3.1 Sediments and Water Quality

Supplemental Environmental Impact Statement/ Overseas Environmental Impact Statement Northwest Training and Testing

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3.1 Sediments and Water Quality

The analysis of impacts on sediments and water quality presented in the 2015 Northwest Training and Testing (NWTT) Final Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) was revised and updated with new information in this section to the extent that the affected environment or the science for evaluating sediment and water quality changed. Relevant literature published or otherwise becoming available since the publication of the 2015 NWTT Final EIS/OEIS was systematically reviewed to assist in determining if sediment and water quality conditions in the Study Area have changed or remain the same.

Information is readily available on the condition of inshore and nearshore sediments and water quality, because of the proximity of those areas to human population centers. However, comparatively less is known about sediments and water quality beyond the continental shelf in ocean basins far from shore. Inshore and nearshore sediments and water quality are negatively impacted mostly by numerous anthropogenic sources (e.g., urban runoff, debris disposal, commercial and recreational vessels) (Keller et al., 2010; Washington Department of Ecology, 2009). Two general assumptions were made in the 2015 NWTT Final EIS/OEIS analysis of impacts on sediment and water quality: (1) water quality and the condition of sediments improves with distance from shore, and (2) deeper waters (generally considered to be greater than 200 meters [m] in depth) are generally of higher quality than surface waters (Coleman & Prior, 1988; Demina & Galkin, 2009; Duursma & Gross, 1971). Research published since the analysis in the 2015 NWTT Final EIS/OEIS was completed shows that the concentration of marine debris is increasing in deep oceanic waters far from shore (Cozar et al., 2014; Desforges et al., 2014; Law et al., 2014; National Oceanic and Atmospheric Administration Marine Debris Program, 2016; Woodall et al., 2014). However, considering that the vast majority of marine debris that accumulates in oceanic waters originates in coastal regions, the assumptions noted above from the 2015 NWTT Final EIS/OEIS have not been altered by the new data.

3.1.1 Assessment of Sediments

The discussion that follows is based largely on information and data on sediments in the West Coast region from the National Coastal Condition Assessment – 2010 (U.S. Environmental Protection Agency, 2016a). This assessment is the Environmental Protection Agency's (EPA's) fifth coastal condition assessment; however, it is the first in the newly named National Aquatic Resource Surveys series. Even though the series is new, it is regarded as a continuation of the National Coastal Condition Reports (I–IV) series (see, e.g., U.S. Environmental Protection Agency (2012b)). Data from the original series were used to evaluate sediments in Section 3.1 (Sediments and Water Quality) of 2015 NWTT Final EIS/OEIS, and data from new series are used in this Supplemental.

Key environmental indicators (e.g., sediment toxicity) used in the new series remain similar to indicators used in the National Coastal Condition Reports (I–IV) series; however, the new National Coastal Condition Assessments are less detailed and use very little data external to the National Aquatic Resource Surveys program (e.g., beach closure or fish advisory information is no longer used). Additionally, the fish tissue and sediment indices used in the new National Coastal Condition Assessments series have been revised based on comments received on previous reports and to reflect advances in science; therefore, the index scores reported in this Supplemental are not directly comparable to scores presented in the National Coastal Condition Reports (I–IV) (U.S. Environmental Protection Agency, 2016a).

As part of updating the series, the EPA revised the criteria for evaluating the condition of sediments in the National Coastal Condition Assessment – 2010 (U.S. Environmental Protection Agency, 2016b). The condition of sediments, quantified by a "sediment quality index," in estuaries is evaluated based on measurements of two criteria: sediment toxicity and the concentrations of sediment contaminants (i.e., sediment chemistry). Previously, total organic carbon was also used as an indicator to assess the condition of sediments, but this metric is no longer used to calculate the sediment quality index. Previous sediment quality assessments in marine waters used the Effects Range Median metric, which is considered adequate for assessing the effects of individual contaminants on the condition of sediments. However, individual contaminants rarely occur alone in the environment; rather, they are almost always present as complex mixtures of contaminants in marine sediments. Therefore, as detailed in the EPA-revised criteria, a better metric for assessing the effects of contaminants on the conditions of sediments, is the average (or mean) of the Effects Range Median Quotient. To arrive at this metric the first step is to calculate the Effects Range Median Quotient by dividing the contaminant concentration by its corresponding Effects Range Median threshold. The Mean Effects Range Median Quotient is then calculated by summing the individual Effects Range Median Quotients for all contaminants and dividing by the total number of contaminants in the mixture (i.e., an average of contaminants in the sediment). To assess the degree of contamination, the Mean Effects Range Median Quotient takes into account (1) the composition of multiple contaminants found in sediment samples, and (2) a corresponding measure of the probability that the level of contamination will be toxic to benthic organisms (U.S. Environmental Protection Agency, 2016b). Effects range median thresholds for EPA-listed chemical contaminants are provided in U.S. Environmental Protection Agency (2016b).

The Mean Effects Range Median Quotient is combined with the results from a computer model that relates chemical concentrations to sediment toxicity in benthic invertebrates. Together, the Mean Effects Range Median Quotient and the model results are used to rate sediment chemistry as either good, fair, or poor based on the concentrations of chemical contaminants. For example, for sediment chemistry to be rated "good" the Mean Effects Range Median Quotient must be less than 0.1 and the maximum probability of observing sediment toxicity (i.e., the results of the model) must be less than (or equal to) 0.5 (i.e., no greater than 50 percent). See Table 3.1-1 for descriptions of the sediment chemistry criteria.

The second metric used to assess sediment condition, sediment toxicity, is based on the survival rates of the estuarine amphipod, *Leptocheirus plumulosus*, in sample sediments. The survival rates of amphipods in a test group are compared to a control group, and if the survival rates of the two groups are found to be statistically different, then some degree of sediment toxicity is present in the sampled sediments. The survival rate and the statistical test are used in tandem to rate sediment toxicity (Table 3.1-1). The overall sediment quality index, rating sediments as good, fair, or poor, is based on the sediment toxicity and sediment chemistry scores.

3.1.2 Assessment of Water Quality

The water quality criteria and metrics for determining the water quality index in the National Coastal Condition Assessment – 2010 (U.S. Environmental Protection Agency, 2016a) are the same as the criteria and index used in previous coastal condition assessments and have not changed since the 2015 NWTT Final EIS/OEIS. Refer to Table 3.1-5 in Section 3.1 (Sediments and Water Quality) of the 2015 NWTT Final EIS/OEIS or U.S. Environmental Protection Agency (2016b) for the specific criteria. Note that in the table the site criteria for dissolved inorganic nitrogen rated fair were incorrectly listed as "0.35 – 1.0 mg/L." The correct range is "0.35 – 0.5 mg/L."

Table 3.1-1: Sediment Quality Criteria and Index

Metric or Index	Criteria		
	Good	**Fair**	**Poor**
Sediment toxicity	Test results not significantly different from control (p>0.05) and ≥80 percent control-corrected survival	Test results significantly different from control (p≤0.05) and ≥80 percent control-corrected survival or Test not significantly different from control (p>0.05) and <80 percent control-corrected survival	Test results significantly different from control (p<0.05) and <80 percent control-corrected survival
Sediment chemistry	mERM-Q <0.1 and LRM Pmax ≤ 0.5	mERM-Q ≥0.1 - ≤0.5 or LRM Pmax >0.5 - <0.75	mERM-Q >0.5 or LRM Pmax ≥0.75
Sediment quality index	Both sediment chemistry index and sediment toxicity index are rated good	Neither sediment chemistry index nor sediment toxicity index are rated poor, and at least one index is rated fair	Either sediment chemistry index or sediment toxicity index are rated poor

Notes: Sediment total organic carbon (TOC) is no longer used for assessment of estuarine sediments.
TOC = total organic carbon, mERM-Q = mean Effects Range Median quotient, Pmax = maximum probability of observing sediment toxicity, LRM = logistic regression model.
Source: U.S. Environmental Protection Agency (2016b).

Section 312(n) of the Clean Water Act requires the EPA and the Department of Defense (DoD) to jointly establish uniform national discharge standards to control 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 nautical miles (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.

The discharge standards are intended to reduce adverse environmental impacts associated with the discharges, stimulate the development of improved pollution control devices, and advance the development of environmentally compliant vessels. Uniform national discharge standards are being implemented in three phases. Phase I, which was completed in 1999, identified all discharges incidental to the normal operation of vessels of the Armed Forces and characterized each discharge to determine if it required control. The determination was made based on the potential of the discharge to have an environmental impact. The rule determined the types of vessel discharges that require control by a marine pollution control device (MPCD) and those that do not require control. The EPA and DoD identified 39 discharges, 25 of which would require control by an MPCD. In Phase II of the implementation, the EPA and DoD will determine MPCD performance standards for the 25 discharges that require control. Phase II was divided into three batches. The Batch One Final Rule was published in the Federal Register on January 11, 2017. Batch Two and Batch Three are still under development, but the Batch Two proposed MPCD performance standards were published in the Federal Register on October 7, 2016. In Phase III, the DoD, in consultation with the EPA and U.S. Coast Guard, will establish regulations governing the design, construction, installation, and use of MPCDs onboard vessels that

must meet the performance standards promulgated in Phase II. Phase III regulations became effective for the Batch One discharges on June 19, 2019.

The U.S. Navy adheres to regulations outlined in the Uniform National Discharge Standards program; as such, the analysis of impacts in this Supplemental 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 for the Prevention of Pollution from Ships (incorporated into U.S. law as 33 U.S.C. sections 1901–1915) or the Uniform National Discharge Standards program. Additional information on the Uniform National Discharge Standards program can be found online at: https://www.epa.gov/vessels-marinas-and-ports/uniform-national-discharge-standards-unds-vessels-armed-forces.

3.1.3 Affected Environment

The affected environment describes sediment quality and water quality in the Study Area, extending from inland waters to offshore, open-ocean areas and deep sea substrates. For purposes of this Supplemental, the Study Area for sediments and water quality remains the same as the areas identified in the 2015 NWTT Final EIS/OEIS. Existing sediment conditions are discussed in Section 3.1.3.1 (Sediments in the Study Area), followed by water quality in Section 3.1.3.4 (Water Quality in the Study Area).

The West Coast region described in the National Coastal Condition Assessment – 2010 (U.S. Environmental Protection Agency, 2016a), which includes the coastal areas of Washington, Oregon, and California, has a total area of over 2,200 square miles (mi.^{2}) and includes 410 estuaries, bays, and smaller estuarine areas. More than 60 percent of the West Coast region is part of three large estuarine systems—the San Francisco Estuary, the Columbia River Estuary, and Puget Sound (including the Strait of Juan de Fuca). Only Puget Sound is within the Study Area; the Columbia River Estuary is adjacent to, but inshore of, the Study Area, which begins 12 NM off the southern coast of Washington State, continuing south for the remainder of the Study Area. Smaller, sub-estuary systems associated with these large systems make up another 27 percent of the West Coast region. The remaining West Coast waterbodies, combined, compose only 12 percent of the total coastal area of the region. Water quality in coastal and inland waters either within or adjacent to Puget Sound and the Columbia River Estuary—areas with a high human population density—heavily influence the overall water quality assessment for the Study Area.

Water quality is generally lower and the concentration of contaminants in coastal sediments is generally higher in densely populated areas (e.g., large coastal cities). The distribution of the human population along the West Coast region varies considerably, with higher population densities occurring in the Seattle–Tacoma area of Puget Sound, in the San Francisco Bay area, and along the Southern California coastline. In contrast, the coastline north of San Francisco Bay through northern Puget Sound (excluding the Seattle–Tacoma area) has a much lower population density.

3.1.3.1 Sediments in the Study Area

The physical characteristics of sediments and their transport into the Study Area are described in Section 3.1 (Sediments and Water Quality) of the 2015 NWTT Final EIS/OEIS and remain accurate and descriptive of current sediment conditions. Briefly, sediments deposited on the continental shelf are mostly transported by rivers, but transport also occurs along the shoreline by local and regional currents and by onshore winds. Most sediments in nearshore areas and on the continental shelf of the North Pacific Ocean are land-derived aluminum silicates transported into the Study Area and deposited at

rates of approximately 10 centimeters per 1,000 years. Sediments are also produced locally by particulate organic matter (i.e., detritus) that sinks to the bottom (Chester, 2003). Many types of substances in the water column, both human made and naturally occurring, including contaminants, attach to particles that, over time, settle to the bottom and become incorporated into bottom sediments (Eggleton & Thomas, 2004; Kszos et al., 2003; Wurl & Obbard, 2004).

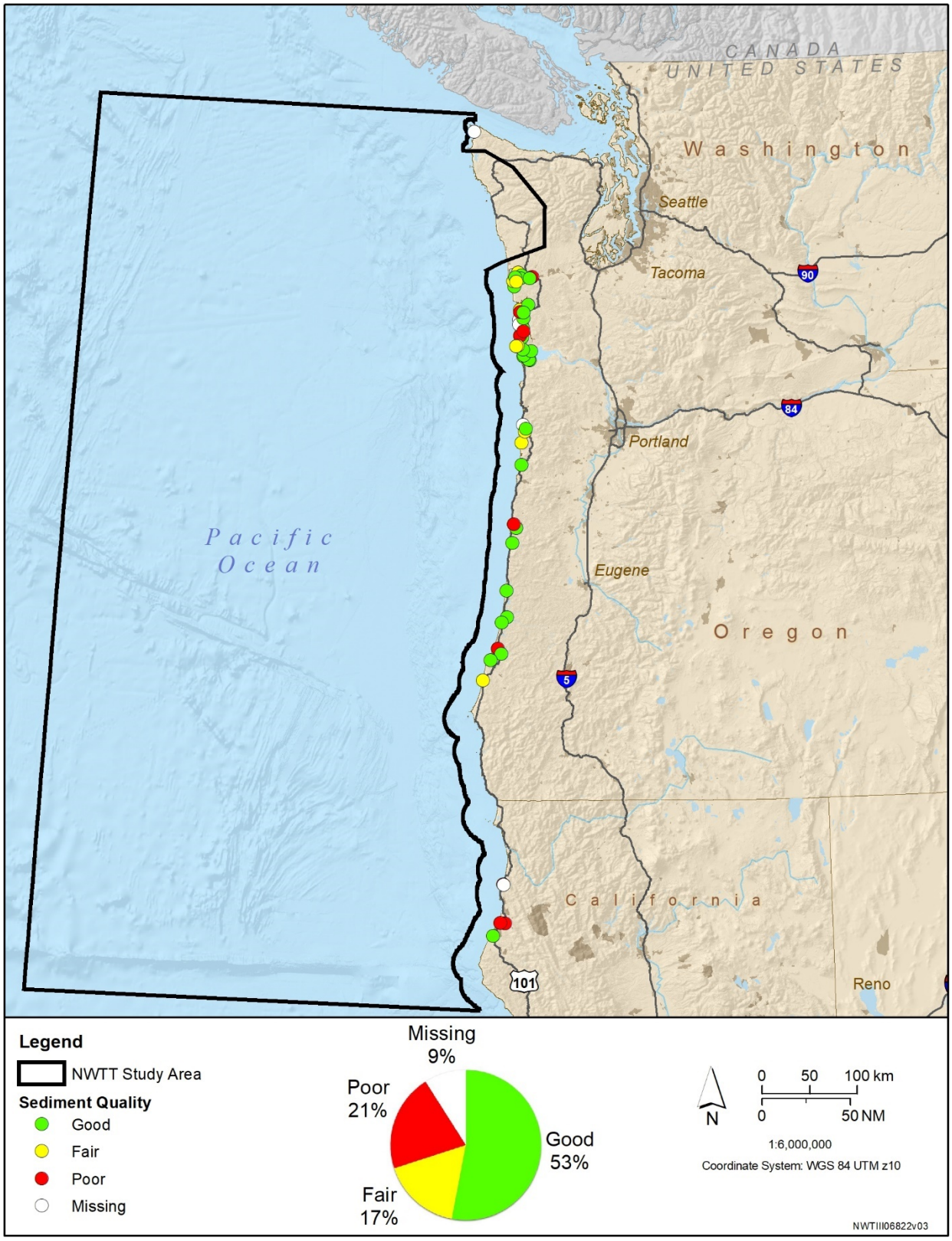
The following subsections discuss sediments for each region in the Study Area (Offshore Area; Inland Waters; and Western Behm Canal, Alaska). As noted above, the information and data on sediments in the West Coast region is primarily based on the National Coastal Condition Assessment – 2010 (U.S. Environmental Protection Agency, 2016a).

3.1.3.1.1 Sediments in the Offshore Area

Data on sediment quality are not available within the boundary of the Offshore Area, which begins 12 NM from shore except for along portions of the Washington coastline where the boundary extends to shore. As described in Section 3.1.1 (Assessment of Sediments), the analysis assumes that sediment quality generally improves with distance from shore and anthropogenic sources of contaminants. Sediment quality in nearshore and estuarine areas along the coastline are used as a proxy for assessing sediment quality in the Offshore Area with the understanding that the offshore sediments are likely in better condition than the coastal sediments. The condition of sediments in the entire West Coast region extending from Puget Sound to the U.S.-Mexico border was rated 31 percent good, 23 percent fair, and 27 percent poor, with 19 percent of data reported missing (U.S. Environmental Protection Agency, 2016a). A classification of "missing" means that data for at least two sediment quality indicators are missing, and the available data do not suggest a fair or poor rating. Compared to sediment quality reported in the 2015 NWTT Final EIS/OEIS, the condition of sediments in the West Coast Region has declined; 89 percent of sediments were rated good in the 2012 National Coastal Condition Report (IV) (U.S. Environmental Protection Agency, 2012b). However, as discussed above, a comparison between the two assessments is not straightforward, because the criteria used to assess sediment quality have changed.

Within the portion of the West Coast region bordering the Study Area, the condition of sediments is rated higher, with 53 percent good, 17 percent fair, and 21 percent poor, with 9 percent of data reported missing (Figure 3.1-1). Sediment toxicity is the main contributor to poor sediment conditions. Just 57 percent of sediments rated good, 11 percent fair, and 21 percent poor for sediment toxicity, with 11 percent of data reported missing. Sediment toxicity measurements assess the additive and synergistic effects of chemical combinations, both human-derived and naturally occurring chemicals, and the ability of organisms to survive and reproduce in that environment (U.S. Environmental Protection Agency, 2016b). Sediment chemistry, which is a measurement of the concentrations of individual contaminants or classes of contaminants in sediments, was rated much higher at 88 percent good, 4 percent fair, and 0 percent poor, with 9 percent of data reported missing (U.S. Environmental Protection Agency, 2016c).

Some of the sites reporting poor sediment conditions were located north of the Columbia River Estuary, which is downstream of the major metropolitan area surrounding Portland, Oregon, and adjacent to Willapa Bay in Washington. Contaminants flowing downstream from Portland and into the Columbia River Estuary and adjacent coastal areas likely contribute to poor sediment conditions in this area (Figure 3.1-1).



Source: U.S. Environmental Protection Agency (2016a)

Figure 3.1-1: Sediment Quality Adjacent to the Offshore Area

3.1.3.1.2 Sediments in the Inland Waters

The condition of sediments in the Inland Waters region of the Study Area, including the Strait of Juan de Fuca, Puget Sound, Hood Canal, and surrounding the San Juan Islands, is reported as 46 percent good, 19 percent fair, and 15 percent poor, with 19 percent of data reported missing (Figure 3.1-2). Similar to the coastal sediments, poorly rated sediment conditions in the Inland Waters region is driven more by sediment toxicity than the mean concentrations of contaminants in sediments (i.e., sediment chemistry). Fifty-four percent of sediments were rated good for toxicity, 19 percent poor, and 26 percent of data were reported missing. By contrast, 77 percent of sediments in the Inland Waters region were rated good for sediment chemistry and 4 percent were rated fair, with 19 percent of data reported missing. No sediments were rated poor for sediment chemistry (U.S. Environmental Protection Agency, 2016c). The Washington State Department of Ecology surveys sediment quality in Washington State inland waters, including the eastern portion of the Strait of Juan de Fuca, Puget Sound, the San Juan Islands, Whidbey Island Basin, Bainbridge Basin, and Admiralty Inlet. The most recent survey results for each of these areas that have become available since the 2015 NWTT Final EIS/OEIS are summarized below. As noted above, a comparison between the previous assessments in the National Coastal Condition Reports (I–IV) and the most recent assessment in the National Coastal Condition Assessment is not straightforward, because the criteria used to assess sediment quality have changed.

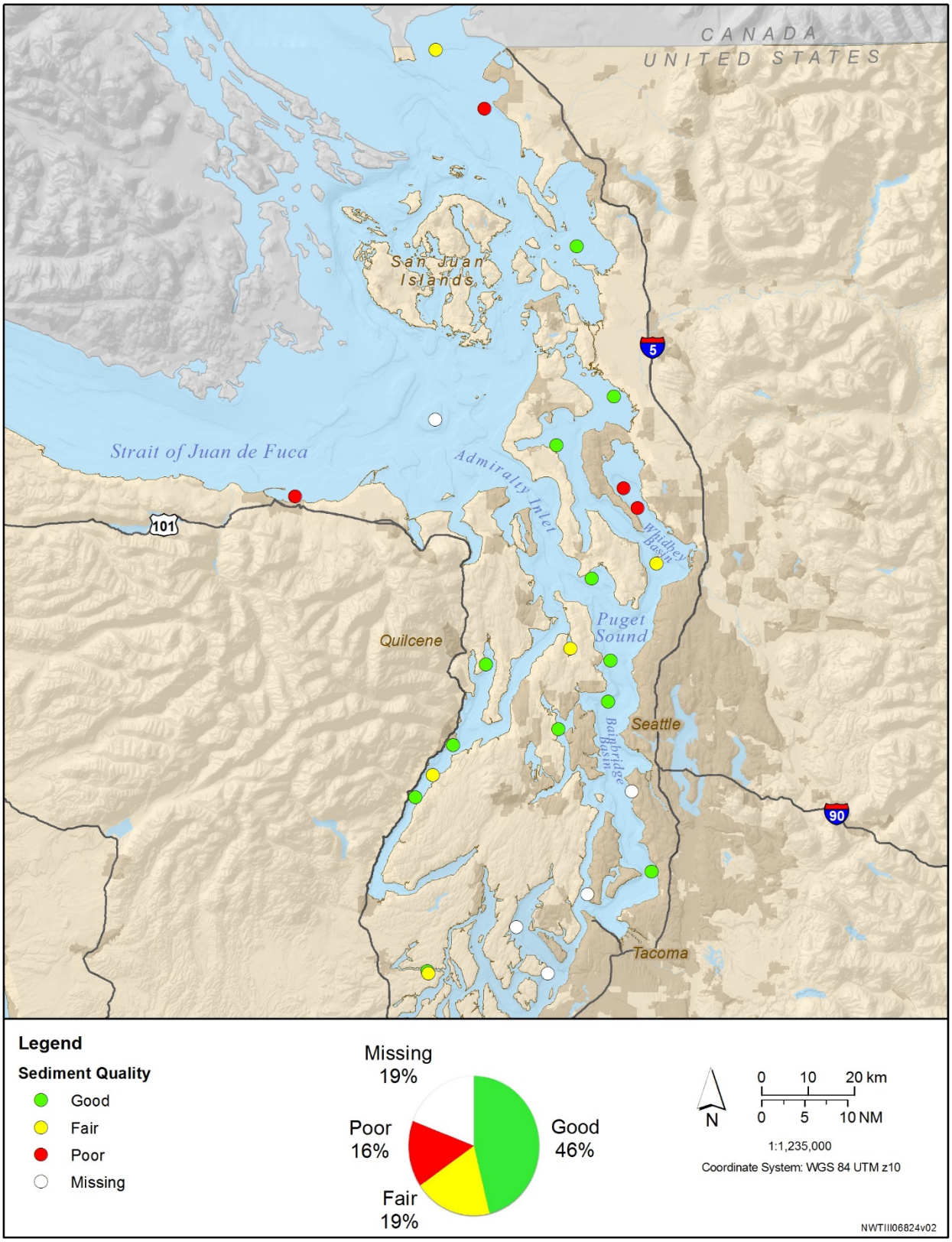
Sediment contaminant concentrations, sediment toxicity, and benthic invertebrate data were collected from multiple locations in each area and combined into indices measuring sediment chemistry, toxicity, benthic invertebrate conditions, and a triad index, which combines the three other measurements.

3.1.3.1.2.1 Eastern Strait of Juan de Fuca

Overall, sediment quality in the eastern Strait of Juan de Fuca has not changed significantly over the 10-year period from 2003 to 2013, based on samples collected from 40 randomly selected sites (Weakland et al., 2015). Sediment chemistry in 2013 was rated 97 percent good and 3 percent fair and above target thresholds. While areas rated good for sediment toxicity decreased between 2003 and 2013, and areas rated poor and fair increased, the differences were not statistically significant. The benthic index remained unchanged between 2003 and 2013 and continued to indicate that 64 percent of benthic invertebrates were adversely affected by benthic conditions. The triad index remained below target thresholds in 2013. The percentage of unimpacted sediments (36 percent) remained the same as in 2003, and the percentage of “possibly impacted” and “inconclusive” areas increased slightly (Weakland et al., 2015).

3.1.3.1.2.2 Puget Sound

Overall, sediment quality in south Puget Sound (south and west of the Tacoma Narrows) as of 2011 remained unimpacted in about two-thirds of the areas sampled, which is approximately the same as in 1999, based on samples collected from 55 randomly selected sites (Partridge et al., 2014a). Both the sediment chemistry and triad indices were above target thresholds in 1999 and 2011. The largest change was in the sediment toxicity index, which showed that 97 percent of sampled areas were rated as non-toxic in 1999 and just 48 percent rated as non-toxic in 2011. Low-to-moderate toxicity occurred in 43 percent of sediment samples, and one site in Budd Inlet, northeast of Olympia, was rated as having high toxicity in the 2011 data.



Source: U.S. Environmental Protection Agency (2016a)

Figure 3.1-2: Sediment Quality in the Inland Waters Area

Sediment samples collected from 80 locations in the central Puget Sound, from Possession Sound south to Tacoma Narrows and including Seattle and Tacoma, in 1998–1999 were compared to samples collected in 2008–2009 (Partridge et al., 2013a). Overall, sediment quality in central Puget Sound decreased over the 10-year period. The change was driven by a decrease in the benthic index, indicating that a larger portion of benthic invertebrate communities in central Puget Sound were classified as adversely affected by natural and human-related stressors in the 2008–2009 samples. Also, the spatial extent of likely impacted sediments (a metric of the triad index) increased and the extent of unimpacted sediments decreased. Sediments with high toxicity measurements were located at stations in Sinclair Inlet (near Bremerton), Dyes Inlet, and Liberty Bay.

3.1.3.1.2.3 San Juan Islands

Overall, sediment quality in the San Juan Islands did not change between surveys in 2002–2003 and surveys in 2012, based on samples collected from 40 randomly selected sites (Partridge et al., 2014b). Sediment quality remained high in 2012. All survey areas had minimum exposure to chemical contaminants, 92 percent of sediments had no toxicity (the remaining 8 percent had low toxicity), and the triad and chemistry indices met or exceeded target thresholds.

3.1.3.1.2.4 Admiralty Inlet

Overall, sediment quality in Admiralty Inlet decreased between baseline surveys conducted in 1998 and 2002–2003 and surveys conducted in 2014, based on samples collected from 43 randomly selected sites (Weakland et al., 2016). Even with the decrease in sediment quality, target thresholds for sediment chemistry and the triad index were exceeded in 2014 (as they were in the baseline survey years). One hundred percent of sampled areas in the baseline surveys were reported as having minimum exposure to sediment contaminants, as measured by the Sediment Chemistry Index. In 2014, only 76 percent were reported as having minimum exposure and the remaining 24 percent were determined to have low exposure to contaminants. A decrease in the benthic index, indicating that a larger portion of benthic invertebrate communities in Admiralty Inlet were classified as adversely affected in the 2014 samples, was the driver reducing overall sediment quality. In the baseline surveys, just 4 percent of sampled areas were rated adversely affected by natural and human-related stressors, and in 2014 the portion increased to 23 percent.

3.1.3.1.2.5 Bainbridge Basin

Overall, sediment quality in Bainbridge Basin (west of Bainbridge Island) declined between surveys conducted in 1998 and surveys conducted in 2009, based on samples collected from 33 randomly selected sites (Weakland et al., 2013). The sediment chemistry index (measuring contaminant concentrations) remained consistent over the 11-year period. However, sediment toxicity increased, benthic conditions declined, and the triad index showed that the percentage of likely impacted sediments increased from 0 percent in 1998 to 16 percent in 2009. Likely impacted sediments occurred in Liberty Bay, southern Dyes Inlet, Phinney Bay, and adjacent to the southern shore of Sinclair Inlet.

3.1.3.1.2.6 Whidbey Basin

Overall, sediment quality in Whidbey Basin remained the same between baseline surveys conducted in 1997 and surveys conducted in 2007, based on samples collected from 40 randomly selected sites (Partridge et al., 2013b). While overall sediment quality remained consistent over the 10-year period, the four individual indices (sediment chemistry, toxicity, benthic conditions, and the triad index) all showed statistically significant improvements. The percentage of sediments with minimum exposure to contaminants improved from 91 percent in 1997 to 97 percent in 2007. Sediments sampled near Everett

that were rated to have moderate to maximum exposure to chemical contaminants in 1997 were rated as having low exposure in 2007. The percentage of non-toxic sediments in Whidbey Basin increased slightly from 94 percent to 95 percent over the 10 years. Sediments at one sample site near Everett were determined to have high toxicity; however, this was an improvement over the 1997 results when multiple sites were rated to have high toxicity. Benthic conditions improved in Whidbey Basin from 1997 to 2007, but 53 percent of sampled sediments remained adversely affected by natural and human-caused stressors.

3.1.3.1.3 Sediments in Western Behm Canal

Sediments in southeast Alaska were not included in the recent National Coastal Condition Assessment – 2010 report (U.S. Environmental Protection Agency, 2016a). Data from the National Coastal Condition Report IV (U.S. Environmental Protection Agency, 2012b), were reported in Section 3.1 (Sediments and Water Quality) of the 2015 NWTT Final EIS/OEIS, and at that time sediment conditions in southeast Alaska were rated 92 percent good and 8 percent fair. There is no scientifically derived data reporting that conditions have changed appreciably since 2015.

3.1.3.2 Marine Debris, Military Expended Materials, and Marine Sediments

A comprehensive review of anthropogenic marine debris, particularly plastics, and their worldwide distribution highlights the growing concern over global environmental impacts and the need for continued scientific research and improved waste disposal management practices (Bergmann et al., 2015). Since the publication of the 2015 NWTT Final EIS/OEIS, which reported on marine debris collected during groundfish surveys in 2007 and 2008, including items of military origin (Keller et al., 2010), the predominance of plastics, and particularly microplastics has become the focus of research on the impacts of anthropogenic debris on the marine environment (Bergmann et al., 2015).

From the early 1970s to the mid-2000s the amount of marine debris that has accumulated in the North Pacific from latitude 25 to 41°N and longitude 130 to 180°W, an area known as the "Garbage Patch," has increased by more than 100 times to a concentration of 459 pieces per square kilometer (Bergmann et al., 2015; Titmus & Hyrenbach, 2011; Venrick et al., 1973). Over 95 percent of that debris was composed of plastics (Titmus & Hyrenbach, 2011), highlighting the critical importance of improving our understanding of how plastics behave in the marine environment and how they impact marine species and habitats, including seafloor sediments.

Many types of plastic are buoyant and will float for years or indefinitely, depending on size and composition, allowing them to be transported thousands of miles in the ocean (U.S. Commission on Ocean Policy, 2004). Although plastics are highly resistant to degradation, when exposed to ultraviolet radiation from the sun they will gradually break down through a process called photo oxidation. However, once plastic debris sinks below the photic zone, degradation rates become much slower, and degradation rates are further reduced once plastic debris reaches the seafloor (Amon et al., 2020; Cauwenberghe et al., 2013; Law et al., 2010). Microbial degradation of plastics in marine sediments does occur but has a negligible impact on the amount of plastic that persists in the environment, because the process is slow and often occurs under low-oxygen or even anoxic conditions (Andrady, 2015). Plastics can take hundreds of years to degrade; some plastics may never fully degrade and would persist in the environment indefinitely (Bergmuller et al., 2007).

Microplastics (pieces < 1 millimeter [mm] in size) are pervasive in the marine environment and occur not only in coastal sediments and on the continental shelf but have recently been discovered in deep sea sediments at multiple locations worldwide in depths ranging up to 5,000 m (Cauwenberghe et al., 2013;

Woodall et al., 2014). The average concentration of microplastics in deep sea sediments is estimated to be 200 pieces/m^2; however, this estimate is based on a limited number of samples and could vary widely (Cauwenberghe et al., 2013). No sampling of deep sea sediments has been conducted in the Study Area, but given the accumulation of microplastics in other ocean basins and in surface waters in the Study Area (Doyle et al., 2010), it is likely that microplastic debris is also present in the deep sea sediments of the Study Area.

While sediments in the deep ocean environment are generally considered to be less impacted by anthropogenic debris than areas closer to shore where most debris and pollutants originate, recent studies are revealing that even the most remote ocean areas are accumulating anthropogenic debris (Amon et al., 2020; Chiba et al., 2018). The most common types of debris encountered in deep waters worldwide are plastics (Andrady, 2015; Bergmann et al., 2015; Chiba et al., 2018); however, metal debris is also prevalent. Metal items typically accumulate in shallower waters closer to land-based sources due to their greater weight which forces metal items to settle on the seafloor while lighter plastic items are transported farther into deeper waters. The study conducted by Amon et al. (2020) in the central and western Pacific Ocean identified ammunition and bombs in their catalogue of metal debris, attributing their occurrence in the deep sea environment to World War II. Of all debris encountered, they estimate that 5.2 percent was related to the War.

3.1.3.3 Climate Change and Sediments

Climate change can affect sediments by increasing ocean acidity (i.e., lowering pH), changing storm activity, and influencing coastal upwelling (Cao et al., 2014; Wang et al., 2015). Breitbarth et al. (2010) referred to seawater temperature and pH as "master variables for chemical and biological processes." As pH decreases and conditions become more acidic, metals tend to dissociate (or detach) from sediment particles to which they are bound, becoming more soluble, and reenter the water column. Higher concentrations of metals in the water column may become more bio-available and lead to concerns over toxicity in biological resources, including those at higher trophic levels (Poloczanska et al., 2016).

Climate change and the associated warming of sea surface temperatures in the oceans is likely to increase the occurrence of more intense tropical cyclones and major storms (National Oceanic and Atmospheric Administration, 2017). Major storms can cause substantial resuspension and redistribution of bottom sediments, particularly in shallow nearshore and inland waters (Wren & Leonard, 2005). Subsequently, disturbance of marine sediments can adversely impact water quality in nearshore and coastal areas where excess turbidity reduces water clarity, and contaminants imbedded in sediments are resuspended and become more widely distributed. In the Pacific Northwest, climate change may alter the coastal marine environment by increasing water temperature, vertical stratification in the water column, and the number of extreme precipitation events; and by changing the intensity and timing of coastal winds that drive all-important upwelling events (Wang et al., 2015; Wang et al., 2009). These climate-related phenomena would not occur independently of each other and could potentially accelerate the onset of climate change effects on the marine environment should they occur synergistically (Poloczanska et al., 2016).

It is important to note that the effects of climate change on the marine environment overall are projected with a high degree of uncertainty (Cao et al., 2014). An apparent hiatus in the warming trend of sea surface temperatures in both the North Atlantic and North Pacific over the last decade has caused climate scientists to reconsider climate models that have been projecting an increase in temperature. Recently, researchers concluded that the warming trend has been obscured by naturally occurring

variability in climate cycling (referred to as the Pacific Multi-decadal Oscillation in the North Pacific), which drives a decrease in sea surface temperatures, offsetting and obscuring the projected warming associated with climate change (England et al., 2014; Steinman et al., 2015). Results reported by Cheng et al. (2020) confirm the persistence of the warming trend. Their analysis of ocean temperatures revealed that 2019 was the warmest year in recorded history, and the top five warmest years are also the previous five years (2015 through 2019). The warming trend, particularly in the top 2,000 m, is apparent in global ocean data housed in the World Ocean Database. The trend is a strong indicator of global climate change, because 90 percent of the planet's excess heat is stored in the world's oceans, and the authors attribute the trend to increases in greenhouse gas emissions (Cheng et al., 2020). Further discussion on the effects of climate change is provided in Section 3.1.3.6 (Climate Change and Marine Water Quality) and in the 2015 NWTT Final EIS/OEIS.

3.1.3.4 Water Quality in the Study Area

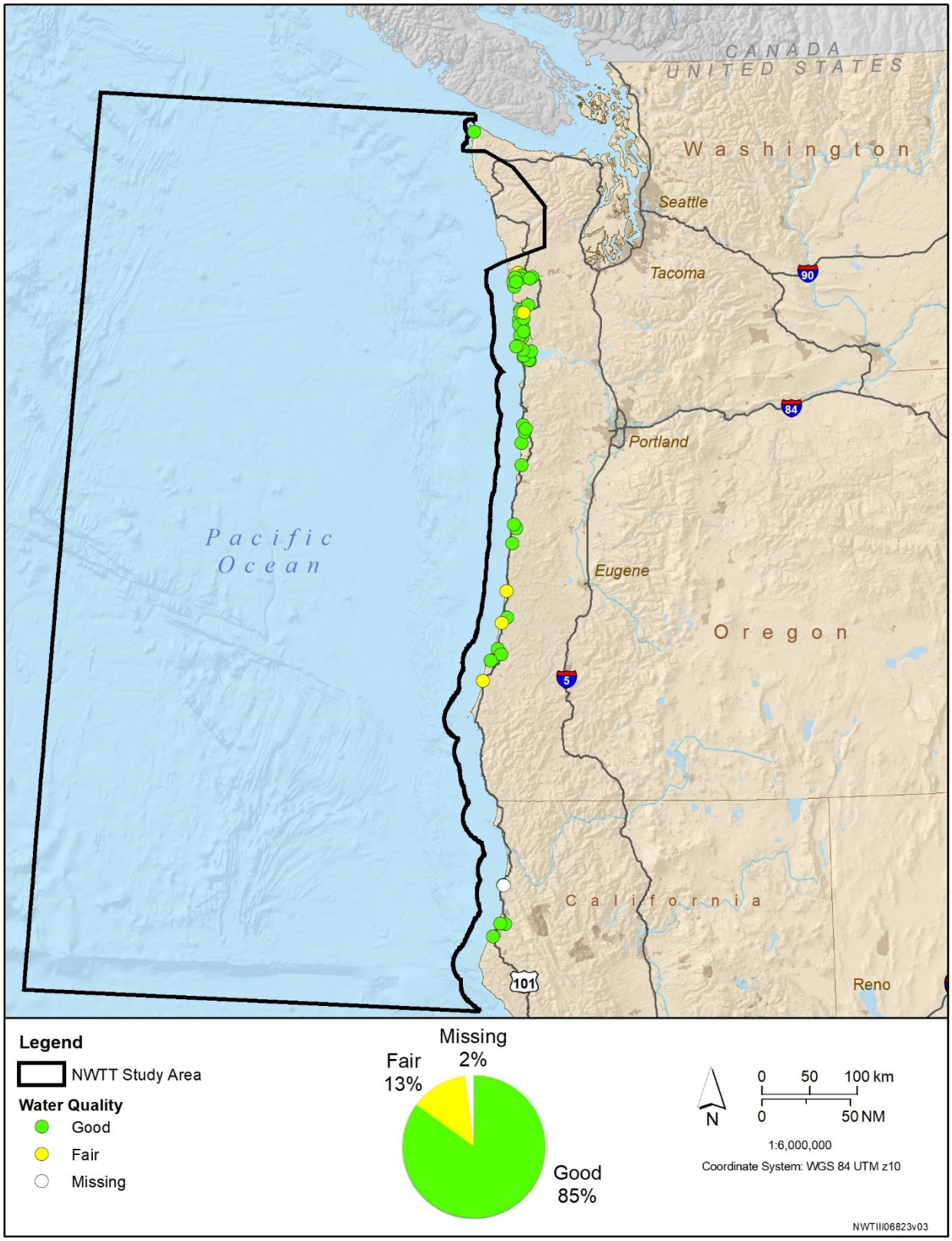
The status of water quality in the Study Area remains largely the same as described in Section 3.1 (Sediments and Water Quality) of the 2015 NWTT Final EIS/OEIS. As noted above in Section 3.1.2 (Assessment of Water Quality), the criteria for evaluating water quality have not changed since publication of the 2015 NWTT Final EIS/OEIS (U.S. Environmental Protection Agency, 2016b).

In general, the environmental contaminants that degrade marine water quality in the Study Area include suspended solids, sediments, nutrients and organic materials (i.e., detritus), metals, synthetic organic compounds (e.g., pesticides and plastics), and pathogens. Sources of these contaminants include runoff from urban and agricultural areas (nonpoint source pollution), commercial and recreational vessels, oil spills, industrial and municipal discharges (point source pollution), legal and illegal ocean dumping, and poorly treated or untreated sewage released into coastal waters (U.S. Environmental Protection Agency, 2016a).

3.1.3.4.1 Water Quality in the Offshore Area

As described in the 2015 NWTT Final EIS/OEIS, water quality in the Offshore Area is influenced by ocean circulation patterns in the North Pacific, particularly the California Current System; freshwater inflow from the Columbia River; large-scale eddies like the semi-permanent eddy off the mouth of the Strait of Juan de Fuca; and prevailing winds (onshore vs. offshore) which influence coastal upwelling (Hickey & Banas, 2003).

In the National Coastal Condition Assessment – 2010 report, the water quality index for coastal waters adjacent to the Offshore Area was rated 85 percent good, 13 percent fair, with 2 percent of data reported missing (Figure 3.1-3) (U.S. Environmental Protection Agency, 2016a). As described above, the water quality index is based on measurements of five component indicators: dissolved inorganic nitrogen, dissolved inorganic phosphorous, chlorophyll-*a*, water clarity, and dissolved oxygen. In coastal waters adjacent to the Offshore Area, all indicators except for chlorophyll-*a* concentrations improved from the 2005-2006 survey results to the 2010 survey results as reflected by increases in the percentage of "good" ratings (U.S. Environmental Protection Agency, 2016a). Coastal waters in the Study Area were rated 96 percent good for both dissolved inorganic nitrogen and dissolved inorganic phosphorus, and 94 percent good for dissolved oxygen. Light transmission, a measure of water clarity, was rated 77 percent good (U.S. Environmental Protection Agency, 2016d). Chlorophyll-*a* concentration, the one indicator that declined, was rated 55 percent good, 42 percent fair, and 2 percent poor with the remaining 2 percent of data reported missing (U.S. Environmental Protection Agency, 2016d).



Source: U.S. Environmental Protection Agency (2016a)

Figure 3.1-3: Water Quality Adjacent to the Offshore Area

Chlorophyll-*a* concentration is a surrogate metric for phytoplankton abundance in surface waters and may be indicative of algal blooms and eutrophication in aquatic systems (Cloern, 2001; Harvey et al., 2015). High phytoplankton abundance in the marine environment is often fueled by elevated levels of nutrients, such as nitrogen and phosphorus, coinciding with the availability of sunlight (Conley et al., 2009). Phytoplankton blooms degrade water quality by reducing or eliminating dissolved oxygen needed by other species (i.e., creating "dead zones"), reducing water clarity and light transmission deeper into the water column, and, if a harmful algal bloom species is present, releasing toxins into the water that can sicken or kill fish, shellfish, and consumers of those species, including humans (Conley et al., 2009; Glibert et al., 2005; Kudela et al., 2005).

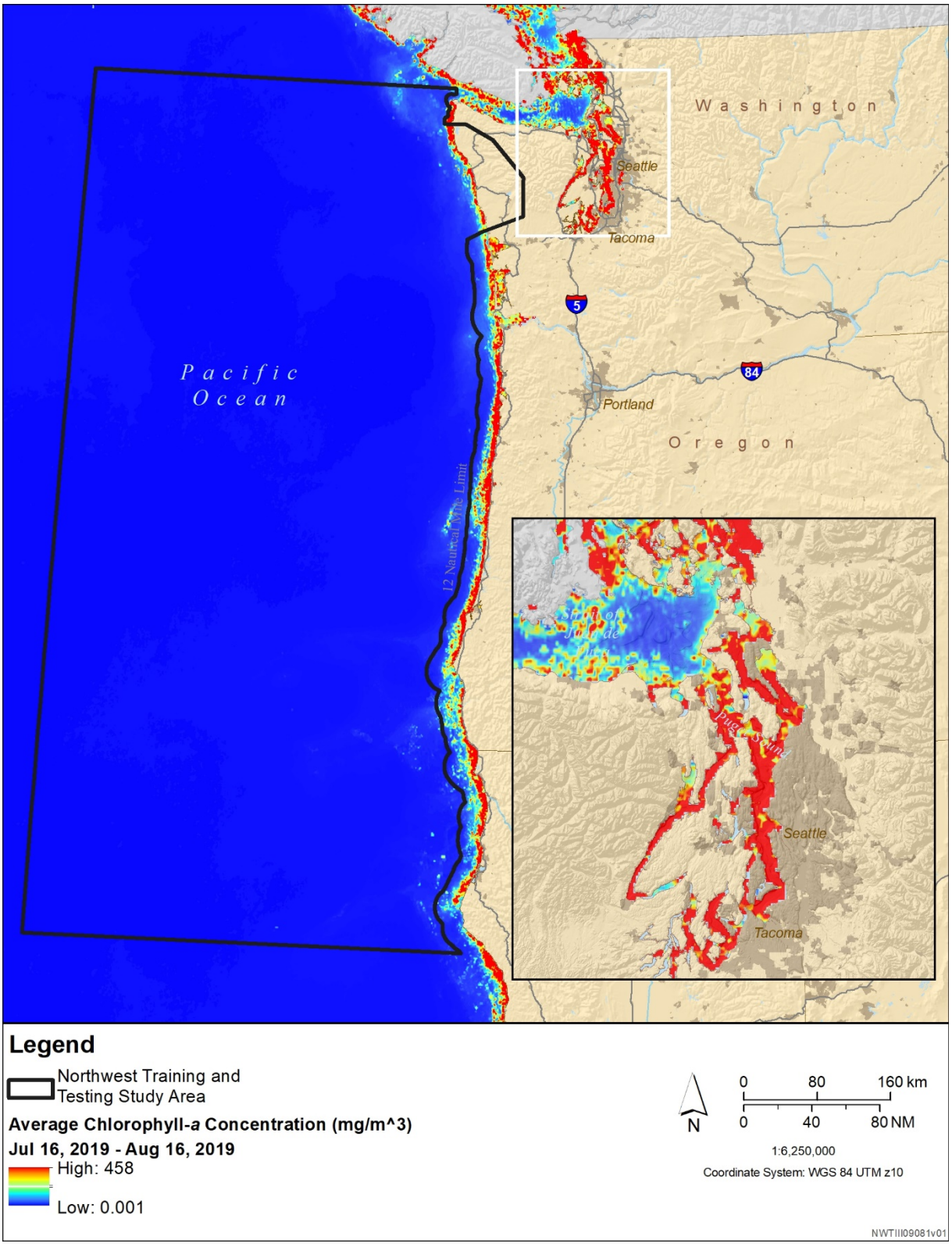
Anthropogenic sources of nutrients include runoff of chemical fertilizers (consisting largely of nitrogen and phosphorous compounds), atmospheric deposition originating from nearby coastal developments, sewage, and, in some locations, aquaculture (Anderson et al., 2002). An influx of nutrients from anthropogenic sources into nearshore and inland waters, including Puget Sound, through runoff from adjacent urban and agricultural regions contributes substantially to poor water quality (Chow et al., 2019; Cloern, 2001; Glibert et al., 2005; Harvey et al., 2015; Puget Sound Federal Task Force, 2018).

Phytoplankton abundance on a broad spatial scale is assessed by satellite-based remote sensing of ocean color, which highlights areas with high concentrations of chlorophyll-*a* (Harvey et al., 2015; Kilpatrick et al., 2018; Legaard & Thomas, 2006).

In the Offshore Area, chlorophyll-*a* concentrations are highest in nearshore waters and predominantly shoreward of the Study Area (Figure 3.1-4, Figure 3.1-5). The influence of anthropogenic sources decreases with distance from shore as the concentration of nutrients in runoff and in tributaries (e.g., the Columbia River) is diluted and nutrients are consumed. As a result, the concentration of chlorophyll-a in the Offshore area is relatively low. The concentration of chlorophyll-*a* varies seasonally as well as spatially (Legaard & Thomas, 2007), with higher concentrations in the Offshore Area occurring in summer when sunlight exposure is longer and seasonal upwelling along the coast brings nutrient-rich waters to the surface (Kilpatrick et al., 2018). While the extent of the highest concentration areas decreases in winter, the effects of nutrient loading from the Columbia River is more evident in winter when the plume flows northward along the coast (Figure 3.1-5). Note that isolated areas of high chlorophyll-*a* concentration in the offshore area in winter are likely due to atmospheric scatter rather than representative of actual areas of phytoplankton abundance.(Anderson et al., 2002)

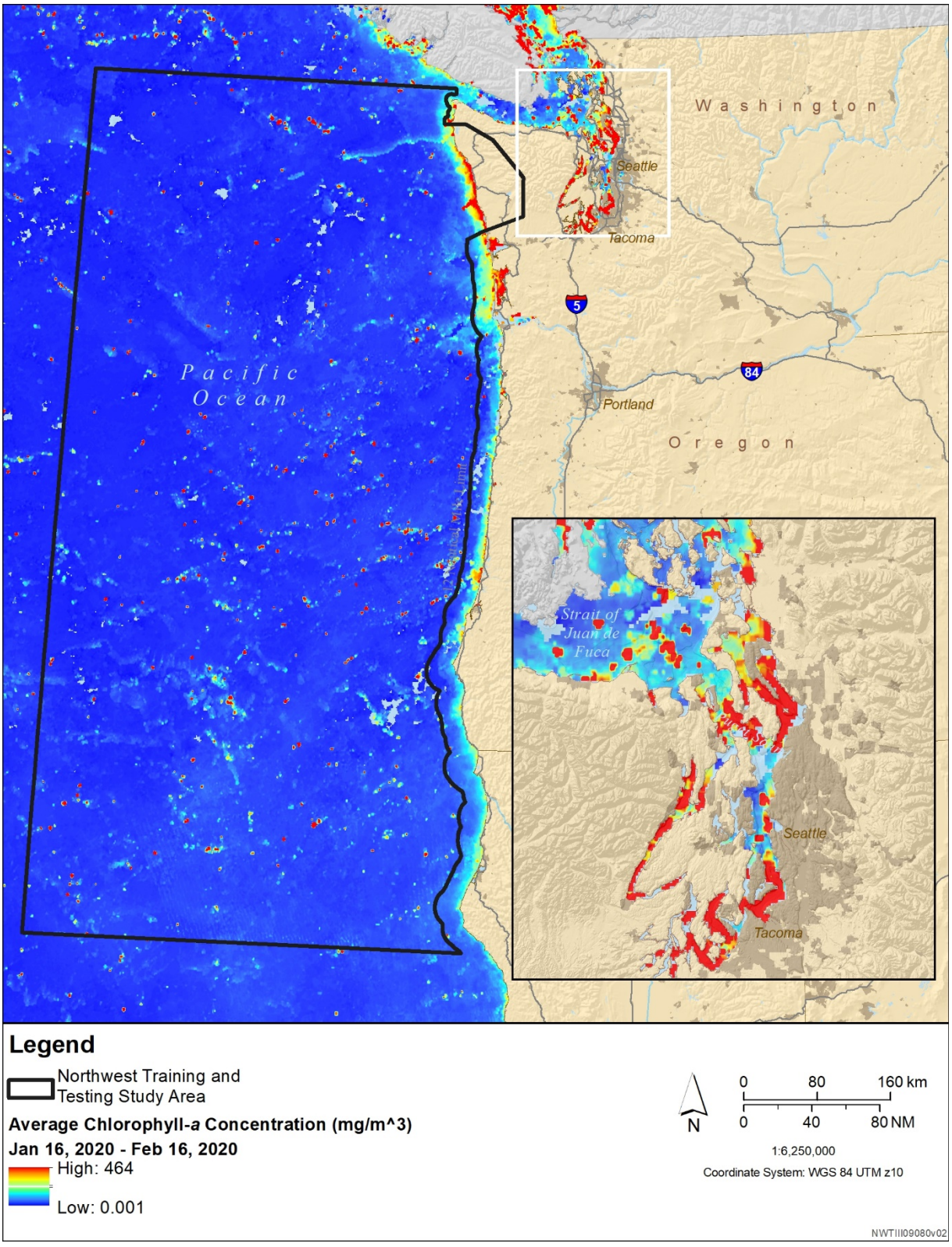
3.1.3.4.2 Water Quality in the Inland Waters

Water quality in the Inland Waters region of the Study Area, including the Strait of Juan de Fuca, Puget Sound, Hood Canal, and surrounding the San Juan Islands, is reported as 81 percent good, 15 percent fair, with 4 percent of data reported missing (Figure 3.1-6) (U.S. Environmental Protection Agency, 2016d). The chlorophyll-*a* indicator declined for the entire West Coast region in the National Coastal Condition Assessment-2010, and in the Inland Waters portion of the Study Area, just 50 percent of sites were rated good for chlorophyll-*a* (U.S. Environmental Protection Agency, 2016d). At the remaining sites, chlorophyll-*a* was rated 38 percent fair, 4 percent poor, and 8 percent of data were reported missing (U.S. Environmental Protection Agency, 2016a, 2016d). Satellite-based remote sensing data show that areas with higher chlorophyll-*a* concentrations are more widespread in the Inland Waters than offshore (Figure 3.1-4, Figure 3.1-5), in large part due to the enclosed geomorphology of Puget Sound and the proximity to anthropogenic sources of nutrients available through runoff and atmospheric deposition. As in the Offshore Area, higher chlorophyll-*a* concentrations occur in summer, due mainly to the greater availability of sunlight driving phytoplankton growth.



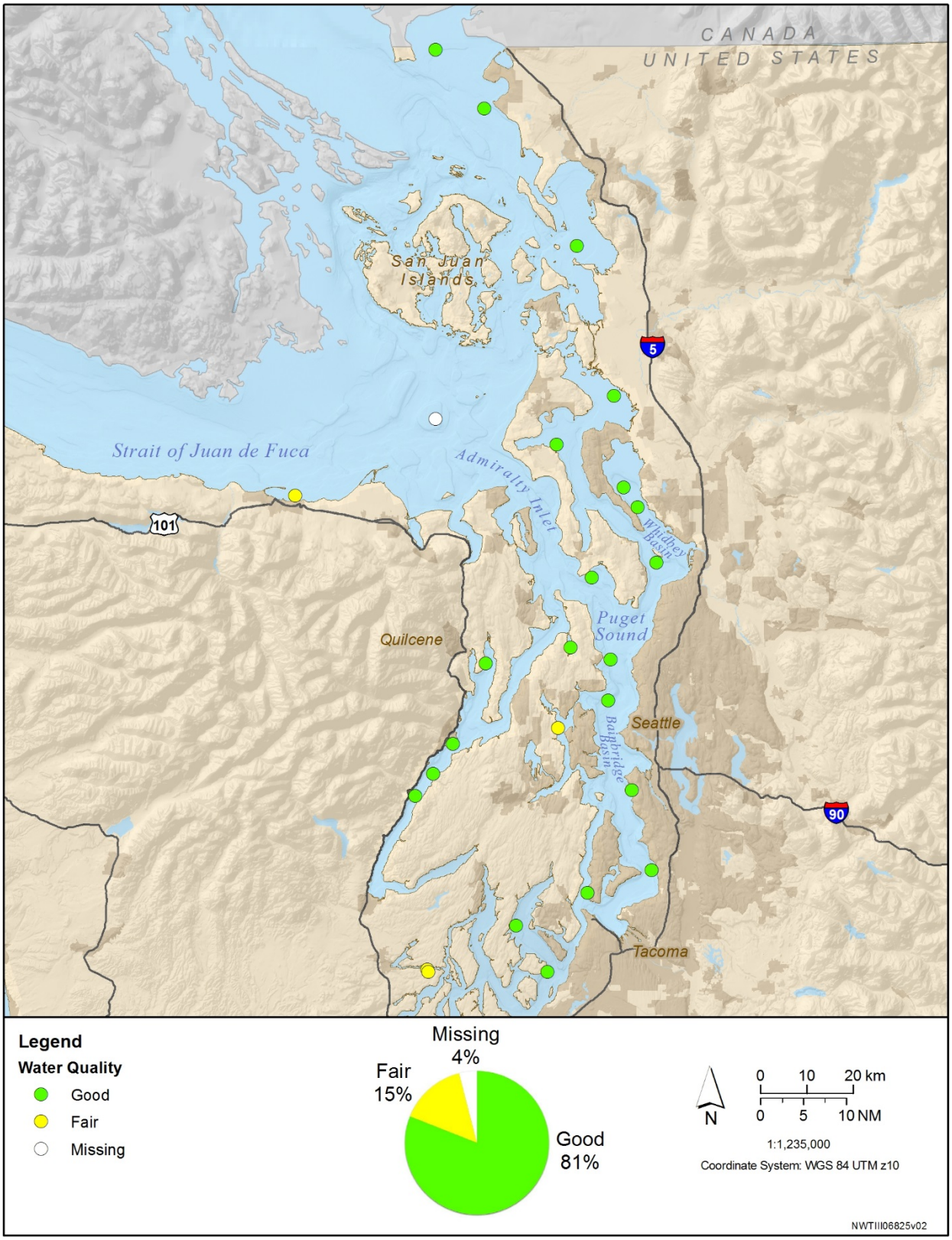
Source: Central and Northern California Ocean Observing System (2020)

Figure 3.1-4: Average Chlorophyll-a Concentration in the Study Area in Summer



Source: Central and Northern California Ocean Observing System (2020)

Figure 3.1-5: Average Chlorophyll-a Concentration in the Study Area in Winter



Source: U.S. Environmental Protection Agency (2016a)

Figure 3.1-6: Water Quality in the Inland Waters Area

In contrast, dissolved inorganic nitrogen was rated good at 93 percent of sites, dissolved inorganic phosphorous was rated good for 81 percent of sites, dissolved oxygen was rated good at 62 percent of sites, and light transmission was rated good at 92 percent of sites (U.S. Environmental Protection Agency, 2016d). These conditions are similar to those reported in the 2015 NWTT Final EIS/OEIS, which highlighted eutrophication (linked to high chlorophyll-a concentrations) and low dissolved oxygen levels as issues of concern in the Inland Waters area. Anthropogenic influences including urban runoff, treated effluent, and agricultural runoff, coupled with low levels of mixing and flushing in much of south Puget Sound continue to cause and exacerbate poor water quality conditions.

3.1.3.4.3 Water Quality in Western Behm Canal

Water quality in southeast Alaska was not included in the recent National Coastal Condition Assessment – 2010 report (U.S. Environmental Protection Agency, 2016a). Data from the National Coastal Condition Report IV (U.S. Environmental Protection Agency, 2012b), were reported in Section 3.1 (Sediments and Water Quality) of the 2015 NWTT Final EIS/OEIS, and at that time sediment conditions in southeast Alaska were rated 95 percent good and 5 percent fair.

3.1.3.5 Marine Debris and Marine Water Quality

Plastic debris has been accumulating in the marine environment for decades and will continue to do so as the production and disposal of plastic products and materials continues to grow worldwide (Bergmann et al., 2015; Cozar et al., 2014; Doyle et al., 2010). Plastic debris accumulates in surface waters in the open ocean mainly but not exclusively at convergence zones associated with the large subtropical gyres that dominate circulation in the ocean basins (Cozar et al., 2014). Plankton surveys conducted in 2006 and 2007 off the U.S. West Coast, including in the Study Area, and in the southeast Bering Sea off the coast of Alaska, documented the ubiquitous distribution and persistence in the marine environment of plastic debris, particularly plastic particles < 2.5 mm in size (Doyle et al., 2010).

Comparatively little information is available on the types and abundance of marine debris occurring in coastal waters near unpopulated areas and on remote beaches, including portions of the Study Area. Since the publication of the 2015 NWTT Final EIS/OEIS, which reported on marine debris collected during groundfish surveys in 2007 and 2008, including items of military origin (Keller et al., 2010), the predominance of plastics, and particularly microplastics, has become the focus of research on the impacts of anthropogenic debris on the marine environment (Bergmann et al., 2015). Davis and Murphy (2015) summarized the results of two independent studies quantifying the distribution of plastic debris along the Inside Passage to Skagway, Alaska, and in inland waters of British Columbia, Canada, and northern Washington, including the Strait of Juan de Fuca and Puget Sound. No plastic debris was collected at a number of sites along the Inside Passage; however, a concentration of up to 200,000 pieces per square kilometer was found in surface waters off Ketchikan, which is located approximately 15 miles south of the Southeast Alaska Ocean Measurement Facility in Western Behm Canal. Ninety-five percent of all debris collected from surface waters during the survey consisted of micro polystyrene foam (< 5 mm in size) and another 1.4 percent consisted of larger pieces of polystyrene foam (Davis & Murphy, 2015).

Polasek et al. (2017) conducted a survey of five National Park Service areas located along the western and southern coasts of Alaska. While the survey areas were all located north of Behm Canal, the ocean circulation in the Gulf of Alaska and the eastern North Pacific is such that similar types of debris could be transported to the beaches and coastal areas of southeast Alaska. All 28 beaches that were surveyed

had marine debris. Hard plastic debris was found on all beaches, and foam (polystyrene) was found at every beach except for one. Various types of rope or netting were present on 23 of the 28 beaches.

Marine debris is also routinely collected along Washington beaches including those adjacent to the Olympic Coast National Marine Sanctuary. Since the earthquake and tsunami that struck Japan in 2011, there has been an increase in the amount of debris slowly moving across the North Pacific and being deposited on beaches and in coastal areas of North America (National Oceanic and Atmospheric Administration, 2016).

Overall, plastic contributed to 60 percent of the total weight of all debris. Given the amount of and nearly universal occurrence of plastic debris found during the survey, it is probable that similar types of debris occur in or near Behm Canal.

Specifically for the Inland Waters, over 600 citizen scientists collected micro debris from sandy beaches, including the eastern portion of the Strait of Juan de Fuca, the San Juan Islands, Puget Sound, and Hood Canal, twice per year from the fall of 2008 through the spring of 2011 (Davis & Murphy, 2015). The surveys were systematic, employing a quadrant-based sampling method, and supervised by researchers to maintain strict protocols. While beaches are not part of the Study Area, debris found at the high tide line on beaches and other shoreline areas are indicative of the types and quantities of debris in the marine and estuarine habitat of the Study Area. Debris was found on 363 of the 402 quadrants (over 90 percent) that were surveyed on 37 beaches in the Inland Waters portion of the Study Area. Pieces of foam (polystyrene) comprised nearly 70 percent of the total count, and plastic fragments and glass made up 11 percent each. Based on these results, Davis and Murphy (2015) estimate that 72 million pieces of debris weighing 5.8 tons are located in a 1 m wide band stretching along all 733 miles of sandy beach habitat in the Salish Sea (which includes the Inland Waters area). This total almost certainly underestimates the total amount of debris in the coastal area, because it excludes debris washed up on other shoreline habitats (e.g., rocky or muddy areas), which make up the remaining 1,733 mi. of coastline. The authors also concluded that debris in the Salish Sea is from local sources and not transported into inland waters from the Pacific Ocean.

3.1.3.6 Climate Change and Marine Water Quality

Marine water quality may be affected in several ways by climate change, such as a decrease in ocean pH (i.e., increasing ocean acidity), a rise in sea surface temperatures, and an increase in the frequency and intensity of extreme storms. As noted above in Section 3.1.3.3 (Climate Change and Sediments), changes in sediment chemistry and disturbance and resuspension of sediments can reduce water quality by increasing turbidity (reducing water clarity), resuspending contaminants, and enabling contaminants to dissociate from particulate matter and remain in the water column (Cao et al., 2014; Schiedek et al., 2007; Wang et al., 2015). Similar effects of climate change on freshwater ecosystems upstream of coastal and inland estuarine waters can exacerbate the direct impacts from climate change on those water bodies (Whitehead et al., 2009). Additional information on how climate change affects marine water quality is presented below and includes research published since the 2015 NWTT Final EIS/OEIS.

Marine invertebrates that use calcium carbonate to construct and maintain their shells and skeletal structures (e.g., corals and cocolithophores—a single-celled phytoplankton) are particularly susceptible to increases in ocean acidity, which is a projected effect of climate change (Poloczanska et al., 2016). Nevertheless, it is unclear how the combination of decreasing pH and increasing water temperatures affect these organisms, which are an important component of the global food chain (McNeil et al., 2004; Poloczanska et al., 2016; Rivero-Calle et al., 2017). Increases in ocean acidity are believed to reduce the

availability of carbonate in the water column, which is needed by organisms to generate calcium carbonate structures. However, increases in sea surface temperature associated with climate change appear to stimulate calcification at an even greater rate, essentially overriding the inhibiting effects of lower pH levels (McNeil et al., 2004) and leading to unexpected high abundance of cocolithophores in some ocean regions (Rivero-Calle et al., 2017). The world's oceans were the warmest in recorded history in 2019, especially the top 2,000 m, and the top five warmest years are also the previous five years (2015 through 2019). The trend is a strong indicator of global climate change, because 90 percent of the planet's excess heat trapped in the earth's climate by greenhouse gasses is stored in the world's oceans (Cheng et al., 2020).

Concerns over climate change modifying the U.S. West Coast upwelling patterns, increasing levels of hypoxia and resulting in ocean acidification have generated targeted research and monitoring efforts at selected "Sentinel Sites" (Lott et al., 2011). The Olympic Coast National Marine Sanctuary, located along the coast of Washington State and extending between 20 and 40 NM offshore, is one of these monitored sites. Scientific uncertainty remains about how and to what degree the effects of climate change will impact water quality and marine species, but acidification of ocean waters could potentially impact the carbon cycle in the ocean and limit the bioavailability of calcium carbonate, which would have implications for organisms at or near the bottom of the marine food chain.

Phytoplankton blooms, including toxic harmful algal blooms, can be characterized on a large scale using satellite-based remote sensing of chlorophyll-*a* concentrations, another metric for assessing water quality, as noted above (Harvey et al., 2015). However, even non-toxic blooms can cause devastating impacts on the ecosystems in bays and estuaries by creating anoxic (low dissolved oxygen) conditions, which are known to result in large and rapid die-offs of fish and benthic invertebrates (Hallegraeff, 2010). The persistence, location, and extent of plankton blooms are influenced by many of the impacts associated with climate change, including pH, sea surface temperature, and storms.

Changes in the chemistry and temperature of marine waters associated with changes in the global climate are already having dramatic effects on marine ecosystems worldwide, including on the planktonic eggs and larval stages of fish and invertebrates in the California Current Ecosystem (Poloczanska et al., 2016). For some species, changing conditions are resulting in shifts in the timing and location of spawning.

3.1.4 Environmental Consequences

Section 3.1 (Sediments and Water Quality) of the 2015 NWTT Final EIS/OEIS analyzed potential impacts of training and testing activities resulting from the following stressors: (1) explosives and explosion byproducts, (2) metals from ordnance and military expended materials, (3) chemicals other than explosives, and (4) other materials. The 2015 NWTT Final EIS/OEIS assessed the likelihood that these stressors would result in the following potential impacts on sediments and water quality:

- The potential release of materials into the water that subsequently disperse, react with seawater, or dissolve over time
- The potential for depositing materials on the seafloor and any subsequent interactions with sediments or the accumulation of such materials over time
- The potential for depositing materials or substances on the seafloor and any subsequent interaction with the water column

- The potential for depositing materials on the seafloor and any subsequent disturbance of those sediments resulting in their resuspension into the water column.

This section evaluates how and to what degree potential impacts on sediments and water quality from stressors described in Section 3.0.1 (Overall Approach to Analysis) may have changed since the analysis presented in the 2015 NWTT Final EIS/OEIS was completed. Tables 2.5-1 through 2.5-3 in Chapter 2 (Description of Proposed Action and Alternatives) list the proposed training and testing activities and include the number of times each activity would be conducted annually and the locations within the Study Area where the activity would typically occur under each alternative. The tables also present the same information for activities described in the 2015 NWTT Final EIS/OEIS so that the incremental changes in the proposed levels of training and testing can be easily identified.

Tables B-1 and B-2 in Appendix B (Activity Stressor Matrices) show which stressors are associated with each proposed training and testing activity and show that many of the proposed activities introduce stressors on sediments and water quality. The annual number and location of activities and items that include various types of stressors that could impact sediments and water quality are shown in Tables 3.0-12 through 3.0-22. Activities using non-explosive practice munitions, for example, (Table 3.0-14) have the potential to impact sediments. The analysis presented in this section also considers the Navy's standard operating procedures described in Chapter 2 (Description of Proposed Action and Alternatives) and mitigation measures described in Chapter 5 (Mitigation) and Appendix K (Geographic Mitigation Assessment). These measures are not specifically designed to offset potential impacts on sediments or water resources; however, implementation of some of these measures intended to mitigate potential impacts on other marine resources analyzed in this Supplemental will minimize or avoid potential impacts on sediments and water quality. For example, Table 5.4-1 lists several protective measures that avoid or minimize disturbance to sensitive habitats (i.e., kelp beds, eel grass, hard bottom areas, and shipwrecks), and these measures would also reduce the disturbance of sediments on the seafloor.

The following stressors are analyzed in this Supplemental:

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

Although stressor names may have changed slightly to remain consistent with other resource sections in this Supplemental, the types of items associated with each stressor are consistent with the items associated with stressors analyzed in the 2015 NWTT Final EIS/OEIS.

3.1.4.1 Explosives and Explosives Byproducts

Explosives are complex chemical mixtures that may affect sediments and water quality through the byproducts of their in-water detonation or through the dispersal of unconsumed explosives into the water column or sediments. Explosive munitions may undergo a high-order detonation or a low-order detonation, or they may fail to detonate. High-order (complete) detonations consume 98–99 percent of the explosive material; the remainder is released into the environment as discrete particles. Low-order (incomplete) detonations consume a lower percentage of the explosive and release larger amounts of explosives materials into the environment. If a munition fails to detonate, the energetic materials it contains may be released into the environment over time as the munitions casing corrodes. In this

discussion, the term "residual explosives" refers to the vast majority of unconsumed explosives remaining after low-order detonations and detonation failures. The term "explosives byproducts" is used to refer to the liquids, gases, and particulate matter that remain after detonation of explosives.

Potential impacts from explosives and explosives byproducts on sediments and water quality were analyzed in detail in Section 3.1.3.1 (Explosives and Explosion Byproducts) in the 2015 NWTT Final EIS/OEIS. The discussion presented below summarizes the results of that analysis and cites studies published since the completion of the 2015 NWTT Final EIS/OEIS.

Over 98 percent of residual explosive materials introduced into the marine environment would result from munitions failures. The remaining 2 percent results from low-order detonations. Failure rates for munitions similar to the munitions used in training and testing activities are between 3 and 5 percent, and low-order detonation rates are less than 0.2 percent (see Table 3.1-8 in the 2015 NWTT Final EIS/OEIS). The majority of explosives byproducts from commonly used explosives materials are naturally occurring compounds in the marine environment (Beck et al., 2018; Lotufo, 2018; Lotufo et al., 2017). For example, 98 percent (by weight) of the explosives byproducts of royal demolition explosive (RDX) consists of nitrogen, carbon dioxide, water, carbon monoxide, ammonia, and hydrogen (see Table 3.1-7 in the 2015 NWTT Final EIS/OEIS).

The analysis that follows focuses on explosives contained in unexploded munitions. In the event of a munitions failure, the explosive materials would remain encased in the intact munition and would have little or no direct exposure to marine waters. Over time, the munitions casing would corrode and may ultimately expose explosive materials to adjacent sediments and the water column (Carniel et al., 2019). Explosive materials deposited in sediments would be limited to small areas surrounding and adjacent to the munition (Beck et al., 2018; Lotufo, 2018). Bottom currents would be expected to transport and disperse explosive materials that leach into the water column slowly over time. As described in detail in Section 3.1.3.1 (Explosives and Explosion Byproducts) in the 2015 NWTT Final EIS/OEIS, the solubility, sorption, and volatility of explosive materials are key factors determining how these materials behave in the marine environment. Unconsumed explosives used in training and testing activities would dissolve slowly over time and thus are not very mobile in marine environments (Beck et al., 2018; Juhasz & Naidu, 2007).

Results reported by Walker et al. (2006) and Beck et al. (2018) demonstrate that trinitrotoluene, RDX, and octogen (HMX) experience rapid biological and photochemical degradation in marine systems. Walker et al. (2006) 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. The mineralization of explosives (RDX and HMX are readily mineralized) requires multiple steps, some of which may be biologically driven (Beck et al., 2018). Tobias (2019) used stable isotope tracers to show that over 50 percent of RDX compounds were mineralized into inert inorganic constituents, particularly in sediments with high organic content. The breakdown of TNT compounds resulted in aqueous (i.e., in a water solution) organic constituents, suggesting that TNT constituents remain suspended in the water column. The results are consistent with observations by Montgomery et al. (2011) that showed TNT may degrade at higher rates where turbidity levels in the water column are higher (e.g., at a turbidity front where fresh water from a river encounters brackish water in an estuary). Juhasz and Naidu (2007) also noted that microbes use explosives as sources of carbon and energy.

3.1.4.1.1 Studies of Munitions and Munitions Constituents in Underwater Environments

There have been no comprehensive studies of the fate and transport of residual explosives residing on the seafloor in the Study Area, and in this instance a site-specific study is not imperative due to the analysis of potential impacts on sediments and water quality completed in other marine environments where conditions on the seafloor are similar. Research conducted at other sites can inform the analysis of potential impacts on sediments and water quality in the Study Area. Scientific research focused on World War II underwater munitions disposal sites in Hawaii (Beck et al., 2018; Briggs et al., 2016; Kelley et al., 2016; Koide et al., 2016); an intensively used live fire range in the Mariana Islands (Carilli et al., 2018; Smith & Marx, 2016); and in nearshore waters of Ostrich Bay near Bremerton, WA and along Elliott Bay near Seattle were published after the 2015 NWTT Final EIS/OEIS. These publications provide information on the impacts of undetonated materials and unexploded munitions on habitat and marine life.

On a localized scale, the studies at munitions ocean disposal sites in Hawaii investigated the sediments, seawater, or marine life, depending on the study, in close proximity to corroding munitions to determine if released constituents from the munitions (including explosive materials and metals) could be detected (Edwards et al., 2016b). Comparisons were made between disposal site samples and "clean" nearby reference sites. Analysis of the samples showed no confirmed detection for explosive materials despite decades since the disposal and a relatively high concentration of munitions at the site. Munitions residing on the seafloor as a result of training and testing activities would be more widely dispersed with much lower concentrations than munitions in a disposal site.

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. A subsequent survey around the island was conducted to identify coral species and specifically species listed under the Endangered Species Act (Carilli et al., 2018). In addition to conducting the in-water coral survey, the Navy reported observations of ordnance and any impacts on nearshore habitat from the use of ordnance (e.g., craters). All but three ordnance items encountered were deemed old based on the amount of encrusted corals and other colonizing species using the ordnance as hard substrate. The report concluded that there were no impacts due to the use of ordnance on the island, including the use of explosive ordnance (Carilli et al., 2018).

Lotufo et al. (2017) found concentrations that exceeded the ecological screening level for at least one explosive in nearshore waters of Ostrich Bay near Bremerton, Washington and along Elliott Bay near Seattle at piers formerly used by the Navy as a supply depot during World War II. The piers, referred to

as Terminal 91, are now managed by the Port of Seattle under the Department of Defense Military Munitions Response Program. It is likely that the small quantities of munitions found at Terminal 91 were dropped overboard during vessel loading; there are no records of detonations occurring at the piers. The Terminal 91 site had a sufficient number of samples to allow for a site-wide characterization of contamination. The Ostrich Bay site had fewer than five samples, which was insufficient to characterize the entire site. Off Terminal 91, 1 out of 12 samples exceeded the screening level for the explosives constituent 2,4,6-trinitrophenylmethylnitramine (or "tetryl"). The data from the Terminal 91 site, and others assessed in the study, appear to be consistent with previous reports that the spatial distribution of munitions constituents in sediments at a given geographic site is highly variable but generally decreases with distance from the munition, such that munitions constituents are not detectable beyond 1 to 2 m from the munition (Edwards et al., 2016b; Lotufo, 2018; Rosen & Lotufo, 2010; University of Hawaii, 2014).

These findings are consistent with other assessments, such as the Navy's Water Range Condition Assessment of the Potomac River Test Range at Dahlgren, Virginia, which has been used since 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 guns), bombs, rockets, mortars, grenades, mines, depth charges, and torpedoes (U.S. Department of the Navy, 2013a). 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 other manmade sources (U.S. Department of the Navy, 2013b).

In summary, multiple investigations since 2007 involving survey and sampling of World War II munitions disposal sites in Hawaii and other locations where munitions are known to reside, have found the following (Briggs et al., 2016; Carniel et al., 2019; Edwards & Bełdowski, 2016; Edwards et al., 2016a; Edwards et al., 2016b; Koide et al., 2016; Silva & Chock, 2016): (1) chemicals and degradation products, including explosive materials, from underwater munitions "do not pose a risk to human health or to fauna living in direct contact with munitions"; (2) the concentrations of metals measured in sediment samples in close proximity to degrading World War II era 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.

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 disposal 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 in the Study Area would be negligible by comparison. As a result, explosives and explosives byproducts would have no meaningful effect on sediments or water quality in the Study Area.

3.1.4.1.2 Impacts from Explosives and Explosive Byproducts

3.1.4.1.2.1 Impacts from Explosives and Explosives Byproducts Under Alternative 1

Impacts from Explosives and Explosives Byproducts Under Alternative 1 for Training Activities

Under Alternative 1, the total number of explosive munitions that would be expended during training activities is less than the number proposed for use in the 2015 NWTT Final EIS/OEIS (Table 3.0-16). The largest reductions in the use of explosive munitions are in the number of large-caliber projectiles and medium-caliber projectiles used under Alternative 1 (Table 3.0-16). The number of explosive

large-caliber projectiles decreases from 390 to 112 annually, and medium-caliber projectiles decrease from 6,368 to 250 annually (Table 3.0-16). The number of explosive bombs and missiles used annually in the Offshore Area would decrease from a combined total of 37 to 16, a 57 percent reduction, under Alternative 1. The number of underwater detonations occurring in the Inland Waters would remain the same as analyzed in the 2015 NWTT Final EIS/OEIS (42 detonations per year). The activities that use explosive munitions would occur in the same general locations and in a similar manner as previously analyzed in the 2015 NWTT Final EIS/OEIS.

As noted in Section 3.1.3.4 (Water Quality in the Study Area), elevated concentrations of chlorophyll-*a* are the primary driver of poor water quality in some locations in the Study Area. The small amounts of nitrogen released into the water column as munitions and explosives on the seafloor degrade over time, would not be significant, and would not compare in volume or extent to other natural and anthropogenic sources of nitrogen compounds. The nitrogen released in deep waters (between 170 and 3,200 m at a distance of 50 NM from shore) at the base of the water column would be diluted long before reaching surface waters where sufficient sunlight is available for phytoplankton growth. Nitrogen from explosives would not contribute to higher concentrations of chlorophyll-*a* in the Study Area.

The conclusions presented in Section 3.1.3.1.6.2 (Alternative 1) of the 2015 NWTT Final EIS/OEIS remain valid. Specifically, short-term impacts on sediments and water quality would arise from explosives byproducts prior to their degradation, and long-term impacts would arise from the presence of unconsumed explosives encased in intact munitions residing on the seafloor. Impacted sediments and water quality would only be immediately adjacent to the munition. Chemical, physical, or biological changes in sediment or water quality would be measurable, but neither state nor federal standards or guidelines would be violated. This conclusion on the level of impact is based on the following: (1) most of the explosives would be consumed during detonation; (2) the frequency of low-order detonations would be low, and therefore the frequency of releases of explosives directly into the water column would be low; (3) the amounts of explosives used would be small relative to the area over which they would be distributed; and (4) the constituents of explosives would be subject to physical, chemical, and biological processes that would render the materials harmless or otherwise disperse them to undetectable levels.

As described in Section 3.1.4.1 (Explosives and Explosives Byproducts) of this Supplemental, the impacts on sediments and water quality would be similar to or less than that described in 2015 NWTT Final EIS/OEIS.

Impacts from Explosives and Explosives Byproducts Under Alternative 1 for Testing Activities

Under Alternative 1, the total number of explosive munitions that would be expended in the Offshore Area during testing activities would increase from 148 as proposed in the 2015 NWTT Final EIS/OEIS to 209 annually, an increase of 41 percent. Specifically, the number of explosive sonobuoys used annually would decrease from 142 to 80 (Table 3.0-16). However, the number of torpedoes would increase from 6 to 8, the number of neutralizers would increase from 0 to 36, the number of mines would increase from 0 to 5, and the number of large-caliber projectiles would increase from 0 to 80 (Table 3.0-16).

No explosive munitions would be used in the Inland Waters or Western Behm Canal, and no testing activities involving seafloor detonations are proposed in any part of the Study Area under Alternative 1. The activities that use explosive munitions would occur in the same general locations and in a similar manner as previously analyzed in the 2015 NWTT Final EIS/OEIS, with one exception. A new mine countermeasure and neutralization testing activity would occur in the Offshore Area approximately two

times per year and would use explosives within the water column (see Chapter 2, Description of Proposed Action and Alternatives). This activity would occur closer to shore than other activities analyzed in the 2015 NWTT Final EIS/OEIS that involved the use of in-water explosives in the Offshore Area. Although this activity would occur closer to shore, it would typically occur in water depths greater than 100 feet (ft.), over similar substrates, and the potential impacts on sediments and water quality would be the same as analyzed in the 2015 NWTT Final EIS/OEIS and summarized above.

As noted in Section 3.1.3.4 (Water Quality in the Study Area), elevated concentrations of chlorophyll-*a* are the primary driver of poor water quality in some locations in the Study Area. The small amounts of nitrogen released into the water column as munitions and explosives on the seafloor degrade over time, would not be significant, and would not compare in volume or extent to other natural and anthropogenic sources of nitrogen compounds. The nitrogen released in deep waters at the base of the water column would be diluted long before reaching surface waters where sufficient sunlight is available for phytoplankton growth. In locations where the water is particularly clear, the photic zone may extend 100 ft. or more in depth. Degrading munitions residing at shallower depths in clear waters may release nitrogen compounds into the water column where light is available. However, the small amounts of nitrogen and highly attenuated sunlight would not be sufficient to fuel a phytoplankton bloom. Nitrogen from explosives would not contribute to higher concentrations of chlorophyll-*a* in the Study Area.

The conclusions presented in Section 3.1.3.1.6.2 (Alternative 1) of the 2015 NWTT Final EIS/OEIS remain valid. Specifically, short-term impacts on sediments and water quality would arise from explosives byproducts prior to their degradation, and long-term impacts would arise from the presence of unconsumed explosives encased in intact munitions residing on the seafloor. Only sediments and water immediately adjacent to the munition would potentially be impacted over time as the munitions casing degrades and releases explosives. Chemical, physical, or biological changes in sediment or water quality would be measurable, but neither state nor federal standards or guidelines would be violated. This conclusion on the level of impact is based on the following: (1) most of the explosives would be consumed during detonation; (2) the frequency of low-order detonations would be low, and therefore the frequency of releases of explosives directly into the water column would be low; (3) the amounts of explosives used would be small relative to the area over which they would be distributed; and (4) the constituents of explosives would be subject to physical, chemical, and biological processes that would render the materials harmless or otherwise disperse them to undetectable levels.

As described in Section 3.1.4.1 (Explosives and Explosives Byproducts) of this Supplemental, the impacts on sediments and water quality would be similar to or less than that described in 2015 NWTT Final EIS/OEIS.

3.1.4.1.2.2 Impacts from Explosives and Explosives Byproducts Under Alternative 2

Impacts from Explosives and Explosives Byproducts Under Alternative 2 for Training Activities

Under Alternative 2, the total number of explosive munitions that would be expended during training activities would increase from 420 under Alternative 1 to 6,981 (Table 3.0-16). The largest increase is in the number of medium-caliber projectiles used in the Offshore Area, which would increase from 250 (under Alternative 1) to 6,490 (under Alternative 2). Other distinctions between Alternative 1 and Alternative 2 are the introduction of two torpedoes, an increase in the use of missiles from 14 under Alternative 1 to 27 under Alternative 2, and an increase in large-caliber projectiles (112 to 390). Overall, the total number of explosive munitions that would be used under Alternative 2 is approximately 2 percent greater than the number of munitions proposed in the 2015 NWTT Final EIS/OEIS, with the

primary difference being the number of medium-caliber projectiles (Table 3.0-16). The number of underwater detonations occurring in the Inland Waters would increase from 42 under Alternative 1 and in ongoing activities to 70 under Alternative 2. The activities that use explosive munitions would occur in the same general locations and in a similar manner as under Alternative 1 and in the 2015 NWTT Final EIS/OEIS.

As discussed under Alternative 1, the small amounts of nitrogen released into the water column as munitions and explosives on the seafloor degrade over time would not be significant and would not compare in volume or extent to other natural and anthropogenic sources of nitrogen compounds. The nitrogen released in deep waters (between 170 and 3,200 m at a distance of 50 NM from shore) at the base of the water column would be diluted long before reaching surface waters where sufficient sunlight is available for phytoplankton growth. Nitrogen from explosives would not contribute to higher concentrations of chlorophyll-*a* in the Study Area.

The conclusions presented in Section 3.1.3.1.6.3 (Alternative 2) of the 2015 NWTT Final EIS/OEIS remain valid. Specifically, short-term impacts on sediments and water quality would arise from explosives byproducts prior to their degradation, and long-term impacts would arise from the presence of unconsumed explosives encased in intact munitions residing on the seafloor. Impacted sediments and water quality would be immediately adjacent to the munition. Chemical, physical, or biological changes in sediment or water quality would be measurable, but neither state nor federal standards or guidelines would be violated. This conclusion on the level of impact is based on the following: (1) most of the explosives would be consumed during detonation; (2) the frequency of low-order detonations would be low, and therefore the frequency of releases of explosives directly into the water column would be low; (3) the amounts of explosives used would be small relative to the area over which they would be distributed; and (4) the constituents of explosives would be subject to physical, chemical, and biological processes that would render the materials harmless or otherwise disperse them to undetectable levels.

As described in detail in Section 3.1.3.1.6.3 (Alternative 2) in the 2015 NWTT Final EIS/OEIS and considering the results of studies described in Section 3.1.4.1 (Explosives and Explosives Byproducts) of this Supplemental, the impacts on sediments and water quality would be greater than under Alternative 1 but similar to ongoing activities.

Impacts from Explosives and Explosive Byproducts Under Alternative 2 for Testing Activities

Under Alternative 2, the number of explosive munitions that would be expended in the Offshore Area during testing activities is the same as proposed under Alternative 1 (Table 3.0-16). No explosive munitions would be used in the Inland Waters or Western Behm Canal. The activities that use explosive munitions would occur in the same general locations and in a similar manner as described under Alternative 1.

As discussed under Alternative 1, the small amounts of nitrogen released into the water column as munitions and explosives on the seafloor degrade over time, would not be significant, and would not compare in volume or extent to other natural and anthropogenic sources of nitrogen compounds. The nitrogen released in deep waters at the base of the water column would be diluted long before reaching surface waters where sufficient sunlight is available for phytoplankton growth. In locations where the water is particularly clear, the photic zone may extend 100 ft. or more in depth. Degrading munitions residing at shallower depths in clear waters may release nitrogen compounds into the water column where light is available. However, the small amounts of nitrogen and highly attenuated sunlight would

not be sufficient to fuel a phytoplankton bloom. Nitrogen from explosives would not contribute to higher concentrations of chlorophyll-*a* in the Study Area.

The conclusions presented in Section 3.1.3.1.6.3 (Alternative 2) of the 2015 NWTT Final EIS/OEIS remain valid. Specifically, short-term impacts on sediments and water quality would arise from explosives byproducts prior to their degradation, and long-term impacts would arise from the presence of unconsumed explosives encased in intact munitions residing on the seafloor. Impacted sediments and water quality would only be immediately adjacent to the munition. Chemical, physical, or biological changes in sediment or water quality would be measurable, but neither state nor federal standards or guidelines would be violated. This conclusion on the level of impact is based on the following: (1) most of the explosives would be consumed during detonation; (2) the frequency of low-order detonations would be low, and therefore the frequency of releases of explosives directly into the water column would be low; (3) the amounts of explosives used would be small relative to the area over which they would be distributed; and (4) the constituents of explosives would be subject to physical, chemical, and biological processes that would render the materials harmless or otherwise disperse them to undetectable levels.

As described in detail in Section 3.1.3.1.6.3 (Alternative 2) in the 2015 NWTT Final EIS/OEIS and considering the results of studies described in Section 3.1.4.1 (Explosives and Explosives Byproducts) of this Supplemental, the impacts on sediments and water quality would be the same as those described under Alternative 1.

3.1.4.1.2.3 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 Study Area. Impacts from explosives and explosives byproducts associated with the Proposed Action on sediments and water quality would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.1.4.2 Metals

Metals would be introduced into the marine environment by activities that expend military materials with metal components including (1) explosive and non-explosive munitions, (2) expended (unrecovered) targets (3) seafloor devices, (4) wires and cables, and (5) certain other military expended materials. These five categories represent the same stressors analyzed in the 2015 NWTT Final EIS/OEIS.

Since the publication of the 2015 NWTT Final EIS/OEIS, the Navy has conducted a review of new literature pertaining to the potential impacts of metals on sediments and water quality. Although additional information was found and briefly summarized in the following paragraphs, the new information does not indicate a measurable change to the existing environmental conditions as described in the 2015 NWTT Final EIS/OEIS.

Because of the physical and chemical reactions that occur with metals in marine systems (e.g., precipitation), metals often concentrate in sediments. Thus, metal contaminants in sediments are a greater issue than metal contaminants in the water column. Section 3.1.3.2.1 (Introduction) in the 2015 NWTT Final EIS/OEIS describes the different types of metals contained in munitions and other military expended materials, many of which, such as iron, zinc, copper, aluminum, and manganese, occur naturally in the marine environment.

In general, one of three things happens to materials that come to rest on the ocean floor: (1) they lodge in sediments below 4 in., where there is little or no oxygen; (2) they remain on the ocean floor and begin to react with seawater; or (3) they remain on the ocean floor and become encrusted by marine organisms. As a result, rates of deterioration depend on the metal or metal alloy and the conditions in the immediate marine and benthic environment. If buried deep in ocean sediments, materials tend to decompose at much lower rates than when exposed to seawater (Ankley, 1996). With the exception of torpedo guidance wires and sonobuoy parts, sediment burial appears to be the fate of most ordnance used in marine warfare (Environmental Science Advisory Committee, 2005; Trembanis & DuVal, 2018).

As described in Section 3.1.4.1 (Explosives and Explosives Byproducts), 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 exposures to seawater and high concentrations of military munitions composed primarily of metal components (Briggs et al., 2016; Kelley et al., 2016; Koide et al., 2016; Smith & Marx, 2016; U.S. Department of the Navy, 2013b). Sediment sampling was conducted on the Canadian Forces Maritime Experimental and Test Ranges near Nanoose, British Columbia, Canada, located north of the Study Area in the Strait of Georgia to analyze impacts from decades of testing on seafloor sediments (Environmental Science Advisory Committee, 2005). Sediment samples were collected from 37 locations on the range and at six reference locations off-range. The study showed that 14 out of 30 different metals tested had statistically significant higher concentrations on the range compared with the off-range sites. The results suggested that materials composed of metals that were expended during military activities on the range resulted in the higher concentrations of some metals. However, six of the 14 metals with higher concentrations (e.g., arsenic, bismuth, cobalt, manganese, molybdenum) are not used in the materials expended on the range; an explanation for the difference between the on-range and off-range concentrations for those metals has not been discovered (Environmental Science Advisory Committee, 2005). Conversely, aluminum and iron have higher mean concentrations off range than on range, although both of these metals have been used in many of the materials expended on the range and deposited on the seafloor since 1965. Thus, the study was inconclusive in determining how metals in expended materials have impacted sediments on the range (Environmental Science Advisory Committee, 2005).

Within the Study Area, sediment and water samples collected from Dabob Bay were analyzed to measure the concentrations of five metals: cadmium, copper, lithium, lead, and zinc (Crecelius, 2001). The purpose of the study was to determine if operations at the Dabob Bay Range Complex were adversely impacting sediments and water and potentially reaching toxic levels for species in the bay. Based on a comparison of concentrations of metals in Dabob Bay sediments and water with similar samples collected from other locations, including Washington waters and ocean waters, and a comparison with environmental standards, it is clear that the concentrations of the six metals are not elevated in Dabob Bay and that there is no measurable impact from metals expended into the bay as part of military activities, including Navy training and testing activities (Crecelius, 2001).

The concentration of munitions and other expended materials with metal components associated with the Proposed Action be would much less than metal concentrations on a munitions disposal site, a target island used for 45 years, or a water range in a river used for almost 100 years. Therefore, impacts from metals would be expected to be much lower, such that chemical, physical, or biological changes to sediments or water quality in the Study Area 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 in expended materials are benign and occur naturally in the marine environment, and those of

potential concern make up a small percentage of metals in expended munitions and other objects with metal components; (2) metals released as corrosion products would be diluted in the water column by currents or bound up and sequestered in adjacent sediments; (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 objects with metal components would be distributed is larger than at a munitions disposal site, a small island bombing range, or a confined riverine testing range.

The impacts of climate change on the marine environment, including ongoing and predicted trends in pH and water temperature, and how sediments and water quality in the Study Area may be affected, are described in Section 3.1.3.3 (Climate Change and Sediments) and Section 3.1.3.6 (Climate Change and Marine Water Quality). Increases or decreases in ocean acidity (i.e., a decrease in pH), dissolved oxygen, and water temperature can affect the rate of processes (e.g., corrosion) that breakdown munitions residing on the seafloor as well as the fate and transport of munitions constituents released from corroding munitions (Beck et al., 2018; Carniel et al., 2019; Jurczak & Fabisiak, 2017; MacLeod, 2016).

Changes in the oceanographic characteristics of the deep sea environment attributed to climate change, such as an increase in water temperature, are not as large as those measured or predicted in the surface layer; however, there are indications that even comparatively small changes may result in a substantial impact on the deep sea environment (Levin & Bris, 2015; Sweetman et al., 2017). Conditions in the water column below the surface layer (approximated at around 200 m but with regional variability) and on the seafloor are typically very stable with near constant physical parameters (e.g., temperature, salinity, pH, dissolved oxygen), and diverse benthic ecosystems have developed under those conditions. Long-term stability also leaves deep sea ecosystems vulnerable to relatively small changes in baseline conditions. Sweetman et al. (2017) predicts that by the year 2100, deep sea (3,000 to 6,000 m) water temperatures could increase by 1°C and the pH of waters between 200 and 3,000 m depths will decrease (become more acidic) by 0.3 or more pH units. Dissolved oxygen concentrations in the water column from 200 to 6,000 m are also expected to decline, which will not only affect benthic ecosystems but also influence reduction-oxidation processes that act to breakdown munitions casings and other metal materials.

The extent to which climate change will alter the physical characteristics of the deep sea environment is not well understood (Sweetman et al., 2017) and, by extension, the impacts of climate change on corrosion rates of munitions and other expended materials on the seafloor is unknown. Research conducted by Jurczak and Fabisiak (2017) on munitions in the Baltic Sea found that the concentration of dissolved oxygen was the primary driver of corrosion rates. Lower oxygen levels at a depth of 140 m inhibited the corrosion of steel at the site. If climate change results in lower dissolved oxygen levels where munitions and other expended materials reside, then corrosion rates could decrease even if the deep sea environment becomes more acidic. Measurements over 14 years on the corrosion rates of World War II era vessels and aircraft in a lagoon in Micronesia revealed a similar relationship between water depth, lower dissolved oxygen in the water column, and decreased corrosion rates (MacLeod, 2016). Vessels located deeper than 38 m in the lagoon, which was below the mixing zone, had a corrosion rate 3.5 times less than vessels located at a depth of 20 m (within the mixing zone) (MacLeod, 2016). The mixing zone is the uppermost part of the water column that is influenced by wind stress. Generally, a greater wind stress results in a deeper mixing depth and higher dissolved oxygen levels in the mixing zone than at greater depths (Mann & Lazier, 1996). The mixing zone in the open ocean, including the Offshore Area, may extend to 200 m or more; however, it would not reach the seafloor where munitions and other expended material with metals would reside.

3.1.4.2.1 Impacts from Metals

3.1.4.2.1.1 Impacts from Metals Under Alternative 1

Impacts from Metals Under Alternative 1 for Training Activities

Under Alternative 1, the number of military materials with metal components that would be expended during training activities is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS.

Comparing the number of munitions and sonobuoys containing metals with their corresponding weights provides another perspective on the relative contribution of various items to the amounts of metals entering the marine environment. For example, under Alternative 1, large-caliber projectiles compose about 7 percent of the total number of items, but they represent 30 percent of the total weight of expended items composed of metals (Table 3.1-2).

When the number of military expended materials containing metals from Table 3.0-14, Table 3.0-16, Table 3.0-17, and Table 3.0-19 are summed, the number of items proposed to be expended under Alternative 1 is approximately 11 percent less than the number of items proposed in the 2015 NWTT Final EIS/OEIS. The largest change is in the number of explosive and non-explosive medium-caliber projectiles used under Alternative 1, which constitute a substantial portion of items containing metals (Table 3.0-14 and 3.0-16). The number of non-explosive medium-caliber projectiles decreases by more than 15,700 annually (Table 3.0-14). The number of explosive large-caliber projectiles and explosive medium-caliber projectiles both decrease under Alternative 1 (390 to 112 annually for large-caliber and 6,368 to 250 annually for medium-caliber projectiles) (Table 3.0-16). The numbers of explosive and non-explosive bombs and missiles also decrease compared with ongoing activities described in the 2015 NWTT Final EIS/OEIS.

Table 3.1-2: Comparison of Training Materials with Metal Components Under Alternative 1

Type of Military Expended Material	Percent of Total	
	By Number	By Weight
Sonobuoys	5.8	49.0
Large-caliber projectiles	1.8	30.6
Medium-caliber projectiles	16.7	6.0
Bombs	< 1	12.6
Missiles	< 1	1.8
Small-caliber projectiles	75.6	< 1

Notes: (1) < = less than; (2) Not all items listed in Table 3.0-14 and Table 3.0-16 are included in this table, because information on weight was not available.

The activities that expend military materials, including munitions, would occur in the same general locations and in a similar manner as analyzed previously. The analysis is not dependent on quantifying that overall amount of metals introduced into the marine environment. As presented in the 2015 NWTT Final EIS/OEIS and summarized in this Supplemental, the analysis shows that the types of metals deposited from training and testing activities occur naturally in the marine environment and would not impact sediments and water quality. Therefore, the impacts on sediments and water quality from metals

in military expended materials would be expected to be the same or slightly reduced compared with ongoing activities.

Therefore, the conclusions presented in Section 3.1.3.2.4.2 (Alternative 1) of the 2015 NWTT Final EIS/OEIS and summarized in Section 3.1.4.2 (Metals) of this Supplemental remain valid. Specifically, metal components would come to rest on the sea floor exposed to seawater or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters (Carniel et al., 2019). Changes in metal concentrations in sediment and water would be very local to each fragment of military material. Sediment and water quality would not be affected regionally and neither state nor federal standards or guidelines would be violated.

Impacts from Metals Under Alternative 1 for Testing Activities

Under Alternative 1, the number of military materials with metal components that would be expended during testing activities would increase compared with the number of items proposed for use in the 2015 NWTT Final EIS/OEIS.

As noted in the discussion on training activities above, comparing the number of items containing metals with their corresponding weights provides another perspective on the relative contribution of various items to metals entering the marine environment. Under Alternative 1, for example, large-caliber projectiles compose about 5 percent of the total number of items and represent 10 percent of the total weight of those items (Table 3.1-3).

Table 3.1-3: Comparison of Testing Materials with Metal Components Under Alternative 1

Type of Military Expended Material	Percent of Total	
	By Number	By Weight
Sonobuoys	94.7	90
Large caliber projectiles	5.3	10
Medium caliber projectiles	0	0
Bombs	0	0
Missiles	0	0
Small-caliber projectiles	0	0

Note: Not all items listed in Table 3.0-14 and Table 3.0-16 are included in this table, because information on weight was not available.

When the number of military expended materials containing metals from Table 3.0-14, Table 3.0-16, Table 3.0-17, and Table 3.0-19 are summed, the number of items increases from approximately 2,800 used in ongoing activities to 10,000 under Alternative 1. The largest change is in the number of non-explosive munitions proposed for use, which would increase from 1,400 to about 4,700 under Alternative 1. The activities that expend military materials containing metals would occur in the same general locations and in a similar manner as analyzed previously in the 2015 NWTT Final EIS/OEIS. Although the overall amount of metals introduced to the Study Area would increase, the analysis is not dependent on quantifying that amount. As presented in the 2015 NWTT Final EIS/OEIS and summarized in this Supplemental, the analysis shows that the types of metals deposited from training and testing activities occur naturally in the marine environment and would not impact sediments and water quality. Although the number of military expended materials including metals would increase under

Alternative 1, the impacts on sediments and water quality from metals would be expected to be the same or slightly greater than impacts from ongoing activities.

Therefore, the conclusions presented in Section 3.1.3.2.4.2 (Alternative 1) of the 2015 NWTT Final EIS/OEIS and summarized in Section 3.1.4.2 (Metals) of this Supplemental remain valid. Specifically, metal components would come to rest on the sea floor exposed to seawater or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters (Carniel et al., 2019). Changes in metal concentrations in sediment and water would be very local to each fragment of military material. Water or sediment quality regionally would not be affected and neither state nor federal standards nor guidelines would be violated.

3.1.4.2.1.2 Impacts from Metals Under Alternative 2

Impacts from Metals Under Alternative 2 for Training Activities

Under Alternative 2, the number of military materials with metal components that would be expended during training activities is greater than under Alternative 1 and the number proposed in the 2015 NWTT Final EIS/OEIS.

As noted in the discussion on training activities under Alternative 1, comparing the number of items containing metals with their corresponding weights provides another perspective on the relative contribution of various items to metals entering the marine environment. Under Alternative 2, for example, small-caliber projectiles compose about 64 percent of the total number of items but represent less than 1 percent of the total weight of those items (Table 3.1-4).

Table 3.1-4: Comparison of Training Materials with Metal Components Under Alternative 2

Type of Military Expended Material	Percent of Total	
	By Number	By Weight
Sonobuoys	4.9	26.9
Large caliber projectiles	5.2	56.8
Medium caliber projectiles	26.1	6.1
Bombs	< 1	7.4
Missiles	< 1	2.3
Small-caliber projectiles	63.7	0.6

Notes: (1) < = less than; (2) Not all items listed in Table 3.0-14 and Table 3.0-16 are included in this table, because information on weight was not available.

When the number of military expended materials from Table 3.0-14, Table 3.0-16, Table 3.0-17, and Table 3.0-19 are summed, the total number of items proposed to be expended under Alternative 2 is approximately 19 percent greater than under Alternative 1 and approximately 6 percent greater than the number of materials used in ongoing activities. The largest changes are in the number of explosive large-caliber projectiles and both explosive and non-explosive medium-caliber projectiles (Table 3.0-14 and 3.0-16). The activities that expend military materials, including munitions, would occur in the same general locations and in a similar manner as under Alternative 1. Although the overall amount of metals introduced to the Study Area would increase, the analysis is not dependent on quantifying that amount. As presented in the 2015 NWTT Final EIS/OEIS and summarized in this Supplemental, the analysis shows

that the types of metals deposited from training and testing activities occur naturally in the marine environment and would not impact sediments and water quality. Although the number of military expended materials including metals would be greater than under Alternative 1, the impacts on sediments and water quality from metals would be expected to be the same or slightly greater than under Alternative 1 and equivalent to impacts from ongoing activities.

Therefore, the conclusions presented in Section 3.1.3.2.4.3 (Alternative 2) of the 2015 NWTT Final EIS/OEIS and summarized in Section 3.1.4.2 (Metals) of this Supplemental remain valid. Specifically, metal components would come to rest on the sea floor exposed to seawater or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters (Carniel et al., 2019). Changes in metal concentrations in sediment and water would be very local to each fragment of military material. Sediment and water quality would not be affected regionally, and neither state nor federal standards or guidelines would be violated.

Impacts from Metals Under Alternative 2 for Testing Activities

Under Alternative 2, the number of military materials with metal components that would be expended during testing activities is greater than under Alternative 1 and the number proposed in the 2015 NWTT Final EIS/OEIS.

As noted in the discussion on testing activities under Alternative 1, comparing the number of items containing metals with their corresponding weights provides another perspective on the relative contribution of various items to metals entering the marine environment. The relationship between the number of expended items composed of metal and the weight of those items is approximately the same under Alternative 2 compared with Alternative 1 (Table 3.1-5).

Table 3.1-5: Comparison of Testing Materials with Metal Components Under Alternative 2

Type of Military Expended Material	Percent of Total	
	By Number	By Weight
Sonobuoys	96.5	93.3
Large-caliber projectiles	3.5	6.7
Medium-caliber projectiles	0	0
Bombs	0	0
Missiles	0	0
Small-caliber projectiles	0	0

Note: Not all items listed in Table 3.0-14 and Table 3.0-16 are included in this table, because information on weight was not available.

When the number of military expended materials from Table 3.0-14, Table 3.0-16, Table 3.0-17, and Table 3.0-19 are summed, the number of items proposed to be expended under Alternative 2 would increase from about 10,000 to 15,000. Under Alternative 2, the largest increase is in the number of non-explosive practice munitions, which would increase from about 4,700 under Alternative 1 to over 7,000 under Alternative 2. Changes compared to ongoing activities are similar to those described above for Alternative 1.

The activities that expend military materials containing metals would occur in the same general locations and in a similar manner as under Alternative 1. Although the overall amount of metals

introduced to the Study Area would increase, the analysis is not dependent on quantifying that amount. As presented in the 2015 NWTT Final EIS/OEIS and summarized in this Supplemental, the analysis shows that the types of metals deposited from training and testing activities occur naturally in the marine environment and would not impact sediments and water quality. Therefore, the impacts on sediments and water quality from metals in military expended materials would be expected to be similar or slightly greater than under Alternative 1 and ongoing activities.

Therefore, the conclusions presented in Section 3.1.3.2.4.3 (Alternative 2) of the 2015 NWTT Final EIS/OEIS and summarized in Section 3.1.4.2 (Metals) of this Supplemental remain valid. Specifically, metal components would come to rest on the sea floor exposed to seawater or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters (Carniel et al., 2019). Changes in metal concentrations in sediment and water would be very local to each fragment of military material. Sediment and water quality would not be affected regionally, and neither state nor federal standards or guidelines would be violated.

3.1.4.2.1.3 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 Study Area. Impacts from metals associated with the Proposed Action on sediments and water quality would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.1.4.3 Chemicals Other than Explosives

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) other chemicals associated with explosive munitions; and (4) chemicals that simulate chemical warfare agents, referred to as "simulants."

Following a review of recent literature, including government technical documents, reports, and scientific journals, the information presented on chemicals other than explosives in the Study Area, as described in the 2015 NWTT Final EIS/OEIS, has not appreciably changed.

3.1.4.3.1 Impacts from Chemicals Other than Explosives

Solid-fuel propellants in missiles and rockets: The EPA issued a paper characterizing the munitions constituents accumulated at over 30 military sites around the United States and Canada where explosives and solid fuel propellants have been used for years (U.S. Environmental Protection Agency, 2012a). 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 includes a case study measuring the amount of residual perchlorate remaining from firing a rocket with solid fuel propellant. The study concluded that 99.997 percent of perchlorate is consumed by the rocket motor (U.S. Environmental Protection Agency, 2012a). Fitzpatrick et al. (2006) found similar results from an air-launched AIM-7 missile, a missile used by the Navy and similar to missiles proposed for use during training and testing activities. 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. In the event of a munitions failure resulting in unconsumed solid propellant in a rocket or missile entering the marine environment, only small amounts of perchlorates would be released into sediments or the water column as the solid fuel (in the form of cubes) is exposed to seawater. The

leaching rate would decrease over time as the concentration of perchlorate in the propellant declined (U.S. Department of the Navy, 2008).

Ammonium perchlorate typically accounts for 50 to 85 percent of the propellant by weight. Perchlorates are readily soluble, with a low affinity for binding to sediments and organic matter and would persist in the environment potentially impacting sediments and the water quality. Perchlorates occur naturally in the environment, but at high concentrations can reach toxicity in plants and animals (Martinelango, 2006; Van Wijk & Hutchinson, 1995). Bacteria and other microbes in the marine environment have been shown to metabolize or otherwise degrade perchlorate into benign chemical products, such as chloride (Chaudhuri et al., 2002; Logan et al., 2001; Okeke et al., 2002). Refer to Section 3.1.3.3.7.1 (Solid-Fuel Propellants) in the 2015 NWTT Final EIS/OEIS for additional analysis.

Otto Fuel II torpedo propellant and combustion byproducts: As discussed in detail in Section 3.1.3.3.7.2 (Otto Fuel II and Combustion Byproducts) in the 2015 NWTT Final EIS/OEIS, combustion byproducts from Otto Fuel II would be released into the water column only in small amounts during combustion. Furthermore, all non-explosive torpedoes are typically recovered for reuse following training and testing activities, which removes any unconsumed fuel from the environment after completion of the activity. Combustion byproducts of Otto Fuel II would be released into the water column where they would dissolve, dissociate, or be dispersed and diluted. Except for hydrogen cyanide, combustion byproducts (such as carbon dioxide, carbon monoxide, nitrogen, hydrogen, methane, and ammonia) are not a concern, because they occur naturally in seawater, are consumed or otherwise chemically converted through biological or other processes, and would not impact water quality (U.S. Department of the Navy, 1996). As noted in Section 3.1.3.4 (Water Quality in the Study Area), elevated concentrations of chlorophyll-*a* are the primary driver of poor water quality in some locations in the Study Area. The small amounts of nitrogen released into the water column through combustion would not be significant and would not compare in volume or extent to other natural and anthropogenic sources of nitrogen compounds. The nitrogen released into the water column would not be sufficient to fuel a phytoplankton bloom and would not contribute to higher concentrations of chlorophyll-*a* in the Study Area.

One combustion byproduct, hydrogen cyanide, does not normally occur in seawater and can pose a risk at high concentrations; however, it is soluble in seawater and would be diluted to less than 1 µg/L (1.0 part per billion) – below EPA recommended concentrations (U.S. Environmental Protection Agency, 2010) – at a distance of approximately 18 ft. from the center of the torpedo's path when first discharged. Additional dilution would occur thereafter, with the rate of dilution depending, in part, upon circulation in the water column in the vicinity of the discharge. Refer to Section 3.1.3.3.7.2 (Otto Fuel II and Combustion Byproducts) in the 2015 NWTT Final EIS/OEIS for additional analysis.

Other chemicals associated with explosive munitions: Residual chemical constituents associated with explosive munitions can remain in the environment after low-order (i.e., incomplete) detonations and in unconsumed explosives. These constituents, listed in Table 3.1-20 of the 2015 NWTT Final EIS/OEIS, are in addition to the explosives contained in the munition. Lead azide, titanium compounds, perchlorates, barium chromate, and fulminate of mercury are not naturally constituents of seawater. Another residual constituent, lead oxide, is a rare, naturally occurring mineral (Agency for Toxic Substances and Disease Registry, 2007).

Simulants: Simulants were not analyzed in the 2015 NWTT Final EIS/OEIS. The Department of Defense is developing equipment to detect chemical and biological warfare agents and uses harmless compounds,

referred to as simulants, as safe substitutes to test the detection equipment. The 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 will trigger a response by sensors in the detection equipment without irritating or injuring the personnel involved in the test. Simulants must have one or more characteristics of a real chemical or biological agent—size, density, or aerosol behavior—to effectively mimic the agent.

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 would be benign (e.g., low toxicity or effects potential) from a human health, safety, and environmental perspective. Exposure levels during testing activities would be well below concentrations associated with any adverse human health or environmental effects. The degradation products of simulants used during testing would also be harmless. Given these characteristics of simulants used during 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.

3.1.4.3.1.1 Impacts from Chemicals Other than Explosives Under Alternative 1

Impacts from Chemicals Other than Explosives Under Alternative 1 for Training Activities

Under Alternative 1, the number of explosive and non-explosive missiles using solid fuel propellants would decrease from 42, proposed in the 2015 NWTT Final EIS/OEIS, to 18. No explosive torpedoes and 18 non-explosive torpedoes (all recovered) would be used during training activities under Alternative 1 (Tables 3.0-15 and 3.0-16). No torpedoes were proposed for training activities in the 2015 NWTT Final EIS/OEIS.

As described in Section 3.1.4.1.1.1 (Impacts from Explosives and Explosives Byproducts Under Alternative 1), the number of explosive munitions that would be expended during training activities would decrease from over 6,800 proposed in the 2015 NWTT Final EIS/OEIS to 420. Based on the detailed analysis in Section 3.1.3.1 (Explosives and Explosion Byproducts) in the 2015 NWTT Final EIS/OEIS and the summary of recent studies in Section 3.1.4.1 (Explosives and Explosives Byproducts) in this Supplemental, concentrations of chemical constituents associated with explosive munitions is expected to be localized to areas adjacent to the munition and similar to concentrations from unimpacted nearby sites.

The analysis in the 2015 NWTT Final EIS/OEIS concluded that, based on the small amount of chemicals other than explosives that would remain from training activities, chemicals would either be undetectable or would have only a minimal and localized impact on sediments and water quality in the Study Area. The impacts on sediments and water quality would be similar to or less than that described in the 2015 NWTT Final EIS/OEIS.

Impacts from Chemicals Other than Explosives Under Alternative 1 for Testing Activities

Under Alternative 1, no missiles using solid rocket propellant would be used during testing activities, and no missiles were proposed for use in the 2015 NWTT Final EIS/OEIS. The number of explosive and non-explosive torpedoes (including the anti-torpedo torpedo) using Otto Fuel II propellant would increase from 722 proposed in the 2015 NWTT Final EIS/OEIS to 746 annually (Table 3.0-14, Table 3.0-15, and Table 3.0-16).

As described in Section 3.1.4.1.1.1 (Impacts from Explosives and Explosives Byproducts Under Alternative 1), the number of explosive munitions that would be expended in the Offshore Area during

testing activities increases from 148 proposed in the 2015 NWTT Final EIS/OEIS to 209, an increase of 41 percent. Based on the detailed analysis in Section 3.1.3.1 (Explosives and Explosion Byproducts) in the 2015 NWTT Final EIS/OEIS and the summary of recent studies in Section 3.1.4.1 (Explosives and Explosives Byproducts) in this Supplemental, concentrations of chemical constituents associated with explosive munitions is expected to be localized to areas adjacent to the munition and similar to concentrations from unimpacted nearby sites.

As described in Section 3.1.4.3.1 (Impacts from Chemicals Other Than Explosives), chemical and biological simulants are benign and would have no impact on sediments and water quality.

The analysis in the 2015 NWTT Final EIS/OEIS concluded that, based on the small amount of chemicals other than explosives that would remain from testing activities, chemicals would either be undetectable or would have only a minimal and localized impact on sediments and water quality in the Study Area. The impacts on sediments and water quality would be similar to or less than that described in 2015 NWTT Final EIS/OEIS.

3.1.4.3.1.2 Impacts from Chemicals Other than Explosives Under Alternative 2

Impacts from Chemicals Other than Explosives Under Alternative 2 for Training Activities

Under Alternative 2, the number of explosive and non-explosive missiles using solid fuel propellants would increase from 18 under Alternative 1 to 42. The number of missiles proposed in the 2015 NWTT Final EIS/OEIS) was also 42. The number of explosive torpedoes using Otto Fuel II during training activities would increase from 0 under Alternative 1 to 2, and the number of non-explosive torpedoes would decrease from 18 to 16 (Table 3.0-15 and Table 3.0-16). No torpedoes were proposed for training activities in the 2015 NWTT Final EIS/OEIS.

As described in Section 3.1.4.1.1.2 (Impacts from Explosives and Explosives Byproducts Under Alternative 2), the number of explosive munitions expended under Alternative 2 would increase from 420 to 6,981 (Table 3.0-16). The number of underwater detonations occurring in the Inland Waters would increase from 42, for ongoing activities and under Alternative 1, to 70 under Alternative 2. Overall, the number of explosive munitions proposed to be expended under Alternative 2 is approximately 2 percent greater than the number of explosives proposed in the 2015 NWTT Final EIS/OEIS (Table 3.0-16).

Based on the detailed analysis in Section 3.1.3.1 (Explosives and Explosion Byproducts) in the 2015 NWTT Final EIS/OEIS and the summary of recent studies in Section 3.1.4.1 (Explosives and Explosives Byproducts) in this Supplemental, concentrations of chemical constituents associated with explosive munitions is expected to be localized to areas adjacent to the munition and similar to concentrations from unimpacted nearby sites.

The analysis in the 2015 NWTT Final EIS/OEIS concluded that, based on the small amount of chemicals other than explosives that would remain from training activities, chemicals would either be undetectable or would have only a minimal and localized impact on sediments and water quality in the Study Area. The impacts on sediments and water quality would be similar to or slightly greater than under Alternative 1.

Impacts from Chemicals Other than Explosives Under Alternative 2 for Testing Activities

Under Alternative 2, no missiles using solid rocket propellant would be used during testing activities. The number of explosive and non-explosive torpedoes (including the anti-torpedo torpedo) using Otto Fuel II

propellant would increase from 746 under Alternative 1 to 797 (Table 3.0-14, Table 3.0-15, and Table 3.0-16).

The number of explosive munitions that would be expended in the Offshore Area during testing activities is the same as proposed under Alternative 1 (Table 3.0-16). No explosive munitions would be used in the Inland Waters or Western Behm Canal. The activities that use explosive munitions would occur in the same general locations and in a similar manner as described under Alternative 1.

Based on the detailed analysis in Section 3.1.3.1 (Explosives and Explosion Byproducts) in the 2015 NWTT Final EIS/OEIS and the summary of recent studies in Section 3.1.4.1 (Explosives and Explosives Byproducts) in this Supplemental, concentrations of chemical constituents associated with explosive munitions is expected to be localized to areas adjacent to the munition and similar to concentrations from unimpacted nearby sites. As described in Section 3.1.4.3.1 (Impacts from Chemicals Other Than Explosives), chemical and biological simulants are benign (i.e., low toxicity or effects potential from a human health, safety, and environmental perspective) and would have no impact on sediments and water quality.

The analysis in the 2015 NWTT Final EIS/OEIS concluded that, based on the small amount of chemicals other than explosives that would remain from testing activities, chemicals would either be undetectable or would have only a minimal and localized impact on sediments and water quality in the Study Area. The impacts on sediments and water quality would the same as impacts under Alternative 1.

3.1.4.3.1.3 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 Study Area. Impacts from chemicals other than explosives associated with the Proposed Action on sediments and water quality would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.1.4.4 Other Materials

Other materials include marine markers and flares, chaff, towed and stationary targets, parachutes, and miscellaneous non-metal components of other devices that were not analyzed in Section 3.1.4.1 (Explosives and Explosives Byproducts), Section 3.1.4.2 (Metals), and Section 3.1.4.3 (Chemicals Other than Explosives). Some expended materials used in training and testing activities are composed of both metal and non-metal components (e.g., targets), and a detailed breakdown of the constituent materials making up each item is not available. Therefore, some items, such as targets, are included in totals presented in this section as well as in previous sections analyzing impacts on metals. Nonmetallic components are made mainly of nonreactive or slowly reactive materials (e.g., glass, carbon fibers, and plastics), or materials such as rubber, cloth, and concrete that break down or decompose into naturally occurring or benign constituents through physical, chemical, and biological processes. Most of these objects would settle to the sea floor where they would (1) be exposed to seawater, (2) become lodged in or covered by seafloor sediments, (3) become encrusted (e.g., by rust) through oxidation, (4) dissolve slowly, or (5) be covered by marine organisms such as coral. Plastics or other lightweight materials (e.g., polystyrene foam) may float or descend to the bottom over time, depending upon their buoyancy.

The various types of expended materials that would be used during training and testing activities are described in detail in Section 3.1.3.4 (Other Materials) in the 2015 NWTT Final EIS/OEIS. That section describes the constituent components of marine markers, flares, and chaff as well as other items and

the fate and transport of those constituents in the marine environment. Pyrotechnic materials in marine markers and flares are largely consumed during use, and combustion byproducts are released into the air and would have limited contact with the water. The chemical constituents of marine markers and flares are listed in Table 3.1-21 of the 2015 NWTT Final EIS/OEIS, and the constituents of chaff are listed in Table 3.1-22 of the 2015 NWTT Final EIS/OEIS. The vast majority of these other materials and items made up of other materials would be expended in the Offshore Area and not in the Inland Waters portion of the Study Area.

The analysis in the 2015 NWTT Final EIS/OEIS concluded that the potential impacts of other materials on sediments and water quality would be short term for items that degrade into benign constituents and long term for items that are composed of persistent materials, such as plastics, that break down over years. However, the potential changes to the chemical, physical, or biological properties of sediments and marine waters from the introduction of these other materials would not be measurable as many of the constituent materials occur naturally in the marine environment and would not be detectable above background levels.

3.1.4.4.1 Impacts from Other Materials

3.1.4.4.1.1 Impacts from Other Materials Under Alternative 1

Impacts from Other Materials Under Alternative 1 for Training Activities

Appendix A (Navy Activities Descriptions) describes the training activities that use the various types of other materials and the types of stressors associated with those activities.

Under Alternative 1, the number of other materials that would be expended during training activities is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS. For example, the number of parachutes used in training activities increases by less than 4 percent, from 9,097 to 9,456 under Alternative 1 (Table 3.0-20). When the total amount of other expended materials from Tables 3.0-14 through 3.0-22 are combined (excluding munitions and other metal items described above), the number of items proposed to be expended under Alternative 1 increases by approximately 5 percent compared with the number of items proposed in the 2015 NWTT Final EIS/OEIS. This change does not appreciably change the impact conclusions presented in the 2015 NWTT Final EIS/OEIS and summarized above in Section 3.1.4.4 (Other Materials). Therefore, the impacts on sediments and water quality from other expended materials would be expected to be the same or slightly greater compared with ongoing activities.

Impacts from Other Materials Under Alternative 1 for Testing Activities

New testing activities not addressed in the 2015 NWTT Final EIS/OEIS would involve the use of a biodegradable polymer as part of a marine vessel stopping system, and, in a separate activity, a new countermeasure emulator device. Marine vessel-stopping systems are designed to deliver the appropriate measure(s) to affect a vessel's propulsion and associated control surfaces to significantly slow and potentially stop the advance of the vessel.

The biodegradable polymers that the Navy uses are designed to temporarily interact with the propeller(s) of a target craft rendering the craft ineffective. Some of the polymer constituents would dissolve within two hours of immersion whereas other components would last longer. Based on the constituents of the biodegradable polymers the Navy proposes to use, it is anticipated that the material will break down into small pieces within a few days to weeks. These smaller pieces will break down further and dissolve into the water column within weeks to a few months. Degradation and dispersal

timelines are influenced by water temperature, currents, and other oceanographic features (Carniel et al., 2019). Overall, the longer the polymer remains in the water, the weaker it becomes making it more brittle and likely to break. The final products are all environmentally benign and will ultimately be dispersed to undetectable concentrations within the water column. Refer to Section 3.0.3.3.5.3 (Biodegradable Polymer) and Table 3.0-21 for information on how often and where biodegradable polymers are used in the Study Area.

A new countermeasure emulator not addressed in the 2015 NWTT Final EIS/OEIS is a device that contains a gas generator module and noisemaker module that would be deployed in the water at various depths. The gas generator module contains solid pucks composed of iron and lithium hydride, which would be released from the device underwater, allowing the lithium hydride to react strongly with water and generating bubbles for several minutes. The pucks would be totally consumed in use, degrading to gases and non-toxic, naturally occurring, compounds that would remain in solution, specifically lithium hydroxide, iron, and sodium bicarbonate. Following the activity, the noisemaker module would be recovered. Given that the residual substances remaining after the pucks dissolve are naturally occurring compounds and that the other components of the device are recovered, no impacts on sediments or water quality are anticipated from this device.

Appendix A (Navy Activities Descriptions) describes the testing activities that use the various types of other materials and the types of stressors associated with those activities.

Under Alternative 1, the total number of other materials that would be expended during testing activities decreases compared with the totals from the 2015 NWTT Final EIS/OEIS. The decrease is primarily a result of reducing the number of flares from 600 to 0 (which reduces the number of expended items associated with the use of flares from 2,400 to 0) and reducing the number of marine markers from 190 to 0 under Alternative 1. When the total amount of other expended materials from Tables 3.0-14 through 3.0-22 are combined (excluding munitions and other metal items described above), the number of items proposed to be expended under Alternative 1 decreases from approximately 7,100 items proposed in the 2015 NWTT Final EIS/OEIS to less than 4,100 (about a 43 percent reduction).

This change does not appreciably change the impact conclusions presented in the 2015 NWTT Final EIS/OEIS and summarized above in Section 3.1.4.4 (Other Materials). Therefore, the impacts on sediments and water quality from other expended materials would be expected to be the same or slightly reduced compared with ongoing activities.

3.1.4.4.1.2 Impacts from Other Materials Under Alternative 2

Impacts from Other Materials Under Alternative 2 for Training Activities

The number of times training activities using other materials (e.g., chaff) occur annually under Alternative 2 is shown in Table 2.5-1. Appendix A (Navy Activities Descriptions) describes the training activities that use the various types of other materials and the types of stressors associated with those activities.

Under Alternative 2, the number of other materials that would be expended during training activities is generally consistent with the number proposed for use in the 2015 NWTT Final EIS/OEIS and under Alternative 1. When the total amount of other expended materials from Tables 3.0-14 through 3.0-22 are combined (excluding munitions and other metal items), the number of items proposed to be expended under Alternative 2 increases by approximately 5 percent compared with the number of items proposed in the 2015 NWTT Final EIS/OEIS and approximately 1 percent compared with Alternative 1.

This change does not appreciably change the impact conclusions presented in the 2015 NWTT Final EIS/OEIS and summarized above in Section 3.1.4.4 (Other Materials). Therefore, the impacts on sediments and water quality from other expended materials would be expected to be the same or slightly greater compared with ongoing activities and activities under Alternative 1.

Impacts from Other Materials Under Alternative 2 for Testing Activities

The number of times testing activities using other materials (e.g., chaff) occur annually under Alternative 2 is shown in Tables 2.5-2 and 2.5-3. Appendix A (Navy Activities Descriptions) describes the testing activities that use the various types of other materials and the types of stressors associated with those activities.

Under Alternative 2, the total number of other materials that would be expended during testing activities decreases compared with the total from the 2015 NWTT Final EIS/OEIS and is greater than the number of other materials expended under Alternative 1. The decrease, compared with ongoing activities, is primarily a result of reducing the number of flares and marine markers to 0, consistent with Alternative 1. When the total amount of other expended materials from Tables 3.0-14 through 3.0-22 are combined (excluding munitions and other metal items), the number of items proposed to be expended under Alternative 2 decreases from approximately 7,100 items proposed in the 2015 NWTT Final EIS/OEIS to 4,100 (about a 42 percent reduction). The number of other expended materials is approximately the same as under Alternative 1.

This change does not appreciably change the impact conclusions presented in the 2015 NWTT Final EIS/OEIS and summarized above in Section 3.1.4.4 (Other Materials). Therefore, the impacts on sediments and water quality from other expended materials would be expected to be the same or slightly reduced compared with ongoing activities and approximately the same as impacts under Alternative 1.

3.1.4.4.2 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 Study Area. Impacts from other materials associated with the Proposed Action on sediments and water quality would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

3.1.4.5 Secondary Stressors

Air pollutants discharged as a result of Navy training and testing activities could have secondary or indirect impacts on water quality (no impacts on sediments would occur). The scavenging of air pollutants from the atmosphere by water droplets—both during cloud formation and during rainfall—is a well-known and well-studied atmospheric process (Luo et al., 2002; Wania et al., 1998). Water droplets can scavenge 85 percent or more of air pollutants during a rainfall event. In so doing, rainfall transfers these pollutants from the atmosphere to the surface. Rainfall scavenging of nitrogen oxides and sulfur oxides from the atmosphere creates dilute solutions of nitric and sulfuric acid (i.e., “acid rain”).

The coastal areas of the Pacific Northwest receive more than 6 ft. of rainfall in an average year, representing tens of billions of gallons of water. Total emissions of criteria air pollutants from training and testing activities would amount to several hundred tons per year, dispersed over large ocean areas in the Study Area. Conservatively assuming that emissions occurred at such times and places that all

emissions were captured by rainfall (instead of being dispersed) and deposited on the surface of the ocean, it is still highly unlikely that pollutant concentrations in a single rainfall event would be measurable in the marine environment, and pollutant concentrations averaged over time would be below detection limits. Upon contact with the ocean surface, pollutants would immediately be dispersed into a much larger volume of water. Thus diluted, these pollutants would have a negligible effect on water quality in the Study Area. Additional information on impacts from air emissions is provided in Section 3.2 (Air Quality) of the 2015 NWTT Final EIS/OEIS and summarized in Section 3.2 (Air Quality) of this Supplemental.

Similarly, as discussed in Section 3.1.3.4 (Water Quality in the Study Area), the concentration of Chlorophyll-*a*, a surrogate measure of phytoplankton abundance, in the Study Area would not be significantly influenced by atmospheric deposition of nitrogen or other compounds in air pollutants introduced into the marine environment by training and testing activities. The dominant anthropogenic source of nutrients fueling phytoplankton growth is runoff from urban and agricultural sites. Naturally occurring coastal upwelling of nutrients also drives phytoplankton growth.

3.1.4.5.1 Impacts from Secondary Stressors

3.1.4.5.1.1 Impacts from Secondary Stressors Under Alternative 1 and Alternative 2

The changes in the numbers of activities that would generate air emissions under Alternative 1 and Alternative 2 are shown primarily in Table 3.0-11, which presents the number of activities using aircraft, and Table 3.0-12, which presents the number of activities involving vessel movements. The changes under Alternative 1 and Alternative 2 would not appreciably change the impact conclusions for secondary stressors presented in the 2015 NWTT Final EIS/OEIS.

3.1.4.5.1.2 Impacts from Secondary Stressors Under the No Action Alternative

Under the No Action Alternative, the Navy would not conduct the proposed training and testing activities in the Study Area. Impacts from secondary stressors associated with the Proposed Action on sediments and water quality would not be introduced into the marine environment. Therefore, existing environmental conditions would either remain unchanged or would improve slightly after cessation of ongoing training and testing activities.

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