gulf of Mexico***	***Effects Range-Low[1]***	***Effects Range-Median[2]***
PAHs	63–7,561	47–10,717	47–2,511	47–2,511	4,022	44,792
PCBs	3–1,413	4–157	4–157	4–157	22.7	180

Table 3.2-3: Comparison of Polycyclic Aromatic Hydrocarbons, Polychlorinated Biphenyls and dichlorodiphenyltrichloroethane in Sediment Samples with Sediment Guidelines Developed by the National Oceanic and Atmospheric Administration (continued)

Sediment Contaminant	*Contaminant Concentration (ppb)*				*National Oceanic and Atmospheric Administration*	
	Northeast	*Mid-Atlantic*	*Southeast*	*Gulf of Mexico*	*Effects Range-Low*[1]	*Effects Range-Median*[2]
DDT[3]	0.001 – 0.15			<MDL– 0.087	1.58	46.1

[1] Effects range-low is the level measured in the sediment below which adverse biological effects were measured 10 percent of the time Long et al. (1995).

[2] Effects range-median is the level measured in the sediment below which adverse biological effects were measured 50 percent of the time.

[3] Data are from 2009: Sericano et al. (2014).

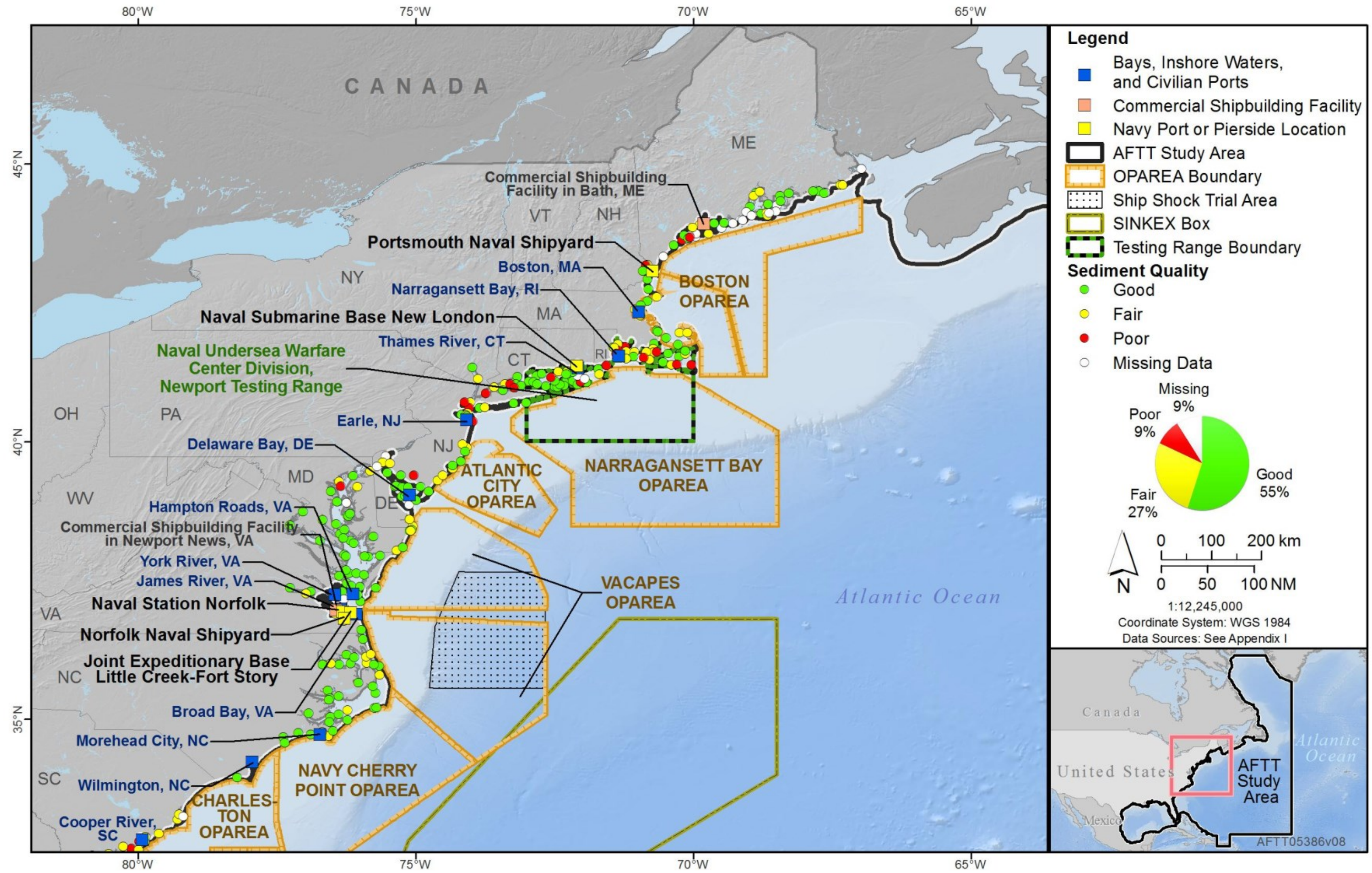
Source: Farrington and Takada (2014)

Notes: PAHs = polycyclic aromatic hydrocarbons, ppb = parts per billion, PCBs = polychlorinated biphenyls, DDT = dichlorodiphenyltrichloroethane, MDL = minimum detection level

Maine. Sediment quality along the Maine coast was rated 51 percent good and 12 percent poor; 37 percent of sampling site data were labeled as missing (Figure 3.2-2). Concerns related to sediments in Maine include polychlorinated biphenyls, mercury, and dioxin. As a result, seafood consumption advisories have been issued. These concerns involve all the state's estuarine and marine habitats. In much smaller areas, bacteria, low dissolved oxygen, copper contamination, and polycyclic aromatic hydrocarbons were also identified (State of Maine Department of Environmental Protection, 2006). Wade and Sweet (2005) reported that sediment from the interior of Casco Bay (Portland, Maine) contains elevated levels of trace metals, polychlorinated biphenyls, dichlorodiphenyltrichloroethane (DDT), and the pesticide chlordane.

New Hampshire. Sediment quality along the New Hampshire coast was rated 67 percent good, 17 percent fair, and 17 percent poor (Figure 3.2-2). Concerns related to sediments in New Hampshire include included metals, polycyclic aromatic hydrocarbons, and dichlorodiphenyltrichloroethane (DDT). These concerns involve all the state's estuarine and marine waters. Marine sediment samples were analyzed for heavy metals (cadmium, chromium, copper, lead, mercury, nickel, and zinc) and organic compounds (polychlorinated biphenyls and polycyclic aromatic hydrocarbons). Results indicate that, with few exceptions, the levels of contaminants detected in shellfish and sediment were within the range of contaminants found elsewhere in New England, other regions of the United States, and the world. Two estuarine areas were impaired due to pesticides. Ocean waters are listed as impaired due to dioxin, mercury, and polychlorinated biphenyls. As noted above, concerns are related to seafood consumption (Comstock et al., 2008; Paliwoda et al., 2016).

Massachusetts. Sediment quality along the Massachusetts coast was rated 67 percent good, 6 percent fair, and 24 percent poor; 5 percent of sampling site data were labeled as missing (Figure 3.2-2). Most poor sediment was concentrated in the Boston Harbor area, which rated as 100 percent poor. For Buzzards Bay, sediment quality was rated 50 percent good and 40 percent poor; 10 percent of sampling site data were labeled as missing.



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

Figure 3.2-2: Sediment Quality Ratings for the Northeast and Mid-Atlantic Coast

Rhode Island. Sediment quality along the Rhode Island coast was rated 64 percent good, 7 percent fair, and 29 percent poor (Figure 3.2-2). In Narragansett Bay sediment quality was rated 50 percent good and 50 percent poor. Issues included high concentrations of metals, dichlorodiphenyltrichloroethane (DDT), and polychlorinated biphenyls. Contaminated sediments were listed as a concern for 1 square mile (mi.^{2}) of estuarine habitat in Rhode Island. The issue involved "legacy/historical pollutants," such as polychlorinated biphenyls in Narragansett Bay (Rhode Island Department of Environmental Management, 2008). No data were available for Block Island Sound.

Connecticut. Long Island Sound comprises most of the nearshore and estuarine habitat along the Connecticut coast. Sediment quality in Long Island Sound was rated 71 percent good, 14 percent fair, and 14 percent poor (Figure 3.2-2). Sampling indicated a trend of decreasing impacts from runoff moving east from New York City (Mecray & Buchholtz ten Brink, 2000; Varekamp et al., 2014). As discussed above (see Section 3.2.2.1.1.2, Sediments in the Northeast and Mid-Atlantic Region), sediments in Long Island Sound have been enriched many times over pre-industrial background levels with silver, cadmium, copper, mercury, and lead. Metal concentrations have been decreasing since the peak levels in the 1970s, due in large part to upgrades of sewage treatment facilities to meet requirement of the Clean Water Act and the laws strictly regulating the use of persistent chemical contaminants, such as polychlorinated biphenyls (Varekamp et al., 2014). However, contaminants still occur in concentrations that impact habitat, particularly along the Connecticut coast, which borders the western portion of Long Island Sound where 50 percent of sediments are rated as poor.

New York/New Jersey. Sediment quality in the New York-New Jersey Bay were rated 100 percent poor on the New York side of the Bay, closer to New York City, and as 67 percent good and 33 percent poor on the New Jersey side (Figure 3.2-2). Issues included elevated concentrations of metals and polychlorinated biphenyls resulting from decades of industrialization and unregulated use and disposal of chemical contaminants (Varekamp et al., 2014). Information for Long Island Sound sediment is presented under the entry for Connecticut and above in Section 3.2.2.1.1.2 (Sediments in the Northeast and Mid-Atlantic Region). Sediment quality in Barnegat Bay on the Atlantic coast was rated 50 percent good and 50 percent poor. Sediment quality for Peconic Bay was rated 100 percent good. Information for Delaware Bay is provide under the entry for Delaware.

Delaware. Sediment quality in Delaware Bay was rated 67 percent good; however 33 percent of sampling site data were missing (Figure 3.2-2). The highest levels of sediment contaminants were near Philadelphia and the Maurice River. There may be some point sources for metals, but organic contaminants appear to be primarily from nonpoint sources. Metals and organic contaminants in sediments tend to decrease from upper to lower Delaware Bay. Sediments in coastal zones have trace amounts of metals and organic contaminants (Hartwell & Hameedi, 2006).

Maryland. Maryland's coastal bays provide a natural buffer between Maryland's Eastern Shore and the Atlantic Ocean. Sediment quality in Maryland's three largest coastal bays on the Atlantic coast, Chincoteague Bay, Assawoman Bay, and Isle of Wight Bay, were all rated 100 percent good in the National Coastal Condition Assessment (U.S. Environmental Protection Agency, 2016) (Figure 3.2-2). However, the Maryland Coastal Bays Program assess other metrics, including the density of bottom dwelling hard clams and seagrasses, which are an indicator of the quality of benthic habitat. According to the Maryland Coastal Bays Program (2015) "report card," the six coastal bays, including the three already mentioned, collectively received a grade of C+, on a scale of A (good to very good) to F (very poor), for 2014 on the program's index for characterizing the health of each coastal bay. Factors that contribute to the grade include water quality indicators (e.g., chlorophyll-*a*, dissolved oxygen), as well as, seagrass and hard clam densities. Chincoteague Bay (B-) scored well for seagrasses but poor for hard clams. Assawoman Bay (C) had poor to very poor grades for both seagrasses and hard clams, and Isle of Wight Bay (C) also received a very poor grade for seagrasses and saw declines in the density of hard clams. While sediment quality may be good, as reported in the coastal condition assessment, other habitat metrics provide additional insight into the suitability of the benthic habitat for sustaining biological resources.

Virginia. The James River flows into the lower Chesapeake Bay north of Norfolk Harbor. Sediment quality in the lower James River is rated 50 percent good and 50 percent poor (Figure 3.2-2). Sediment quality in the Elizabeth River, which flows through heavily industrialized and urban areas in the cities of Norfolk, Portsmouth, and Chesapeake was rated 100 percent poor. On Virginia's Atlantic coast, Back Bay, which is adjacent to Back Bay National Wildlife Refuge, received a sediment quality rating of 100 percent good.

North Carolina. Sediment quality in Albemarle Sound was rated 83 percent good and 17 percent poor. Sediment quality in Pamlico Sound located south of Albemarle Sound and west of Cape Hatteras is rated 86 percent good and 14 percent poor. Currituck Sound, located along the Atlantic coast north of Albemarle Sound received a rating of 100 percent good for sediment quality (Figure 3.2-2). Hackney et al. (1998) stated that, "between 37.5 and 75.8 percent of surface sediments in North Carolina's sounds and estuaries were contaminated, and between 19 and 36 percent were highly contaminated." Contaminants included nickel, arsenic, dichlorodiphenyltrichloroethane (DDT), chromium, polychlorinated biphenyls, and mercury. The most contaminated areas were the Neuse and Pamlico Rivers. In general, areas with limited tidal flushing and high river discharge were most contaminated. Hyland et al. (2000), reported that 38 percent of the total area of North Carolina estuaries had at least one chemical contaminant present at a concentration in excess of levels at which biological effects can be expected. The most common contaminants in their study were arsenic, mercury, chromium, nickel, pesticides, and polychlorinated biphenyls. There were relatively few degraded sites in the open portions of Pamlico Sound and smaller estuaries south of Cape Lookout.

Chesapeake Bay. The Chesapeake Bay watershed includes portions of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia. In order to simplify the discussion and reduce repetition, sediment issues in Chesapeake Bay are not reviewed on a state-by-state basis because: (1) many of the sediment issues are common to most or all of these bordering states, and (2) Navy training and testing activities discussed in this Environmental Impact Statement/Overseas Environmental Impact Statement are limited to the extreme southeast portion of the bay and do not appreciably impact sediment quality in the bay as a whole.

Point source pollution, urban and suburban runoff from continued development, atmospheric deposition, and agricultural practices in the bay's watershed introduce contaminants into the bay (Coxon et al., 2016). The U.S. Environmental Protection Agency (2012b) reports widespread occurrence of polychlorinated biphenyls, polycyclic aromatic hydrocarbons, herbicides, and mercury. Localized occurrence of pesticides, including dichlorodiphenyltrichloroethane (DDT), and certain metals (i.e., aluminum, chromium, iron, lead, manganese, and zinc) within the bay also contribute to degraded habitat in those areas.

In 2014, the Chesapeake Bay Program adopted a goal to create or reestablish 85,000 acres (ac.) of tidal and non-tidal wetlands in the bay's watershed by 2025, with the ultimate goal of reducing the bay's Total Maximum Daily Load, a measure of pollutants entering the bay. The bulk of the created or reestablished wetlands acreage (83,000 ac.) would be on agricultural lands, which are significant source of point source pollutants. As of 2016, 7,623 ac. have been created or reestablished on formerly agricultural lands, which is 7.45 percent of the overall goal (Bonfil et al., 2008).

Fish consumption advisories have been issued in all watershed states primarily out of concerns for contamination from mercury and polychlorinated biphenyls (Bonfil et al., 2008). Chesapeake Bay and several small tidal tributaries have had fish advisories for polychlorinated biphenyls in place since 2004 (Virginia Department of Public Health, 2016).

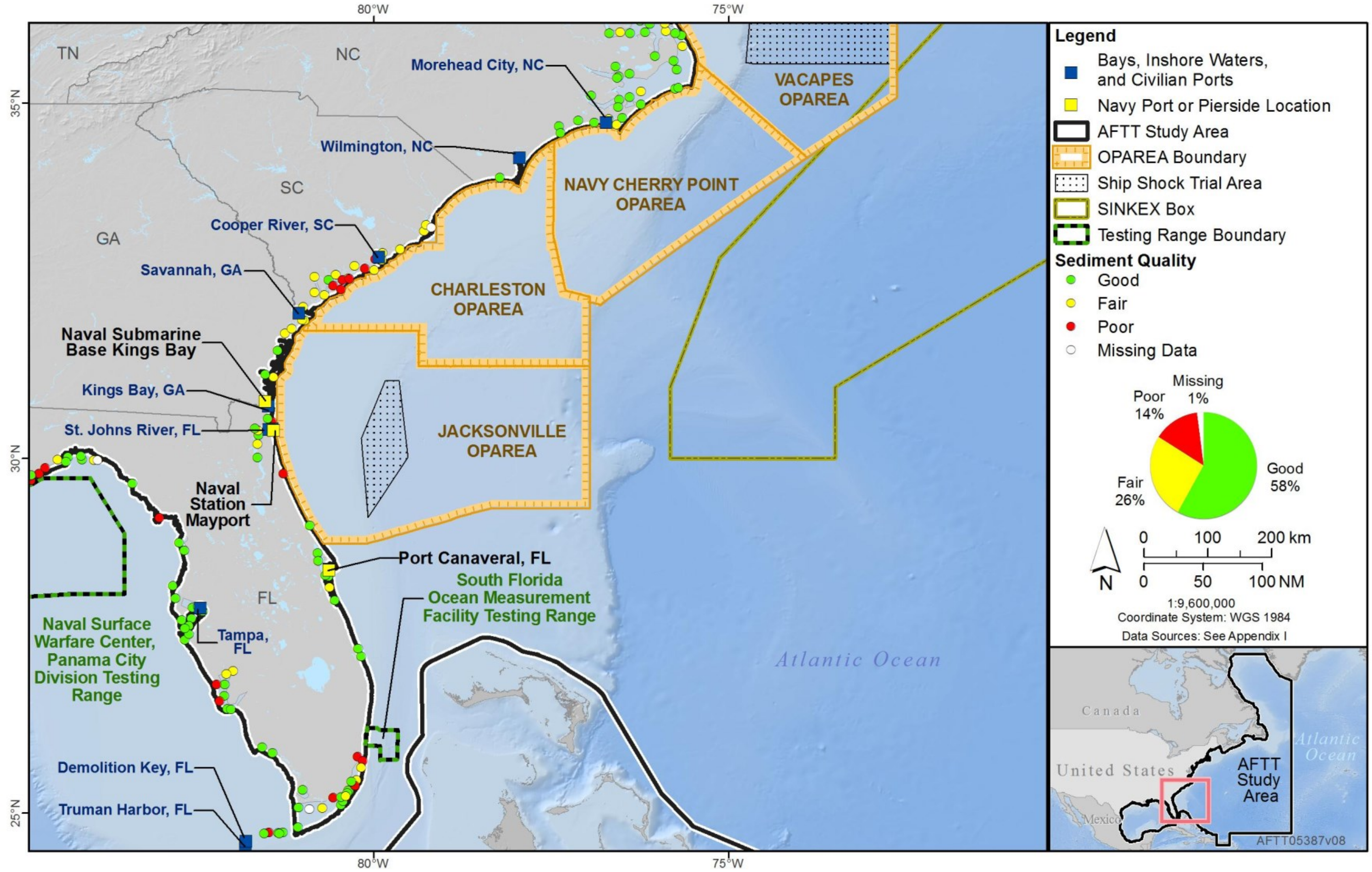
3.2.2.1.1.3 Sediments in the Southeast Region

Moving south from Cape Hatteras, coastal sediment changes from largely land-based sources to largely marine-based sources. Weathering of sediment in the piedmont and coastal plain provinces in the southeast is mostly chemical; deposition of sediment is mostly by rivers. Sediment farther north was more heavily influenced by mechanical (glacial) processes and glacial deposition. Off the coast of the Carolinas, the calcium carbonate content of sediment is between 5 and 50 percent; this increases to 100 percent on the East Florida Shelf. Sources of calcium carbonate include the shells of molluscs, echinoderms, barnacles, coralline algae, foraminifera; and ooids, small (0.25 to 2 mm) spherical deposits of calcium carbonate (Milliman et al., 1972). Some areas of the continental shelf along the southeast coast have been swept clean of sediment by the Gulf Stream, exposing the underlying bedrock (Riggs et al., 1996). Sediment on the continental shelf off the east coast of Florida is primarily composed of silt and clay sized particles (Milliman et al., 1972).

Sediment Quality in the Southeast Region

States in the Southeast Region bordering on the Southeast U.S. Continental Shelf Large Marine Ecosystem include southeastern North Carolina, South Carolina, Georgia, and the Atlantic coast of Florida. See Figure 3.0-1 in Section 3.0 (Introduction) for range complexes occurring within this region, and Figure 3.0-5 for bathymetry in the Southeast region. The current quality of sediments in nearshore areas in this regions is described below. Overall sediment quality for the coastal areas from North Carolina through the southern tip of Florida is rated as good. Sediments for 80 percent of this coastal area rated good, 2 percent rated fair, and 12 percent rated poor (6 percent of the data was missing) (Figure 3.2-3). Except where otherwise indicated, information provided below, including the data used in the sediment quality map, was drawn from the USEPA's National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016). Concentrations of the contaminant chemicals polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and dichlorodiphenyltrichloroethane (DDT) for the southeast region are provided in (Table 3.2-3). Windom et al. (1989) noted that it is not unusual for natural trace metal concentrations in coastal sediment to range over two orders of magnitude, particularly in the southeastern United States. Boehm and Gequejo (1986) noted that sediment hydrocarbons along the southeast coast were less than 10 parts per million (ppm) in all cases.

North Carolina. Information regarding sediment along the North Carolina coast is provided in Section 3.2.2.1.1.2 (Sediments in the Northeast and Mid-Atlantic Region).



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

Figure 3.2-3: Sediment Quality Ratings for the Southeast Coast

South Carolina. Sediment quality along the South Carolina coast was rated 62 percent good and 33 percent poor; 5 percent of sampling site data were missing (Figure 3.2-3). Just over 4 percent of the state's estuarine area (17.3 $mi.^2$) is impaired by metals, mostly by copper, but also nickel and zinc (South Carolina Department of Health and Environmental Control, 2008). A 2006 study found that 33 monitoring points (12 open water and 21 tidal creeks) had at least one contaminant that exceeded concentrations shown to have biological effects in 10 percent of published studies. Contaminants included polycyclic aromatic hydrocarbons, dichlorodiphenyltrichloroethane (DDT), and five metals: arsenic, cadmium, copper, lead, and zinc (Van Dolah et al., 2006).

Georgia. Sediment quality along the Georgia coast was rated 71 percent good, 22 percent fair, and 7 percent poor (Georgia Department of Natural Resources, 2010). In terms of toxicity, 97 percent of Georgia's sediments rated as good and 2 percent rated as poor; 1 percent of sampling site data were missing. In terms of sediment likely to have biological effects, 72 percent rated good, 24 percent rated fair, and 4 percent rated poor. Four miles of coastal streams were reported as impaired by mercury, and 2 miles (mi.) were impaired by elevated levels of cadmium. Pesticides (in fish tissue) impaired 8 mi. of coastal streams, and polychlorinated biphenyls (in fish tissue) impaired 26 mi. of coastal streams (Georgia Department of Natural Resources, 2010). Hyland et al. (2000) examined the presence of a wide variety of trace metals and persistent organic pollutants in the water and sediment between 2 and 77 kilometers (km) off the Georgia coast. The maximum values found were well below levels expected to induce biological effects.

Florida. Sediment quality along the Atlantic coast of Florida varied by location. Sediments in the Matanzas River, which runs parallel to coastal route A1A and empties into the ocean at the city of St. Augustine, rated as 100 percent poor (Figure 3.2-3). Sediment quality in the Mosquito Lagoon just north of Cape Canaveral rated as 100 percent good. Sediments in the Indian River Lagoon also rated as 100 percent good based on total organic carbon content. Farther south, sediment quality in Biscayne Bay, located adjacent to and south of Miami, was rated 60 percent good and 40 percent poor. In a discussion of sediment quality guidelines, MacDonald et al. (1996) noted that Biscayne Bay is contaminated with trace metals, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and pesticides, and that sediment from the St. Johns River had elevated levels of polychlorinated biphenyls. Windom et al. (1989) found lead and zinc-contaminated sediment from Biscayne Bay, apparently influenced by discharge from the Miami River.

In 2010, the Florida Department of Environmental Protection (2010) assessed metal concentrations in estuarine sediments and determined that concentrations were most often above background levels for cadmium, mercury, lead, and zinc. Also, 70 percent of samples tested for organic chemicals indicated the presence of polycyclic aromatic hydrocarbons. The following metals impaired estuarine habitat: copper (100 $mi.^2$), iron (98 $mi.^2$), nickel (40 $mi.^2$), arsenic (8 $mi.^2$), and lead (7 $mi.^2$). Copper has also impaired 83 mi. of Florida's 8,400 mi of coastal waters (Florida Department of Environmental Protection, 2010). More than 993,000 acres of the 1,671,159 acres assessed by the Florida Department of Environmental Protection in 2016 were impaired with at least one contaminant (Washington Tribes, 2015). A study of sediment in south Florida estuaries by Macauley et al. (2002) also found that elevated concentrations of pesticides were fairly common, but that elevated levels of metals were not as common.

3.2.2.1.1.4 Sediments in the Gulf of Mexico Region

States bordering the Gulf of Mexico Large Marine Ecosystem include the west coast of Florida, Alabama, Mississippi, Louisiana, and Texas. Refer to Figure 3.0-1 in Section 3.0 (Introduction) for range complexes within the Gulf of Mexico Large Marine Ecosystem and Figure 3.0-6 for bathymetry in the Gulf of Mexico region. Except where otherwise indicated, information provided below, including the data used in the sediment quality map, was drawn from the USEPA's National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016).

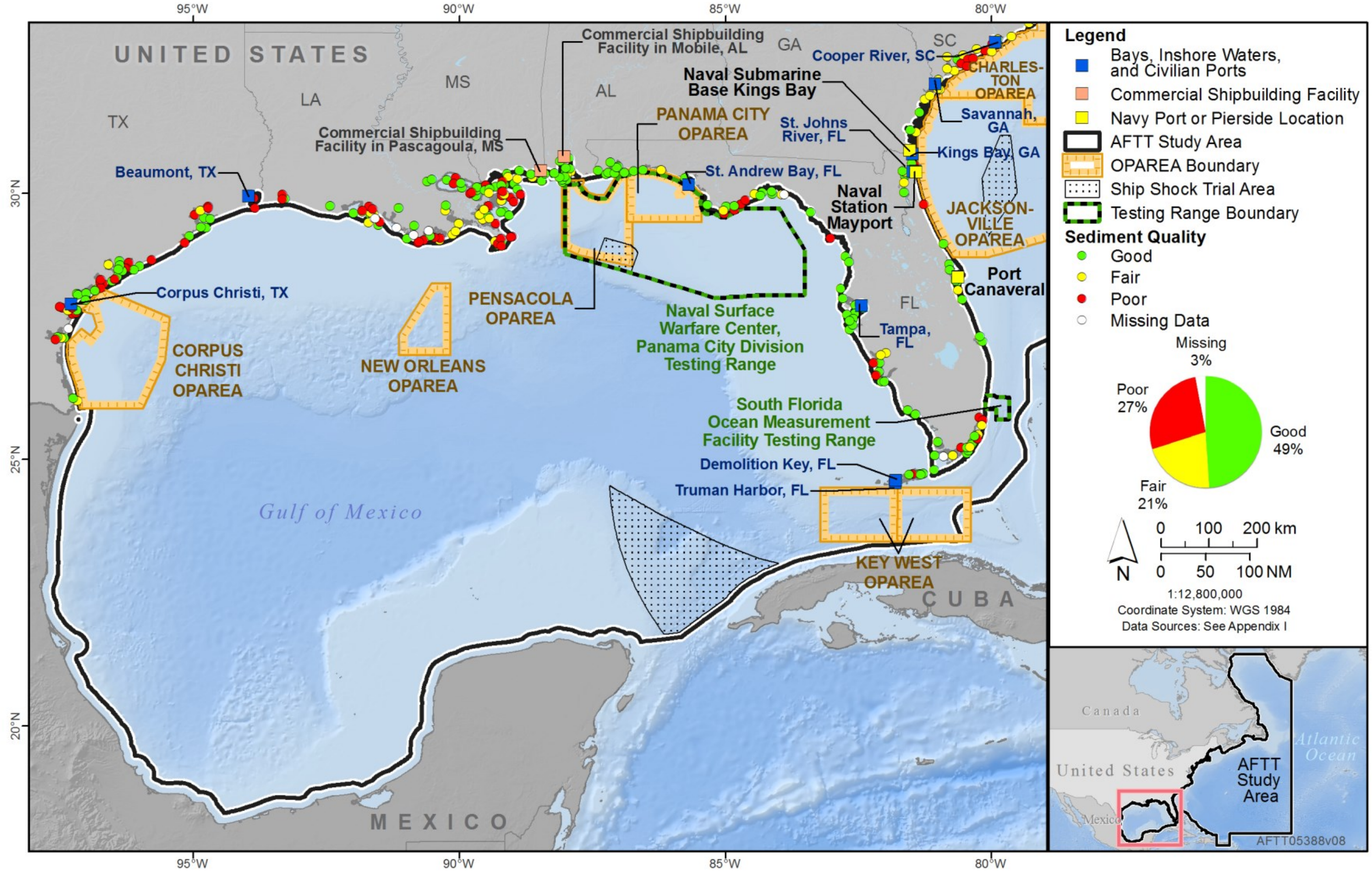
The western and central portions of the Gulf of Mexico are dominated by sediment deposition from the Rio Grande and Mississippi River systems, mostly in the form of sandstone and shale (Galloway et al., 2000). DeSoto Canyon, a submarine feature southwest of Pensacola, Florida, marks the transition between the Mississippi River-influenced sediment to the west (Alabama, Mississippi, Louisiana, and Texas) and the carbonate-dominated sediment to the east and south along western Florida (Gearing et al., 1976). The Naval Surface Warfare Center, Panama City Division Testing Range straddles this transition area. Sediment is predominantly carbonate-sand mixture. Carbonate sources include corals, molluscs, and marine microbes. The amount of organic material mixed with the sand generally increases with the distance from shore. Like other deep ocean areas, the central portions of the Gulf of Mexico are dominated by clay-sized particles (less than 0.002 mm).

<u>Sediment Quality in the Gulf of Mexico Region</u>

Information regarding the quality of sediments in nearshore areas of the states bordering the Gulf of Mexico—Florida, Alabama, Mississippi, Louisiana, and Texas—is provided below. Except where otherwise indicated, information provided below, including the data used in the sediment quality map, was drawn from the USEPA's National Aquatic Resource Surveys database *(U.S. Environmental Protection Agency, 2016)*. In the Gulf of Mexico—from the southern tip of Florida to the Texas-Mexico border—sediment quality was rated 54 percent good, 17 percent fair, and 25 poor; 4 percent of sampling site data were reported as missing (Figure 3.2-4).

According to Summers et al. (1996), of the sites in the Gulf of Mexico enriched by three or more metals, 44 percent occur near populated areas and 56 percent occur in agricultural watersheds or the Mississippi River. Many contaminated sites are in watersheds with Superfund sites established under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 or are identified by the USEPA National Sediment Inventory as "areas of probable concern" (U.S. Environmental Protection Agency, 2008a). Wade et al. (1988) evaluated coastal sediment at 51 sites in the Gulf of Mexico chosen for their distance from known point sources of polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and chlorinated pesticides. The concentrations of the 18 polycyclic aromatic hydrocarbons tested averaged 507 parts per billion (ppb) (range: less than 5 ppb to 36,701 ppb). Eleven percent of all samples had no detectable polycyclic aromatic hydrocarbons. Polychlorinated biphenyl concentrations ranged from less than 5 to 50 ppb, and chlorinated pesticides ranged from less than 0.02 to 5 ppb, with most samples below the limits of detection.

The Gulf of Mexico has several natural hydrocarbon seeps (Kvenvolden & Cooper, 2003). In the eastern Gulf of Mexico, Boehm and Gequejo (1986) found that sediment hydrocarbons are mainly marine in origin, although the Loop Current carries hydrocarbon-laden sediment from the Mississippi River into the eastern Gulf (concentration: 0.4–0.5 ppm). West of the Mississippi River, the concentration of hydrocarbons increases in shallow (less than 30 feet [ft.]) nearshore areas (20–70 ppm), and those increases are predominantly from anthropogenic sources.



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

Figure 3.2-4: Sediment Quality Ratings for the Gulf of Mexico Coast

Along the Texas coast, sediment hydrocarbon concentrations ranged from 0.5 to 20 ppm; proximity to urban and riverine sources increased the contribution from man-made sources. Farther offshore, hydrocarbons carried on wind as a result of burning fuels were more common.

Concentrations of the contaminant chemicals polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and dichlorodiphenyltrichloroethane (DDT) for the Gulf of Mexico region are provided in Table 3.2-3.

Coastal sediments rated as 93 percent good for contaminants (3 percent fair and 0 percent poor), but just 46 percent good for toxicity (15 percent fair and 25 percent poor). The poor rating for toxicity is the primary reason the extent of the region rated as good for sediment quality decreased from nearly 70 to 54 percent between 2006 and 2010. Contaminants resulting in elevated levels of toxicity included metals, pesticides, polychlorinated biphenyls, and, occasionally, polycyclic aromatic hydrocarbons (U.S. Environmental Protection Agency, 2016). Except where otherwise indicated, information provided below was drawn from the National Coastal Condition Aquatic Resource Surveys (U.S. Environmental Protection Agency, 2016).

The Deepwater Horizon oil spill occurred in the Gulf of Mexico in 2010, leaking millions of gallons of oil into the Gulf over 87 days. The impact area extended from the Florida panhandle to western Louisiana, and 143 of the sites sampled during the 2010 survey fell within those boundaries (U.S. Environmental Protection Agency, 2016). The same sampling protocols used to collect samples for previous coastal condition assessments were used during the 2010 survey, which allowed for a comparison with past survey results. Sediment toxicity in the areas impacted by the oil spill showed an increase from 8 percent in the 2005-2006 survey to 27 percent in the 2010 survey, which was a significantly greater increase than observed in other areas of the Gulf.

Florida. Within the Gulf of Mexico, the sediment quality in Charlotte Harbor, Tampa Bay, and Sarasota Bay were all rated 100 percent good (Figure 3.2-4). Sediment quality in Florida Bay, located between the southern tip of Florida and the Florida Keys, was rated 83 percent poor with 17 percent of sampling site data reported as missing. Florida Bay was severely impacted by a seagrass die-off in 1987, which led to subsequent increases in turbidity and the frequency of algal blooms (Boyer et al., 1999). Restoration of the bay is dependent on reestablishing seagrass communities to their historic state. Modeling by Herbert et al. (2011) predicts that increasing the freshwater inflow from the Everglades would substantially alter conditions within the eastern portion of the bay and create favorable habitat for seagrasses that were present in the bay prior to the die-off.

Sediment samples from Pensacola Bay near port facilities were contaminated by lead and zinc (Windom et al., 1989). Lewis et al. (2001) noted that sediment in three bayous of Pensacola Bay contained, on average, as much as 10 times more total heavy metals (e.g., cadmium, copper, and zinc) than sediment collected in Pensacola Bay near the entrance to the bayous. Pesticide concentrations were as much as 45 times greater in the bayou sediment than in those from Pensacola Bay. The authors noted that the bayous were acting as sinks or reservoirs for many contaminants, reducing their transport and availability in Pensacola Bay. The probable source of the contamination was storm water runoff from urbanized watersheds. The authors also indicated that metals and persistent organic pollutant levels in three bayous of Pensacola Bay decreased with distance from shore (seaward).

MacDonald et al. (1996) noted that sediment from Tampa Bay and Pensacola Bay is contaminated with trace metals, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and pesticides. Sediment from Choctawhatchee Bay and St. Andrew Bay is contaminated by metals, polycyclic aromatic hydrocarbons, and pesticides; and sediments from St. Andrew, Apalachicola, Naples, Rookery bays, and Charlotte Harbor had elevated levels of polychlorinated biphenyls. As noted above, more recent data indicate that sediment quality has improved in Tampa Bay and Charlotte Harbor (and possibly in other locations as well) since the mid-1990s.

Alabama. Mobile Bay make up nearly the entire Alabama coastline. Sediment quality in Mobile Bay was rated 92 percent good and 8 percent poor (Figure 3.2-4). Mobile Bay, in addition to the sources of polycyclic aromatic hydrocarbons common to a major port, is also the site of coal burning facilities, natural gas production facilities, and drilling platforms (Peachey, 2003). The Alabama coast has impaired ocean and estuarine habitat due to mercury (201 $mi.^2$) and thallium (94 $mi.^2$) (Alabama Department of Environmental Management, 2010). According to Peachey (2003), Mobile Bay and eight smaller bodies of water were designated as impaired due to high levels of pesticides, persistent organic pollutants, and metals. The study found that the level of polycyclic aromatic hydrocarbons in bay sediments decreased from the upper bay to the lower bay, and that the main source of the polycyclic aromatic hydrocarbons was the burning of fossil fuels.

Mississippi. Sediment quality in the Mississippi Sound was rated 86 percent good and 14 percent poor (Figure 3.2-4). Most sites sampled along the Mississippi coast indicated good sediment quality, including in Biloxi Bay and the eastern portion of Chandeleur Sound.

Louisiana. Louisiana has numerous coastal water bodies that were assessed as part of the national coastal condition assessment (U.S. Environmental Protection Agency, 2016); however, sediment quality in the larger coastal bays and in smaller bays adjacent to the Gulf of Mexico are most relevant to the analysis in the EIS/OEIS. Sediment quality in the western portion of Chandeleur Sound was rated 50 percent good and 50 percent poor (Figure 3.2-4). Sediment quality in Black Bay, which is closer to shore than Chandeleur Sound and downstream of New Orleans, was rated 100 percent poor. East Bay is located at the mouth of the Mississippi River and adjacent to the southernmost coastline in Louisiana. Sediments in East Bay were rated 33 percent good and 67 percent poor. Sediments in coastal areas downstream of New Orleans and other areas receiving outflow from the Mississippi River have historically been affected by polycyclic aromatic hydrocarbons, pesticides, and some heavy metals (Santschi et al., 2001; Van Metre & Horowitz, 2013; Wang et al., 2014). In addition, polycyclic aromatic hydrocarbons, which are associated with petroleum products, were detected farther from shore in sediments on the continental shelf; however these hydrocarbons differed in chemical structure from those found in nearshore marsh sediments, indicating that the shelf hydrocarbons originated from offshore sources rather than urban runoff or atmospheric deposition (Wang et al., 2014). Farther west and adjacent to undeveloped coastline, sediment quality in Caillou Bay and Terrebone Bay were rated 100 percent good. Sediment quality in Atchafalaya Bay at the mouth of the Atchafalaya River was rated 67 percent good and 33 percent poor.

Texas. Galveston Bay, Matagorda Bay, and Corpus Christi Bay are the three largest coastal embayments along the Texas coast. Sediment quality in in Galveston Bay rated as 50 percent good and 50 percent poor (Figure 3.2-4). Galveston Bay sediments were rated as very good for metal contaminants (Gonzalez, 2011). Sediment concentrations in the five areas within the bay that have been sampled regularly since the 1970s have improved for all metals, with the exception of mercury levels in the Houston shipping channel. The concentrations of organic contaminants associated with industrial processes, including polycyclic aromatic hydrocarbons and polychlorinated biphenyls, have also increased in the Houston shipping channel while sediments in other areas of the bay remain in very good condition. Farther south along the coastline, Matagorda Bay sediment quality was rated 67 percent good and 33 percent poor, and sediment quality in Corpus Christi Bay was rated 29 percent good and 71 percent poor.

3.2.2.1.1.5 Sediments in the Caribbean Region

The Caribbean Sea Large Marine Ecosystem includes offshore marine areas south and southeast of the Florida Keys. The majority of the Key West Range Complex is located within this ecosystem. See Figure 3.0-1 in Section 3.0 (Introduction) for range complexes located within each large marine ecosystem in the Study Area and Figure 3.0-5 for bathymetry in the Caribbean region. Sediment in the Straits of Florida consists of 50–95 percent carbonate sand, mud, and silt (Cronin, 1983). Sediment distribution in shallower areas (100 to 500 m) is influenced by tides and the Gulf of Mexico Loop Current; those at intermediate depths are influenced by the eastward-flowing Florida Current; and low-energy, westward-flowing currents dominate in deeper areas (greater than 800 m) (Brooks & Holmes, 1990). Sediments in Florida Bay are discussed above in the sections specific to Florida. Contamination of sediment and shellfish by organic and inorganic compounds was low in nearshore areas of Key West (Cantillo et al., 1997).

Sediment Quality in the Caribbean Region

Sediment quality in Puerto Rico was not assessed in the 2016 publication of the coastal condition assessment, but a 2012 publication, the National Coastal Condition Report IV, did assess sediment quality in island territories (U.S. Environmental Protection Agency, 2012b). Coastal sediment in Puerto Rico was rated 72 percent good, 2 percent fair, and 20 percent poor with 6 percent of data missing. Elevated levels of total organic carbon and contaminants in approximately 10 percent of coastal areas sample contributed to the poor ratings (U.S. Environmental Protection Agency, 2012b).

As discussed in Section 3.2.3.3 (Metals), Pait et al. (2010) surveyed areas at Vieques, Puerto Rico, that had been used extensively for Navy training and found generally low concentrations of metals in marine sediments. Coastal sediment in the U.S. Virgin Islands was rated 83 percent good and 17 percent poor. Elevated levels of total organic carbon and sediment toxicity were found at several sites across the islands of St. Croix, St. Thomas, and St. John (U.S. Environmental Protection Agency, 2012b). Whitall et al. (2015) sampled sediments in Fish and Coral bays on St. John Island in the U.S. Virgin Islands and analyzed the samples for metal contaminants, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and other chemical contaminants. Sediment contamination was low, with the exception of copper and chlordane concentrations which exceeded their Effects Range-Low thresholds.

3.2.2.1.2 Marine Debris, Military Materials, and Marine Sediments

In 2010, the Navy conducted hydrographic and geophysical surveys and sediment sampling with benthic imagery acquisitions off the coast of Florida so that sensitive underwater features could be avoided during construction of the Undersea Warfare Training Range. Approximately 700 square nautical miles (NM^2) of seabed across the shelf break in water depths ranging from 120 to 1,200 ft. were mapped, with image acquisition from a remotely operated vehicle. Although the study's intent was not to inventory debris on the seafloor, observations of debris were noted when observed. Trash was noted in multiple locations; however, only one instance of military materials was detected (a MK 58 Mod 1 marine location marker used for antisubmarine warfare, search and rescue operations, man-overboard markings, and as a target for practice bombing at sea) (U.S. Department of the Navy, 2010c). Evidence of decomposition and colonization of benthic organisms can be seen in Figure 3.2-5. Other studies in the

Atlantic Ocean inventoried marine debris (i.e., Law et al., 2010; Sheavly, 2007; U.S. Environmental Protection Agency, 2010), but did not differentiate military materials from trash from other sources.

Figure 3.2-5: Marine Marker Deposited on a Mound at 300 meter Depth

As suggested by the seafloor survey reported in Keller et al. (2010), of the 469 tows in which marine debris was recovered, none of the debris off of Washington, Oregon, or Northern California contained military expended material. Watters et al. (2010) conducted a visual survey of the seafloor that included a portion of the Navy's Southern California Range Complex as part of a 15-year quantitative assessment of marine debris on the seafloor off the California coast. Watters et al. (2010) found plastic was the most abundant material and, along with recreational monofilament fishing line, dominate in the debris (note that U.S. Navy vessels have a zero-plastic trash discharge policy and return all plastic waste to appropriate disposition sites on shore). There was only one item found that was potentially "military" in origin.

Because they are buoyant, many types of plastic items float and may travel thousands of miles in the ocean (U.S. Commission on Ocean Policy, 2004). Exceptions include heavy nets and ropes. Because many plastics remain in the water column, additional discussion of marine debris is provided in Section 3.0.3.3.6 (Ingestion Stressors). Although plastics are resistant to degradation, they do gradually break down into smaller particles due to sunlight (photolysis) and mechanical wear (Law et al., 2010). Thompson et al. (2004) found that microscopic particles were common in sediment at 18 beaches around the United Kingdom. They noted that such particles were ingested by small filter and deposit feeders, with unknown effects. The fate of plastics that sink beyond the continental shelf is largely unknown. However, analysis of debris in the center of an area near Bermuda with a high concentration of plastic debris on the surface showed no evidence of plastic as a substantial contributor to debris sinking at depths of 1,650–10,500 ft. (Law et al., 2010). Marine microbes and fungi are known to degrade biologically produced polyesters such as polyhydroxyalkanoates, a bacterial carbon and energy source (Doi et al., 1992). Marine microbes also degrade other synthetic polymers, although at slower rates (Shah et al., 2008).

3.2.2.1.3 Climate Change and Sediment

Aspects of climate change that influence sediment include increasing ocean acidity (pH), increasing sea surface water temperatures, and increasing storm activity. Breitbarth et al. (2010) referred to seawater temperature and pH as "master variables for chemical and biological processes," and noted that effects of changes on trace metal biogeochemistry "may be multifaceted and complex." Under more acidic conditions, metals tend to dissociate from particles to which they are bound in sediment, become more soluble, and potentially more available.

As noted in the beginning of this section, tropical storms can have significant impacts on the resuspension and distribution of bottom sediment (Wren & Leonard, 2005). However, no consensus appears to exist on whether climate change will generate more tropical storms or whether those storms will be more intense. If storm frequency and intensity increase, the additional disturbance of sediment may impact water quality in nearshore and coastal areas. A more detailed discussion of this issue is provided in Section 3.2.2.2 (Water Quality).

3.2.2.2 Water Quality

The current state of water quality in the Study Area, from nearshore areas to the open-ocean and deep sea bottom, is discussed below. Additional information on ocean currents in the Study Area is included in Section 3.0.2 (Ecological Characterization of the Study Area). Water quality screening criteria for contaminants in marine waters are shown in Table 3.2-4 and are referred to in assessing contaminant concentrations in the Atlantic and Gulf coast regions in the Study Area.

Table 3.2-4: Water Quality Screening Criteria for Metals and Organic Contaminants in Marine Waters

	Water Quality Guidelines – National Oceanic and Atmospheric Administration (ppb)	
Metal	***Acute***	***Chronic***
Antimony	1,500	500
Arsenic	69	36
Barium	1,000	200
Beryllium	1,500	100
Boron	N	1,200
Cadmium	40	8.8
Chromium III	10,300	27.4
Chromium IV	1,100	50
Cobalt	N	1
Copper	4.8	3.1
Iron	300	50
Lead	210	8.1
Mercury	1.8	0.94
Molybdenum	N	23
Nickel	74	8.2
Silver	0.95	N
Tin (tributyltin)	0.42	0.0074
Zinc	90	81
Organic Chemicals		
PAHs (Total)	300	N
PCBs (Sum)	0.033	0.03
DDT (Sum)	0.065	0.0005
Dieldrin	0.355	0.00095

Notes: Criteria are pH dependent. N = None provided.
PCBs = polychlorinated biphenyls, PAHs = polycyclic aromatic hydrocarbons, DDT = dichlorodiphenyltrichloroethane, ppb = parts per billion

3.2.2.2.1 Water Quality in the North Atlantic Region

The North Atlantic Region consists of the West Greenland Shelf, the Newfoundland-Labrador Shelf, and the Scotian Shelf Large Marine Ecosystems, as well as the Labrador Current Open Ocean Area. The area includes the coasts and offshore marine areas southwest of Greenland, east and northeast of Newfoundland and Labrador, and those surrounding Nova Scotia. Although there are no designated range complexes in this region, the area may be used for Navy training and testing activities.

Because of the low population densities and low levels of development, pollution from land-based sources is limited in the North Atlantic area (Aquarone & Adams, 2009a, 2009b; Aquarone et al., 2009). However, pollution is increasing from oil and gas development activities (Aquarone & Adams, 2009a, 2009b), and concern has been expressed regarding spills, discharges, and contaminants from marine vessels (Aquarone & Adams, 2009a).

3.2.2.2.2 Water Quality in the Northeast and Mid-Atlantic Region

The Northeast Region includes the Northeast and Virginia Capes Range Complexes and the Naval Undersea Warfare Center Division, Newport Testing Range. The testing range includes waters of Narragansett Bay, Rhode Island Sound, Block Island Sound, Buzzards Bay, Vineyard Sound, and Long Island Sound. The range complexes and testing range partially overlay the Northeast U.S. Continental Shelf Large Marine Ecosystem. See Figure 3.0-1 in Section 3.0 (Introduction) for the locations of these areas and Figure 3.0-4 for bathymetry in the northeast and mid-Atlantic region.

3.2.2.2.2.1 Open Ocean Water Quality

Sauer et al. (1989) surveyed the micro-surface layer and subsurface water at five open ocean sites off the Delaware-New Jersey shore for the presence of polychlorinated biphenyls and several chlorinated pesticides. Micro-surface layer samples collected contained polychlorinated biphenyl concentrations between less than 2 and 20 nanograms per liter (ng/L; 2–20 parts per trillion) and pesticide concentrations between less than 7 and 80 ng/L (7–80 parts per trillion). Subsurface water samples contained polychlorinated biphenyl concentrations between 0.007 and 0.17 ng/L (0.007–0.17 parts per trillion), and pesticide concentrations between 0.01 and 0.09 ng/L (0.01–0.09 parts per trillion). The screening criterion for acute concentrations of polychlorinated biphenyls is 0.033 parts per billion (equivalent to 33 parts per trillion), which is greater than the concentrations measured in the micro-surface layer measured by Sauer et al. (1989) (Table 3.2-4). The upper limit of the concentration of pesticides measured in the micro-surface layer exceeded the acute criterion for dichlorodiphenyltrichloroethane (DDT), but was well below the chronic level. The micro-surface layer represents the interface between the ocean and the atmosphere and is defined as the upper 1.0 mm of the water column (Wurl & Obbard, 2004). However the interface can serve as both a sink and a source of anthropogenic contaminants, including chlorinated hydrocarbons and heavy metals, and because of its physical and chemical properties, concentrations of chemicals can be several hundred times greater than in subsurface waters (Wurl & Obbard, 2004). Concentrations of polychlorinated biphenyls in the open ocean in the North Atlantic and Gulf of Mexico have been measures at less than 1 ng/L and open-ocean concentrations of dichlorodiphenyltrichloroethane (DDT) were measured as less than 0.2 ng/L (Wurl & Obbard, 2004).

In the western North Atlantic, Wallace et al. (1977) tested surface waters between Massachusetts and Bermuda. The authors reported that concentrations of metals measured in the study were well below the effects thresholds shown in Table 3.2-4.

In all cases except cadmium, the maximum values were found closest to the shore southeast of Cape Cod. The authors noted that suspended clay minerals and biologically produced particles are important concentrators of trace metals in the marine environment, and that the influence of river-borne suspended sediment extends approximately 1 mile offshore.

3.2.2.2.2.2 Nearshore Water Quality

States bordering the Northeast and Mid-Atlantic Region include Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, and northeast North Carolina. Information regarding the current quality of marine waters in nearshore areas of these states is provided below.

The U.S. Environmental Protection Agency (2016) rated the waters along the northeast U.S. Atlantic coast as 44 percent good, 49 percent fair and 6 percent poor (Figure 3.2-6). Most of these poor sites were concentrated in a few estuarine systems, such as the New York/New Jersey Harbor, upper Delaware Bay, and upper Chesapeake Bay. The poor ratings were based on chlorophyll-*a* (a measure of turbidity) and low dissolved oxygen. Past and ongoing industrial activities also impact water quality (Aquarone & Adams, 2009c). Except where otherwise indicated, information provided below, including the data used in the water quality map, was drawn from the USEPA's National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016).

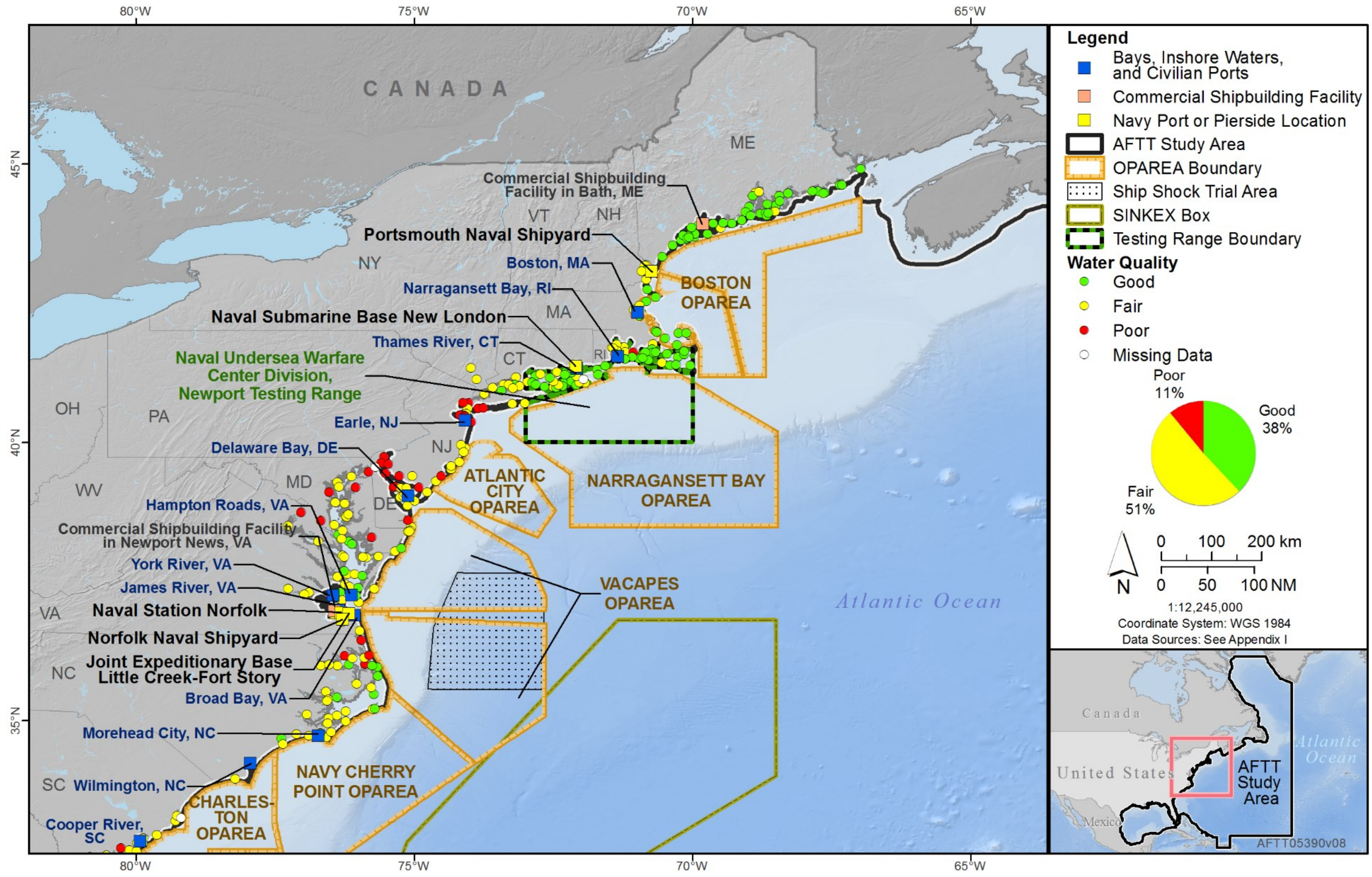
Maine. Water quality for all the estuaries and bays assessed in Maine is rated 88 percent good and 12 percent fair (Figure 3.2-6). All estuarine and marine waters in Maine have an advisory for the consumption of shellfish, specifically lobster tomalley, the green substance found inside the carapace that many consider to be a delicacy, due to the presence of polychlorinated biphenyls and dioxins, presumed to be from atmospheric deposition or prior industrial activity (U.S. Environmental Protection Agency, 2008b).

New Hampshire. Water quality for coastal waters, including estuaries and bays, assessed in New Hampshire was rated 33 percent good and 67 percent fair (Figure 3.2-6). The main concerns were over the contaminants dioxin, polychlorinated biphenyls, and mercury. Elevated levels of nutrients, pathogens, and turbidity were also noted as factors impacting water quality. Offshore and nearshore waters assessed in the surveys were also considered impaired based on similar concerns.

Massachusetts. Water quality for 82 percent of estuaries and bays assessed in Massachusetts is rated good, and 15 percent is rated fair, and 3 percent is poor, mostly due to the presence of pathogens (Figure 3.2-6). Toxic organics, high levels of nutrients, and low dissolved oxygen were also cited as contributors to fair and poor water quality.

Rhode Island. Water quality for 64 percent of estuaries and bays assessed in Rhode Island is rated good, and 36 percent is rated fair (Figure 3.2-6). The main contributors to impaired water quality included low dissolved oxygen levels, fecal coliform, and excess nutrients (i.e., nitrogen).

Connecticut. Water quality for 25 percent of estuaries and bays assessed in Connecticut is rated good, and 75 percent is rated fair (Figure 3.2-6). The main contributors to impaired water quality included low dissolved oxygen levels, eutrophication, and excess nutrients (i.e., nitrogen).



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

Figure 3.2-6: Water Quality Ratings for the Northeast and Mid-Atlantic Coast

New York. Water quality for 45 percent of estuaries and bays assessed in New York is rated good, 33 percent is rated fair, and 20 percent is rated poor (Figure 3.2-6). The main contaminant affecting water quality was polychlorinated biphenyls; other factors contributing to poor water quality included total coliform (bacteria in the water), low dissolved oxygen levels, elevated concentrations of cadmium, and excess nutrients (i.e., nitrogen). The most highly polluted areas were nearshore waters off of New York Harbor.

New Jersey. Water quality for 61 percent of estuaries and bays assessed in New Jersey is considered fair, and 39 percent is considered poor (Figure 3.2-6). The main contributors to impaired water quality included pesticides, polychlorinated biphenyls, low dissolved oxygen levels, and elevated concentrations of mercury. The report notes similar concerns for coastal and offshore marine waters.

Delaware. Water quality for all the estuaries and bays assessed in Delaware was rated 45 percent fair and 45 percent poor with 10 percent of data reported as missing (Figure 3.2-6). Excess nutrients (nitrogen and phosphorus), and pathogens were contributed approximately equally to reduced water quality. Poorest water quality was in the upper Delaware Bay downstream of Wilmington, the state's largest city.

Maryland. Water quality for 44 percent of the Maryland's coastal waters is rated good, 33 percent is rated fair, and 22 percent is rated poor (Figure 3.2-6). Wazniak et al. (2004) indicates that water quality conditions in Maryland's coastal bays range from generally degraded conditions within or close to tributaries to better conditions in the bay regions farther from shore. Excess nutrient levels are a contributor to most of the impaired waters. Tributaries generally show poor to very degraded water quality, primarily due to high nutrient inputs, while the open bays have good to excellent water quality. The Maryland Coastal Bays Program uses water quality indicators (e.g., chlorophyll-*a*, dissolved oxygen) as well as other metrics such as seagrass and hard clam densities to assess or grade the health of Maryland's coastal bays (Maryland Coastal Bays Program, 2015). The 2014 "report card" indicates that the collectively received a grade of C+, on a scale of A (good to very good) to F (very poor), on the program's index for characterizing the health of each coastal bay. Specifically for the water quality components of the report card, Chincoteague Bay (overall B-) scored good to very good for nitrogen, phosphorus, and chlorophyll-*a*, and dissolved oxygen was moderate. Assawoman Bay (C), scored as moderate for dissolved oxygen, nitrogen, and phosphorus (declined since 2013), and chlorophyll-*a* was very good (improved since 2013). Isle of Wight Bay (C) scored good to very good for nitrogen and chlorophyll-*a*, moderate for dissolved oxygen (a significant improvement), but poor to very poor for phosphorus. In Newport Bay (C-), chlorophyll-*a* was very good, and dissolved oxygen, nitrogen, and phosphorus were all moderate, an overall improvement since 2013.

Also, the northern bays are generally in poorer condition than the southern bays due to the extent of development and, to a lesser degree, the extent of flushing that occurs. Areas within the tidal portion of the Potomac River have been placed on the state 303(d) "impaired waters" list because of contamination by polychlorinated biphenyls (Interstate Commission on the Potomac River Basin, 2008).

Virginia. Water quality for 22 percent of coastal waters in Virginia is rated good, 74 percent is rated fair, and 4 percent is rated poor (Figure 3.2-6). The main issues involve polychlorinated biphenyls, noxious aquatic plants, and low dissolved oxygen. Water quality parameters are measured at over 4,000 stations in Virginia's coastal zone. Monitoring data show that 316 coastal water bodies are impaired (Virginia Department of Environmental Quality, 2001). Shellfish concerns are related to bacteria, and health advisories have been issued for fish consumption related to polychlorinated biphenyls and mercury (Virginia Department of Environmental Quality, 2016).

North Carolina. Water quality along the North Carolina coast was rated 25 percent good, 64 percent fair, and 11 percent poor. The main issues reported are mercury and selenium (at limited locations) in fish tissue. Impaired water quality was observed in the state's large coastal estuaries. In Albemarle Sound, 67 percent of survey sites reported either fair or poor water quality, and in Currituck Sound, 100 percent of sites rate poor for water quality. According to Mallin (2000), most estuaries in North Carolina exhibit low-to-moderate eutrophication. However, conditions in three estuaries—the Pamlico River, Neuse River, and New River—were rated as highly eutrophic based on frequency and extent of algal blooms, bottom-water hypoxia and anoxia, fish kills, and loss of submerged aquatic vegetation. Impairment is primarily the result of runoff from agricultural and urban areas that leads to excess nutrients and increased turbidity from algal blooms.

Chesapeake Bay. Bay water is listed as impaired under Section 303(d) of the federal Clean Water Act due to excess nutrients and sediment (U.S. Geological Survey, 2005). The most contaminated sites were concentrated at the northern end of the bay, where development is most intensive. Nutrient enrichment in the bay arises from agricultural and other nonpoint source runoff, and municipal and industrial wastewater treatment facilities (U.S. Army Corps of Engineers, 2009).

The Chesapeake Bay watershed includes portions of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia. In order to simplify the discussion and reduce repetition, water quality issues in the bay are not reviewed on a state-by-state basis because: (1) many of the water quality issues are common to most or all of these bordering states; and (2) Navy training and testing activities are limited to the extreme southeast portion of the bay and do not appreciably impact water quality in the bay as a whole.

3.2.2.2.3 Water Quality in the Southeast Region

The Southeast U.S. Continental Shelf Large Marine Ecosystem includes the Navy Cherry Point and Jacksonville Range Complexes, and the South Florida Ocean Measurement Facility Testing Range. See Figure 3.0-1 in Section 3.0 (Introduction) for the locations of these areas and Figure 3.0-5 for bathymetry in the Southeast region.

3.2.2.2.3.1 Open Ocean Water Quality

Of the large marine ecosystems in the Study Area, the southeast is judged to be in the best ecological condition (Aquarone et al., 2009). Sauer et al. (1989) surveyed the micro-surface layer and subsurface water at five open ocean sites between Cape Hatteras, North Carolina and Florida for the presence of polychlorinated biphenyls and several chlorinated pesticides. Micro-surface layer samples collected contained polychlorinated biphenyl concentrations between less than 0.5 and 1.5 ng/L and pesticide concentrations between less than 0.5 and 1.0 ng/L. Subsurface water samples contained polychlorinated biphenyl concentrations between 0.003 and 0.424 ng/L and pesticide concentrations between 0.013 and 0.1 ng/L. No concentrations exceeded the acute concentration criteria for either contaminant. The concentration of pesticides exceeded the chronic concentration criterion for dichlorodiphenyltrichloroethane (DDT) in the micro-surface layer, but not in the subsurface layers (Table 3.2-4).

3.2.2.2.3.2 Nearshore Water Quality

States bordering the Southeast U.S. Continental Shelf Large Marine Ecosystem include southeast North Carolina, South Carolina, Georgia, and the Atlantic coast of Florida. Information regarding the current quality of marine waters in the nearshore areas of these states is provided below (Figure 3.2-7). The USEPA (2016) rated 21 percent good, 69 percent of the waters along the southeast coast as fair, and 9 percent of the sites sampled rated poor. Except where otherwise indicated, information provided below, including the data used in the water quality map, was drawn from the USEPA's National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016).

North Carolina. Refer to the Section 3.2.2.2.2.2 (Nearshore Water Quality) for the Northeast and Mid-Atlantic states.

South Carolina. For South Carolina, water quality for 86 percent of coastal waters was rated fair, 10 percent is rated poor, and 5 percent is reported as missing (Figure 3.2-7). Estuaries in South Carolina exhibit low or moderate eutrophication (Mallin et al., 2000). Poor water quality is primarily linked to high turbidity levels, which reduce water clarity in coastal and estuarine areas.

Georgia. Water quality along Georgia's coast was rated 57 percent fair and 43 percent poor based on five indicators: dissolved oxygen, dissolved inorganic nitrogen, dissolved inorganic phosphorus, turbidity as measured by chlorophyll-*a*, and water clarity (Figure 3.2-7). Eighty percent of the state's estuaries rated fair, 18 percent rated poor, and 2 percent rated good. Increasing eutrophication and decreasing water clarity were noted as concerns (Sheldon & Alber, 2010).

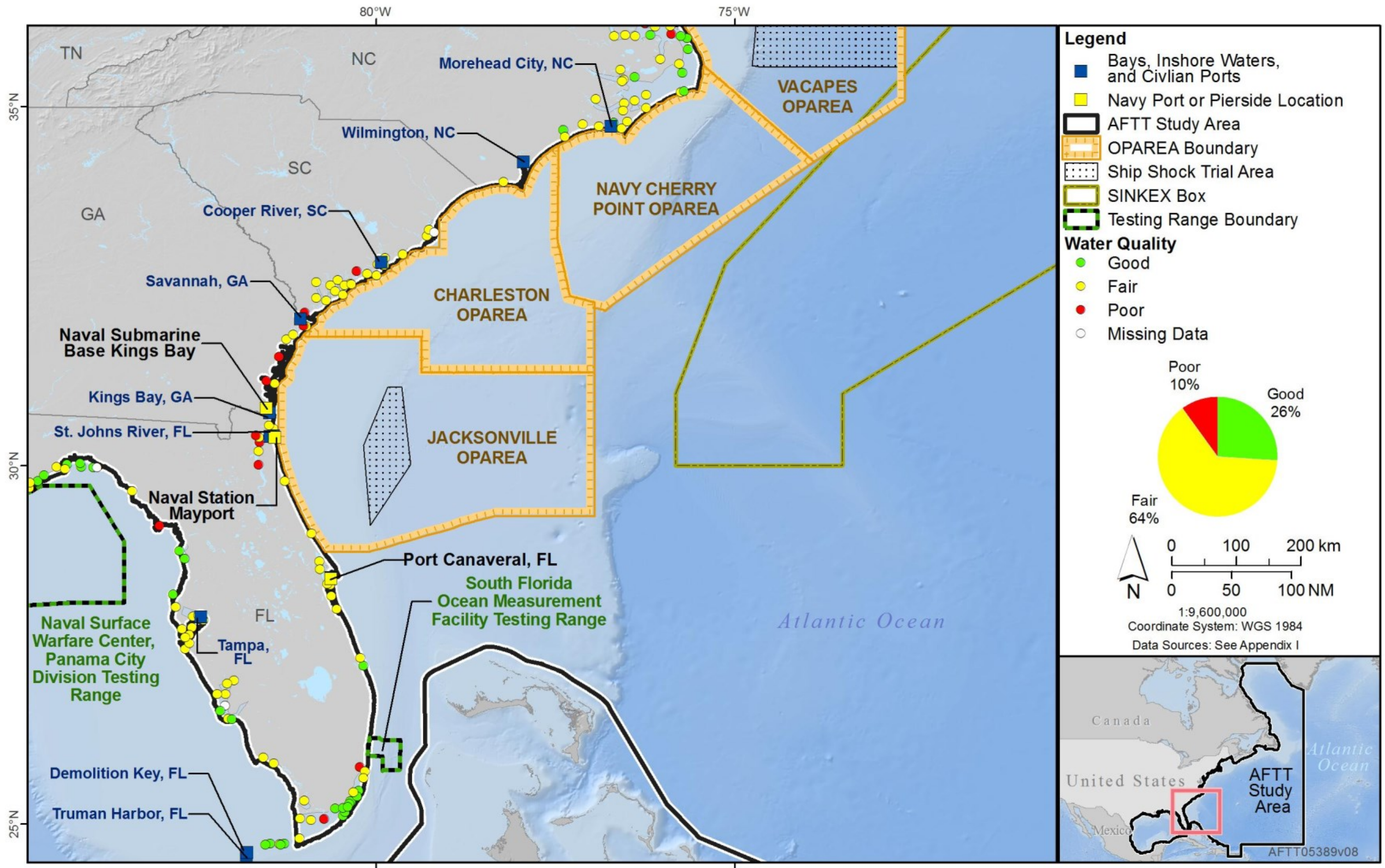
Florida. Water quality along Florida's Atlantic coast is rated 13 percent good, 70 percent fair, and 17 percent poor (Figure 3.2-7). Most of the state's estuaries and coastal waters are considered impaired because of mercury in fish tissue, low dissolved oxygen, high turbidity as measured by chlorophyll-*a* concentrations, fecal coliform, and bacteria in shellfish. Harmful algal blooms and nutrient enrichment are of increasing concern (Florida Department of Environmental Protection, 2010).

3.2.2.2.4 Water Quality in the Gulf of Mexico Region

The Gulf of Mexico Region includes the Gulf of Mexico Range Complex, which consists of four Operating Areas: Panama City, Pensacola, New Orleans, and Corpus Christi. Also within the Gulf of Mexico Large Marine Ecosystem are the Naval Surface Warfare Center, Panama City Division Testing Range (Florida) and a portion of the Key West Range Complex. See Figure 3.0-1 in Section 3.0 (Introduction) for range complexes within each large marine ecosystem and Figure 3.0-6 for bathymetry in the Gulf of Mexico region.

3.2.2.2.4.1 Open Ocean Water Quality

Unlike the other areas, no open ocean areas are specifically designated for the Gulf of Mexico. However, Sauer et al. (1989) surveyed the micro-surface layer and subsurface water at six sites in the west central part of the Gulf of Mexico for the presence of polychlorinated biphenyls and several chlorinated pesticides. Micro-surface layer samples collected contained polychlorinated biphenyl concentrations between less than 0.2 and 1.0 ng/L and pesticide concentrations between less than 0.1 and 0.5 ng/L. Subsurface water samples contained polychlorinated biphenyl concentrations between 0.0006 and 0.0024 ng/L and pesticide concentrations between 0.0002 and 1.46 ng/L. No concentrations exceeded the acute concentration criteria for either contaminant. The highest concentration of pesticides equaled the chronic concentration criterion for dichlorodiphenyltrichloroethane (DDT) in the micro-surface layer, and exceeded the chronic concentration criterion in the subsurface layers (Table 3.2-4).



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

Figure 3.2-7: Water Quality Ratings for the Southeast Coast

3.2.2.2.4.2 Nearshore Water Quality

States bordering the Gulf of Mexico Region include the Gulf coast of Florida, Alabama, Mississippi, Louisiana, and Texas. Information regarding the current quality of marine waters in the nearshore areas of these states is provided. The USEPA (2016) rated the gulf waters as 16 percent good, 58 percent fair, and 24 percent poor. Various combinations of all the water quality indicators were responsible for poor site conditions. Onshore development, oil and gas extraction, and excess nutrients are the main sources of stress on the Gulf of Mexico (Heileman & Rabalais, 2008). Except where otherwise indicated, information provided below, including the data used in the water quality map, was drawn from the USEPA's National Aquatic Resource Surveys database (U.S. Environmental Protection Agency, 2016).

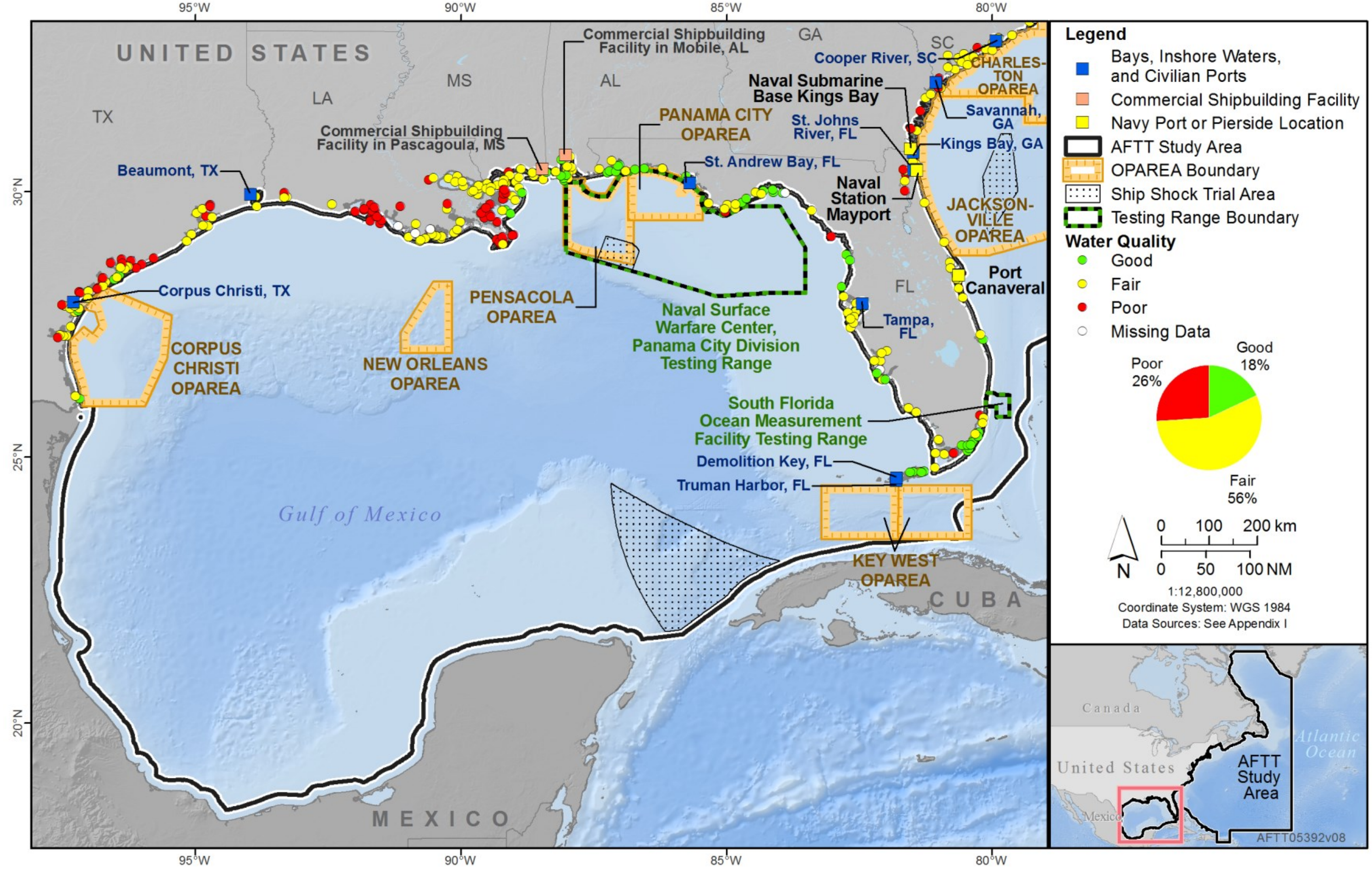
Florida. Water quality along Florida's Gulf coast was rated 47 percent good, 47 percent fair, and 4 percent poor with 3 percent of data reported as missing (Figure 3.2-8). Mercury in fish tissue, bacteria in shellfish, low dissolved oxygen, high turbidity as measured by chlorophyll-*a*, and fecal coliform are also concerns along the Gulf coast.

Lewis et al. (2001) studied the impacts of urbanization on three areas in Pensacola Bay. Although total metal concentrations varied widely, copper and zinc were most commonly detected in surface waters. Average levels for copper exceeded both the chronic (3.1 µg/L) and acute (4.8 µg/L) exposure levels established to protect marine life. Cadmium, chromium, and nickel were detected in fewer samples but, where detected, concentrations exceeded chronic exposure levels. Concentrations of most chlorinated pesticides, polycyclic aromatic hydrocarbons, and all polychlorinated biphenyls were below the limits of detection. The most commonly detected pesticides were diazinon (0.03–0.22 µg/L) and atrazine (0.03–0.30 µg/L). The authors noted that some pesticides occasionally exceeded the recommended maximum surface water concentration of 0.004 µg/L and that total polycyclic aromatic hydrocarbon concentrations at some sites exceeded the recommended annual average of less than or equal to 0.031 µg/L, but these occasions were "uncommon." Petroleum hydrocarbons were detected in surface water collected from several sites, but most commonly in Bayou Grande, where the average concentrations ranged from 1.1 to 8.9 µg/L.

Alabama. Water quality for the coastal waters assessed for Alabama was rated 35 percent good and 65 percent fair (Figure 3.2-8). Pathogens (e.g., fecal bacteria) and mercury in fish tissue contributed to reduced water quality.

Mississippi. Of the 23 mi. of coastal Mississippi shoreline assessed, 10 percent rated good, 80 percent rated fair, and 10 percent rated poor (Figure 3.2-8). The main issue was pathogens (fecal bacteria). Sampling along the coast indicated degraded water clarity and high phosphorus levels contributed to poor water quality.

Louisiana. Water quality for the coastal waters assessed for Louisiana was rated 3 percent good, 47 percent fair, and 46 percent poor with 3 percent of data reported as missing (Figure 3.2-8). Clark and Goolsby (2000) studied herbicide concentrations in the Mississippi River at Baton Rouge between 1991 and 1997. Peak herbicide concentrations generally followed peak discharges in late winter or early spring. Herbicides and their metabolites were detected in more than half of the samples (e.g., alachlor, atrazine, metolachlor, deethylatrazine, and cyanazine). No compound exceeded 5 µg/L, and the total herbicide concentration did not exceed 10 µg/L. None of the average annual concentrations of the herbicides examined in that study exceeded maximum contaminant levels or the health advisory levels established at that time.



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

Figure 3.2-8: Water Quality Ratings for the Gulf of Mexico Coast

Texas. Water quality for the coastal waters in Texas was rated 11 percent good, 55 percent fair, and 34 percent poor (Figure 3.2-8). In nearshore waters and estuaries, the main concerns were with bacteria (in oyster waters) and low dissolved oxygen. Farther offshore, impairment was associated with bacteria concentrations and mercury in fish tissue.

3.2.2.2.5 Water Quality in the Caribbean Region

The Caribbean Region includes offshore marine areas south and southeast of the Florida Keys. The majority of the Key West Range Complex is located within this ecosystem. See Figure 3.0-1 in Section 3.0 (Introduction) for range complexes within each large marine ecosystem and Figure 3.0-5 for bathymetry in the Caribbean region. These marine waters are clear and poor in nutrients (Heileman & Mahon, 2008). Water quality in nearshore waters of Puerto Rico was not assessed in the 2016 publication of the coastal condition assessment, but a 2012 publication, the National Coastal Condition Report IV, did assess sediment quality in island territories (U.S. Environmental Protection Agency, 2012b). Coastal water quality in Puerto Rico was rated 50 percent good, 40 percent fair, and 10 percent poor. Poor water clarity ratings in combination with elevated dissolved inorganic phosphorous levels or chlorophyll-*a* concentrations at individual sites resulted in the poor ratings (U.S. Environmental Protection Agency, 2012b). Several of the poor water quality ratings were in coastal areas near San Juan, the most populous city on the island. Coastal water quality in the U.S. Virgin Islands was rated 60 percent good, 34 percent fair, and 0 percent poor with 6 percent of data reported as missing (U.S. Environmental Protection Agency, 2012b).

Specific information regarding water quality in the Key West Range Complex could not be located. As with other coastal areas, nearshore water quality is mostly influenced by onshore activities and development, plus the discharge of solid waste and wastewater from commercial and cruise vessels (Heileman & Mahon, 2008; Lapointe et al., 1994).

3.2.2.2.6 Marine Debris and Water Quality

The National Marine Debris Monitoring Program developed three categories of marine debris for its study of the extent of man-made materials in the oceans: land-based, ocean-based, and general (i.e., origin unspecified) (Sheavly, 2007). Land-based debris may blow in on the wind, be washed in with storm water, arise from recreational use of coastal areas, and be generated by extreme weather such as hurricanes. Ocean-based sources of marine debris include commercial shipping and fishing, private boating, offshore mining and extraction, and legal and illegal dumping at sea. Ocean current patterns, weather and tides, and proximity to urban centers, industrial and recreational areas, shipping lanes, and fishing grounds influence the types and amount of debris found (Sheavly, 2010). These materials are concentrated at the surface and in the near-surface water column.

According to Sheavly (2010), land-based sources account for about half of marine debris, and ocean- and waterway-based sources contribute another 18 percent. Galgani et al. (2015) confirm that the majority of marine debris originates from land. Land-based debris included syringes, condoms, metal beverage cans, motor oil containers, balloons, six-pack rings, straws, tampon applicators, and cotton swabs as well as other items. Ocean-based debris included gloves, plastic sheets, light bulbs and tubes, oil and gas containers, pipe-thread protectors, nets, traps and pots, fishing line, light sticks, rope, salt bags, fish baskets, cruise line logo items, and floats and buoys. Plastics, generally referring to petroleum-based, manmade materials, make up the vast majority of marine debris (Galgani et al., 2015; Law et al., 2014). Microscopic plastic fragments enter the marine environment from use as scrubbers in hand cleaning and other cosmetic products, abrasive beads for cleaning ships, and deterioration of macroscopic plastics

(Teuten et al., 2007). Microplastic beads commonly used in cosmetic products such as facial scrubs and other exfoliants are not broken down in wastewater treatment facilities and are largely not filtered out of the waste stream before they are flushed into the marine environment in enormous quantities (Chang, 2015; Napper et al., 2015). These microbeads are found worldwide in marine sediments, persist in the marine environment, and accumulate up the food chain (Cole & Galloway, 2015).

Plastics may serve as vehicles for transport of various pollutants, whether by binding them from seawater or from the constituents of the plastics themselves. Mato et al. (2001) noted that polypropylene resin pellets (precursors to certain manufactured plastics) collected from sites in Japan contained polychlorinated biphenyls, dichlorodiphenyldichloroethylene (a breakdown product of DDT), and the persistent organic pollutant nonylphenol (a precursor to certain detergents). Polychlorinated biphenyls and dichlorodiphenyldichloroethylene were adsorbed from seawater. The original source of nonylphenol was less clear; it may have originated from the pellets themselves or may have been adsorbed from the seawater and accumulated on the surface of plastics. Microbeads have also been shown to adsorb hydrophobic chemical contaminants, such as DDT, from seawater, allowing for the accumulation and transport of these often toxic chemicals to widely dispersed areas of the oceans. While the impacts on the marine ecosystem are largely unknown, some examples illustrating potential widespread impacts have been discussed. For example, it has been suggested that white and blue microplastic beads, common in many exfoliants, resemble plankton and may be mistakenly ingested by plankton-feeding fishes, which rely on visual cues to find prey (Napper et al., 2015; Wright et al., 2013). The long-term effects on the environment from the proliferation of microbeads and other microplastics are still being researched. Since there is no way of effectively removing microplastics from the marine environment, and given that plastics are highly resistant to degradation, it is likely that the quantity of microplastics in the marine environment will only continue to increase, and therefore the likelihood of environmental impacts can only increase (Napper et al., 2015). The only way to reduce long-term impacts is to reduce or eliminate the use of microplastics, a course of action that is gaining recognition (Chang, 2015).

Marine debris findings in the Study Area (Sheavly, 2007) are provided in Table 3.2-5. In a recent survey of marine debris in the North Atlantic, 62 percent of all net tows contained detectable amounts of plastic debris (Law et al., 2010). The highest concentrations were observed between 22° and 38° north latitude (roughly south of Florida to Maine). Tows closest to land, such as along the Florida coast and in the Gulf of Maine, found relatively small amounts of plastic.

Because of their buoyancy, many types of plastic items float and may travel thousands of miles in the ocean (U.S. Commission on Ocean Policy, 2004). Exceptions include heavy nets and ropes. Although plastics are resistant to degradation, they do gradually break down into smaller particles due to sunlight and mechanical wear (Law et al., 2010). A study by Teuten et al. (2007) indicated that the water-borne phenanthrene (a type of polycyclic aromatic hydrocarbon) adhered preferentially to small pieces of plastic ingested by a bottom-dwelling marine lugworm and incorporated into its tissue. Marine microbes and fungi are known to degrade biologically produced polyesters, such as polyhydroxyalkanoates, a bacterial carbon and energy source (Doi et al., 1992). Marine microbes also degrade other synthetic polymers, although at slower rates (Shah et al., 2008).

Table 3.2-5: Percent Marine Debris by Source in Atlantic Fleet Training and Testing Study Area

Sheavly Study Area	*Locations within Study Area*	*Land-Based (%)*[1]	*Ocean-Based (%)*[1]	*General (%)*[1]
Region 1 (Provincetown, Massachusetts to Canadian border)	Northeast Range Complexes	28	42	30
Region 2 (Cape Cod, Massachusetts to Beaufort, North Carolina)	Northeast and Virginia Capes Range Complexes; Naval Undersea Warfare Center Division, Newport Testing Range	63	7	30
Region 3 (Morehead City, North Carolina to Port Everglades, Florida)	Navy Cherry Point and Jacksonville Range Complexes; South Florida Ocean Measurement Facility	41	14	44
Regions 4 & 5 (Port Everglades, Florida to Mexican border)	Gulf of Mexico and Key West Range Complexes; Naval Surface Warfare Center, Panama City Division Testing Range	48	16	36

[1] Numbers may not sum due to rounding.
Notes: % = percent

Annex V of the International Convention for the Prevention of Pollution from Ships prohibits the discharge of plastic waste from vessels at sea, and the U.S. Act to Prevent Pollution from Ships brought U.S. public vessels in alignment with the international convention. The National Defense Authorization Act of 1996 specifically directed the Navy to install plastic waste processors aboard the surface fleet. The U.S. Navy's plastics waste processors compress and melt shipboard-generated plastic waste into dense, sanitary disks of compressed plastics that can be stored over long at-sea deployments. The plastic waste items include lightly contaminated food containers as well as clean plastics and other materials that may be combined with, or contain, plastic components that cannot be processed in the normal solid waste stream. The plastic waste disks are offloaded for proper disposal once a ship comes into port. The plastic compression technology enables Navy ships to operate at sea over long time periods without discharging plastics into the oceans.

3.2.2.2.7 Climate Change and Water Quality

According to the U.S. Global Change Research Program, the rise in ocean temperature over the last century will continue into the future, with continued and perhaps increasing impacts on ocean circulation, marine chemistry, and marine ecosystems. Because the ocean currently absorbs about a quarter of human-produced carbon dioxide emissions, increasing carbon dioxide absorption will increase acidification of ocean waters. This in turn will alter the distribution, abundance, and productivity of many marine species and affect water quality in coastal and open ocean waters (Melillo et al., 2014).

Key findings of the 2014 National Climate Assessment that may pertain to waters in the AFTT Study Area:

- Local sea level rise (amplified by coastal subsidence) is greater than the global average for the Chesapeake Bay.
- Sea level rise and related flooding and erosion threaten coastal homes, infrastructure, and commercial development, including ports.

- Ecosystems of the southeast are vulnerable to loss from relative sea level rise, especially tidal marshes and swamps.
- The incidence of harmful algal blooms is expected to increase with climate change, as are health problems previously uncommon in the region.
- The number of land-falling tropical storms may decline in the gulf, reducing important rainfall, while there has been an increase in the frequency of tropical storms and major hurricanes in the North Atlantic.
- The Florida Keys, South Florida, and coastal Louisiana are particularly vulnerable to additional sea level rise and saltwater intrusion.

The Paris Agreement builds upon the Convention and — for the first time — brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

At the 2015 Paris Climate Conference, 195 parties to the United Nations Framework Convention on Climate Change adopted the first-ever universal, global climate agreement, referred to as the Paris Agreement in which all countries voluntarily set and committed to individual carbon reduction goals. The Agreement marks the latest step in the evolution of the United Nations climate change initiative and builds on the work undertaken under the Convention over the past several decades.

The Paris Agreement seeks to accelerate and intensify the actions and investment needed for sustaining low carbon emissions into the future. Its central aim is to strengthen the global response to the threat of climate change and greenhouse gas emissions by limiting a global temperature rise over this century to no more than 2 degrees Celsius above pre-industrial levels. The Paris Agreement also includes a commitment to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

The United States signed the Paris Agreement on April 22, 2016, and on September 3, 2016, the United States accepted ratification of the Agreement. However, on June 1, 2017, the President announced that the United States would withdraw from the Paris Agreement. The official withdrawal requires a formal process, which will take nearly four years to complete. According to the rules of the Paris Agreement, a nation wishing to withdraw must first submit a document to the United Nations specifying its intent to withdraw. The submission of the document is permitted only after three years have passed since the agreement entered into force, in this case November 4, 2016. The earliest the United States can submit its written notice is November 4, 2019, and the earliest the United States could complete the withdrawal process is November 4, 2020.

3.2.3 ENVIRONMENTAL CONSEQUENCES

This section evaluates how and to what degree the training and testing activities described in Chapter 2 (Description of Proposed Action and Alternatives) may impact sediments and water quality in the Study Area. Tables 2.6-1 through 2.6-4 present proposed training and testing activity locations for each alternative, including number of events conducted annually and over a five-year period for alternatives 1 and 2. Each water quality stressor is introduced, analyzed by alternative, and analyzed for training activities and testing activities. Potential impacts could be from:

- releasing materials into the water that subsequently disperse, react with seawater, or may dissolve over time;

- depositing materials on the ocean bottom and any subsequent interactions with sediments or the accumulation of such materials over time;
- depositing materials or substances on the ocean bottom and any subsequent interaction with the water column; and
- depositing materials on the ocean bottom and any subsequent disturbance of those sediments or their resuspension in the water column.

These potential impacts may result from four stressors: (1) explosives and explosives byproducts, (2) metals, (3) chemicals other than explosives, and (4) other materials. The term "stressor" is used because materials in these four categories may directly impact sediments and water quality by altering their physical and chemical characteristics.

The area of analysis for sediments and water quality includes the estuaries, nearshore areas, and the open ocean (including the seafloor) in the Study Area. The environmental fate of explosives, explosives byproducts, metals, and other materials depends on environmental factors, geochemical conditions, and various mechanisms that transport the constituents in the environment. Some natural transport mechanisms, such as advection by currents, dispersion, dissolution (dissolving), precipitation by chemical reaction, and adsorption (the adhesion of a chemical constituent onto the surface of a particle in the environment [e.g., clay]) reduce concentrations in water and redistribute constituents between the water and sediments. Other processes, such as biodegradation, may change or destroy the explosive compounds but would not affect metals. For this analysis, potential impacts on sediments and water quality from military expended materials that come to rest in sediment at a given distance from shore are assumed to be similar whether off the Atlantic coast or the Gulf of Mexico.

3.2.3.1 Explosives and Explosives Byproducts

Explosives may be introduced into the seawater and sediments by the Proposed Action. The explosive fillers contained within the munitions used during training and testing activities and their degradation products can enter the environment through high-order detonations (i.e., the munition functions as intended and the vast majority of explosives are consumed), low-order detonations (i.e., the munition partially functions with only a portion of the explosives consumed), or unexploded munitions (i.e., the munition fails to detonate and explosives remain in the casing). In the case of a successful detonation, only a small or residual amount of explosives may enter the marine environment (U.S. Environmental Protection Agency, 2012a). A low-order detonation would result in some residual explosives and some unconsumed explosives remaining in the munitions casing entering the water. In the case of unexploded munitions, the explosives contained in the munition would not be consumed and would remain encased within the munition as it enters the marine environment. The munitions casing may corrode or rupture over time and release explosives into the sediments and water column.

The behavior of explosives and explosives byproducts in marine environments and the extent to which those constituents of explosives have adverse impacts are influenced by a number of processes, including the ease with which the explosive dissolves in a liquid such as water (solubility), the degree to which explosives are attracted to other materials in the water (e.g., clay-sized particles and organic matter, sorption), and the tendency of the explosives to evaporate (volatilization). These characteristics, in turn, influence the extent to which the material is subject to biotic (biological) and abiotic (physical and chemical) transformation and degradation (Pennington & Brannon, 2002). The solubility of various explosives is provided in Table 3.2-6. In the table, higher values indicate greater solubility. For example, high melting explosive is virtually insoluble in water. Table salt, which dissolves easily in water, is included in the table for comparison.

Table 3.2-6: Water Solubility of Common Explosives and Explosive Degradation Products

Compound	*Water Solubility*[1] *(mg/L at 20 ˚C)*
Table salt (sodium chloride)[2]	357,000
Ammonium perchlorate (O)	249,000
Picric acid (E)	12,820
Nitrobenzene (D)	1,900
Dinitrobenzene (E)	500
Trinitrobenzene (E)	335
Dinitrotoluene (D)	160
Trinitrotoluene (TNT) (E)	130
Tetryl (E)	51
Pentaerythritol tetranitrate (E)	43
Royal Demolition Explosive (E)	38
High Melting Explosive (E)	7

[1] Units are milligrams per liter (mg/l) at 20 degrees Celsius.
[2] Table salt is not an explosive degradation product
Notes: D = explosive degradation product, E = explosive, O = oxidizer additive;
TNT = trinitrotoluene
Source: U.S. Department of the Navy (2008a)

According to Walker et al. (2006), trinitrotoluene (TNT), royal demolition explosive, and high melting explosive experience rapid biological and photochemical degradation in marine systems. The authors noted that productivity in marine and estuarine systems is largely controlled by the limited availability of nitrogen. Because nitrogen is a key component of explosives, they are attractive as substrates for marine bacteria that metabolize other naturally occurring organic matter, such as polycyclic aromatic hydrocarbons. Juhasz and Naidu (2007) also noted that microbes use explosives as sources of carbon and energy.

Carr and Nipper (2003) indicated that conversion of trinitrotoluene (TNT) to carbon dioxide, methane, and nitrates in coastal sediments (a process referred to as mineralization) occurred at rates that were typical for naturally occurring compounds such as phenanthrene, fluoranthene, toluene, and naphthalene. They noted that transformation of 2, 6-dinitrotoluene and picric acid by organisms in sediments is dependent on temperature and type of sediment (e.g., finer-grained). Pavlostathis and Jackson (2002) reported that the marine microalgae *Anabaena* spp. were highly efficient at the removal and metabolism of trinitrotoluene (TNT) in a continuous flow experiment. Nipper et al. (2002) noted that irreversible binding to sediments and biodegradation of 2, 6-dinitrotoluene, tetryl, and picric acid occurred in fine-grained sediments high in organic carbon resulting in lower concentrations of the contaminants. Cruz-Uribe et al. (2007) noted that three species of marine macroalgae metabolize trinitrotoluene (TNT) to 2-amino-4,6-dinitrotoluene and 4-amino-2, 6-dinitrotoluene, and speculate that "the ability of marine macroalgae to metabolize trinitrotoluene (TNT) is widespread, if not generic." The studies cited above indicate that trinitrotoluene (TNT) and its constituent products can be removed from the environment by naturally occurring biological processes in sediments, reducing sediment toxicity from these chemical contaminants.

Singh et al. (2009) indicated that biodegradation of royal demolition explosive and high melting explosive occurs with oxygen (aerobic) and without oxygen (anoxic or anaerobic), but that they were more easily degraded under anaerobic conditions. Crocker et al. (2006) indicated that the mechanisms of high melting explosive and royal demolition explosive biodegradation are similar, but that high melting explosive degrades more slowly. Singh et al. (2009) noted that royal demolition explosive and high melting explosive are biodegraded under a variety of anaerobic conditions by specific microbial species and by mixtures of such species. Zhao et al. (2004a); (2004b) found that biodegradation of royal demolition explosive and high melting explosive occurs in cold marine sediments.

According to Singh et al. (2009), typical end products of the degradation of royal demolition explosive include nitrite, nitrous oxide, nitrogen, ammonia, formaldehyde, formic acid, and carbon dioxide. Crocker et al. (2006) stated that many of the primary and secondary intermediate compounds from biodegradation of royal demolition explosive and high melting explosive are unstable in water and spontaneously decompose. Thus, these explosives are degraded by a combination of biotic and abiotic reactions. Formaldehyde is subsequently metabolized to formic acid, methanol, carbon dioxide, or methane by various microorganisms (Crocker et al., 2006).

A series of research efforts focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al., 2016; Kelley et al., 2016; Koide et al., 2016; University of Hawaii, 2010) and an intensively used live fire range in the Mariana Islands (Smith & Marx, 2016) provide information in regard to the impacts of undetonated materials and unexploded munitions on marine life.

On a localized scale, research at World War II munitions ocean disposal sites in Hawaii investigated nearby sediments, seawater, or marine life to determine if released constituents from the munitions (including explosive components and metals) could be detected. Comparisons were made between disposal site samples and “clean” reference sites. The samples analyzed showed no confirmed detection for explosives.

Investigations by Kelley et al. (2016) and Koide et al. (2016) found that intact munitions (i.e., ones that failed to detonate or non-explosive practice munitions) residing in or on soft sediments habitats provided hard substrate similar to other disposed objects or “artificial reefs” that attracted “hard substrate species,” which would not have otherwise colonized the area. Sampling these species revealed that there was no bioaccumulation of munitions-related chemicals in the species (Koide et al., 2016).

On a broader scale, the island of Farallon De Medinilla (in the Mariana Islands) has been used as a target area for both explosive and non-explosive munitions since 1971. Between 1997 and 2012, the Navy has conducted 14 underwater scientific surveys around the island, providing a consistent, long-term investigation of a single site where munitions have been used regularly (Smith & Marx, 2016). Marine life assessed during these surveys included algae, corals, benthic invertebrates, sharks, rays, bony fishes, and sea turtles. The investigators found no evidence over the 16-year period, that the condition of the physical or biological resources had been adversely impacted to a significant degree by the training activities (Smith & Marx, 2016). Furthermore, they found that the health, abundance, and biomass of fishes, corals and other marine resources were comparable to or superior to those in similar habitats at other locations within the Mariana Archipelago.

These findings are consistent with other assessments such as that done for the Potomac River Test Range at Dahlgren, Virginia, which was established in 1918 and is the nation’s largest fully instrumented, over-the-water gun-firing range. Munitions tested at Dahlgren have included rounds from small-caliber guns up to the Navy’s largest (16 inch [in.] guns), bombs, rockets, mortars, grenades, mines, depth charges, and torpedoes (U.S. Department of the Navy, 2013b). Results from the assessment indicate that munitions expended at Dahlgren have not contributed significant concentrations of explosive materials or explosives byproducts to the Potomac River water and sediments given those contributions are orders of magnitude less than concentrations already present in the Potomac River from natural and manmade sources (U.S. Department of the Navy, 2013a).

Underwater detonations for training purposes have been conducted approximately five miles off the coast of Virginia Beach, Virginia using demolition charges on non-explosive underwater mine shapes. Training activities at the underwater ordnance disposal site began after World War II, but became a regular occurrence in 1968. The primary munitions used at the site are the M112 demolition charge (consisting of 91 percent hexahydro-1,3,5-trinitro-1,3,5-triazine [i.e., royal demolition explosive]), M456 detonation cord (containing pentaerythritoltetranitre [also referred to as “PETN”]), and the M700 time blasting fuse. Based on the analysis reported in U.S. Department of the Navy (2012), accumulation of explosive byproducts was not expected to occur in sediments at the site, because of the infrequent nature of the detonations, the small amounts of chemicals of concern produced by the detonations, and the large attenuation capacities of the affected water body (i.e., nearshore areas of the Atlantic Ocean).

In summary, multiple investigations since 2007 involving survey and sampling of World War II munition dump sites off Oahu Hawaii and other locations, have found the following: (1) chemicals and degradation products from underwater munitions “do not pose a risk to human health or to fauna living in direct contact with munitions,” (2) metals measured in sediment samples next to World War II munitions are lower than naturally occurring marine levels and “do not cause a significant impact on the environment,” and (3) sediment is not a significant sink of chemicals released by degradation of the explosive components in munitions (Edwards et al., 2016).

Bauer and Kendall (2010) reported on the collection and analysis of sediment samples that were tested for the presence of explosive compounds at Vieques, Puerto Rico following the cessation of Navy training activities on the island. Sediment samples were analyzed for the parent compounds, 2,4,6-trinitrotoluene (TNT), high melting explosive, royal demolition explosive, and Tetryl (2,4,6-trinitrophenyl-n-methylnitramine), and for degradation products including 1,3,5-trinitrobenzene, 2,4-dinitrotoluene, and 2,6-dinitrotoluene. Of the 78 samples collected, 14 showed signs of explosive compounds and required a more in depth analysis to confirm the presence of explosive compounds or degradation products. The analysis revealed that explosives were either not present or were present at such low concentrations that they could not be measured.

The concentration of explosive munitions and any associated explosives byproducts at any single location in the Study Area would be a small fraction of the totals that have accumulated over decades at World War II era dump sites and military ranges. Based on findings from much more intensively used locations, effects on sediments from the use of explosive munitions during training and testing activities would be negligible by comparison. As a result, explosives by-products and unexploded munitions would have no meaningful effect on sediments.

Most explosive material is consumed in an explosion, so the vast majority of intact explosive material entering the marine environment would be encased in munitions that failed to detonate. Failure rates are not available for the vast majority of munitions used in the Proposed Action; however, based on the data that are available Table 3.2-7, a 5-percent munitions failure rate was selected as a reasonable average rate to estimate the failure rates for all munitions used in the Proposed Action. Based on the available data, low-order detonation rates for all munitions are assumed to be at least an order of magnitude less than the failure rates and are not considered in the analysis.

Table 3.2-7: Failure and Low-Order Detonation Rates of Military Munitions

Munitions	*Failure Rate (Percent)*	*Low-Order Detonation Rate (Percent)*
Guns/artillery	4.68	0.16
Hand grenades	1.78	n/a
Explosive munitions	3.37	0.09
Rockets	3.84	n/a
Submunitions	8.23	n/a

Source: MacDonald and Mendez (2005)
Note: n/a = not available

Most activities involving explosives and explosives byproducts would be conducted more than 3 NM offshore in each range complex and testing range. Activities in these areas (3–200 NM) would be subject to federal sediment and water quality standards and guidelines.

Explosives are also used in nearshore areas (low tide line to 3 NM) specifically designated for mine countermeasure and mine neutralization activities. These activities would be subject to state sediment and water quality standards and guidelines.

For explosives byproducts, “local” refers to the water column in the vicinity of the underwater detonation. For unconsumed explosives, “local” refers to the area of potential impact from explosives in a zone of sediment about 6 ft. in diameter around the unconsumed explosive where it comes to rest on the seafloor.

3.2.3.1.1 Impacts from Explosives and Explosives Byproducts under Alternative 1

3.2.3.1.1.1 Impacts from Explosives and Explosives Byproducts under Alternative 1 for Training Activities

The distribution of explosives used in training activities is not uniform throughout the Study Area. Approximately 30 percent of the explosives used annually during training activities would be used in the Jacksonville Range Complex and 60 percent would be used in the Virginia Capes Range Complex. The remaining 10 percent would be distributed in other locations of the Study Area. Of all explosive munitions used during training activities, approximately 55 percent of explosives used in the Jacksonville Range Complex and 60 percent of explosives used in the Virginia Capes Range Complex would have a net explosive weight between 0.1 and 0.25 pounds (lb.) per munition. Training activities are further described in Chapter 2 (Description of Proposed Action and Alternatives) and listed in Table 2.3-2 and Table 2.6-1.

The highest concentrations of munitions residues results from munitions failures (i.e., low-order detonations). As a general rule, between 10,000 and 100,000 high-order detonations deposit the same mass of explosives residue as one low-order detonation of the same munition (U.S. Environmental Protection Agency, 2012a) Therefore, an estimate of the amount of explosives material and byproducts from an explosion that would be introduced into the environment is based solely on the failure rate for each type of munition, discounting the negligible contribution from munitions that successfully detonate. The military does not track failure rates for all munitions. The available data typically report failure rates ranging from less than 2 percent up to 10 percent (Table 3.2-7). For the purpose of estimating the amount of explosives and explosives byproducts entering the marine environment, a 5-percent failure rate is applied to all types of munitions used during training activities. The amount of explosive materials is estimated by multiplying the failure rate by the number of explosive munitions and the net explosive weight of each munition used during training activities.

To better organize and facilitate the analysis of different types of explosive munitions, each munition using in training and testing activities was grouped into a series of source classification bins, or source bins (see Section 3.0.3.3.2, Explosive Stressors). Each source bin is defined by a range of net explosive weights (e.g., bin E3 has a range of 0.5 to 2.5 lb. net explosive weight). To estimate the amount of explosive materials entering the marine environment, the average net explosive weight was calculated for each source bin. For example, for bin E1 (0.1 to 0.25 lb. net explosive weight) under Alternative 1:

> Explosives = 0.05 (Failure Rate) x 1,600 (Munitions in Bin E1) x 0.175 lb. (Average Net Explosive Weight) = 14 lb.

One other factor needs to be considered when estimating the amount of explosives entering the marine environment in munitions that fail to detonate. The net explosive weight of an explosive munition is based on the equivalent amount of trinitrotoluene (TNT) that would be required to generate the desired amount of energy upon detonation. Most modern munitions no longer use trinitrotoluene (TNT) as the primary explosive material. Other more powerful and stable explosives such as royal demolition explosive are used in a greater number of explosive munitions. Because royal demolition explosive is more powerful than trinitrotoluene (TNT), a lesser amount of royal demolition explosive is needed to generate the equivalent explosion using trinitrotoluene (TNT). The equivalency factors for royal demolition explosive is 1.60, meaning that, to generate an explosion equivalent to 1 kilogram (kg) of trinitrotoluene (TNT) only 0.625 kg of royal demolition explosive is needed. Revising the equation above to incorporate the trinitrotoluene (TNT) equivalency factor:

> Explosives = 0.05 (Failure Rate) x 1,600 (Munitions in Bin E1) x 0.175 lb. (Average Net Explosive Weight) x 0.625 (equivalency factor) = 8.75 lb.

Using this approach, and considering all training activities in the AFTT Study Area, up to approximately 4,000 lb. of explosive material could enter the environment annually in the form of munitions that failed to detonate. Approximately 40 percent, or 1,600 lb. of explosives, would come from munitions in the E5 bin. These munitions are used at least 3 NM and often more than 12 NM from shore, which diminishes any potential impact on nearshore sediments and water quality. Water depth increases with distance from shore, such that munitions residing on the seafloor at depths greater than 250 m would be in a low light, low temperature environment slowing the corrosion of munitions casings and that degradation of any exposed explosives. Larger projectiles (e.g., missiles, rockets, bombs) that fail to detonate would enter the water at a high rate of speed, and, depending on the type of seafloor substrate (e.g., soft sediments), can become imbedded in the seafloor. Munitions that are buried partially or completely beneath sediments may remain intact for decades where geochemical conditions (e.g., low dissolved oxygen) inhibit corrosion of the metal casing. Studies conducted at several Navy ranges where explosives have been used for decades indicate that explosives constituents are released into the aquatic environment over long periods of time and do not result in water or sediment toxicity (Briggs et al., 2016; U.S. Department of the Navy, 2010a, 2010b, 2013a).

The overarching conclusions from the Hawaii Undersea Military Munitions Assessment project is that degrading munitions at the disposal site do not pose a risk to human health or to the fauna living in direct contact with the degrading munitions (Edwards et al., 2016). During a comprehensive survey of the site, explosive materials were detected in sediments at only two locations and the concentrations were low. Concentrations of metals introduced into sediments and the water column from deteriorating munitions casings were below screening levels for the marine environment, and the authors concluded that the metals are not impacting the environment.

Data supporting these conclusions were collected from World War II era munitions disposal sites characterized by relatively high concentrations of munitions. Munitions used in the proposed training activities would be widely dispersed by comparison, resulting in lower concentrations of munitions that failed to detonate and lower concentrations of residual explosives and explosives byproducts than reported in Edwards et al. (2016). Based on this analysis, impacts on sediments and water quality are expected to be minimal.

In the event a munition fails to detonate, the explosives contained within the intact munition would remain isolated from the water column and sediments. Based on analyses of munitions disposal sites, explosives would only leach from the munitions casing slowly, over decades, once the munitions casing corrodes and is breached, exposing the explosives to seawater or sediments (Briggs et al., 2016). Small amounts of explosives may leach into sediments and the adjacent water column. In the event the munition fails to detonate but the casing is nevertheless breached upon impact, explosives may enter the water column as the breached munitions sinks to the seafloor. Analysis from munitions disposal sites indicates that munitions constituents and degradation products are only detected at measurable levels in sediments within a few feet of a degrading munition. Many constituents released into the water column would be expected to dissolve (refer to Table 3.2-6 for water solubility) and disperse with ocean currents and not concentrate at levels that would result in water toxicity. Explosives released into sediments from a partially buried munition may persist in sediments or degrade slowly over time if the explosive material or its constituents are not soluble in seawater (e.g., royal demolition explosive). In deep water (greater than 250 m), benthic habitats, bottom temperatures are near freezing, and dissolved oxygen levels are low (or event anoxic) in sediments only a few inches below the water column-seafloor interface. These physical conditions inhibit degradation and dispersion of the explosives and constituents beyond an isolated area adjacent to the munition. Based on this analysis, impacts on sediments and water quality are expected to be minimal.

The sinking exercise activity is likely to result in the highest concentration of munitions of any proposed training or testing activity. During each sinking exercise, for example, an estimated 216 explosive munitions would be expended, 93 percent of which would consist of large-caliber projectiles in the E5 bin. Approximately 178 lb. of explosive materials could be released per sinking exercise if the munitions utilized failed to detonate. For the purpose of this example, the area encompassing the sinking exercise activity is estimated to be approximately 2 NM^2. Thus, during each sinking exercise, approximately 108 munitions would be used per NM^2 and 89 lb. of explosive material per NM^2 would sink to the ocean floor encased within munitions that failed to detonate. During an actual sinking exercise munitions are directed at the target vessel, which occupies an area much smaller than 2 NM^2, and it is likely that a failure rate of less than 5 percent would occur for this type of activity. All Sinking Exercises are conducted at least 50 NM from shore in waters at least 6,000 ft. deep. Based on these conditions and the results of the analysis of munitions degradation rates in the studies described above, which occurred at shallower depths and closer to shore, adverse effects on seafloor sediments and water quality are not expected even in areas where the concentration of munitions is likely to be relatively high.

3.2.3.1.1.2 Impacts from Explosives and Explosives Byproducts under Alternative 1 for Testing Activities

The distribution of explosives used in testing activities is not uniform throughout the Study Area. Approximately 30 percent of the explosives used annually during testing activities would be used in the Jacksonville Range Complex and 50 percent would be used in the Virginia Capes Range Complex. The remaining 20 percent would be distributed in other locations of the Study Area. Of all explosive munitions used during testing activities, approximately 70 percent are in the E1 bin (0.1 to 0.25 lb. per munition). Excluding munitions in the E1 bin, which primarily consist of medium-caliber projectiles, approximately 50 percent of other munitions are in the E3 bin (0.5 to 2.5 lb. net explosive weight) and 30 percent are in the E5 bin (5 to 10 lb.).

As described for training activities in Section 3.2.3.1.1.1 (Impacts from Explosives and Explosives Byproducts under Alternative 1 for Training Activities), over 98 percent of explosives byproducts introduced into the environment would result from the failure of a munition to detonate, because little to no explosive material remains after a successful detonation. The amount of residual explosives materials resulting from testing activities is estimated in the same way it was estimated for training activities: by multiplying the failure rate by the number of explosive munitions and the average net explosive weight for the bin in which each explosive munitions is classified.

The Ship Shock Trial activity conducted by Naval Sea Systems Command is the only activity that would use explosives in the E16 and E17 bins. In the unlikely event munitions in either of these two bins failed to detonate during a Ship Shock Trial activity, additional attempts would be made to detonate the explosive. If an explosive cannot be detonated or disarmed and recovered, then to safeguard human life, the explosive will be disposed of at sea in accordance with established Ammunition and Explosives Safety Afloat requirements.

Over the past 29 years, there have been approximately 11 Ship Shock Trials involving a combined total of between 33 and 40 separate detonations. Of those detonations, only two munitions did not detonate as planned. One of those munitions was ultimately detonated after the activity was completed, and the second was disposed of at sea in a known and marked area designated for unexploded ordnance and munitions disposal. Based on three decades of Ship Shock Trials, a detonation failure rate of 2.5 to 3 percent could be expected. The proposed Large Ship Shock Trial activity would occur once over a 5-year period and use up to 64 munitions in the E17 bin, and the Small Ship Shock Trial activity would occur up to three times over a 5-year period and use up to 64 munitions in the E16 bin (see Table 2.6-3 in Chapter 2 [Description of Proposed Action and Alternatives]). Applying a failure rate of 3 percent results in approximately two failed detonations in the E17 bin and two in the E16 bin. Considering that only one munition in one of the two bins remained intact in the marine environment after conducting 11 Ship Shock Trails over nearly 30 years, the probability of a detonation failure occurring during no more than 4 Ship Shock Trials over a 5-year period is expected to be very low. Therefore, munitions in the E16 and E17 bins were excluded from estimates of the amount of explosives entering the marine environment in the event of a detonation failure.

For testing activities in the AFTT Study Area, up to approximately 2,400 lb. of explosive material would enter the environment annually in munitions that failed to detonate. Approximately 44 percent, 1,150 lb., are from munitions in the E10 bin (250 to 500 lb.), which are used at least 3 NM and often more than 12 NM from shore, and 15 percent are from munitions failures in the E5 bin. The testing activities Air to Surface Missile Test and Missile and Rocket Testing use all munitions in the E10 bin. For more information on those activities, refer to Appendix A (Navy Activity Descriptions).

In the event a munition fails to detonate, the explosives would remain mostly intact and contained within the munitions casing, which is composed mostly of iron with smaller quantities of other metals. Explosive materials would only leach from the casing slowly, over years, as the casing corrodes and degrades in the deepwater (greater than 250 m) environment. Once exposed to the environment, explosives materials are quickly broken down into constituent materials (Briggs et al., 2016). Ocean currents would quickly disperse constituents entrained into the water column. Chemical constituents that settle onto sediments in the immediate vicinity of the munition are likely to persist in the environment due to a combination of low water solubility, the products of hydrolysis forming a coating that prevents further decomposition, and near freezing temperatures at deepwater sites that typically inhibit chemical dissolution (Briggs et al., 2016).

Larger projectiles used in testing activities that fail to detonate would enter the water at a high rate of speed and may become imbedded in soft sediments, depending on water depth and the composition of seafloor substrate. Munitions buried partially or completely beneath sediments may remain intact for decades in places where geochemical conditions (e.g., low dissolved oxygen) inhibit corrosion of the metal casing. Studies conducted at several Navy ranges where explosives have been used for decades indicate that explosives constituents are released into the aquatic environment over long periods of time and do not result in water or sediment toxicity (Briggs et al., 2016; U.S. Department of the Navy, 2010a, 2010b, 2013a). Based on the results from studies of underwater munitions disposal sites and water ranges, impacts on sediments and water quality are expected to be minimal and localized.

The overarching conclusions from the Hawaii Undersea Military Munitions Assessment project is that degrading munitions at the disposal site do not pose a risk to human health or to the fauna living in direct contact with the degrading munitions (Edwards et al., 2016). During a comprehensive survey of the site, explosive materials were detected in sediments at only two locations and the concentrations were low. Concentrations of metals introduced into sediments and the water column from deteriorating munitions casings were below screening levels for the marine environment, and the authors concluded that the metals are not impacting the environment.

Data supporting these conclusions were collected from World War II era munitions disposal sites characterized by relatively high concentrations of munitions. Munitions used in the proposed testing activities would be widely dispersed by comparison, resulting in lower concentrations of munitions that failed to detonate and lower concentrations of residual explosives and explosives byproducts than reported in Edwards et al. (2016). Based on this analysis, impacts on sediments and water quality are expected to be minimal.

3.2.3.1.2 Impacts from Explosives and Explosives Byproducts under Alternative 2

3.2.3.1.2.1 Impacts from Explosives and Explosives Byproducts under Alternative 2 for Training Activities

Under Alternative 2, the number of explosive munitions used during training activities would be the same as under Alternative 1. Therefore, the impacts of underwater explosives and explosives byproducts would be the same as described under Alternative 1.

3.2.3.1.2.2 Impacts from Explosives and Explosives Byproducts under Alternative 2 for Testing Activities

Under Alternative 2, the number of explosive munitions used during the Airborne Mine Neutralization Test conducted by Naval Air Systems Command would increase over Alternative 1. The activity, which is conducted at the NSWC Panama City Training Range and the Virginia Capes Range Complex would use

10 E11 mines (5 in each location) and 10 E4 neutralizers (5 in each location). However, the amount of explosives entering the environment would remain essentially the same, because mines that failed to detonate as planned would be detonated by other means and would not be permitted to remain in the environment as intact munitions. Based on a 5-percent failure rate, only 2 to 3 neutralizers would be expected to fail over five years, resulting in no more than 15 lb. of explosives deposited on the seafloor in intact munitions over five years. This is a less than one-tenth of 1 percent of the total amount of explosives released under Alternative 1 and is negligible. The amount of explosives byproducts would increase; however, for the reasons described above in Section 3.2.3.1.1.1 (Impacts from Explosives and Explosives Byproducts under Alternative 1 for Training Activities), the amount of additional explosives byproducts entering the environment would be undetectable and impacts would therefore be the same as under Alternative 1.

3.2.3.1.3 Impacts from Explosives and Explosives Byproducts under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Under this alternative, there would be no potential for impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of explosives would decrease the amounts of related chemical constituents in marine waters and sediments in the Study Area. The effect, however, would likely not be measurable due to the rapid dissolution and dispersion of explosives and explosives byproducts in the water column and the slow, sometimes decades-long corrosion of undetonated munitions on the seafloor. Explosives and explosives byproducts released into sediments from degrading munitions would be decomposed and disperse, or, if persistent in sediments, would only be expected at higher concentrations in sediments within a few feet of the munition.

3.2.3.2 Chemicals Other Than Explosives

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

Hazardous air pollutants from explosives and explosives byproducts are discussed in Section 3.1 (Air Quality). Explosives and explosives byproducts are discussed in Section 3.2.3.1 (Explosives and Explosives Byproducts). Fuels onboard manned aircraft and vessels are not reviewed, nor are fuel-loading activities, refueling at sea, onboard operations, or maintenance activities reviewed, because normal operation and maintenance of Navy equipment is not part of the Proposed Action.

The largest chemical constituent of missiles is solid propellant. Solid propellant contains both the fuel and the oxidizer, a source of oxygen needed for combustion. An extended-range Standard Missile-2 typically contains 1,822 lb. of solid propellant. Ammonium perchlorate is an oxidizing agent used in most modern solid-propellant formulas (Chaturvedi & Dave, 2015). It normally accounts for 50 to 85 percent of the propellant by weight. Ammonium dinitramide may also be used as an oxidizing agent. Aluminum powder as a fuel additive ranges from 5 to 22 percent by weight of solid propellant; it is added to increase missile range and payload capacity. The high-explosives high melting explosive (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) and royal demolition explosive (hexahydro-1,3,5-trinitro-1,3,5-triazine) may be added, although they usually comprise less than 30 percent of the propellant by weight.

Many of the constituents used in propellants are also commonly used for commercial purposes but require additional processing to achieve certain properties necessary for rocket and missile propulsion. (Missile Technology Control Regime, 1996).

The U.S. Environmental Protection Agency issued a paper characterizing the munitions constituents accumulated at over 30 military sites around the United States and Canada where explosives and propellants have been used (U.S. Environmental Protection Agency, 2012b). The sites assessed in the paper were all land-based ranges; however, the results are useful for analyzing similar activities conducted at sea. The paper noted that perchlorate was generally not detected at anti-tank ranges and that perchlorate is so soluble in water and mobile in soil that surface accumulation apparently does not occur. The paper includes a case study that estimates the amount of residual perchlorate deposited from a rocket fired at a test track. The rocket propellant contained 68 lb. of ammonium perchlorate. Samples were collected both behind the firing point and along the test track before and after the rocked was fired. No differences in perchlorate concentrations in soils were detected at any location before or after the firing, and all measurements recorded perchlorate concentrations of less than 1 microgram per kilogram (μg/kg). That case study concluded that 99.997 percent of perchlorate is consumed by the rocket motor (U.S. Environmental Protection Agency, 2012b). Jenkins et al. (2008) found similar results from an air-launched AIM-7 missile, a missile used by the Navy and similar to missiles used in the Proposed Action. These studies, and others cited in each paper, demonstrate that the motors used in rockets and missiles are highly efficient at burning propellant fuels, leaving only trace amounts often at undetectable levels in the environment.

Several torpedoes (e.g., MK-54) use Otto Fuel II as a liquid propellant. Otto Fuel II is composed of primarily three synthetic substances: Propylene glycol dinitrate and nitro-diphenylamine (76 percent), dibutyl sebacate (22 percent) and 2-nitrodiphenylamine as a stabilizer (2 percent). Propylene glycol dinitrate, which is a liquid, is the explosive component of Otto Fuel II. Dibutyl sebacate, also known as sebacic acid, is also a liquid. It is used commercially to make plastics, many of which are used for packaging food, and to enhance flavor in foods such as ice cream, candy, baked goods, and nonalcoholic drinks. The third component, 2-nitrodiphenylamine, is a solid substance used to control the combustion of the propylene glycol dinitrate (U.S. Health and Human Services 1995). Combustion byproducts of Otto Fuel II include nitrous oxides, carbon monoxide, carbon dioxide, hydrogen, nitrogen, methane, ammonia, and hydrogen cyanide. During normal venting of excess pressure or upon failure of the torpedo's buoyancy bag, the following constituents are discharged: carbon dioxide, water, hydrogen, nitrogen, carbon monoxide, methane, ammonia, hydrochloric acid, hydrogen cyanide, formaldehyde, potassium chloride, ferrous oxide, potassium hydroxide, and potassium carbonate (Arai & Chino, 2012).

Target vessels are only used during sinking exercises, which occur infrequently. Polychlorinated biphenyls are a concern because they are present in certain solid materials (e.g., insulation, wires, felts, and rubber gaskets) on vessels used as targets for sinking exercises. These vessels are selected from a list of Navy-approved vessels that have been cleaned in accordance with USEPA guidelines (U.S. Environmental Protection Agency, 2014). By rule, a sinking exercise must be conducted at least 50 NM offshore and in water at least 6,000 ft. deep (40 CFR part 229.2).

The USEPA estimates that as much as 100 lb. of polychlorinated biphenyls remain onboard sunken target vessels. The USEPA considers the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.) (U.S. Environmental Protection Agency, 2014). Under a 2014 agreement with the USEPA, the Navy will not likely use aircraft carriers or submarines as the targets for a sinking exercise (U.S. Environmental

Protection Agency, 2014). Based on these considerations, polychlorinated biphenyls will not be considered further.

Table 3.2-8 lists the chemical constituents produced in the combustion of propellants and fuels, as described above, and lists constituents remaining after the detonations of non-munitions, such as spotting charges and tracers. Not all of the listed chemical constituents in propellant and Otto Fuel II would be used in combination; some are substitutes that would replace another chemical in the list, depending on the type of propellant used. For example, ammonium perchlorate is the preferred oxidizer in propellant, but ammonium dinitramide could act as the oxidizer in some propellants. These constituents are in addition to the explosives contained in munitions, which were discussed in Section 3.2.3.1 (Explosives and Explosives Byproducts).

The environmental fate of Otto Fuel II and its components is largely unknown. Neither the fuel mixture nor its three main components are particularly volatile or soluble in water; however, when mixed with water propylene glycol dinitrate forms a volatile mixture, making evaporation an important fate process (U.S. Department of Health and Human Services, 1995). The compound 2-Nitrodiphenylamine may precipitate from water or be taken up by particulates. Dibutyl sebacate is rapidly biodegraded. Neither propylene glycol dinitrate nor 2-nitrodiphenylamine are readily biodegradable, but both of these chemicals break down when exposed to ultraviolet light (Powell et al., 1998).

Table 3.2-8: Constituents in Munitions Other Than Explosives

Munitions Component	***Constituent***
Pyrotechnics Tracers Spotting Charges	Barium chromate Potassium perchlorate Chlorides Phosphorus Titanium compounds
Oxidizers	Lead (II) oxide
Propellant (rockets and missiles)	High melting explosive Royal demolition explosive Hydroxyl-terminated polybutadiene Carboxyl-terminated polybutadiene Polybutadiene-acrylic acid-acrylonitrile Triphenyl bismuth Nitrate esters Nitrated plasticizers Polybutadiene-acrylic acid polymer Elastomeric polyesters Polyethers Nitrocellulose plasticized with nitroglycerine 2-nitrodiphenylamine N-methyl-4-nitroaniline Hydrazine

Lead azide, titanium compounds, perchlorates, barium chromate, and fulminate of mercury are not natural constituents of seawater. Lead oxide is a rare, naturally occurring mineral. It is one of several lead compounds that form films on lead objects in the marine environment (Agency for Toxic Substances and Disease Registry, 2007). Metals are discussed in more detail in Section 3.2.3.3 (Metals).

Because chemical and biological warfare agents remain a security threat, the Department of Defense uses relatively harmless compounds (chemical simulants) as substitutes for chemical and biological warfare agents to test equipment intended to detect their presence. Chemical and biological agent detectors monitor for the presence of chemical and biological warfare agents and protect military personnel and civilians from the threat of exposure to these agents. The simulants trigger a response by sensors in the detection equipment without irritating or injuring personnel involved in testing detectors.

Table 3.2-8: Constituents in Munitions Other Than Explosives (continued)

Munitions Component	***Constituent***
Otto Fuel II (torpedoes)	Propylene glycol dinitrate and Nitro-diphenylamine (76 percent by weight) dibutyl sebacate (22 percent by weight 2-nitrodiphenylamine (2 percent by weight) Combustion products (nitrous oxides, carbon monoxide, carbon dioxide, hydrogen, nitrogen, methane, ammonia, hydrogen cyanide) Venting or buoyancy bag failure (hydrochloric acid, hydrogen cyanide, formaldehyde, potassium chloride, ferrous oxide, potassium hydroxide, and potassium carbonate)
Chemical Simulants	Navy Chemical Agent Simulant 82 glacial acetic acid triethyl phosphate sulfur hexafluoride 1,1,1,2 tetrafluoroethane 1,1-difluoroethane
Delay Elements	Barium chromate Potassium perchlorate Lead chromate
Fuses	Potassium perchlorate
Detonators	Fulminate of mercury Potassium perchlorate
Primers	Lead azide

Navy Chemical Agent Simulant 82 (commonly referred to as NCAS-82), glacial acetic acid, triethyl phosphate, sulfur hexafluoride, 1,1,1,2 tetrafluoroethane (a refrigerant commonly known as R134), and 1,1-difluoroethane (a refrigerant commonly known as R-152a) are also referred to as gaseous simulants and can be released in smaller quantities in conjunction with glacial acetic acid or triethyl phosphate releases. The types of biological simulants that may be used include spore-forming bacteria, non-spore-forming bacteria, ovalbumin, bacteriophage MS2, and *Aspergillus niger*. The simulants are generally dispersed by hand at the detector or by aircraft as a fine mist or aerosol. The exposure of military personnel or the public to even small amounts of real warfare agents, such as nerve or blistering agents, or harmful biological organisms, such as anthrax, is potentially harmful and is illegal in most countries, including the United States. Furthermore, their use, including for the testing of detection equipment, is banned by international agreement.

Simulants must have one or more characteristic of a real chemical or biological agents—size, density, or aerosol behavior—to effectively mimic the agent. Simulants must also pose a minimal risk to human health and the environment to be used safely in outdoor tests. Simulants are selected using the following criteria: (1) safety to humans and the environment, and (2) the ability to trigger a response by sensors used in the detection equipment. Simulants must be relatively benign (e.g., low toxicity or effects potential) from a human health, safety, and environmental perspective. Exposure levels during testing activities should be well below concentrations associated with any adverse human health or environmental effects. The degradation products of simulants must also be harmless. Given these criteria for choosing simulants for use in testing activities, it is reasonable to conclude that simulants would have no impact on sediments and water quality in the Study Area. Simulants are not analyzed further in this section.

3.2.3.2.1 Impacts from Chemicals Other Than Explosives under Alternative 1

3.2.3.2.1.1 Impacts from Chemicals Other Than Explosives under Alternative 1 for Training Activities

The distribution of munitions that use chemicals other than explosives is not uniform throughout the Study Area. The largest quantities of chemicals would be derived from the use of propellants and fuels in munitions, specifically rockets, missiles, and torpedoes. Approximately 48 percent of these munitions, used annually during training activities would be used in the Jacksonville Range Complex and 43 percent would be used in the Virginia Capes Range Complex. The remaining 9 percent would be distributed in other locations of the Study Area. Of all of these munitions, approximately 94 percent are rockets (expending the byproducts of propellant combustion), and 4 percent are missiles. Approximately 100 torpedoes using Otto Fuel II would be used annually. The propellant used by rockets and missiles is typically consumed prior to impact at the water's surface even if the munition fails to detonate upon impact, leaving little residual propellant to enter the water. By contrast, torpedo fuel is consumed underwater and all combustion products enter the marine environment.

For properly functioning munitions, chemical, physical, or biological changes in sediments or water quality would not be detectable. Impacts would be minimal for the following reasons: (1) the size of the area in which expended materials would be distributed is large; (2) most propellant combustion byproducts are benign, while those of concern would be diluted to below detectable levels within a short time; (3) most propellants are consumed during normal operations; (4) most byproducts of Otto Fuel II combustion are naturally occurring chemicals, and most torpedoes are recovered after use, such that any fuel that is not consumed would be recovered along with the torpedo, limiting any direct exposure of sediments and water to Otto Fuel II; (5) the failure rate of munitions using propellants and other combustible materials is low; and (6) most of the constituents of concern are biodegradable by various marine organisms or by physical and chemical processes common in marine ecosystems.

3.2.3.2.1.2 Impacts from Chemicals Other Than Explosives under Alternative 1 for Testing Activities

The distribution of munitions that use chemicals other than explosives is not uniform throughout the Study Area. Approximately 28 percent of these munitions used annually during testing activities would be used in the Virginia Capes Range Complex, 25 percent would be used in the Jacksonville Range Complex, 23 percent would be used in the Navy Cherry Point Range Complex, and 23 percent would be used in the Northeast Range Complexes. Of all of these munitions used during testing activities, approximately 90 percent are biological chemical simulants, which, as noted above, are benign and would have no impact on sediments and water quality. Excluding biological simulants, 38 percent of munitions using chemicals other than explosives are rockets (expending the byproducts of propellant combustion), 30 percent are missiles, and 30 percent are torpedoes (using Otto Fuel II).

For properly functioning munitions, chemical, physical, or biological changes in sediments or water quality would not be detectable. Impacts would be minimal for the following reasons: (1) the size of the area in which expended materials would be distributed is large; (2) most propellant combustion byproducts are benign, while those of concern would be diluted to below detectable levels within a short time; (3) most propellants are consumed during normal operations; (4) most byproducts of Otto Fuel II combustion are naturally occurring chemicals, and most torpedoes are recovered after use, such that any fuel that is not consumed would be recovered along with the torpedo, limiting any direct exposure of sediments and water to Otto Fuel II; (5) the failure rate of munitions using propellants and other combustible materials is low; and (6) most of the constituents of concern are biodegradable by various marine organisms or by physical and chemical processes common in marine ecosystems.

3.2.3.2.2 Impacts from Chemicals Other Than Explosives under Alternative 2

3.2.3.2.2.1 Impacts from Chemicals Other Than Explosives under Alternative 2 for Training Activities

Under Alternative 2, the number of expended munitions that use propellants (missiles and rockets) and Otto Fuel II (torpedoes) would be the same as described under Alternative 1. The amounts of other expended materials which could release chemicals into the marine environment would be similar to the amounts under Alternative 1. Therefore, the release of chemicals derived from propellants and fuels would have the same environmental impacts as described under Alternative 1.

3.2.3.2.2.2 Impacts from Chemicals Other Than Explosives under Alternative 2 for Testing Activities

The number of munitions that use propellants (rockets and missiles) and Otto Fuel II (torpedoes) annually would increase under Alternative 2. Over a five-year period, an additional 400 rockets, 130 missiles, and 300 torpedoes would be used during testing activities. Because rocket and missile motors are over 99 percent efficient at burning propellant, no additional measurable amounts of propellant or combustion products would enter the water column. As described in Section 3.2.3.2 (Chemicals Other than Explosives), most byproducts of Otto Fuel II combustion are naturally occurring chemicals. Most practice torpedoes are recovered after use, such that any fuel that is not consumed would be recovered along with the torpedo limiting any direct exposure of sediments and water to Otto Fuel II. Therefore, the use of torpedoes would not result in the accumulation of byproducts of Otto Fuel II in water or sediments. The amounts of other expended materials which could release chemicals into the marine environment would be similar to the amounts under Alternative 1. Therefore, the release of chemicals derived from propellants and fuels would have the same environmental impacts as described under Alternative 1.

3.2.3.2.3 Impacts from Chemicals Other Than Explosives under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Under this alternative, there would be no potential for impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of chemicals other than explosives would decrease the amounts of these chemicals and their constituents in marine waters and sediments in the Study Area. The effect, however, would likely not be measurable due to the highly efficient use of propellants and fuels by motors used in rockets and missiles, resulting in often undetectable trace amounts of propellants expended into the environment. Perchlorates, which make up a large percentage of rocket and missile propellants, are also water soluble and would dissolve and be dispersed in surface waters and would not accumulate in marine sediments. Similarly, it is unlikely that Otto Fuel II used in torpedoes would be exposed to sediments or water, and most combustion byproducts of Otto Fuel II occur naturally in the marine environment.

3.2.3.3 Metals

Anthropogenic sources of metals include the processing of industrial ores (e.g., iron ore), production of chemicals, fertilizers used in agriculture, the marine industry (e.g., anti-fouling anti-corrosion paints), runoff from urban and suburban sprawl, dredge spoil disposal, exhaust from automotive transportation, atmospheric deposition, and industrial emissions (Järup, 2003). Metals are introduced into nearshore and offshore marine waters and sediments by the Proposed Action. Because of the physical and chemical reactions that occur with metals in marine systems, many metals will precipitate out of seawater and settle in solid form on the seafloor where they can concentrate in sediments. Thus, metal contaminants in sediments pose a greater environmental concern than metals in the water column.

Military expended materials such as steel bomb bodies or fins, missile casings, small arms projectiles, and naval gun projectiles may contain small percentages (less than 1 percent by weight) of lead, manganese, phosphorus, sulfur, copper, nickel, tungsten, chromium, molybdenum, vanadium, boron, selenium, columbium, or titanium. Small-caliber projectiles are composed of steel with small amounts of aluminum and copper and brass casings that are 70 percent copper and 30 percent zinc. Medium- and large-caliber projectiles are composed of steel, brass, copper, tungsten, and other metals. The 20-mm cannon shells used in close-in weapons systems are composed mostly of tungsten alloy. Some projectiles have lead cores (U.S. Department of the Navy, 2008b). Torpedo guidance wire is composed of copper and cadmium coated with plastic (U.S. Department of the Navy, 2008a). Sonobuoy components include batteries and battery electrodes, lead solder, copper wire, and lead used for ballast. Thermal batteries in sonobuoys are contained in an airtight, sealed and welded stainless steel case that is 0.03–0.1 in. thick and resistant to the battery electrolytes (U.S. Department of the Navy, 2008a). Rockets are usually composed of steel and steel alloys, although composite cases made of glass, carbon, or Kevlar fiber are also used (Missile Technology Control Regime, 1996).

Non-explosive practice munitions consist of ammunition and components that contain no explosive material, and may include (1) ammunition and components that have had all explosive material removed and replaced with non-explosive material, (2) empty ammunition or components, and (3) ammunition or components that were manufactured with non-explosive material in place of all explosive material. These practice munitions vary in size from 25 to 500 lb. and are designed to simulate the characteristics of explosive munitions for training and testing activities. Some non-explosive practice munitions may also contain unburned propellant (e.g., rockets), and some may contain spotting charges or signal cartridges for locating the point of impact (e.g., smoke charges for daylight spotting or flash charges for night spotting) (U.S. Department of the Navy, 2010a). Non-explosive bombs—also called "practice" or "bomb dummy units"—are composed mainly of iron and steel casings filled with sand, concrete, or vermiculite. These materials are similar to those used to construct artificial reefs. Large, non-explosive bombs are configured to have the same weight, size, center of gravity, and ballistics as explosive bombs (U.S. Department of the Navy, 2006). Practice bombs do not contain the explosives materials.

Decommissioned vessels used as targets for sinking exercises are selected from a list of U.S. Navy-approved vessels that have been cleaned or remediated in accordance with USEPA guidelines. By rule, vessel-sinking exercises must be conducted at least 50 NM offshore and in water at least 6,000 ft.

deep (40 CFR part 229.2). The USEPA requires the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.).

In general, three things happen to materials that come to rest on the ocean floor: (1) they lodge in sediments where there is little or no oxygen below 4 in., (2) they remain on the ocean floor and begin to react with seawater, or (3) they remain on the ocean floor and become encrusted by marine organisms. As a result, rates of deterioration depend on the metal or metal alloy and the conditions in the immediate marine and benthic environment. If buried deep in ocean sediments, materials tend to decompose at much lower rates than when exposed to seawater (Ankley, 1996). With the exception of torpedo guidance wires and sonobuoy parts, sediment burial appears to be the fate of most munitions used in marine warfare (Environmental Sciences Group, 2005).

When metals are exposed to seawater, they begin to slowly corrode, a process that creates a layer of corroded material between the seawater and uncorroded metal. This layer of corrosion removes the metal from direct exposure to the corrosiveness of seawater, a process that further slows movement of the metals into the adjacent sediments and water column. This is particularly true of aluminum. Elevated levels of metals in sediments would be restricted to a small zone around the metal, and any release to the overlying water column would be diluted. In a similar fashion, as materials become covered by marine life, both the direct exposure of the material to seawater and the rate of corrosion decrease. Dispersal of these materials in the water column is controlled by physical mixing and diffusion, both of which tend to vary with time and location. The analysis of metals in marine systems begins with a review of studies involving metals used in military training and testing activities that may be introduced into the marine environment.

In one study, the water was sampled for lead, manganese, nickel, vanadium, and zinc at a shallow bombing range in Pamlico Sound (estuarine waters of North Carolina) immediately following a training event with non-explosive practice bombs. All water quality parameters tested, except nickel, were within the state limits. The nickel concentration was significantly higher than the state criterion, although the concentration did not differ significantly from the control site located outside the bombing range. The results suggest that bombing activities were not responsible for the elevated nickel concentrations (U.S. Department of the Navy, 2010a, 2012).

The results of a separate study conducted by the U.S. Marine Corps near the bombing sites in Pamlico Sound sampled sediments and water quality for 26 different constituents, including lead and magnesium, related to munitions use. With the exception of perchlorate, which was found at extremely low concentrations in only 4 of 95 sediment samples, no constituents were found above minimum detection limits (U.S. Department of the Navy, 2010a). The concentrations of all other chemical constituencies were believed to be consistent with background levels in nearshore sediments and sea water. Perchlorate concentrations in sediments near the bombing targets were more likely to be from naturally occurring sources rather than associated with bombing range activities given that perchlorate is extremely soluble in water. The results of the sampling indicate that munitions constituents are not accumulating at concentrations that pose a risk to ecological receptors or humans and are not migrating from the bombing sites to off-range areas.

A study by Pait et al. (2010) of previous Navy training areas at Vieques, Puerto Rico found generally low concentrations of metals in marine sediments. Areas in which live ammunition and loaded weapons were used ("live-fire areas") were included in the analysis. These results are relevant because the concentrations of expended munitions at Vieques are significantly greater than would be found anywhere in the AFTT Study Area. Table 3.2-9 compares the sediment concentrations of several metals from those naval training areas with sediment screening levels established by the National Oceanic and Atmospheric Administration (Buchman, 2008).

As shown in Table 3.2-9, average sediment concentrations of the metals evaluated, except for copper, were below both the threshold and probable effects levels (metrics similar to the effects range levels). The average copper concentration was above the threshold effect level, but below the probable effect level. For other elements: (1) the mean sediment concentration of arsenic at Vieques was 4.37 micrograms per gram (µg/g), and the highest concentration was 15.4 µg/g. Both values were below the sediment quality guidelines examined, and (2) the mean sediment concentration of manganese in sediment was 301 µg/g, and the highest concentration was 967 µg/g (Pait et al., 2010). The National Oceanic and Atmospheric Administration did not report threshold or probable effects levels for manganese.

Table 3.2-9: Concentrations of and Screening Levels for Selected Metals in Marine Sediments, Vieques, Puerto Rico

Metal	*Sediment Concentration (µg/g)*			*Sediment Guidelines – National Oceanic and Atmospheric Administration (µg/g)*	
	Minimum	*Maximum*	*Average*	*Threshold Effects Level**	*Probable Effects Level**
Cadmium	0	1.92	0.15	0.68	4.21
Chromium	0	178	22.5	52.3	160
Copper	0	103	25.9	18.7	390
Lead	0	17.6	5.42	30.24	112
Mercury	N/R	0.112	0.019	130	700
Nickel	N/R	38.3	7.80	15.9	42.8
Zinc	N/R	130	34.4	124	271

*Threshold Effects Level and Probable Effects Level are metrics similar to the effects range metrics (i.e., Effects Range-Low and Effects Range-Median) used to assess potential effects of contaminants on sediments. The Threshold Effects Levels is the average of the 50th percentile and the 15th percentile of a dataset and the Probable Effects Level is the average of the 50th percentile and the 85th percentile of a dataset.
Notes: µg/g = micrograms per gram, N/R = not reported

The impacts of lead and lithium were studied at the Canadian Forces Maritime Experimental and Test Ranges near Nanoose Bay, British Columbia, Canada (Environmental Sciences Group, 2005). These materials are common to expendable mobile anti-submarine warfare training targets, acoustic device countermeasures, sonobuoys, and torpedoes. The study noted that lead is a naturally occurring metal in the environment, and that typical concentrations of lead in seawater in the test range were between 0.01 and 0.06 ppm, while concentration of lead in sediments was between 4 and 16 ppm. Cores of marine sediments in the test range show a steady increase in lead concentration from the bottom of the core to a depth of approximately 20 cm. This depth corresponds to the late 1970s and early 1980s, and the lead contamination was attributed to atmospheric deposition of lead from gasoline additives. The sediment cores showed a general reduction in lead concentration to the present time, coincident with the phasing out of lead in gasoline by the mid-1980s. The study also noted that other training ranges have shown minimal impacts of lead ballasts because they are usually buried deep in marine sediments where they are not biologically available. The study concluded that the lead ballasts would not adversely impact marine organisms because of the low probability of mobilization of lead.

A study by the Navy examined the impacts of materials from activated seawater batteries in sonobuoys that freely dissolve in the water column (e.g., lead, silver, and copper ions), as well as nickel-plated steel housing, lead solder, copper wire, and lead shot used for sonobuoy ballast (U.S. Department of the Navy, 1993). The study concluded that constituents released by saltwater batteries as well as the decomposition of other sonobuoy components did not exceed state or federal standards, and that the reaction products are short-lived in seawater.

A series of research efforts focused on World War II underwater munitions disposal sites in Hawaii (Briggs et al., 2016; Kelley et al., 2016; Koide et al., 2016; University of Hawaii, 2010) and an intensively used live fire range in the Mariana Islands (Smith & Marx, 2016) provide information in regard to the impacts of undetonated materials and unexploded munitions on marine life.

On a localized scale, research at World War II munitions ocean disposal sites in Hawaii investigated nearby sediments, seawater, or marine life to determine if metals could be detected. For metals, although there were localized elevated levels of arsenic and lead in several biota samples and in the sediment adjacent to the munitions, the origin of those metals could not be definitively linked to the munitions since comparison of sediment between the clean reference site and the disposal site showed relatively little difference. This was especially the case for a comparison with samples for ocean disposed dredge spoils sites (locations where material taken from the dredging of harbors on Oahu was disposed). At individual sampling sites adjacent to munitions, the concentrations of metals were not significantly higher as compared to the background at control sites and not significant in comparison to typical deep-sea marine sediments (Briggs et al., 2016). Observations and data collected also did not indicate any adverse impact to the localized ecology due to the presence of munitions degrading for over 75 years when compared to control sites. When specifically looking at marine organisms around the munitions (Kelley et al., 2016; Koide et al., 2016), the analysis indicated that in soft bottom habitats the expended items were providing hard substrate similar to other disposed objects or “artificial reefs” that attracted “hard substrate species” that would not have otherwise colonized the area and that there was no bioaccumulation of munitions-related chemicals for the species sampled (Koide et al., 2016).

On a broader scale, the island of Farallon de Medinilla (in the Mariana Islands) has been used as a target area since 1971. Between 1997 and 2012, there were 14 underwater scientific survey investigations around the island providing a long-term look at potential impacts on the marine life from training and testing involving the use of munitions (Smith & Marx, 2016). Munitions use has included explosive rounds from gunfire, high explosive bombs by Navy aircraft and U.S. Air Force B-52s, in addition to the expenditure of inert rounds and non-explosive practice bombs. Marine life assessed during these surveys included algae, corals, benthic invertebrates, sharks, rays, bony fishes, and sea turtles. The investigators found no evidence over the 16-year period, that the condition of the biological resources had been adversely impacted to a significant degree by the training activities (Smith & Marx, 2016). Furthermore, they found that the health, abundance, and biomass of fishes, corals, and other marine resources were comparable to or superior to those in similar habitats at other locations within the Mariana Archipelago.

These findings are consistent with other assessments such as those performed for the Potomac River Test Range at Dahlgren, Virginia, which was established in 1918 and is the nation’s largest fully instrumented, over-the-water gun-firing range. Munitions tested at Dahlgren have included rounds from small-caliber guns up to the Navy’s largest (16-in. guns), bombs, rockets, mortars, grenades, mines, depth charges, and torpedoes (U.S. Department of the Navy, 2013b). Results from the assessment indicate that munitions expended at Dahlgren have not contributed significant concentrations of metals to the Potomac River and that the concentrations of metals in local sediments are orders of magnitude lower than in other areas of the Potomac River where metals are introduced from natural and other manmade sources (U.S. Department of the Navy, 2013a).

3.2.3.3.1 Impacts from Metals under Alternative 1

3.2.3.3.1.1 Impacts from Metals under Alternative 1 for Training Activities

Many activities included in the Proposed Action would involve the expenditure of munitions and other materials with metal components. Refer to Chapter 2 (Description of Proposed Action and Alternatives) for information on training activities and their frequency of annual occurrence under Alternative 1 and Appendix A (Navy Activity Descriptions) for a detailed description of munitions and other materials that would be used during training activities.

The distribution of non-explosive munitions and other expended materials composed of or containing metals that are used in training activities is not uniform throughout the Study Area. Non-explosive munitions are the largest portion of expended objects composed of metal or containing metal components (with the exception of target vessels). Approximately 50 percent of the non-explosive munitions and other expended metals used annually during training activities would be used in the Virginia Capes Range Complex, 24 percent in the Jacksonville Range Complex, and 15 percent would be used in the Navy Cherry Point Range Complex. The remaining 11 percent would be distributed in other locations of the Study Area. Over 8 million munitions and other items containing metals would be used in the Study Area annually; 75 percent of those munitions and items are small-caliber projectiles and over 20 percent are medium-caliber projectiles. Small-caliber projectiles are less than 0.5 in. in diameter and a few inches in length, and weigh up to 0.17 lb. A 30 mm medium-caliber projectile is larger, weighing just under 1 lb., and it is approximately 30 mm (or about 1 in.) in diameter and 7 in. long.

While the Navy is proposing to conduct one Sinking Exercise per year, historically, the Navy has not conducted this activity on an annual basis. The last Sinking Exercise conducted in the Atlantic was in 2009; one was also conducted in 2008. A Navy vessel used as a target would weigh between 5,000 and 10,000 tons (aircraft carriers would not be used as a target in Sinking Exercises). The vessel used during the Sinking Exercise would comprise a substantial amount of the metal used in the Study Area by weight, and would also represent the greatest concentration of expended metal objects (including munitions) in any location in the Study Area once the vessel sinks to the seafloor. As noted in previous sections, decommissioned vessels used as targets for sinking exercises have been cleaned or remediated in accordance with USEPA guidelines. Sinking exercises must be conducted at least 50 NM offshore and in water at least 6,000 ft. deep (40 CFR part 229.2). The USEPA considers the contaminant levels associated with the sinking of a target vessel to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.).

Metals from munitions, vessels and other targets, and other expended materials would sink to the seafloor where they would most likely be buried or partially buried in sediments, depending on the type of seafloor substrate. In the AFTT Study Area, the offshore substrate is predominantly composed of soft sediments (see Section 3.5, Habitats), which would increase the likelihood of complete or partial burial of expended materials, including munitions. Metals exposed to the seawater would slowly corrode over years or decades, releasing small amounts of water soluble metal compounds into the water column and corrosion products into adjacent sediments. The low, near freezing water temperatures and low oxygen levels in sediments only a few inches below the water column-seafloor interface that characterize deep water (greater than 250 m), benthic habitats would inhibit corrosion of metals and any dispersion of metals and corrosion products beyond isolated areas adjacent to the munition.

As described in Section 3.2.3.3 (Metals), sediment samples collected from World War II era munitions disposal sites and heavily used Navy ranges show that metals are not impacting sediment quality despite longtime use and high concentrations of military munitions composed primarily of metal components. The concentration of munitions and other expended materials containing metals in any one location in the AFTT Study Area would be a small fraction of that from a munitions disposal site, a target island used for 45 years, or a water range in a river used for almost 100 years. Chemical, physical, or biological changes to sediments or water quality in the Study Area would not be detectable and would be similar to nearby areas without munitions or other expended materials containing metals. This conclusion is based on the following: (1) most of the metals are benign, and those of potential concern make up a small percentage of expended munitions and other metal objects; (2) metals released through corrosion would be diluted by currents or bound up and sequestered in adjacent sediment; (3) elevated concentrations of metals in sediments would be limited to the immediate area around the expended material; and (4) the areas over which munitions and other metal components would be distributed are large.

Based on findings from these and other intensively used locations, the sediment and water quality effects from metals used in munitions, expended materials, target vessels, or other devices resulting from any of the proposed activities would be negligible by comparison.

3.2.3.3.1.2 Impacts from Metals under Alternative 1 for Testing Activities

The distribution of non-explosive munitions and other expended materials composed of or containing metals that are used in testing activities is not uniform throughout the Study Area. Munitions are the largest portion of expended objects composed of metal or containing metal components. Approximately 36 percent of the non-explosive munitions and other expended metals used annually during testing activities would be used in the Virginia Capes Range Complex, and 29 percent would be used in the Jacksonville Range Complex. The remaining 35 percent would be more widely distributed in other locations of the Study Area. Over 12 million munitions and other items containing metals would be used in the Study Area annually; over 45 percent of those munitions and items are non-explosive medium-caliber projectiles, 17 percent are non-explosive large-caliber projectiles, and 10 percent are small-caliber projectiles.

As described in Section 3.2.3.3 (Metals), sediment samples collected from World War II era munitions disposal sites and heavily used Navy ranges show that metals are not impacting sediment quality despite longtime use and high concentrations of military munitions composed primarily of metal components. The concentration of munitions and other expended materials containing metals in any one location in the Study Area would be a small fraction of that found in a munitions disposal site, a target island used for 45 years, or a water range in a river used for almost 100 years. Chemical, physical, or biological changes to sediments or water quality in the Study Area would not be detectable and would be similar to nearby areas without munitions or other expended materials containing metals. This conclusion is based on the following: (1) most of the metals are benign, and those of potential concern make up a small percentage of expended munitions and other metal objects; (2) metals released through corrosion would be diluted by currents or bound up and sequestered in adjacent sediment; (3) elevated concentrations of metals in sediments would be limited to the immediate area around the expended material; and (4) the areas over which munitions and other metal components would be distributed are large (thousands of square nautical miles).

Based on findings from these and other intensively used locations, the sediment and water quality effects from metals used in munitions, expended materials, or other devices resulting from any of the proposed activities would be negligible by comparison.

3.2.3.3.2 Impacts from Metals under Alternative 2

3.2.3.3.2.1 Impacts from Metals under Alternative 2 for Training Activities

Under Alternative 2, the number of munitions and other expended materials containing metals used during training activities would be the same as under Alternative 1. Therefore, metals contained in munitions and other military expended materials would have the same environmental impacts as described under Alternative 1.

3.2.3.3.2.2 Impacts from Metals under Alternative 2 for Testing Activities

Under Alternative 2, the number of munitions and other expended materials containing metals used during testing activities would increase compared to the number under Alternative 1. As shown in Chapter 2 (Description of Proposed Action and Alternatives) Tables 2.6-2 through 2.6-4, several Navy testing activities would be conducted more often under Alternative 2, resulting in an increase of 10 explosive mines and 40 neutralizers (10 explosive and 30 non-explosive) used annually. Under Alternative 1, no explosive mines would be used by Naval Air Systems Command. In addition, some activities would be conducted more frequently over a five-year period, resulting in the use of more munitions and other expended materials (see Tables 2.6-2 through 2.6-4). Over a five-year period, there would be an overall 8 percent increase in munitions and other expended materials containing metals used under Alternative 2. These include 300 additional torpedo accessories, which contain lead ballast; over 600 neutralizers, over 70,000 medium-caliber projectiles (30 percent explosive and 70 percent non-explosive); 170 missiles (70 percent explosive and 30 percent non-explosive); over 600 rockets (60 percent explosive and 40 percent non-explosive); and 60 surface targets.

The increase in the use of munitions and other objects containing metals would increase the amount of metals introduced into the seafloor environment over the amount in Alternative 1. However, the increase is not a substantial increase over the number of munitions used under Alternative 1 and would not alter the conclusions presented for Alternative 1. Specifically, the concentration of munitions and other expended materials containing metals in any one location in the AFTT Study Area would be a small fraction of the concentrations found on a munitions disposal site, a target island used for 45 years, or a water range in a river used for almost 100 years. The increase in the chemical, physical, or biological changes to sediments or water quality in the Study Area would not be detectable. The areas over which the additional 9 percent of munitions and other metal components would be distributed are large (thousands of square nautical miles); therefore, any increase would have a negligible effect on metal concentrations in seafloor sediments.

Based on findings from intensively used locations, the sediment and water quality effects from metals used in munitions, expended materials, or other devices resulting from any of the proposed activities would be negligible by comparison. Therefore, metals in munitions and other military expended materials are expected to have similar potential environmental impacts as under Alternative 1.

3.2.3.3.3 Impacts from Metals under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Under this alternative, there would be no adverse impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of non-explosive munitions and other expended materials containing metals would decrease the amounts of metal contaminants in marine waters and sediments. The effect, however, would likely not be measurable due to the slow, sometimes decades-long corrosion rates of metals on the seafloor. Metals released into sediments from corroding munitions and other metallic materials would only be expected at marginally higher concentrations in sediments within a few feet of the munition relative to a nearby location without munitions. Furthermore, most metals used in non-explosive munitions and other expended materials occur naturally in the marine environment and would not be elevated to toxic levels by slowly corroding munitions or other metallic materials.

3.2.3.4 Other Materials

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

Towed and stationary targets include floating steel drums, towed aerial targets, the trimaran, and inflatable, floating targets. The trimaran is a three-hulled boat with a 4 ft. square sail that is towed as a moving target. Large, inflatable, plastic targets can be towed or left stationary. Towed aerial targets are either (1) rectangular pieces of nylon fabric 7.5 ft. by 40 ft. that reflect radar or lasers or (2) aluminum cylinders with a fiberglass nose cone, aluminum corner reflectors (fins), and a short plastic tail section. This second target is about 10 ft. long and weighs about 75 lb. These four targets are recovered after use, and will not be considered further.

Marine markers are pyrotechnic devices that are dropped on the water's surface during training exercises to mark a position, to support search and rescue activities, or as a bomb target. The MK 58 marker is a tin tube that weighs about 12 lb. Markers release smoke at the water surface for 40 to 60 minutes. After the pyrotechnics are consumed, the marine marker fills with seawater and sinks. Iron and aluminum constitute 35 percent of the marker by weight. To produce the lengthy smoke effect, approximately 40 percent of the marker by weight is made up of pyrotechnic materials. The propellant, explosive, and pyrotechnic constituents of the MK 58 include red phosphorus (2.19 lb.) and manganese (IV) dioxide (1.40 lb.). Other constituents include magnesium powder (0.29 lb.), zinc oxide (0.12 lb.), nitrocellulose (0.000017 lb.), nitroglycerin (0.000014 lb.), and potassium nitrate (0.2 lb.). The failure rate of marine markers is approximately 5 percent (U.S. Department of the Navy, 2010a, 2010b).

Flares are used to signal, to illuminate surface areas at night in search and attack operations, and to assist with search and rescue activities. They range in weight from 12 to 30 lb. The major constituents of flares include magnesium granules and sodium nitrate. Containers are constructed of aluminum, and the entire assembly is usually consumed during flight. Flares may also contain a primer such as trinitrotoluene (TNT), propellant (ammonium perchlorate), and other explosives. These materials are present in small quantities (e.g., 1.0 x 10^{-4} ounces [oz.] of ammonium perchlorate and 1.0 x 10^{-7} oz. of explosives). Small amounts of metals are used to give flares and other pyrotechnic materials bright and distinctive colors. Combustion products from flares include magnesium oxide, sodium carbonate, carbon dioxide, and water. Illuminating flares and marine markers are usually entirely consumed during use; neither is intended to be recovered. Table 3.2-10 summarizes the components of markers and flares (U.S. Air Force, 1997).

Table 3.2-10: Summary of Components of Marine Markers and Flares

Flare or Marker	*Constituents*	*Composition (%)*
LUU-2 Paraflare	Magnesium granules, sodium nitrate, aluminum, iron, trinitrotoluene (TNT), royal demolition explosive, ammonium perchlorate, potassium nitrate, lead, chromium, magnesium, manganese, nickel	Magnesium (54), sodium nitrate (26), aluminum (14), iron (5)
MK45 Paraflare	Aluminum, sodium nitrate, magnesium powder, nitrocellulose, trinitrotoluene (TNT), copper, lead, zinc, chromium, manganese, potassium nitrate, pentaerythritol-tetranitrate, nickel, potassium perchlorate	Magnesium (45), sodium nitrate (30), aluminum (22)
MK58 Marine Marker	Aluminum, iron, chromium, copper, lead, lead dioxide, manganese dioxide, manganese, nitroglycerin, red phosphorus, potassium nitrate, silver, zinc, zinc oxide	Iron (60), aluminum (35)

Most of the pyrotechnic components of marine markers are consumed and byproducts are released into the air. Thereafter, the aluminum and steel canister sinks to the bottom. Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms. The amount of flare residue is negligible. Phosphorus contained in the marker settles to the seafloor, where it reacts with the water to produce phosphoric acid until all phosphorus is consumed by the reaction. Phosphoric acid is a variable, but normal, component of seawater (Sverdrup et al., 1970). The aluminum and iron canisters are expected to be covered by sand and sediment over time, to become encrusted by chemical corrosion, or to be covered by marine plants and animals. Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble, adheres to particulates, and is transported to the bottom sediments (Monterey Bay Research Institute, 2010).

Red phosphorus, the primary pyrotechnic ingredient, constitutes 18 percent of the marine marker weight. Toxicological studies of red phosphorus revealed an aquatic toxicity in the range of 10–100 milligrams per liter (10–100 ppm) for fish, *Daphnia* (a small aquatic crustacean), and algae (European Flame Retardants Association, 2002). Red phosphorus slowly degrades by chemical reactions to phosphine and phosphorus acids. Phosphine is very reactive and usually undergoes rapid oxidation. The final products, phosphates, are harmless (Salocks & Kaley, 2003). A study by the U.S. Air Force (1997) found that, in salt water, the degradation products of flares that do not function properly include magnesium and barium.

Chaff is an electronic countermeasure designed to confuse enemy radar by deflecting radar waves and thereby obscuring aircraft, ships, and other equipment from radar tracking sources. Chaff consists of small, thin glass fibers coated in aluminum that are light enough to remain in the air anywhere from 10 minutes to 10 hours (Farrell & Siciliano, 2007). Chaff is typically packaged in cylinders that measure approximately 6 in. by 1.5 in. (15.2 cm by 3.8 cm), weigh about 5 oz. (140 grams [g]), and contain a few million fibers. Chaff may be deployed from an aircraft or may be launched from a surface vessel.

The chaff fibers are approximately the thickness of a human hair (generally 25.4 microns in diameter), and range in length from 0.8 to 5.1 cm. The major components of the chaff glass fibers and the aluminum coating are provided in Table 3.2-11 (Arfsten et al., 2002; Farrell & Siciliano, 2007; Spargo, 1999; U.S. Air Force, 1997; U.S. Department of the Navy, 1999).

Factors influencing chaff dispersion include the altitude and location where it is released, prevailing winds, and meteorological conditions (Spargo, 1999, 2007). Doppler radar has tracked chaff plumes containing approximately 900 g of chaff drifting 200 mi. from the point of release, with the plume covering a volume of greater than 400 cubic miles (Arfsten et al., 2002). Based on the dispersion characteristics of chaff, large areas of open water would be exposed to chaff, but the chaff concentrations would be low. For example, Spargo (1999) calculated that an area 8 km by 12 km (96 square kilometers) would be affected by deployment of a single cartridge containing 150 g of chaff. The resulting chaff concentration would be about 5.4 g per NM^2. This corresponds to less than 0.005 fiber per square meters, assuming that each canister contains 5 million fibers.

Chaff is generally resistant to chemical weathering and likely remains in the environment for long periods. However, all the components of chaff's aluminum coating are present in seawater in trace amounts, except magnesium, which is present at 0.1 percent (Nozaki, 1997). Aluminum and silicon are the most common minerals in the earth's crust as aluminum oxide and silicon dioxide, respectively. Aluminum is the most common metal in the Earth's crust and also occurs naturally in trace amounts in the aquatic environment. Ocean waters are constantly exposed to these minerals, so the addition of small amounts of chaff would not affect water quality or sediment composition (Spargo, 1999).

Table 3.2-11: Major Components of Chaff

Component	***Percent by Weight***
Glass Fiber	
Silicon dioxide	52–56
Alumina	12–16
Calcium oxide, magnesium oxide	16–25
Boron oxide	8–13
Sodium oxide, potassium oxide	1–4
Iron oxide	≤ 1
Aluminum Coating	
Aluminum	99.45 (minimum)
Silicon and Iron	0.55 (maximum)
Copper	0.05
Manganese	0.05
Zinc	0.05
Vanadium	0.05
Titanium	0.05
Others	0.05

The dissolved concentration of aluminum in seawater ranges from 1 to 10 µg/L (1 to 10 ppb). For comparison, the concentration in rivers is 50 µg/L (50 ppb). In the ocean, aluminum concentrations tend to be higher on the surface, lower at middle depths, and higher again at the bottom (Li et al., 2008). Aluminum is a very reactive element, and is seldom found as a free metal in nature except under highly acidic (low pH) or alkaline (high pH) conditions. It is found combined with other elements, most commonly with oxygen, silicon, and fluorine. These chemical compounds are commonly found in soil, minerals, rocks, and clays (Agency for Toxic Substances and Disease Registry, 2008; U.S. Department of the Air Force, 1994). Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble, and is scavenged by particulates and transported to bottom sediments (Monterey Bay Research Institute, 2010).

Because of their light weight, chaff fibers tend to float on the water surface for a short period. The fibers are quickly dispersed by waves and currents. They may be accidentally or intentionally ingested by marine life, but the fibers are non-toxic. Chemicals leached from the chaff would be diluted by the surrounding seawater, reducing the potential for chemical concentrations to reach levels that can affect sediment quality or benthic habitats.

Systems Consultants (1977) placed chaff samples in Chesapeake Bay water for 13 days. No increases in concentration of greater than 1 ppm of aluminum, cadmium, copper, iron, or zinc were detected. Accumulation and concentration of chaff constituents is not likely under natural conditions. A U.S. Air Force study of chaff analyzed nine elements under various pH conditions: silicon, aluminum, magnesium, boron, copper, manganese, zinc, vanadium, and titanium. Only four elements were detected above the 0.02 milligrams per liter detection limit (0.02 ppm): magnesium, aluminum, zinc, and boron (U.S. Air Force, 1994). Tests of marine organisms detected no impacts of chaff exposure at levels above those expected in the Study Area (Farrell & Siciliano, 2007).

3.2.3.4.1 Impacts from Other Materials under Alternative 1

3.2.3.4.1.1 Impacts from Other Materials under Alternative 1 for Training Activities

The distribution of other expended materials used in training activities would not be uniform throughout the Study Area. These other expended materials include marine markers and flares, chaff, expendable towed and stationary targets, non-explosive sonobuoys, fiber-optic cables, and miscellaneous components. Approximately 44 percent of these other expended materials would be used annually in the Jacksonville Range Complex, 30 percent in the Key West Range Complex, and 20 percent would be used in the Navy Cherry Point Range Complex. Over 270,000 other expended materials would be used in the Study Area annually; 46 percent of those materials are chaff, 34 percent are flares, and 16 percent are non-explosives sonobuoys (i.e., passive and acoustic), which contain metals and other materials including plastics. The composition of chaff is much like clay minerals common in ocean sediments (aluminosilicates), and studies indicate that impacts are not anticipated even at concentrations many times the level anticipated during proposed training activities. Most pyrotechnics in marine markers and flares are consumed during use and combustion byproducts are expended into the air. The failure rate of flares and marine markers is low (5 percent), and the remaining amounts are small and subject to additional chemical reactions and subsequent dilution in the ocean.

Under Alternative 1, approximately 94,000 flares would be used in the AFTT Study Area, and approximately 4,700 (5 percent) would enter the water with unconsumed pyrotechnic materials. As show in Table 3.2-10, the bulk of these materials are metals and other chemical compounds that occur naturally in the marine environment and would be dispersed at low concentrations in the water column or would sink to the seafloor. The analysis and conclusions presented in Section 3.2.3.3 (Metals) would apply to metals in pyrotechnics as well, and the analysis concludes that sediment and water quality effects from metals would be negligible. The small amounts of explosives used in flares, specifically trinitrotoluene (TNT) and royal demolition explosive, released into the sediments would not impact marine sediments for the same reasons presented in Section 3.2.3.1 (Explosives and Explosives Byproducts). Based on the results of studies conducted at multiple marine and freshwater ranges where explosives have been used intensively over decades, no impacts on sediments and water quality from explosives in unconsumed flares would be expected.

Plastics and other floating expended materials (e.g., rubber components) would either degrade over time in the water column or on the seafloor or wash ashore. Materials that sink to the seafloor would be widely distributed over the large areas used for training. As described in Section 3.2.2.1.2 (Marine Debris, Military Materials, and Marine Sediments), the worldwide use and disposal of plastics is rapidly increasing the amount of plastic debris accumulating in large areas of the world’s oceans. Small pieces of plastic associated with the use of chaff, flares, and targets would likely persist in the marine environment as floating debris in the water column or on the seafloor. Plastic floating near the surface and exposed to the sun and mechanical wear and tear would break down over time. Plastic that sinks in the water column below the photic zone or to the seafloor would degrade more slowly or not at all. Because only small pieces of plastics would be expended—larger pieces from targets are recovered—and dispersed over a large area, only negligible impacts on sediments or water quality are expected. The potential effects of plastic from military expended materials on living marine resources and habitats are analyzed in other sections of the EIS/OEIS.

Devices temporarily deployed on the seafloor and then recovered following completion of the activity would likely increase turbidity in the vicinity of the device. Most seafloor devices are stationary; however, some devices (e.g., crawlers) are mobile and move very slowly along the bottom. While a minimal increase in turbidity would be expected during installation, recovery, and, if applicable, movement of seafloor devices, particularly where the seafloor is composed of soft sediments, the increase is expected to be negligible and have no lasting impact on sediments or water quality.

3.2.3.4.1.2 Impacts from Other Materials under Alternative 1 for Testing Activities

The distribution of other expended materials used in testing activities would not be uniform throughout the Study Area. These other expended materials include marine markers and flares, chaff, expendable towed and stationary targets, non-explosive sonobuoys, fiber-optic cables, and miscellaneous components. Approximately 35 percent of these other expended materials would be used annually in the Virginia Capes Range Complex, 29 percent in the Jacksonville Range Complex, 9 percent would be used in the Gulf of Mexico Range Complex, and 8 percent each would be used in the Key West Range Complex and the Northeast Range Complexes. The remaining 11 percent would be distributed in other locations of the Study Area. Over 264,000 other expended materials would be used in the Study Area annually; 65 percent of those materials are sabots. A sabot is a device used to keep a projectile centered in the barrel during firing. Sabots are constructed of metal with plastic parts. Of the remaining other expended materials, 13 percent are non-explosive sonobuoys, 9 percent are chaff, and 8 percent are flares.

Most pyrotechnics in marine markers and flares are consumed during use combustion byproducts are expended into the air. The failure rate of flares and marine makers is low (5 percent), and the remaining amounts are small and subject to additional chemical reactions and subsequent dilution in the ocean. The analysis and conclusions presented in Section 3.2.3.3 (Metals) would apply to metals in pyrotechnics as well, and the analysis concludes that sediment and water quality effects from metals would be negligible. The small amounts of explosives used in flares, specifically trinitrotoluene (TNT) and royal demolition explosive, released into the sediments would not impact marine sediments for the same reasons presented in Section 3.2.3.1 (Explosives and Explosives Byproducts). Based on the results of studies conducted at multiple marine and freshwater ranges where explosives have been used intensively over decades, no impacts on sediments and water quality from explosives in unconsumed flares would be expected.

Plastics and other floating expended materials (e.g., rubber components) would either degrade over time in the water column or on the seafloor or wash ashore. Materials that sink to the seafloor would be widely distributed over the large areas used for testing. As described in Section 3.2.2.1.2 (Marine Debris, Military Materials, and Marine Sediments), the worldwide use and disposal of plastics is rapidly increasing the amount of plastic debris accumulating in large areas of the world's oceans. Small pieces of plastic associated with the use of chaff, flares, and targets would likely persist in the marine environment as floating debris in the water column or on the seafloor. Plastic floating near the surface and exposed to the sun and mechanical wear and tear would break down over time. Plastic that sinks in the water column below the photic zone or to the seafloor would degrade more slowly or not at all. Because only small pieces of plastics would be expended—larger pieces from targets are recovered—and dispersed over a large area, only negligible impacts on sediments or water quality are expected. The potential effects of plastic from military expended materials on living marine resources and habitats are analyzed in other sections of the Final EIS/OEIS. Some testing activities would involve the use of a biodegradable polymer as part of a vessel entanglement system. Based on the constituents of the biodegradable polymer, the Navy anticipated that the material will break down into small pieces within a few days to weeks. The polymer will break down further and dissolve into the water column within weeks to a few months. The final breakdown products are all environmentally benign and will be dispersed quickly to undetectable concentrations within the water column.

Devices temporarily deployed on the seafloor and then recovered following completion of the activity would likely increase turbidity in the vicinity of the device. Most seafloor devices are stationary; however, some devices (e.g., crawlers) are mobile and move very slowly along the bottom. While a minimal increase in turbidity would be expected during installation, recovery, and, if applicable, movement of seafloor devices, particularly where the seafloor is composed of soft sediments, the increase is expected to be negligible and have no lasting impact on sediments or water quality.

3.2.3.4.2 Impacts from Other Materials under Alternative 2

3.2.3.4.2.1 Impacts from Other Materials under Alternative 2 for Training Activities

Under Alternative 2, the number of other expended materials would increase by just 0.6 percent. The additional expended materials are non-explosive buoys and their small decelerators/parachutes and bathythermographs. The small increase in plastics, metals, and explosives in the additional expended materials would not change the conclusions presented under Alternative 1. Therefore, impacts from other materials would be expected to be the same as those analyzed under Alternative 1.

3.2.3.4.2.2 Impacts from Other Materials under Alternative 2 for Testing Activities

Under Alternative 2, the number of other expended materials would increase by 0.3 percent. The additional expended materials are non-explosive sonobuoys and their small decelerators/parachutes. The small increase in plastics and metals in the additional expended materials would not change the conclusions presented under Alternative 1. Therefore, impacts from other materials would be expected to be the same as those analyzed under Alternative 1.

3.2.3.4.3 Impacts from Other Materials under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Under this alternative, there would be no adverse impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of military expended materials would decrease the amounts of these materials in marine waters and sediments. The effect, however, would likely not be measurable due to the slow, sometimes decades-long degradation of these materials, including plastics, in the water column and on the seafloor. Other expended materials in sediments would have only negligible impacts, because only small pieces of plastics would be expended—larger pieces from targets are recovered—and dispersed over a large area.

3.2.4 SUMMARY OF POTENTIAL IMPACTS ON SEDIMENTS AND WATER QUALITY

The stressors that may impact sediments and water quality include explosives and explosives byproducts, metals, chemicals other than explosives, and other materials. As described in Section 3.0.3.5 (Resource-Specific Impacts Analysis for Multiple Stressors), this section evaluates the potential for combined impacts of all the stressors on sediments and water quality. The analysis and conclusions for the potential impacts from each of the individual stressors are discussed in the sections above. Stressors associated with Navy training and testing activities do not typically occur in isolation but rather occur in some combination. For example, some anti-submarine warfare activities use explosive sonobuoys, which may introduce residual explosives, explosives byproducts, metals, and plastic materials into the environment during a single activity. An analysis of the combined impacts of all stressors on sediments and water quality considers the potential consequences of aggregate exposure to all stressors and the repetitive or additive consequences of exposure over multiple years.

3.2.4.1 Combined Impact of all Stressors under Alternative 1

Most Navy training and testing activities impact small, widely dispersed areas of the Study Area, limiting the spatial extent of sediments and the water column that would be exposed to contaminants to isolated areas within the Study Area. However, some Navy activities recur in the same location (e.g., gunnery and mine warfare activities), which concentrates munitions and other materials and their associated stressors in those areas. Despite recent, comprehensive data collection and analysis specific to military munitions impacts on sediments and water quality (Briggs et al., 2016; Edwards & Bełdowski, 2016; Edwards et al., 2016; Tomlinson & De Carlo, 2016), analysis of the potential effects from the Proposed Action is mainly qualitative. Where combinations of explosives, explosives byproducts, metals, and other chemicals and materials are co-located, the potential for combined impacts is present (Thompson et al., 2009).

When considered together, the impact of the four stressors would be additive. Under Alternative 1, chemical, physical, or biological changes in sediments and water quality would be minimal and only detectable in the immediate vicinity of munitions. Even in areas where multiple munitions and expended materials are located in close proximity (e.g., munitions disposal sites) chemical degradation products from each source or item are largely isolated from each other. The low failure rate of explosive munitions proposed for use reduces the likelihood of exposure to explosives materials that remain in intact munitions. Measurable concentrations of contaminants and other chemicals in the marine environment from munitions disposal sites have been shown to be below screening levels or similar to nearby reference areas where munitions are not present. Many components of non-explosive munitions and other expended materials are inert or corrode slowly over years. Metals that could impact benthic habitat at higher concentrations comprise only a small portion of the alloys used in expended materials, and corrosion of metals in munitions casings and other expended materials is a slow process that allows for dilution. The chemicals products from hydrolysis are predominantly naturally occurring chemicals. Elevated concentrations of metals and other chemical constituents in sediments would be limited to small zones adjacent to the munitions or other expended materials and would still most likely remain below screening levels even after years residing on the seafloor. It is also possible that Navy stressors will combine with non-Navy stressors, particularly in nearshore areas and bays, such as the mouth of Chesapeake Bay, to exacerbate already impacted sediments and water quality. This is qualitatively discussed in Chapter 4 (Cumulative Impacts).

3.2.4.2 Combined Impact of all Stressors under Alternative 2

Under Alternative 2, when considered separately, the impacts of the four stressors on sediments and water quality would be the same as discussed under Alternative 1, because the types and amounts of explosives, chemicals other than explosives, metals, and military expended materials are approximately equivalent under the two alternatives.

The amounts of explosives are greater under Alternative 2, because of the nominal increase in munitions used in some testing activities under Alternative 2. While the potential impact to sediments would be greater than under Alternative 1, metals in the additional munitions would be subject to the same slow degradation rates expected to occur in the deepwater environment limiting any increase in metal concentrations to sediments that are immediately adjacent a munition (see Section 3.2.3.3, Metals, for additional discussion). As non-explosive or unexploded munitions degrade over time on the seafloor, they may become encrusted with oxidation products (e.g., rust) or by marine organisms attracted to hard substrates, which would further slow degradation rates. As discussed in Section 3.2.3.1 (Explosives and Explosives Byproducts), degrading munitions at World War II era munitions disposal sites do not pose a risk to human health or to the fauna living in direct contact with the degrading munitions (Edwards et al., 2016). During a comprehensive survey of a disposal site off of Hawaii, explosive materials were detected in sediments at only two locations and the concentrations were low. Data supporting these conclusions were collected from several World War II era munitions disposal sites and ranges characterized by relatively high concentrations of munitions. Munitions used in the proposed training and testing activities would be widely dispersed by comparison, resulting in lower concentrations of munitions that failed to detonate and lower concentrations of residual explosives and explosives byproducts than reported in Edwards et al. (2016).

Based on this analysis, impacts on sediments and water quality may be greater than under Alternative 1, but would still be minimal. Therefore, combined impacts from all stressors would also be similar to impacts described under Alternative 1.

3.2.4.3 Combined Impact of all Stressors under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the AFTT Study Area. Under this alternative, there would be no adverse impacts on sediments and water quality from training and testing activities. It is reasonable to assume that ceasing all training and testing activities involving the use of explosives and explosives byproducts, metals, chemicals other than explosives, and other materials would decrease the amounts these materials in marine waters and sediments. The effect, however, would likely not be measurable due to the slow, sometimes decades-long corrosion of metals on the seafloor. Metals, explosives, and explosives byproducts released into sediments from corroding munitions and other metallic materials would only be expected at marginally higher concentrations in sediments within a few feet of the munition relative to a nearby location without munitions. Furthermore, most metals used in non-explosive munitions and other expended materials occur naturally in the marine environment and would not be elevated to toxic levels by slowly corroding munitions or other metallic materials. The effect of chemicals other than explosives would likely not be measurable due to the highly efficient use of propellants and fuels by motors used in rockets and missiles, resulting in often undetectable trace amounts of propellants expended into the environment. Perchlorates, which make up a large percentage of rocket and missile propellants, are also water soluble and would dissolve and be dispersed in surface waters and would not accumulate in marine sediments. Other expended materials in sediments would have only negligible impacts, because only small pieces of plastics would be expended—larger pieces from targets are recovered—and dispersed over a large area.

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