3.7 Marine Vegetation

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3.7 MARINE VEGETATION

MARINE VEGETATION SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following have been analyzed for marine vegetation:

- Acoustic (underwater explosives)
- Physical disturbance and strike (vessel and in-water device strikes, military expended materials, and seafloor devices)

Preferred Alternative (Alternative 1)

- No Endangered Species Act-listed marine vegetation species are found in the Northwest Training and Testing Study Area.
- Acoustic and Physical Disturbance and Strike: Underwater explosives and physical disturbance and strike could affect marine vegetation by destroying individual plants or damaging parts of plants. The impacts of these stressors are not expected to result in detectable changes in growth, survival, or propagation, and are not expected to result in population-level impacts on marine plant species.
- Secondary: Secondary stressors are not expected to result in detectable changes in growth, survival, propagation, or population-level impacts because changes in sediment and water quality or air quality are not likely to be detectable.
- These conclusions are based on the fact that the areas of impact are very small compared to the relative distribution and the locations where explosions or physical disturbance or strikes occur.
- Pursuant to the Essential Fish Habitat (EFH) requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives and other impulse sources, vessel movement, in-water devices, military expended materials, and seafloor devices during training and testing activities may have an adverse effect on EFH by reducing the quality and quantity of marine vegetation that constitutes EFH or Habitat Areas of Particular Concern.

3.7.1 INTRODUCTION

This section analyzes potential impacts on marine vegetation found in the Northwest Training and Testing (NWTT) Study Area (Study Area). Pierside maintenance and testing that would occur in the Offshore Area, Inland Waters (Puget Sound), and in Southeast Alaska (Behm Canal), would not create stressors affecting marine vegetation and, therefore, pierside maintenance and testing are not addressed in this section. Marine vegetation, including marine algae and flowering plants, are found throughout the Study Area. No Endangered Species Act (ESA)-listed species are found in the Study Area. United States (U.S.) Department of the Navy (Navy) training and testing activities are evaluated for their potential impacts on six major taxonomic groups of marine vegetation, as appropriate (Table 3.7-1).

Essential Fish Habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act will be described in the Essential Fish Habitat Assessment (EFHA), and conclusions from the EFHA will be summarized in each substressor section.

The distribution and condition of offshore abiotic (non-living) substrates associated with attached macroalgae and the impact of stressors on those substrates are described in Section 3.3 (Marine Habitats).

Additional information on the biology, life history, and conservation of marine vegetation can be found on the websites of the following agencies and groups:

- National Marine Fisheries Service, Office of Protected Resources (including ESA-listed species distribution maps)
- Conservation International
- Algaebase
- National Resources Conservation Service
- National Museum of Natural History

The marine vegetation found in the Study Area consists of five groups of marine algae and one group of flowering plants (Table 3.7-1). More information on each of the major taxonomic groups is provided in the offshore, inshore, and southeast Alaska section discussions in Section 3.7.2 (Affected Environment).

Table 3.7-1: Major Taxonomic Groups of Marine Vegetation in the Study Area

Marine Vegetation Groups[1]		Distribution in the Study Area[2]		
Common Name (Taxonomic Group)	**Description**	**Offshore Area**	**Inland Waters**	**Western Behm Canal (Alaska)**
Dinoflagellates (phylum Dinophyta)	Most are photosynthetic single-celled algae that have two whip-like appendages (flagella); Some live inside other organisms. Some produce toxins that can result in red tides or ciguatera poisoning.	Sea surface	Sea surface	Sea surface
Blue-green algae (phylum Cyanobacteria)	Many form mats that attach to reefs and produce nutrients for other marine species through nitrogen fixation.	Sea surface	Seafloor	Seafloor
Green algae (phylum Chlorophyta)	Marine species occur as unicellular algae, filaments, and large seaweeds.	None	Sea surface, seafloor	Sea surface, seafloor
Diatoms, brown and golden-brown algae (phylum Heterokontophyta)	Single-celled algae that form the base of the marine food web; brown and golden-brown algae are large multi-celled seaweeds that form extensive canopies, providing habitat and food for many marine species.	Sea surface	Sea surface, seafloor	Sea surface, seafloor
Red algae (phylum Rhodophyta)	Single-celled algae and multi-celled large seaweeds; some form calcium deposits.	Sea surface	Seafloor	Seafloor
Seagrass and cordgrass (phylum Spermatophyta)	Flowering plants are adapted to salty marine environments in mudflats and marshes, providing habitat and food for many marine species.	None	Seafloor	Seafloor

[1] Species groups are based on the Catalogue of Life (Bisby et al. 2010).
[2] "None" indicates absence of the taxonomic group within the Study Area portion (see map of the Study Area in Figure 2.1-1).

3.7.2 AFFECTED ENVIRONMENT

Factors that influence the distribution and abundance of vegetation in the large marine ecosystems and open ocean areas of the Study Area are the availability of light, nutrients, water quality, water clarity, salinity level, seafloor type (important for rooted or attached vegetation), currents, tidal schedule, and temperature (Green and Short 2003). Marine ecosystems in the Study Area depend almost entirely on the energy produced by photosynthesis of marine plants and algae (Castro and Huber 2000), which is the transformation of the sun's energy into chemical energy. In surface waters of the open ocean and coastal waters, as well as within the portion of the water column illuminated by sunlight, marine algae and flowering plants provide oxygen, food, and habitat for many organisms (Dawes 1998).

Marine vegetation along the Pacific Northwest coast is represented by more than 700 varieties of seaweeds (such as corallines and other red algae, brown algae including kelp, and green algae), seagrasses (Dethier 1990; Berry and Ritter 1995; Wyllie-Echeverria and Ackerman 2003), and canopy-forming kelp species (Eissinger 2009). Red algae are the most diverse of the macroalgae in the Pacific Northwest, based on number of genera (about 115) and species (at least 265) (Waaland 1977). In intertidal and shallow subtidal areas, red algae often occupy the understory of the larger kelp. Green algae are the second most common vegetation in the intertidal areas of the Strait of Juan de Fuca (Bailey et al. 1998). Brown algae, such as the kelp beds in the Pacific Northwest, are among the most extensive and elaborate in the world. Kelp beds extend into the Strait of Juan de Fuca to Crescent Rock; however, they are uncommon in Dabob Bay and northern Hood Canal. In the Behm Canal near the Southeast Alaska Acoustic Measurement Facility (SEAFAC) portion of the Study Area, the marine vegetation mainly occurs in the near coastal waters around Back Island and includes green, brown, and red algae on rocky substrates, and some eelgrass on sandy substrates (U.S. Department of the Navy 1988). The rest of the SEAFAC area is composed of soft substrate outside of the photic zone and therefore lacks marine vegetation.

Certain species of microscopic algae (dinoflagellates and diatoms, for example) can form algal blooms, which can be toxic to human health and wildlife species. Harmful algal blooms can deplete oxygen within the water column and block sunlight that other organisms need to live, and some algae within algal blooms release toxins that are dangerous to human and ecological health (Center for Disease Control and Prevention 2004). These algal blooms have a negative economic impact of hundreds of millions of dollars annually world-wide (National Centers for Coastal Ocean Science 2010) with significant losses incurred by closed commercial fisheries and the public health costs of illnesses.

The marine vegetation in the taxonomic groups of seagrass and cordgrass has more limited distributions; none occur in open ocean areas. The relative distribution of seagrass is influenced by the availability of suitable substrate in low-wave-energy areas at depths that allow sufficient light exposure. Cordgrasses form dense colonies in salt marshes that develop in temperate areas in protected, low-energy environments, along the intertidal portions of coastal lagoons, tidal creeks or rivers, or estuaries, wherever the sediment can support plant root development (Mitsch et al. 2009).

3.7.2.1 General Threats

Stressors on marine vegetation are products of human activities (industrial, residential, and recreational) and natural occurrences such as storms. Species-specific information is discussed, where applicable, in Section 3.7.2.2 (Marine Vegetation Groups and Distribution), and the cumulative impacts of these threats are analyzed in Chapter 4 (Cumulative Impacts).

Human-made stressors that act on marine vegetation include excessive nutrient input (fertilizers, etc.), siltation (the addition of fine particles to the ocean), pollution (oil, sewage, trash), climate change, overfishing (Mitsch et al. 2009, Steneck et al. 2002), shading from structures (National Marine Fisheries Service 2002), habitat degradation from construction and dredging (National Marine Fisheries Service 2002), and invasion by exotic species (Hemminga and Duarte 2000, Spalding et al. 2003). The seagrass, and cordgrass taxonomic group is more sensitive to stressors than the algal taxonomic groups. The great diversity of algae makes generalization difficult but, overall, algae are resilient and colonize disturbed environments (Levinton 2009b).

Seagrasses and cordgrasses are all susceptible to the human-made stressors on marine vegetation, and their presence in the Study Area has decreased because of these stressors. Each of these types of vegetation is sensitive to additional unique stressors. Seagrasses are uprooted by dredging and scarred by boat propellers (Hemminga and Duarte 2000, Spalding et al. 2003). Seagrass beds that are scarred from boat propellers can take years to recover. Cordgrasses are damaged by sinking salt marsh habitat, a process known as marsh subsidence.

Oil in runoff from land-based sources, natural seeps, and accidental spills (such as offshore drilling and oil tanker leaks) is a major source of pollution in the marine environment (Levinton 2009a). The types and amounts of oil spilled, weather conditions, season, location, oceanographic conditions, and the method used to remove the oil (containment or chemical dispersants) are some of the factors that determine the severity of the effects. Sensitivity to oil varies among marine vegetation species and within species, depending on the life stage; generally, early-life stages are more sensitive than adult stages (Hayes et al. 1992).

Oil pollution can impact seagrasses directly by smothering the plants, or indirectly by lowering their ability to combat disease and other stressors (U.S. National Response Team 2010). Seagrasses that are totally submerged are less susceptible to oil spills because they largely escape direct contact with the pollutant. Depending on various factors, oil spills such as the Gulf War oil spill in 1991 (Kenworthy et al. 1993) range from no impact on seagrasses to long-term impacts, such as the 4-year decrease in eelgrass density caused by the *Exxon Valdez* oil spill in 1989 (Peterson 2001). Algae are relatively resilient to oil spills. Salt marshes can also be severely impacted by oil spills, and the effects can be long term (Culbertson et al. 2008).

3.7.2.2 Marine Vegetation Groups and Distribution

3.7.2.2.1 Dinoflagellates (Phylum Dinophyta)

Dinoflagellates are single-celled organisms with two flagella (whiplike structures used for locomotion) in the phylum Dinophyta (Bisby et al. 2010). Dinoflagellates are predominantly marine algae, with an estimated 1,200 species living in surface waters of the ocean worldwide (Castro and Huber 2000). Most dinoflagellates can use the sun’s energy to produce food through photosynthesis and also can ingest small food particles. Photosynthetic dinoflagellates are important primary producers in coastal waters (Waggoner and Speer 1998). Organisms such as zooplankton (microscopic animals that drift passively in the water column), feed on dinoflagellates. In the oceanic system, dinoflagellates utilize a suite of light harvesting compounds to convert solar energy into chemical energy, the most common being Chlorophyll *a*. Rates of photosynthetic production can vary from between less than 0.1 gram of carbon (gC)/square meter (m^2)/day in less productive regions, such as the western equatorial Pacific, to more than 10 gC/m^2/day in highly productive areas (Thurman 1997).

Dinoflagellates cause some types of harmful algal blooms which result from sudden increases in nutrients (e.g., fertilizers) from land into the ocean or changes in temperature and sunlight (Levinton 2009c). About 75–80 percent of toxic phytoplankton species are dinoflagellates (Cembella 2003) and are known to cause harmful algal blooms. Harmful algal blooms often kill fish and shellfish either directly, because of toxin production, or because of effects caused by large numbers of cells that clog the animal's gills and deplete them of oxygen (Smayda 1997). When affected shellfish or fish are eaten by humans, they cause diseases like paralytic shellfish poisoning, neurotoxic shellfish poisoning, diarrheic shellfish poisoning, and ciguatera (Lehane and Lewis 2000). Additional information on harmful algal blooms can be accessed on the Centers for Disease Control and the National Oceanic and Atmospheric Administration websites.

3.7.2.2.1.1 Offshore Area

The coast of the Pacific Northwest supports high primary productivity (Sutor et al. 2005). Because most dinoflagellates are photosynthetic and use Chlorophyll *a* to undergo the photosynthetic process, concentrations of Chlorophyll *a* measured in the Offshore Area can indicate the presence and population density of dinoflagellates. Concentrations greater than 3.0 milligrams of chlorophyll per cubic meter (mg chl/m^3) are present throughout the spring, summer, and fall within 40 kilometers (km) of shore, and rarely expand beyond 100 km offshore (Thomas and Strub 2001). Lowest concentrations (< 0.25 mg chl/m^3) are usually located over 200 km offshore and intrude towards the coast in mid-summer (June–July). Each year, two blooms occur, one in spring and another in summer. The timing of the first bloom varies, occurring from early April to May. The second offshore expansion typically occurs in August (Thomas and Strub 2001). Dinoflagellates produce some of the Chlorophyll *a* detected in the Offshore Area (Figure 3.7-1). The distribution of dinoflagellates depends on factors such as light intensity, salinity, water temperature, currents, topography, nutrients, reproductive cycles, and predators (Richlen and Lobel 2011).

3.7.2.2.1.2 Inland Waters

Most Chlorophyll *a* production in the Inland Waters is detected in the Strait of Juan de Fuca (Figure 3.7-1), which is where the highest concentrations of phytoplankton such as dinoflagellates will occur.

3.7.2.2.1.3 Western Behm Canal, Alaska

A study of sea surface chlorophyll concentrations for southeastern Alaska conducted in 2004 shows increased phytoplankton biomass near the Western Behm Canal portion of the Study Area between June and August (SALMON Project 2004). These late summer blooms of phytoplankton are triggered by wind driven vertical mixing of nutrients (Iverson et al. 1974, Ziemann et al. 1991). Dinoflagellates produce some of the Chlorophyll *a* detected in this portion of the Study Area.

3.7.2.2.2 Blue-Green Algae (Phylum Cyanobacteria)

Blue-green algae are single-celled, photosynthetic bacteria that inhabit the lighted surface waters and seafloors of the world's oceans (Bisby et al. 2010). Blue-green algae are key primary producers in the marine environment, and provide valuable ecosystem services such as producing oxygen and nitrogen. The blue-green algae *Prochlorococcus* is responsible for a large part of the oxygen produced globally by photosynthetic organisms. Other species of blue-green algae have specialized cells that convert nitrogen gas into a form that can be used by other marine plants and animals (nitrogen fixation) (Hayes et al. 2007; Sze 1998).

3.7.2.2.2.1 Offshore Area

The coast of the Pacific Northwest supports high primary productivity (Sutor et al. 2005). Concentrations greater than 3.0 mg chl/m^3 are present throughout the spring, summer, and fall within 40 km of shore, and rarely expand beyond 100 km offshore (Thomas and Strub 2001). Lowest concentrations (< 0.25 mg chl/m^3) are usually located over 200 km offshore and intrude towards the coast in mid-summer (June–July). Each year, two blooms occur, one in spring and another in summer. The timing of the first of these episodes varies, occurring from early April to May. The second offshore expansion typically occurs in August (Thomas and Strub 2001). Blue-green algae produce some of the Chlorophyll *a* detected in the Offshore Area (Figure 3.7-1).

3.7.2.2.2.2 Inland Waters

Most Chlorophyll *a* production in the Inland Waters is detected in the Strait of Juan de Fuca (Figure 3.7-1), which is where the highest concentrations of phytoplankton such as blue-green algae occurs. The inland waters show less variability in Chlorophyll *a* production than the Offshore Area.

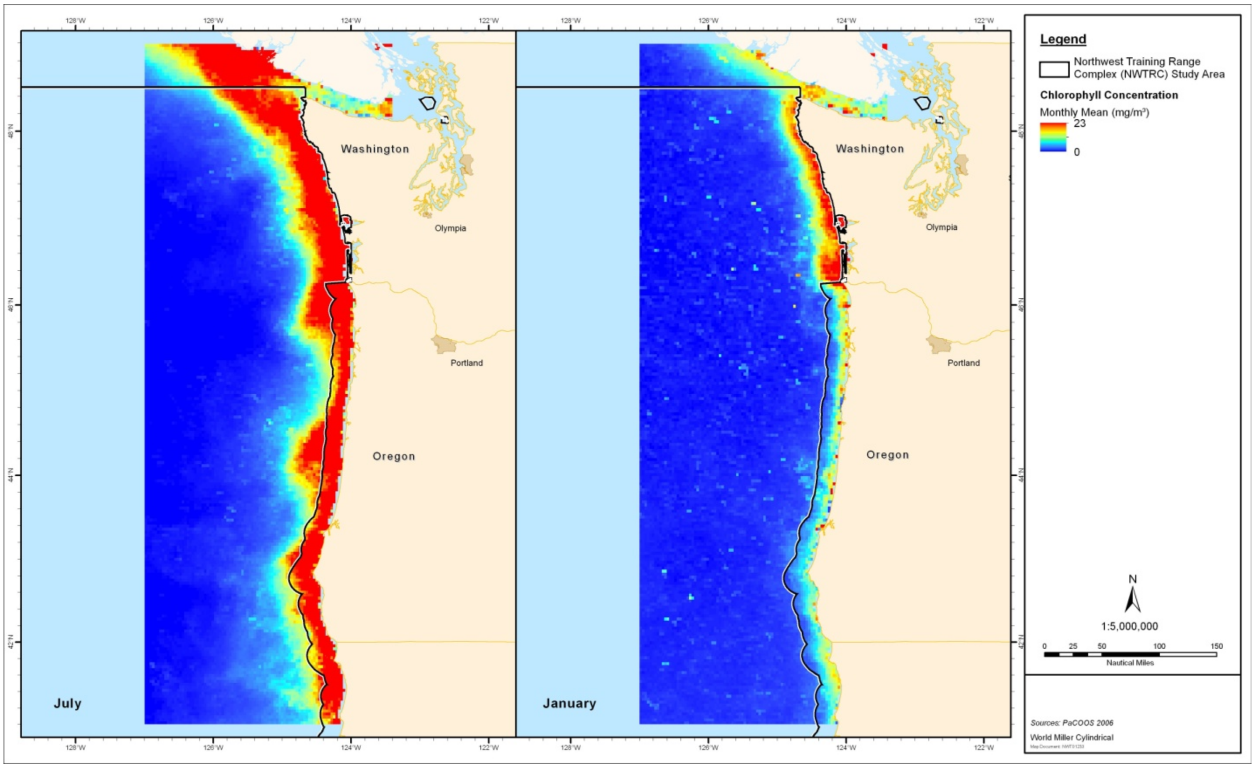

Figure 3.7-1: Chlorophyll *a* Concentrations in the Northwest Training and Testing Study Area

3.7.2.2.2.3 Western Behm Canal, Alaska

A study of sea surface chlorophyll concentrations for southeastern Alaska conducted in 2004 shows increased phytoplankton biomass near the Western Behm Canal portion of the Study Area between June and August (SALMON Project 2004). These late summer blooms of phytoplankton are triggered by wind-driven vertical mixing of nutrients (Iverson et al. 1974, Ziemann et al. 1991). Blue-green algae produce some of the Chlorophyll *a* detected in this portion of the Study Area.

3.7.2.2.3 Green Algae (Phylum Chlorophyta)

Green algae are single-celled organisms in the phylum Chlorophyta that may form large colonies of individual cells (Bisby et al. 2010). Green algae are predominately found in freshwater, with only 10 percent of the estimated 7,000 species living in the marine environment (Castro and Huber 2000). These species are important primary producers that play a key role at the base of the marine food web.

3.7.2.2.3.1 Offshore Area

Green algae are less common in the exposed areas of the outer coast. However, sometimes they are found to occur on the sea surface and sea floor of the Offshore Area (Bailey et al. 1998). Green algae produce some of the Chlorophyll *a* detected in the Offshore Area (see Figure 3.7-1).

3.7.2.2.3.2 Inland Waters

Green algae inhabit the more protected marine and estuarine areas in Washington, primarily in tide pools and rocky intertidal areas. They are the second most common vegetation in the intertidal areas of the Strait of Juan de Fuca (Bailey et al. 1998). The green algae community primarily is in the upper 330 feet (ft.) (100 meters [m]) of the water column. The distribution of phytoplankton depends on factors such as light intensity, salinity, water temperature, currents, topography, nutrients, reproductive cycles, and predators (Smith 1977, Strub et al. 1990, Batchelder et al. 2002). During the spring and summer, the upwelling of nutrient-rich waters into the surface layers combines with high solar radiation and long days to produce huge numbers of these tiny plants (Strub et al. 1990, Batchelder et al. 2002, Perry et al. 1989).

3.7.2.2.3.3 Western Behm Canal, Alaska

A study of sea surface chlorophyll concentrations for southeastern Alaska conducted in 2004 shows increased phytoplankton biomass near the Western Behm Canal portion of the Study Area between June and August (SALMON Project 2004). These late summer blooms of phytoplankton are triggered by wind-driven vertical mixing of nutrients (Iverson et al. 1974, Ziemann et al. 1991). Green algae produce some of the Chlorophyll *a* detected in this portion of the Study Area. In addition to single cellular green algae, there are various species of green macroalgae in this portion of the Study Area, such as *Acrosiphonia mertensii*, *Enteromorpha linza*, and *Cladophora columbiana* (Guiry and Guiry 2013).

3.7.2.2.4 Brown Algae (Phylum Heterokontophyta)

Brown and golden-brown algae can be single-celled (diatoms) or large, multi-celled species with structures varying from filamentous to thick, leathery forms.

3.7.2.2.4.1 Diatoms

Diatoms are single-celled organisms with cell walls made of silicon dioxide. Two major groups of diatoms are generally recognized, centric diatoms and pennate diatoms. Centric diatoms exhibit radial symmetry (symmetry about a point), while the pennate diatoms are bilaterally symmetrical (symmetry about a line). Diatoms such as *Coscinodiscus* species (spp.) commonly occur in the Study Area. Some strains of another genus of diatoms, *Pseudo-nitzschia*, produce a toxic compound called domoic acid. Humans, marine mammals, and seabirds become sick or die when they eat organisms that feed on *Pseudo-nitzschia* strains that produce the toxic compound. Strains of another genus of diatoms, *Alexandrium*, produce a toxic bloom causing paralytic shellfish poisoning. Blooms that result in catastrophic losses of cultured and wild fish, but do not cause illness in humans are caused by a few species of the diatom genus *Chaetoceros*, which clogs fish gills (Boesch et al. 1997). Decreases in the movement of cool, nutrient-rich waters by the wind in combination with pollutants carried from land to the ocean by rainwater are believed to be the main causes of these harmful algal blooms in the Study Area (Kudela and Cochlan 2000). Researchers in the Olympic coastal region, which occurs in the Study Area, are testing the hypothesis that these harmful algal bloom events affecting coastal communities are largely caused by toxic algal species growing in the vicinity of the Juan de Fuca eddy which are transported to nearshore waters by storms (National Oceanic and Atmospheric Administration 2013).

Offshore Area

The diatom community primarily is in the upper 330 ft. (100 m) of the water column (Walsh et al. 1977, Estrada and Blasco 1979, Hardy 1993). The distribution of diatoms depends on factors such as light intensity, salinity, water temperature, currents, topography, nutrients, reproductive cycles, and predators (Smith 1977, Strub et al. 1990, Batchelder et al. 2002). The coast of the Pacific Northwest supports a high density of diatoms (Sutor et al. 2005). During the spring and summer, the upwelling of nutrient-rich waters into the surface layers combines with high solar radiation and long days to produce huge numbers of these tiny cells (Strub et al. 1990, Batchelder et al. 2002, Perry et al. 1989).

Inland Waters

Most Chlorophyll *a* production in the Inland Waters is detected in the Strait of Juan de Fuca (see Figure 3.7-1), which is where the highest concentrations of phytoplankton such as diatoms will occur.

Western Behm Canal, Alaska

Diatoms are known to occur in the sea surface and sea floor of the southeast Alaska portion of the Study Area. The main diatom species in this portion of the Study Area are *Thalassiosira, Skeletonema,* and *Chaetoceros* (Waite et al. 1992).

3.7.2.2.4.2 Other Brown Algae Species

Most brown algae species are attached to the seafloor in coastal waters, although *Sargassum* may occur in a free-floating form in the Study Area (Eissinger 2009).Two species of brown algae dominate the Pacific Northwest, bull kelp (*Nereocystis leutkeana*) and giant kelp (*Macrocystis intergrifolia*). Bull kelp (*Nereocystis luetkeana*) can grow up to 5 inches (in.) (13 centimeters [cm]) per day (Dayton 1985). Bull kelp attaches to rocky substrate, and can grow up to 164 ft. (50 m) in length in nearshore areas. The giant kelp (*Macrocystis intergrifolia*) can live up to 8 years, and can reach lengths of 197 ft. (60 m). The leaf-like fronds can grow up to 24 in. (61 cm) per day (Leet et al. 2001). Sargassum (*Sargassum muticum*) is a non-indigenous brown algae from Asia and elsewhere that has been established in the Pacific Northwest for decades (Eissinger 2009).

Offshore Area

Kelp and Sargassum may occur in the sea surface of the Offshore Area of the Study Area. In turbid waters, the offshore edge of kelp beds occurs at depths of 50–60 ft. (15–18 m), which can extend to a depth of 100 ft. (30 m). The highest densities and most persistent kelp beds occur on solid rock substrate with moderately low relief and moderate sand coverage (Foster and Schiel 1985, Graham 1997). Sargassum, however, is least common along the outer coast, and offshore section of the Study Area (Shaffer 1998). Distribution of kelp and Sargassum in the Offshore Area is depicted in Figure 3.7-2.

Inland Waters

Kelp and *Sargassum* are known to occur in the sea surface and sea floor of the Inland Waters of the Study Area. Sargassum is common along the shorelines of the Hood Canal, San Juan Archipelago, and Strait of Georgia, whereas kelp is mostly found in the Strait of Juan de Fuca (Figure 3.7-2).

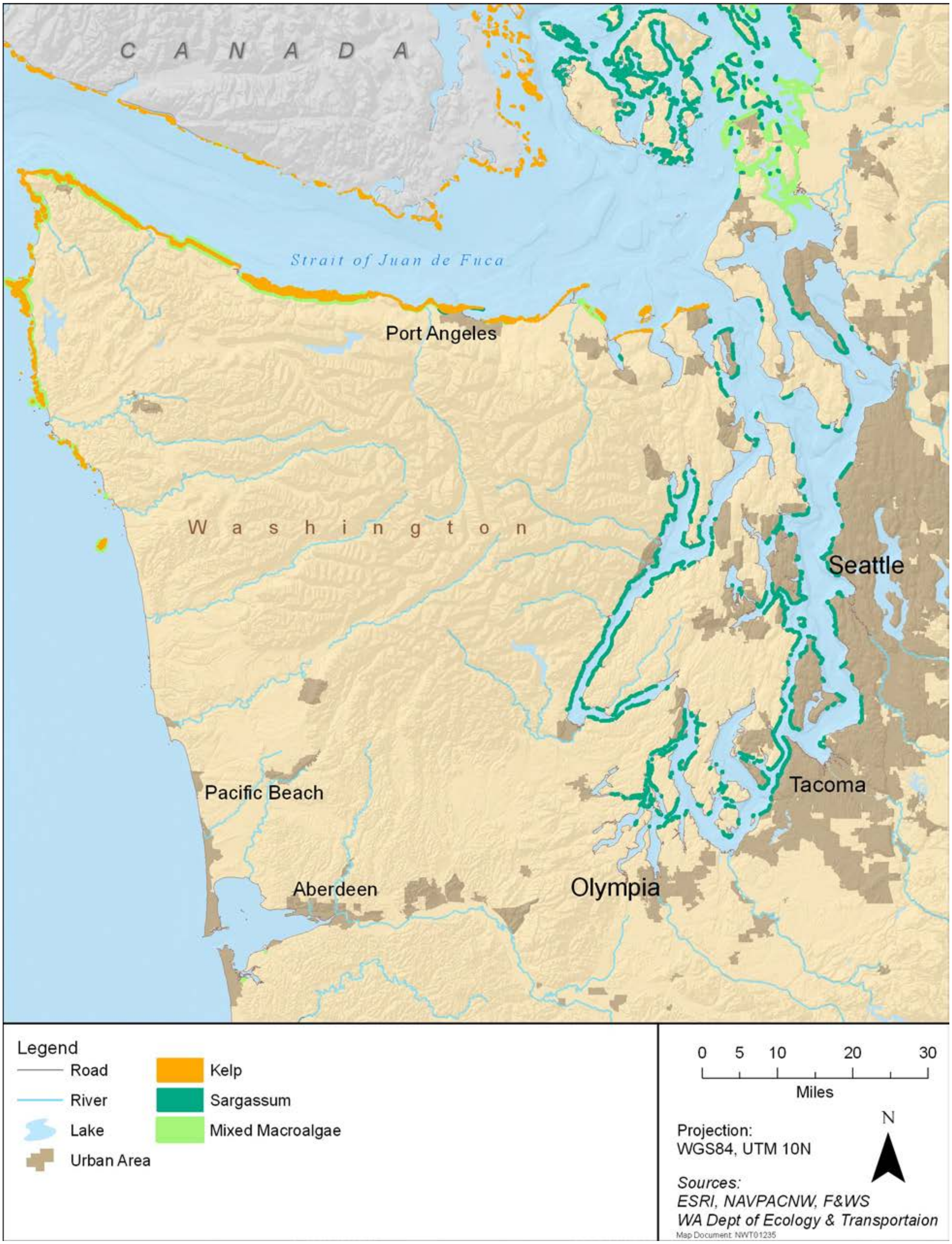

Figure 3.7-2: Kelp and *Sargassum* in the Northwest Training and Testing Study Area

Western Behm Canal, Alaska

Rockweed and kelp are known to occur in the sea surface and sea floor of the Western Behm Canal portion of the Study Area. Common species of rockweed and kelp in the Western Behm Canal portion of the Study Area include *Fucus distichus* and *Agarum marginata* (Guiry and Guiry 2013).

3.7.2.2.5 Red Algae (Phylum Rhodophyta)

Red algae are predominately marine, with approximately 4,000 species worldwide (Castro and Huber 2000). Red algal species exist in a range of forms, including single and multicellular forms (Bisby et al. 2010)—from fine filaments to thick calcium carbonate crusts.

3.7.2.2.5.1 Offshore Area

Red algae, such as *Rhodomela larix*, are known to occur in the sea surface of the Offshore Area of the Study Area (Guiry and Guiry 2013).

3.7.2.2.5.2 Inland Waters

Red algae are known to occur on the sea floor of the Inland Waters of the Study Area. Within this portion of the Study Area, a common species is *Mastocarpus papillatus* which is found in the waters of Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca (Lindstrom 2005).

3.7.2.2.5.3 Western Behm Canal, Alaska

In the Western Behm Canal portion of the Study Area shallow waters with rocky substrate are known to support red alga (*Rhodomela larix*) and even deeper waters were observed to be mainly sand substrates with patches of some red algae (U.S. Department of the Navy 1988).

3.7.2.2.6 Seagrasses and Cordgrasses (Phylum Spermatophyta)

Seagrasses and cordgrasses are flowering marine plants in the phylum Spermatophyta (Bisby et al. 2010). These marine flowering plants create important habitat for many marine species (Harborne et al. 2006, Heck et al. 2003, National Oceanic and Atmospheric Administration 2001). Cordgrasses are temperate salt-tolerant land plants that inhabit salt marshes, mudflats, and other soft-bottom coastal habitats (Castro and Huber 2000). Salt marshes develop in intertidal, protected low-energy environments, usually in coastal lagoons, tidal creeks, rivers, or estuaries (Mitsch et al. 2009).

Seagrasses are unique among flowering plants because they grow submerged in shallow marine environments. Except for some species that inhabit the rocky intertidal zone, seagrasses grow in shallow, subtidal, or intertidal sediments, and can extend over a large area to form seagrass beds (Garrison 2004; Phillips and Meñez 1988). Seagrass beds provide habitat for numerous vertebrates and invertebrates, including nurseries for commercially important crustaceans, fish, and shellfish (Harborne et al. 2006; Heck et al. 2003; National Oceanic and Atmospheric Administration 2001). Additionally, seagrass beds combat coastal erosion, promote nutrient cycling through the breakdown of detritus (Dawes 1998), and improve water quality. Seagrasses also contribute a high level of primary production to the marine environment, which supports high species diversity and biomass (Spalding et al. 2003).

3.7.2.2.6.1 Offshore Area

In the Pacific Northwest the dominant native seagrasses are eelgrass (*Zostera marina*) and surfgrass (*Phyllospadix* spp.) (den Hartog 1970). Eelgrass grows in shallow, subtidal or intertidal unconsolidated sediments, where as surfgrass grows on wave-beaten rocky shores. The primary vegetation in the Offshore Area is surfgrass (Figure 3.7-3).

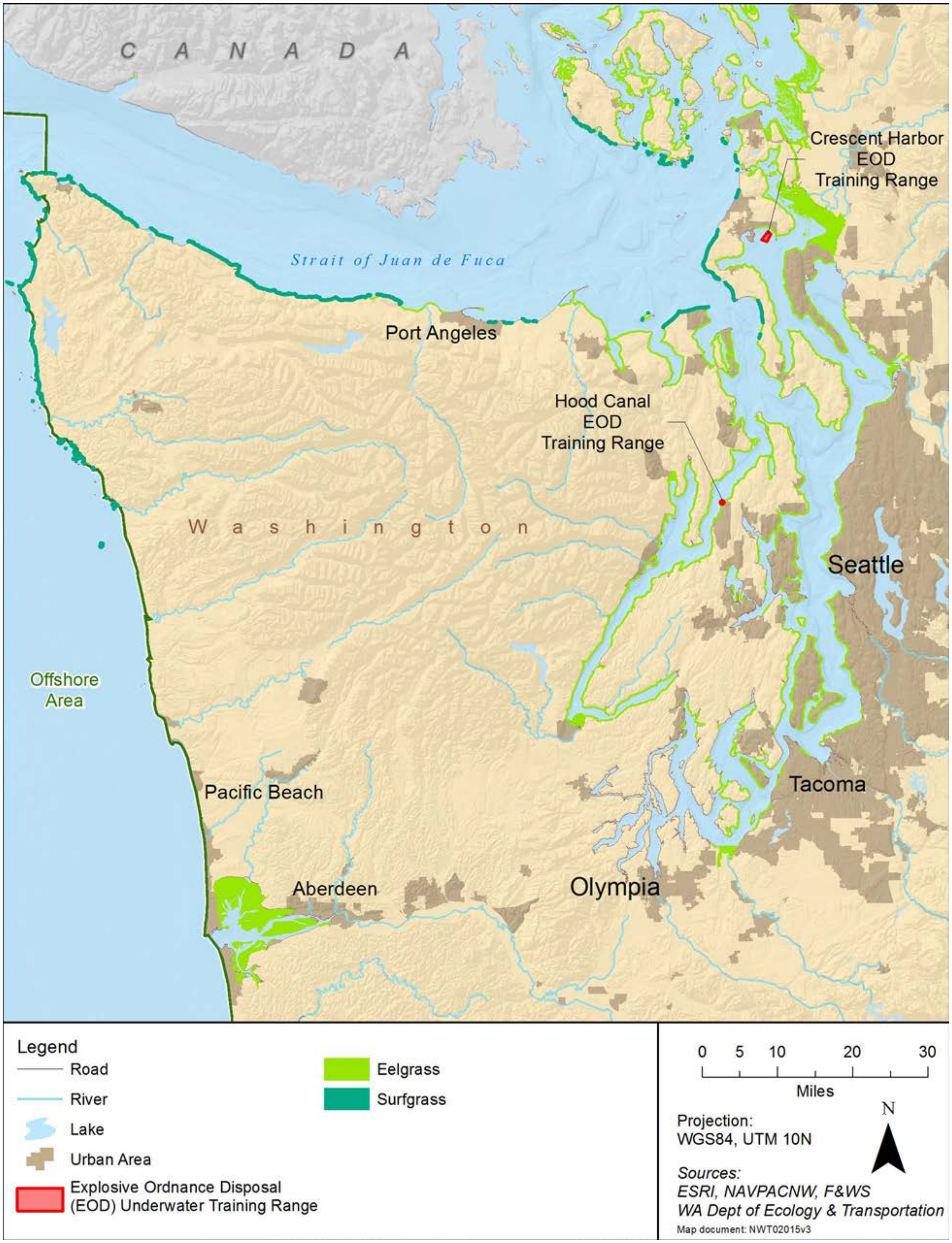

Figure 3.7-3: Surfgrass and Eelgrass in the Northwest Training and Testing Study Area

3.7.2.2.6.2 Inland Waters

Eelgrass grows in shallow, subtidal or intertidal unconsolidated sediments, whereas surfgrass grows on wave-beaten rocky shores. The primary vegetation in the intertidal areas of the Strait of Juan de Fuca and Puget Sound is eelgrass, which covers approximately 40 percent of the intertidal area (Bailey et al. 1998). Atlantic cordgrass (*Spartina alterniflora*) is a native cordgrass species from the Atlantic and Gulf coasts, and is considered an invasive species in the Study Area because it produces seeds at higher rates than the native cordgrass, and can quickly colonize mudflats (Howard 2008). Atlantic cordgrass is found in mudflats in Skagit, Clallam, and Jefferson counties (Puget Sound Partnership 2013).

3.7.2.2.6.3 Western Behm Canal, Alaska

Eelgrass is found in the Western Behm Canal portion of the study area on sandy substrates in deeper waters surrounding Back Island (U.S. Department of the Navy 1998).

3.7.3 Environmental Consequences

This section evaluates how and to what degree the activities described in Chapter 2 (Description of Proposed Action and Alternatives) potentially impact marine vegetation. General characteristics of all Navy stressors were introduced in Section 3.0.5.3 (Identification of Stressors for Analysis), and living resources' general susceptibilities to stressors are described in Appendix H (Biological Resource Methods). Each marine vegetation stressor is introduced, analyzed by alternative, and analyzed for training activities and testing activities. Tables F-3 through F-5 in Appendix F show the warfare areas and associated stressors that were considered for analysis of marine vegetation.

The stressors vary in intensity, frequency, duration, and location within the Study Area (Table 3.7-2). Based on the general threats to marine vegetation discussed in Section 3.7.2 (Affected Environment) the stressors applicable to marine vegetation are:

- Acoustic (underwater explosives)
- Physical disturbance or strikes (vessel and in-water device disturbance, military expended materials)
- Secondary stressors (sediments and water quality)

Because marine vegetation is not susceptible to energy, entanglement, or ingestion stressors, those stressors will not be assessed. Only the Navy training and testing activity stressors and their components that occur in the same geographic location as marine vegetation are analyzed in this section. Training and testing activities pose no direct threat to some types of marine vegetation habitats. Training activities are not proposed in the Western Behm Canal; therefore, only the Offshore Area and the Inland Waters will be analyzed under Training Activities. Details of all training and testing activities, stressors, components that cause the stressor, and geographic occurrence within the Study Area, are summarized in Section 3.0.5.3 (Identification of Stressors for Analysis) and detailed in Appendix A (Navy Activities Descriptions).

3.7.3.1 Acoustic Stressors

This section analyzes the potential impacts of acoustic stressors that may occur during Navy training and testing activities on marine vegetation within the Study Area. The acoustic stressors that may impact marine vegetation include explosives that are detonated on or near the surface of the water, or underwater; therefore, only these types of explosions are discussed in this section.

3.7.3.1.1 Impacts from Underwater Explosives

Various types of explosives are used during training and testing activities. The type, number, and location of activities that use explosives under each alternative are discussed in Section 3.0.5.3.1.2 (Explosives). Explosive sources are the only acoustic stressor applicable to this resource because explosives could physically damage marine vegetation.

Table 3.7-2: Stressors for Marine Vegetation in the Northwest Training and Testing Study Area

Components	Area	Number of Components or Activities					
		No Action Alternative		Alternative 1		Alternative 2	
		Training	Testing	Training	Testing	Training	Testing
Acoustic Stressors							
Explosives	Offshore Area	378	0	502	148	502	164
	Inland Waters	4	0	42	0	42	0
	W. Behm Canal	0	0	0	0	0	0
Physical Disturbance and Strike Stressors							
Activities including vessels	Offshore Area	996	37	1,096	138	1,096	162
	Inland Waters	4	337	31	582	31	640
	W. Behm Canal	0	28	0	60	0	83
Activities including in-water devices	Offshore Area	429	40	484	154	484	183
	Inland Waters	0	379	1	648	1	716
	W. Behm Canal	0	0	0	0	0	0
Military expended materials	Offshore Area	189,668	621	196,888	2,511	196,888	2,764
	Inland Waters	8	446	85	517	85	568
	W. Behm Canal	0	0	0	0	0	0
Activities including seafloor devices	Offshore Area	0	5	0	6	0	7
	Inland Waters	2	210	16	225	16	239
	W. Behm Canal	0	0	0	5	0	15
Secondary Stressors							
Habitat (sediments and water quality; air quality)	Offshore Area	QUALITATIVE					
	Inland Waters						
	W. Behm Canal						

The potential for an explosion to injure or destroy marine vegetation would depend on the amount of vegetation present, the number of munitions used, and their net explosive weight. In areas where marine vegetation and locations for explosions overlap, vegetation on the surface of the water, in the water column, or rooted in the seafloor may be impacted. Single-celled algae may overlap with acoustic stressors, but the impact would be minimal relative to their total population level; therefore, they will not be discussed further. Seafloor macroalgae, seagrass, and eelgrass may overlap with underwater and sea surface explosion locations. If these vegetation types are near an explosion, only a small number of them are likely to be impacted relative to their total population level. The low number of explosions relative to the amount of seafloor macroalgae in the Study Area also decreases the potential for impacts on these vegetation types. In addition, seafloor macroalgae are resilient to high levels of wave action (Mach et al. 2007), which may aid in their ability to withstand underwater explosions that occur near them. Underwater explosions also may temporarily increase the turbidity (sediment suspended in the water) of nearby waters, incrementally reducing the amount of light available to marine vegetation. This increase in the amount of sediments and nutrients (e.g., iron) in the water may cause algal blooms (Anderson et al. 2002). Additionally, areas of sea floor impacted by explosions may become re-colonized by algae species (Emerson and Zedler 1978).

3.7.3.1.1.1 No Action Alternative

Training Activities

Offshore Area

Under the No Action Alternative, training activities would utilize source class E4 explosives, which detonate at a depth of 66 ft. (20 m); source class E5 explosives, which detonate at a depth of 1 ft. (0.3 m); source class E8 and source class E11 explosives, both of which detonate at a depth of 90 ft. (27 m); and source class E12 explosives, which detonate at a depth of 3.3 ft. (1 m) (see Table 3.0-11). There are 378 training activities proposing the use of underwater explosions in the Offshore Area under the No Action Alternative. These explosions would likely occur over unvegetated seafloor because it is the predominant bottom type in the areas proposed for these activities; in addition, detonations would occur in waters greater than 200 ft. (61 m) in depth and greater than 3 nautical miles (nm) from shore. Detonations associated with anti-submarine warfare (source class E4) would typically occur in water greater than 600 ft. (183 m) depth. Underwater and surface explosions conducted for training activities in the Offshore Area are not expected to result in detectable changes to kelp beds, floating marine algae, or other marine algae because (1) the relative coverage of marine algae and vegetation is low in this portion of the Study Area, (2) new growth may result from floating and attached marine algae and vegetation exposure to explosives (see Section 3.7.3.1.1, Impacts from Underwater Explosives; Emerson and Zedler 1978), and (3) the impact area of underwater explosions is very small (see Figure 2.1-2) relative to marine algae and vegetation distribution. Based on these factors, potential impacts on marine algae and vegetation from underwater and surface explosions are not expected to result in detectable changes to growth, survival, or propagation, and are not expected to result in population level impacts.

Inland Waters

The potential for seagrass, cordgrass, and eelgrass to overlap with underwater and surface explosions is limited to Underwater Demolition Training areas in Crescent Harbor and Hood Canal. Seagrasses could be uprooted or damaged by sea surface or underwater explosions. They are much less resilient to disturbance than other marine algae; regrowth after uprooting can take up to 10 years (Dawes et al. 1997). Explosions may also temporarily increase the turbidity (sediment suspended in the water) of nearby waters, but the sediment would settle to pre-explosion conditions within a number of days. Sustained high levels of turbidity may reduce the amount of light that reaches vegetation.

Under the No Action Alternative, there would be a total of four explosive training events in the inshore portion of the Study Area. The impact of underwater explosions from mine neutralization activities on bottom habitats provides some perspective on the potential impact area. The total impact footprint of all underwater explosions under the No Action Alternative on bottom habitats would be approximately 313.28 square feet ($ft.^2$) (29.1 m^2). This impact footprint is small relative to the distribution of marine algae, such as kelp, in the inland portion of the Study Area, which is over 45.7 square nautical miles (nm^2).

Underwater and surface explosions conducted for training activities in the Inland Waters are not expected to pose a risk to seagrass because (1) the impact area of underwater explosions is very small

(313.28 ft.^{2} [29.1 m^2]) relative to seagrass distribution (45.7 nm^2); (2) the low number of charges reduces the potential for impacts; and (3) disturbance would be temporary, dependent upon the level of sediment redistributed, the amount of time it takes the sediment to settle, and the amount of light that reaches the disturbed area. The use of surface and underwater explosions is not expected to result in detectable changes to their growth, survival, or propagation, and is not expected to result in population-level impact for marine algae and seagrass.

Testing Activities

Offshore Area

No testing activities with underwater, surface, or seafloor detonations are proposed in the Offshore Area under the No Action Alternative.

Inland Waters

No testing activities with underwater, surface, or seafloor detonations are proposed in the Inland Waters under the No Action Alternative.

Western Behm Canal, Alaska

No testing activities with underwater, surface, or seafloor detonations are proposed in the Western Behm Canal under the No Action Alternative.

3.7.3.1.1.2 Alternative 1

Training Activities

Offshore Area

Under Alternative 1, the total number of explosives used in training events in the Offshore Area would increase by approximately 33 percent over No Action Alternative (see Table 3.7-2). The potential impacts on marine algae and vegetation from exposure to underwater and surface explosions are slightly increased, but remain similar in nature as described in Section 3.7.3.1.1.1 (No Action Alternative).

In comparison to the No Action Alternative, the increase in activities presented in Alternative 1 may increase the risk to marine algae from exposure to underwater and surface explosions. However, most of the increase under Alternative 1 comes from explosives with less than 10 pounds (lb.) of net explosive weight (see Table 3.0-11). Underwater and surface explosions conducted for training activities are not expected to pose a risk to marine algae and vegetation because (1) the impact area of underwater explosions is very small relative to marine algae and vegetation distribution in this portion of the Study Area; (2) the low number of charges reduces the potential for impacts; and (3) disturbance would be temporary, dependent upon the level of sediment redistributed, the amount of time it takes the sediment to settle, and the amount of light that reaches the disturbed area. For the same reasons as stated in Section 3.7.3.1.1.1 (No Action Alternative) for marine algae and vegetation, the use of surface and underwater explosions is not expected to result in detectable changes to their growth, survival, or propagation, and are not expected to result in population-level impacts.

Inland Waters

Under Alternative 1, the total number of explosive training events would increase relative to the No Action Alternative, due to the additional use of 18 shock wave action generators (SWAG) in Crescent Harbor and 18 SWAG in Hood Canal. The mine neutralization exercises would increase from two 1.5 lb. mine neutralization charges to three 2.5 lb. charges in Hood Canal and from two to three 2.5 lb. mine neutralization exercises in Crescent Harbor.

The potential impacts on marine algae from exposure to underwater and surface explosions are as described in Section 3.7.3.1.1.1 (No Action Alternative). The impact of underwater explosions from mine neutralization activities on bottom habitats provides some perspective on the potential impact area. The impact footprint of underwater explosions on bottom habitats in the Inland Waters of the Study Area for the three 2.5 lb. charges and 18 SWAG (that occur three times) in Crescent Harbor, along with the three 2.5 lb. charges and 18 SWAG (that occur three times) in the Hood Canal Range, is approximately 823.14 $ft.^2$ (76.5 m^2) (see Table 2.8-1, Baseline and Proposed Training Activities). This impact footprint is small (see Figure 2.1-3) relative to the distribution of marine algae, such as kelp, in the Study Area.

In comparison to the No Action Alternative, the increase in activities presented in Alternative 1 may increase the risk to marine algae from exposure to underwater and surface explosions. However, underwater and surface explosions conducted for training activities are not expected to cause population level impacts to seagrass because (1) the impact area of underwater explosions is very small (see Figure 2.1-2) relative to seagrass distribution; (2) the low number of charges reduces the potential for impacts; and (3) disturbance would be temporary, dependent upon the level of sediment redistributed, the amount of time it takes the sediment to settle, and the amount of light that reaches the disturbed area. For the same reasons as stated in Section 3.7.3.1.1.1 (No Action Alternative) for marine algae and seagrass, the use of surface and underwater explosions is not expected to result in detectable changes to their growth, survival, or propagation, and is not expected to result in population-level impacts.

Testing Activities

Offshore Area

Under Alternative 1, testing activities would involve the use of 148 explosives, during activities such as Naval Sea Systems Command (NAVSEA) torpedo testing and Naval Air Systems Command (NAVAIR) Improved Extended Echo Ranging (IEER) testing (see Tables 2.8-2 and 2.8-3). The majority of underwater explosions in the Offshore Area would occur over unvegetated seafloor because it is the predominant bottom type in the areas proposed for these activities. Underwater and surface explosions conducted for testing activities in the Offshore Area are not expected to cause any risk to marine algae and vegetation because (1) the relative coverage of marine algae and vegetation is low (see Figure 2.1-2), (2) new growth may result from marine algae and vegetation exposure to explosives (see Section 3.7.3.1.1, Impacts from Underwater Explosives), and (3) the impact area of underwater explosions is very small (see Figure 2.1-2) relative to marine algae and vegetation distribution in this portion of the Study Area. Based on these factors, potential impacts on marine algae and vegetation from underwater and surface explosions are not expected to result in detectable changes to growth, survival, or propagation, and are not expected to result in population level impacts.

Inland Waters

No testing activities with underwater, surface, or seafloor detonations are proposed in the Inland Waters under Alternative 1.

Western Behm Canal, Alaska

No testing activities with underwater, surface, or seafloor detonations are proposed in the Western Behm Canal under Alternative 1.

3.7.3.1.1.3 Alternative 2

Training Activities

Offshore Area

Under Alternative 2, the same number of underwater detonations would occur as under Alternative 1. Therefore, underwater detonations in the Offshore Area under Alternative 2 would have the same impacts on marine algae and vegetation as under Alternative 1.

Inland Waters

Under Alternative 2, the same number of underwater detonations would occur in the Inland Waters as under Alternative 1. Therefore, underwater detonations under Alternative 2 would have the same impacts on marine vegetation as under Alternative 1.

Testing Activities

Offshore Area

Under Alternative 2, testing activities would involve the use of explosives, such as NAVSEA torpedo testing and NAVAIR IEER testing (see Tables 2.8-2 and 2.8-3) and would increase by approximately 10 percent over Alternative 1. The majority of underwater explosions in the Offshore Area would likely occur over unvegetated seafloor because it is the predominant bottom type in the areas proposed for these activities. Underwater and surface explosions conducted for testing activities in the Offshore Area are not expected to cause any risk to marine algae and vegetation because (1) the relative coverage of marine algae and vegetation is low (see Figure 2.1-2), (2) new growth may result from marine algae and vegetation exposure to explosives (see Section 3.7.3.1.1, Impacts from Underwater Explosives), and (3) the impact area of underwater explosions is very small (see Figure 2.1-2) relative to marine algae and vegetation distribution. Based on these factors, potential impacts on marine algae and vegetation from underwater and surface explosions are not expected to result in detectable changes to growth, survival, or propagation, and are not expected to result in population level impacts.

Inland Waters

No testing activities with underwater, surface, or seafloor detonations are proposed in the Inland Waters under Alternative 2.

Western Behm Canal, Alaska

No testing activities with underwater, surface, or seafloor detonations are proposed in the Western Behm Canal, Alaska portion of the Study Area under Alternative 2.

3.7.3.1.2 Substressor Impact on Marine Vegetation as Essential Fish Habitat from Explosives (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives during training and testing activities may have an adverse effect on EFH by reducing the quality and quantity of marine vegetation that constitutes EFH or Habitat Areas of Particular Concern. Impact on attached macroalgae is determined to be minimal and temporary to short term throughout the Study Area. Given the available information, the impact on submerged rooted vegetation beds is determined to be minimal and long term.

3.7.3.2 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts on marine vegetation of the various types of physical disturbance stressors during training and testing activities within the Study Area. Three types of physical stressors are evaluated for their impacts on marine vegetation, including (1) vessels and in-water devices, (2) military expended materials, and (3) seafloor devices.

The evaluation of the impacts of physical disturbance stressors on marine vegetation focuses on proposed activities that may cause vegetation to be damaged by an object that is moving through the water (e.g., vessels and in-water devices), or dropped to the seafloor (e.g., military expended materials, anchors). Not all activities are proposed throughout the Study Area. Wherever appropriate, specific geographic areas of potential impact are identified.

Single-celled algae may overlap with physical disturbance stressors. However, as suspended particles, they are displaced by vessel movement in the same way as the water around them. The impact is negligible because the nature of the activity does not alter lifecycle or habitat; therefore, it does not affect the productivity or population health of these species. Impacts to single-cell algae will not be discussed further. Seagrasses and macroalgae on the seafloor on the sea surface are the only types of marine vegetation that occur in locations where physical disturbance stressors may be encountered. Therefore, only seagrasses and macroalgae are analyzed further for potential impacts of physical disturbance or strike stressors. Since the occurrence of marine algae is an indicator of marine mammal and sea turtle presence, some mitigation measures designed to reduce impacts on these resources may indirectly reduce impacts on marine algae; see Section 5.3.2.2 (Physical Disturbance and Strike).

3.7.3.2.1 Impacts from Vessels and In-Water Devices

Several different types of vessels (ships, submarines, boats, amphibious vehicles) and in-water devices (towed devices and unmanned underwater vehicles [UUVs]) are used during training and testing activities throughout the Study Area, as described in Section 3.0.5.3.3.1 (Vessels). Vessel movements occur intermittently, are variable in duration, ranging from a few hours to a few weeks, and are dispersed throughout the Study Area. Events involving large vessels are widely spread over offshore areas, while smaller vessels are more active in nearshore areas.

The potential impacts of Navy vessels and in-water devices used during training and testing activities on marine vegetation are based on the vertical distribution of the vegetation. Surface vessels include ships, boats, and amphibious vehicles, and seafloor devices include UUVs and autonomous underwater vehicles. Vessels may impact vegetation by disturbing vegetation on the sea surface or seafloor (Spalding et al. 2003). In the open ocean, marine algae on the sea surface such as kelp paddies have a patchy distribution. Marine algae could be temporarily disturbed by moving vessels or by the propeller action of transiting vessels. Fragmentation would be on a small spatial scale, and marine algal mats would be expected to re-form. These disturbances could also injure the organisms that inhabit kelp paddies or other marine algal mat, such as sea turtles, birds, marine invertebrates, and fish (see Sections 3.5, 3.6, 3.8, and 3.9, respectively). In open-ocean areas, marine algae on the sea surface may be disturbed by vessels and in-water devices. Marine algae could be temporarily disturbed by transiting vessels or by their propellers. It is resilient to winds, waves, and severe weather that could sink the mat or break it into pieces. Impacts on marine algae by vessels and in-water devices may collapse the pneumatocysts (air sacs) that keep the mats afloat. Evidence suggests that some floating marine algae will continue to float even when up to 80 percent of the pneumatocysts are removed (Zaitsev 1971).

Seafloor macroalgae may be present in locations where these vessels and in-water devices occur, but the impacts would be minimal because of their resilience, distribution, and biomass, although some types of microalgae are expected to recover faster than others. A literature search of at-risk marine macroalgae species in the Study Area (International Union for Conservation of Nature 2012) did not indicate that these species are more resilient to stressors than other marine vegetation. Additionally, seafloor macroalgae in coastal areas are adapted to natural disturbances, such as storms and wave action that can exceed 33 ft. (10 m) per second (Mach et al. 2007), and are expected to quickly recover from vessel and in-water device movements.

Towed in-water devices include towed targets that are used during activities such as Missile Exercises and Gun Exercises. These devices are operated at low speeds either on the sea surface or below it. The analysis of in-water devices will focus on towed surface targets because of the potential for impacts on marine algae. Unmanned underwater vehicles and autonomous underwater vehicles are used in training and testing activities in the Study Area. They are typically propeller-driven, and operate within the water column. The propellers of these devices are encased, eliminating the potential for seagrass propeller scarring. Algae on the seafloor could be disturbed by these devices; however, for the same reasons given for vessel disturbance, UUVs are not expected to compromise the health or condition of algae, and the impact would be minimal relative to their total population level.

Estimates of relative vessel use and location for each alternative are provided in Section 3.0.5.3.3.1 (Vessels). These estimates are based on the number of activities predicted for each alternative. While these estimates provide a prediction of use, actual Navy vessel use depends upon military training and testing requirements, deployment schedules, annual budgets, and other unpredictable factors. Testing and training activity concentrations are most dependent upon locations of Navy shore installations and established testing and training areas.

Under all alternatives, a variety of vessels and in-water devices would be used throughout the Study Area during training and testing activities, as described in Chapter 2 (Description of Proposed Action and Alternatives). The concentration of use in and the manner in which the Navy uses vessels to accomplish its mission requirements is likely to remain consistent with the range of variability observed over the last decade. Consequently, the Navy is not proposing appreciable changes in the levels, frequency, or locations where vessels have been used over the last decade.

On the open ocean, vessel disturbance of marine vegetation would be limited to floating marine algae. Vessel movements may disperse or injure algal mats. Because algal distribution is patchy, mats may re-form, and events would be on a small spatial scale. Navy training activities involving vessel movement would not impact the general health of marine algae; the impact would be minimal relative to their total population level. Navy protective measures would ensure that vessels avoid large algal mats, eelgrass beds, or other sensitive vegetation that other marine life depend on for food or habitat; these measures would safeguard sensitive vegetation from vessel strikes. In addition, Navy protective measures would require helicopter crews that tow in-water devices for mine warfare exercises to monitor the water surface before and during exercises to identify and avoid marine algae, algal mats, eelgrass beds, or other sensitive vegetation that other marine life depend on for food or habitat.

Marine vegetation in the path of moving vessels or in-water devices may have a clearly detectable response (e.g., algal mats dispersing, rupture of individual plant cells), followed by a recovery period lasting weeks to months. Marine vegetation growth near vessels or in-water devices used for training activities under the No Action Alternative, Alternative 1, and Alternative 2 would be inhibited during recovery. However, long-term survival, reproductive success, or lifetime reproductive success on a population level would not be impacted.

3.7.3.2.1.1 No Action Alternative

Training Activities

Offshore Area

Under the No Action Alternative, the impacts of vessel and in-water devices physical disturbances of marine vegetation during training activities in the Offshore Area would be limited to floating algal mats and seaweeds. The net impact of vessel, in-water device, and in-water device physical disturbances on marine vegetation is expected to be short-term and temporary based on (1) the implementation of Navy protective measures; (2) the quick recovery (weeks) of most vegetation types; (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas; and (4) the deployment of in-water devices at depths where they would not likely come in contact with marine vegetation.

Inland Waters

Under the No Action Alternative, the impacts of vessel physical disturbances on marine vegetation during training activities in the Inland Waters would be limited to floating algal mats, kelp canopies, and seaweeds. No training activities involving in-water devices occur in the inland waters. Vessel movement for training activities in the Inland Waters is caused by the small boats for Explosive Ordnance Disposal (EOD), and the Sea, Air, Land Teams, and by access between pier and open water activities. The net impact of vessel physical disturbances on marine vegetation is expected to be negligible under the No Action Alternative, based on (1) the implementation of Navy protective measures; (2) the quick recovery of most vegetation types; and (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas.

Testing Activities

Offshore Area

Under the No Action Alternative, testing activities in the Offshore Area would include activities where vessels and in-water devices could come in contact with marine vegetation, including certain types of UUVs used in the Quinault Range Site during such training events as Recovery Operations (Appendix A.2.4.1). However, most testing activities in the Offshore Area would occur at depths greater than 100 ft. (30 m). Surf zone activities would occur in the Offshore Area at Pacific Beach in the Quinault Range Site, which extends north to south 5 nm along the eastern boundary of W-237A, approximately 3 nm to shore along the mean low water line, and encompasses 1 mile (1.6 km) of shoreline at Pacific Beach, Washington. Surf zone activities would be conducted from an area on the shore going toward the sea. Surf zone activities have the potential to effect marine vegetation that is rooted to the sea floor or floating in the water column. However, these testing activities are unlikely to have a population level effect on marine vegetation under the No Action Alternative. The net impact of vessel, in-water device physical disturbances on marine vegetation is expected to be negligible based on (1) the implementation of Navy protective measures; (2) the quick recovery of most vegetation types; (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas; and (4) the deployment of in-water devices at depths where they would not likely come in contact with marine vegetation.

Inland Waters

Under the No Action Alternative, testing activities in the Inland Waters of the Study Area would include activities where vessels and in-water devices, such as with certain types of UUVs, could come in contact marine vegetation. These in-water devices used for testing activities could have a temporary (not permanent) effect on marine vegetation under the No Action Alternative. The net impact of vessel and in-water devices physical disturbances on marine vegetation is expected to be short term and temporary under the No Action Alternative, based on (1) the implementation of Navy protective measures; (2) the quick recovery of most vegetation types; (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas; and (4) the deployment of in-water devices at depths where they would not likely come in contact with marine vegetation.

Western Behm Canal, Alaska

Under the No Action Alternative, approximately 28 events under testing activities involving vessels would occur in the Western Behm Canal portion of the Study Area (see Table 3.7-2). These vessels used for testing activities could have an effect on marine vegetation under the No Action Alternative. The net impact of vessel physical disturbances on marine vegetation is expected to be short term and temporary under the No Action Alternative, based on (1) Navy protective measures; (2) the quick recovery of most vegetation types; and (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas. Therefore, eelgrass and seagrass bed damage is not likely; however, if it occurs, the impacts would be minor, such as short-term turbidity increases.

3.7.3.2.1.2 Alternative 1

Training Activities

Offshore Area

Under Alternative 1, training activities that involve vessels and in-water devices in the Offshore Area would increase slightly, from 1,425 events in the No Action Alternative to 1,572 events (see Table 3.7-2). The impacts of vessel physical disturbances of marine vegetation during training activities in the Offshore Area would be limited to floating algal mats and seaweeds. The net impact of vessel and in-water device physical disturbances on marine vegetation is expected to be short term and temporary based on (1) the implementation of Navy protective measures; (2) the quick recovery of most vegetation types; (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas; and (4) the deployment of in-water devices at depths where they would not likely come in contact with marine vegetation.

Inland Waters

Under Alternative 1, training activities that involve vessels and in-water devices in the Inland Waters of the Study Area would increase by 28 events over the No Action Alternative (see Table 3.7-2). The Navy follows protective measures that minimize conduct of training within zones of algal mats or fixed vegetation, so the risk of causing direct injury is low. Under Alternative 1, the impacts of vessel physical disturbances, including the addition of new Anti-Surface Warfare activities at Crescent Harbor; small boat Anti-Terrorism Force Protection at Crescent Harbor, Hood Canal, and the Keyport Range site; and the addition of in-water devices (used in Civilian Port Defense) during training activities in the inshore waters, would cause minimal disturbances to algal mats, kelp canopies, and seaweeds. The net impact of vessel physical disturbances on marine vegetation is expected to be negligible under Alternative 1, based on (1) Navy protective measures; (2) the quick recovery of most vegetation types; (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas; and (4) the deployment of in-water devices at depths where they would not likely come in contact with marine vegetation. Therefore, eelgrass and seagrass bed damage is not likely; however, if it occurs, the impacts would be minor, such as short-term (weeks) turbidity increases.

Testing Activities

Offshore Area

Under Alternative 1, testing activities that would include vessels and in-water devices would increase by approximately 215 events over the No Action Alternative (see Table 3.7-2). This increase would be in the tempo of testing activities in the Offshore Area, not the type of activities as described under the No Action Alternative. Therefore, the impacts under Alternative 1 would be expected to be similar to those described under the No Action Alternative. Under Alternative 1, the net impact of vessel and in-water device physical disturbances on marine vegetation is expected to be negligible based on (1) Navy protective measures; (2) the quick recovery of most vegetation types; (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas; and (4) the deployment of in-water devices at depths where they would not likely come in contact with marine vegetation.

Inland Waters

Under Alternative 1, testing activities that involve vessels and in-water devices in the Inland Waters of the Study Area would increase to 1,230 events over 716 events under the No Action Alternative (see Table 3.7-2). Additionally, testing activities that involve vessels and in-water devices would be extended to Carr Inlet. Testing activities in the Inland Waters of the Study Area would include activities where vessels and in-water devices could come in contact marine vegetation, such as with certain types of UUVs. These in-water devices used for testing activities could have an effect on marine vegetation under Alternative 1. The net impact of vessel physical disturbances on marine vegetation is expected to be negligible under Alternative 1, based on (1) Navy protective measures; (2) the quick recovery of most vegetation types; (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas; and (4) the deployment of in-water devices at depths where they would not likely come in contact with marine vegetation. Therefore, eelgrass and seagrass bed damage is not likely but, if it occurs, the impacts would be minor, such as short-term turbidity increases.

Western Behm Canal, Alaska

Under Alternative 1, approximately 60 events under testing activities involving vessels would occur in the Western Behm Canal portion of the Study Area (see Table 3.7-2). These vessels used for testing activities could have an effect on marine vegetation under Alternative 1. The net impact of vessel physical disturbances on marine vegetation is expected to be negligible under Alternative 1, based on (1) Navy protective measures; (2) the quick recovery of most vegetation types; and (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas. Therefore, eelgrass and seagrass bed damage is not likely but, if it occurs, the impacts would be minor, such as short-term turbidity increases.

3.7.3.2.1.3 Alternative 2

Training Activities

Offshore Area

Under Alternative 2, training activities that involve vessels in the Offshore Area would remain the same as under Alternative 1 (see Table 3.7-2). The impacts of vessel physical disturbances of marine vegetation during training activities in the Offshore Area would be limited to floating algal mats and seaweeds. The net impact of vessel and in-water device physical disturbances on marine vegetation is expected to be negligible based on (1) Navy protective measures; (2) the quick recovery of most vegetation types; (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas; and (4) the deployment of in-water devices at depths where they would not likely come in contact with marine vegetation.

Inland Waters

Under Alternative 2, training activities that involve vessels and in-water devices in the Inland Waters of the Study Area would remain the same number as described under Alternative 1 (see Table 3.7-2). Therefore, impacts from training in the Inland Waters would be similar to what is described in Section 3.7.3.2.1.2 (Alternative 1).

Testing Activities

Offshore Area

Under Alternative 2, testing activities that would include vessels and in-water devices would increase by approximately 268 events over the No Action Alternative (see Table 3.7-2). This increase would be in the tempo of testing activities by NAVAIR and NAVSEA in the Offshore Area, but it would not increase the potential effect on marine vegetation. Therefore the net impact of vessel and in-water device physical disturbances on marine vegetation is expected to be negligible based on (1) Navy protective measures; (2) the quick recovery of most vegetation types; (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas; and (4) the deployment of in-water devices at depths where they would not likely come in contact with marine vegetation.

Inland Waters

Under Alternative 2, the number of testing activities involving vessels, and in-water devices in the Inland Waters would increase by 10 percent compared to Alternative 1 (see Table 3.7-2). Despite this increase, the impacts to marine vegetation are expected to be the same as under Alternative 1.

Western Behm Canal, Alaska

Under Alternative 2, approximately 83 events under testing activities involving vessels would occur in the Western Behm Canal portion of the Study Area (see Table 3.7-2). These vessels used for testing activities could have an effect on marine vegetation under Alternative 2. The net impact of vessel physical disturbances on marine vegetation is expected to be negligible under Alternative 2, based on (1) Navy protective measures; (2) the quick recovery of most vegetation types; and (3) the short-term nature of most vessel movements and local disturbances of the surface water, with some temporary increase in suspended sediment in shallow areas. Therefore, eelgrass and seagrass bed damage is not likely but, if it occurs, the impacts would be minor, such as short-term turbidity increases.

3.7.3.2.1.4 Substressor Impact on Marine Vegetation as Essential Fish Habitat from Vessels and In-Water Devices (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of vessels and in-water devices during training and testing activities would have no impact on attached macroalgae or submerged rooted vegetation that constitutes EFH or Habitat Areas of Particular Concern. Any impacts on marine vegetation incurred by vessel movements and in-water devices would be minimal and short term.

3.7.3.2.2 Military Expended Materials

This section analyzes the disturbance potential to marine vegetation of the following categories of military expended materials: (1) non-explosive practice munitions; (2) fragments of high-explosive munitions; and (3) expended materials other than ordnance, such as sonobuoys, vessel hulks, and expendable targets. For a discussion of the types of activities that use military expended materials, where they are used, and how many activities would occur under each Alternative, see Section 3.0.5.3.3.3 (Military Expended Material).

Military expended materials can impact floating marine algae in the open ocean, and seagrass and other types of algae on the seafloor in coastal areas. Single-celled algae would not be impacted by military expended materials due to the nature of the algae and because there would not be any population-level impacts. Most types of military expended materials are deployed in the open ocean. In coastal water training areas, only projectiles (small and medium), target fragments, and countermeasures could be introduced into areas where shallow water vegetation such as seagrass and seafloor macroalgae may be impacted.

The following are descriptions of the types of military expended materials that could impact marine algae and seagrass. Marine algae could overlap with military expended materials anywhere in the Study Area. Puget Sound is the only location where these materials could overlap with seagrasses. Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 present the numbers and locations of activities that expend military materials during training and testing activities by location and alternative.

Small-, Medium-, and Large-Caliber Projectiles. Small-, medium-, and large-caliber non-explosive practice munitions, or fragments of high-explosive projectiles expended during training and testing activities rapidly sink to the seafloor. The majority of these projectiles would be expended in the open ocean areas of the Study Area. Because of the small sizes of the projectiles and of their casings, damage to marine vegetation is unlikely. Large-caliber projectiles are primarily used in the Offshore Area at depths greater than 26 m (85.3 ft.), while small- and medium-caliber projectiles would be expended in both offshore and coastal areas at depths less than 26 m (85.3 ft.). Marine algae could occur where these materials are expended, but seagrasses generally do not because these activities do not normally occur in water that is shallow enough for seagrass to grow (26 m [85.3 ft.]).

Bombs, Missiles, and Rockets. Bombs, missiles, and rockets, or their fragments (if high-explosive) are expended offshore (at depths greater than 26 m [85.3 ft.]) during training and testing activities, and rapidly sink to the seafloor. Marine algae could occur where these materials are expended, but seagrass generally does not because of water depth limitations for activities that expend these materials.

Parachutes. Parachutes of varying sizes are used during training and testing activities. The types of activities that use parachutes, the physical characteristics of these expended materials, where they are used, and the number of activities that would occur under each alternative are discussed in Section 3.0.5.3.4.2 (Parachutes). Marine algae could occur in any of the locations where these materials are expended.

Targets. Many training and testing activities use targets. Targets that are hit by munitions could break into fragments. Target fragments vary in size and type, but most fragments are expected to sink. Pieces of targets that are designed to float are recovered when possible. Marine algae and seagrass could occur where these materials are expended.

Vessel Hulk. Vessel hulks are a notable type of military expended material because of their size. Vessel hulks are expended at sea during sinking exercises (SINKEX). Sinking exercises use a target (vessel hulk) against which live high-explosive or non-explosive munitions are fired; the SINKEX is conducted in a manner that results in the sinking of the target. This activity would only be conducted in designated areas with bottom depths greater than 3,000 m (9,842.5 ft.). Floating marine algal mats could occur where these materials are expended, but seagrass could not.

Countermeasures. Defensive countermeasures such as chaff and flares are used to protect against missile and torpedo attack. Chaff is made of aluminum-coated glass fibers and flares are pyrotechnic devices. Chaff, chaff canisters, and flare end caps are expendable materials. Chaff and flares are dispensed from aircraft or fired from ships. Floating marine algal mats could occur in any of the locations that these materials are expended.

3.7.3.2.2.1 No Action Alternative

<u>Training Activities</u>

Offshore Area

Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 list the numbers and locations of military expended materials, most of which are small- and medium-caliber projectiles. The numbers and footprints of military expended materials from training activities under the No Action Alternative in the Offshore Area are detailed in Tables 3.7-2 and 3.3-4.

Floating marine algal mats and other types of algae that occur on the sea surface in the Offshore Area may be temporarily disturbed by military expended materials. This type of disturbance would not likely be different from conditions created by waves or rough weather. If enough military expended materials land on algal mats, the mats can sink, but sinking occurs as a natural part of the aging process of marine algae (Schoener and Rowe 1970) and would, therefore, not be expected to impact the population. This disturbance would have a minor, temporary impact on marine algae. These stressors may impact the organisms that inhabit marine algae (e.g., sea turtles, birds, marine invertebrates, and fish); for analysis of potential impacts on the species that inhabit marine algae, see Sections 3.5, 3.6, 3.8, and 3.9.

The largest deposition in the No Action Alternative training activities is the SINKEX hulk that goes into very deep water. The rest of the material deposited is typically in small fragments. Military expended materials used for training activities are not expected to pose a risk to marine algae because (1) the relative coverage of marine algae in the Offshore Area is low, (2) new growth may result from marine algae exposure to military expended materials (see Section 3.7.3.1.1, Impacts from Underwater Explosives), and (3) the impact area of military expended materials is very small relative to marine algae distribution. Based on these factors, potential impacts on marine algae from military expended materials in the Offshore Area are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts. There are no potential impacts on seagrass.

Inland Waters

Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 list the numbers and locations of military expended materials in the Study Area. The numbers and footprints of military expended materials in the Inland Waters are detailed in Tables 3.7-2 and 3.3-6.

Kelp, cordgrass, seagrass and other types of algae that occur on the in the Inland Waters of the Study Area may be temporarily disturbed when sediments are displaced by object settlement. Sediment displacement may cause short-term, local turbidity. This type of disturbance would not likely be different from conditions created by waves or rough weather (Mach et al. 2007). This disturbance would have no impact to marine algae. Although these stressors may impact the organisms that inhabit marine algae (e.g., sea turtles, birds, marine invertebrates, and fish), for analysis of potential impacts to the species that inhabit marine algae, see Sections 3.5, 3.6, 3.8, and 3.9.

Military expended materials used for training activities in the Inland Waters are not expected to pose a risk to marine algae, cordgrass, and seagrass because (1) new growth may result from exposure to military expended materials, and (2) the impact area of military expended materials is very small relative to marine algae and seagrass distribution. Based on these factors, potential impacts on marine algae and seagrass from military expended materials in the Inland Waters portion of the Study Area are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts.

Testing Activities

Offshore Area

Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 list the numbers and locations of military expended materials. The numbers and footprints of military expended materials from testing activities under the No Action Alternative in the Offshore Area are detailed in Tables 3.7-2 and 3.3-5.

Floating marine algal mats and other types of algae that occur on the sea surface in the Offshore Area may be temporarily disturbed by military expended materials. This type of disturbance would not likely be different from conditions created by waves or rough weather. If enough military expended materials land on algal mats, the mats can sink, but sinking occurs as a natural part of the aging process of marine algae (Schoener and Rowe 1970) and would, therefore, not be expected to impact the population. This disturbance would have no impact to marine algae. These stressors may impact the organisms that inhabit marine algae (e.g., sea turtles, birds, marine invertebrates, and fish); for analysis of potential impacts to the species that inhabit marine algae, see Sections 3.5, 3.6, 3.8, and 3.9.

Under the No Action Alternative, military expended materials used for testing activities in the Offshore Area are not expected to pose a risk to marine algae because (1) the relative coverage of marine algae in the Study Area is low, (2) new growth may result from marine algae exposure to military expended materials (see Section 3.7.3.1.1, Impacts from Underwater Explosives), and (3) the impact area of military expended materials is very small relative to marine algae distribution. Based on these factors, potential impacts on marine algae in the Offshore Area from military expended materials are not expected to result in detectable changes in its growth, survival, or propagation, and are not expected to result in population-level impacts. There are no potential impacts on seagrass.

Inland Waters

Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 list the numbers and locations of military expended materials. The numbers and footprints of military expended materials in the Inland Waters of the Study Area are detailed in Tables 3.7-2 and 3.3-6.

Under the No Action Alternative, military expended materials used for testing activities in the Inland Waters of the Study Area are not expected to pose a risk to marine algae, cordgrass, and seagrass because (1) new growth may result from marine algae exposure to military expended materials, and (2) the impact area of military expended materials is very small relative to marine algae distribution. Based on these factors, potential impacts on marine algae and seagrass in the Inland Waters of the Study Area from military expended materials are not expected to result in detectable changes in its growth, survival, or propagation, and are not expected to result in population-level impacts.

Western Behm Canal, Alaska

No testing activities with military expended materials are proposed in the southeast Alaska portion of the Study Area under the No Action Alternative.

3.7.3.2.2.2 Alternative 1

Training Activities

Offshore Area

Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 list the numbers and locations of military expended materials, most of which are small- and medium-caliber projectiles. The numbers and footprints of military expended materials are detailed in Tables 3.7-2 and 3.3-4. Under Alternative 1, military expended materials would increase in the Offshore Area by approximately 4 percent as compared to the No Action Alternative.

Floating marine algal mats and other types of algae that occur on the sea surface in the Offshore Area may be temporarily disturbed by military expended materials. This type of disturbance would not likely be different from conditions created by waves or rough weather. If enough military expended materials land on algal mats, the mats can sink, but sinking occurs as a natural part of the aging process of marine algae (Schoener and Rowe 1970) and would, therefore, not impact the population. This disturbance would have no impact on marine algae. These stressors may impact the organisms that inhabit marine algae (e.g., sea turtles, birds, marine invertebrates, and fish); for analysis of potential impacts to the species that inhabit marine algae, see Sections 3.5, 3.6, 3.8, and 3.9.

Therefore, military expended materials used for training activities under Alternative 1 are not expected to pose a risk to marine algae because (1) the relative coverage of marine algae in the Offshore Area is low, (2) new growth may result from marine algae exposure to military expended materials (see Section 3.7.3.1.1, Impacts from Underwater Explosives), and (3) the impact area of military expended materials is very small relative to marine algae distribution. Based on these factors, potential impacts on marine algae from military expended materials in the Offshore Area are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts. There are no potential impacts on seagrasses.

Inland Waters

Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 list the numbers and locations of military expended materials in the Study Area. Under Alternative 1, military expended materials would increase in the Inland Waters by 77 items as compared to the No Action Alternative. This increase is due almost entirely from EOD underwater detonations in which the military expended material consists of residue from the explosives.

Kelp, cordgrass, seagrass and other types of algae that occur on the in the Inland Waters of the Study Area may be temporarily disturbed by military expended materials. This type of disturbance would not likely be different from conditions created by waves or rough weather. This disturbance would have no impact to marine algae. These stressors may impact the organisms that inhabit marine algae (e.g., sea turtles, birds, marine invertebrates, and fish); for analysis of potential impacts to the species that inhabit marine algae, see Sections 3.5, 3.6, 3.8, and 3.9.

The increase in military expended materials used for training activities under Alternative 1 in the Inland Waters is not expected to pose a risk to marine algae and seagrass because (1) new growth may result from exposure to military expended materials, and (2) the impact area of military expended materials is very small relative to marine algae and seagrass distribution. Based on these factors, potential impacts on marine algae and seagrass from military expended materials in the Inland Waters portion of the Study Area are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts.

Testing Activities

Offshore Area

Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 list the numbers and locations of military expended materials expended under Alternative 1 in the Offshore portion of the Study Area. The numbers and footprints of military expended materials in the Offshore Area are detailed in Table 3.3-5, which mainly include sonobuoys and parachutes. Under Alternative 1 the amount of military expended materials in the Offshore Area would increase from 621 items under the No Action Alternative to 2,511 items (see Table 3.7-2).

Floating marine algal mats and other types of algae that occur on the sea surface in the Offshore Area may be temporarily disturbed by military expended materials. This type of disturbance would not likely be different from conditions created by waves or rough weather. If enough military expended materials land on algal mats, the mats can sink, but sinking occurs as a natural part of the aging process of marine algae (Schoener and Rowe 1970) and would, therefore, not impact the population. This disturbance would have no impact on marine algae. Although these stressors may impact the organisms that inhabit marine algae (e.g., sea turtles, birds, marine invertebrates, and fish), for analysis of potential impacts to the species that inhabit marine algae, see Sections 3.5, 3.6, 3.8, and 3.9.

Under the Alternative 1, the increased amounts of military expended materials used for testing activities in the Offshore Area are not expected to pose a risk to marine algae because (1) the relative coverage of marine algae in the Study Area is low, (2) new growth may result from marine algae exposure to military expended materials (see Section 3.7.3.1.1, Impacts from Underwater Explosives), and (3) the impact area of military expended materials is very small relative to marine algae distribution. Based on these factors, potential impacts on marine algae in the Offshore Area from military expended materials are not expected to result in detectable changes in its growth, survival, or propagation, and are not expected to result in population-level impacts. There are no potential impacts on seagrass.

Inland Waters

Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 list the numbers and locations of military expended materials; the numbers and footprints of military expended materials in the Inland Waters of the Study Area are detailed in Table 3.3-6.

Under Alternative 1, a small increase in military expended materials occurs for testing activities from the No Action Alternative. The increase in military expended materials is associated with Naval Undersea Warfare Center Division, Keyport and Naval Surface Warfare Center, Carderock Division Detachment Puget Sound testing activities.

Kelp, cordgrass, seagrass and other types of algae that occur on the in the Inland Waters of the Study Area may be temporarily disturbed by military expended materials. This type of disturbance would not likely be different from conditions created by waves or rough weather. This disturbance would have no impact to marine algae. These stressors may impact the organisms that inhabit marine algae (e.g., sea turtles, birds, marine invertebrates, and fish); for analysis of potential impacts to the species that inhabit marine algae, see Sections 3.5, 3.6, 3.8, and 3.9.

The minimal increase in military expended materials used for testing activities under Alternative 1 in the Inland Waters is not expected to pose a risk to marine algae and seagrass because (1) new growth may result from exposure to military expended materials, and (2) the impact area of military expended materials is very small relative to marine algae and seagrass distribution. Based on these factors, potential impacts on marine algae and seagrass from military expended materials in the Inland Waters portion of the Study Area are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts.

Western Behm Canal, Alaska

No testing activities with military expended materials are proposed in the southeast Alaska portion of the Study Area under the Alternative 1.

3.7.3.2.2.3 Alternative 2

Training Activities

Offshore Area

Under Alternative 2, military expended materials would increase by approximately 4 percent as compared to the No Action Alternative, the same increase as described above in Section 3.7.3.2.2.2 (Alternative 1). Therefore, impacts from military expended materials under Alternative 2 would be the same as under Alternative 1.

Inland Waters

Under Alternative 2, military expended materials would increase in the Inland Waters by 77 items as compared to the No Action Alternative, the same as described above in Section 3.7.3.2.2.2 (Alternative 1). Therefore, impacts from military expended materials under Alternative 2 would be the same as under Alternative 1.

Testing Activities

Offshore Area

Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 list the numbers and locations of military expended materials. The numbers and footprints of military expended materials in the Offshore Area are detailed in Table 3.3-5, which mainly includes sonobuoys and parachutes. Under Alternative 2 the number of military expended materials in the Offshore Area would increase from 621 items under the No Action Alternative to 2,764 items.

Floating marine algal mats and other types of algae that occur on the sea surface in the Offshore Area may be temporarily disturbed by military expended materials. This type of disturbance would not likely be different from conditions created by waves or rough weather. If enough military expended materials land on algal mats, the mats can sink, but sinking occurs as a natural part of the aging process of marine algae (Schoener and Rowe 1970) and would, therefore, not impact the population. This disturbance would have no impact on marine algae. Although these stressors may impact the organisms that inhabit marine algae (e.g., sea turtles, birds, marine invertebrates, and fish), for analysis of potential impacts to the species that inhabit marine algae, see Sections 3.5, 3.6, 3.8, and 3.9.

Under the Alternative 2, the increased amounts of military expended materials used for testing activities in the Offshore Area are not expected to pose a risk to marine algae because (1) the relative coverage of marine algae in the Study Area is low, (2) new growth may result from marine algae exposure to military expended materials (see Section 3.7.3.1.1, Impacts from Underwater Explosives), and (3) the impact area of military expended materials is very small relative to marine algae distribution. Based on these factors, potential impacts on marine algae in the Offshore Area from military expended materials are not expected to result in detectable changes in its growth, survival, or propagation, and are not expected to result in population-level impacts. There are no potential impacts on seagrass.

Inland Waters

Tables 3.0-20 through 3.0-22 and Tables 3.0-25 through 3.0-28 list the numbers and locations of military expended materials. The numbers and footprints of military expended materials in the Inland Waters of the Study Area are detailed in Table 3.3-6.

Under Alternative 2, there is a small increase in military expended materials for testing activities under Alternative 2 from the No Action Alternative (see Table 3.7-2).

Kelp, cordgrass, seagrass and other types of algae that occur in the Inland Waters of the Study Area may be temporarily disturbed by military expended materials. This type of disturbance would not likely be different from conditions created by waves or rough weather. This disturbance would have no impact to marine algae. These stressors may impact the organisms that inhabit marine algae (e.g., sea turtles, birds, marine invertebrates, and fish); for analysis of potential impacts to the species that inhabit marine algae, see Sections 3.5, 3.6, 3.8, and 3.9.

The minimal increase in military expended materials used for testing activities under Alternative 2 in the Inland Waters is not expected to pose a risk to marine algae and seagrass because (1) new growth may result from exposure to military expended materials, and (2) the impact area of military expended materials is very small relative to marine algae and seagrass distribution. Based on these factors, potential impacts on marine algae and seagrass from military expended materials in the Inland Waters portion of the Study Area are not expected to result in detectable changes in their growth, survival, or propagation, and are not expected to result in population-level impacts.

Western Behm Canal, Alaska

No training or testing activities with military expended materials are proposed in the southeast Alaska portion of the Study Area under Alternative 2.

3.7.3.2.2.4 Substressor Impact on Marine Vegetation as Essential Fish Habitat from Military Expended Materials (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, military expended materials used for training and testing activities may adversely affect EFH by reducing the quality and quantity of marine vegetation that constitutes EFH or Habitat Areas of Particular Concern. Any impacts of military expended materials on attached macroalgae or submerged rooted vegetation would be minimal and long term.

3.7.3.2.3 Impacts from Seafloor Devices

Four training and testing activities include the use of seafloor devices—items that may contact the ocean bottom temporarily. The activities and the specific seafloor devices are: (1) precision anchoring training, where anchors are lowered to the seafloor and recovered; (2) EOD mine countermeasures training exercises, where some mine targets may be moored to the seafloor; (3) crawler UUV tests in which UUVs “crawl” across the seafloor; and (4) various testing activities where small anchors are placed on the seafloor to hold instrumentation in place. Marine vegetation on the seafloor may be impacted by seafloor devices, while vegetation on the sea surface such as marine algal mats and single-celled algae are not likely to be impacted and will not be discussed further. Seagrasses and seafloor macroalgae in the Study Area may be impacted by the use of seafloor devices.

Seafloor device operation or removal could impact seagrass by physically removing vegetation (e.g., uprooting), crushing the vegetation, temporarily increasing the turbidity (sediment suspended in the water) of waters nearby, or shading seagrass, which may interfere with photosynthesis. If seagrass is not able to photosynthesize, its ability to produce energy is compromised. Seagrasses occur in all areas where seafloor devices are operated, except for the surf zone area of the Quinault Range Site in the Offshore Area.

Training activities involving seafloor devices occur only in the Inland Waters, so the Offshore Area will not be analyzed under training activities.

3.7.3.2.3.1 No Action Alternative

Training Activities

Inland Waters

Two EOD mine countermeasure exercises would occur each year in the Inland Waters under the No Action Alternative. These two activities could occur at either the Hood Canal EOD Training Range or the Crescent Harbor EOD Training Range. Not every activity would include a bottom-moored mine, as some exercises involve only a floating mine shape.

Eelgrass could be present where the mine countermeasure training activity takes place. Seafloor devices may impact vegetation in benthic habitats, but the impacts would be temporary (not permanent) and would be followed by rapid (within a few weeks) recovery. Eelgrass beds show signs of recovery after a cessation of physical disturbance; the rate of recovery is a function of the severity of the disturbance (Neckles et al. 2005). The main factors that contribute to eelgrass recovery include improving water quality and cessation of major disturbance activities (Chavez 2009). Bottom-moored mine shapes would have a minor impact limited to the area of the actual footprint of the mooring (approximately 1 $ft.^2$ [0.1 m^2]).

Seafloor device use in shallow water habitats under the No Action Alternative training activities would pose a negligible risk to marine vegetation. Any damage from seafloor devices would be followed by a rapid recovery period lasting weeks. Population-level impacts are unlikely because of the small, local impact areas, the limited frequency of training activities, and the wider geographic distribution of seagrasses in and adjacent to training areas.

Testing Activities

Offshore Area

Five crawler UUV testing activities would occur in the Offshore Area under the No Action Alternative. Because of the absence of marine vegetation in the surf zone area where the testing occurs, and the infrequency of testing, impacts to marine vegetation are unlikely.

Inland Waters

As shown in Table 3.7-2, 210 annual testing activities would occur in the Inland Waters under the No Action Alternative. These activities could include the use of small anchors or crawler UUVs.

Eelgrass could be present where these testing activities take place. Marine vegetation could be affected by the use of seafloor devices (e.g., anchors, targets, and crawler UUVs). However, these effects would be short term, would affect a very small portion of the Study Area (several yards at most), and would not result in long-term changes in the distribution or abundance of these populations. Activities usually last less than a day and are localized within a small area. Given that the size of the disturbed area would be small (several yards at most) and the activities would be short term and infrequent, impacts would be negligible. In addition, the disturbed area would likely be re-colonized within a relatively short time (a few weeks) as the disturbed sediments would not be removed, but rather redistributed in the same location. Therefore, there would be minimal impacts to marine vegetation with the implementation of the No Action Alternative within the Inland Waters.

Western Behm Canal, Alaska

No testing activities with seafloor devices are proposed in the Western Behm Canal, Alaska, portion of the Study Area under the No Action Alternative.

3.7.3.2.3.2 Alternative 1

<u>Training Activities</u>

Inland Waters

Under Alternative 1, the total number of explosive training events would increase relative to the No Action Alternative, due to the additional use of 18 SWAG in Crescent Harbor and 18 SWAG in Hood Canal. The mine neutralization exercises would increase from two 1.5 lb. mine neutralization charges to three 2.5 lb. charges in Hood Canal and from two to three 2.5 lb. mine neutralization exercises in Crescent Harbor. Not every activity would include a bottom-moored mine, as some exercises involve only a floating mine shape.

In addition, 10 precision anchoring training exercises would occur, in two locations within the Inland Waters: (1) a general anchorage area at Naval Station Everett, and (2) an anchorage area at Indian Island.

Eelgrass could be present at all of these locations. For the same reasons as described under the No Action Alternative, these activities would pose a negligible risk to marine vegetation. Any damage from anchors would be followed by a recovery period lasting weeks to months. Population-level impacts are unlikely because of the small, local impact areas; the limited frequency of training activities; and the wider geographic distribution of seagrasses in and adjacent to training areas.

<u>Testing Activities</u>

Offshore Area

Six crawler UUV testing activities would occur in the Offshore Area under Alternative 1, an increase of one over the No Action Alternative. Because of the absence of marine vegetation in the surf zone area where the testing occurs, and the frequency of testing, impacts to marine vegetation are unlikely.

Inland Waters

As shown in Table 3.7-2, 225 annual testing activities would occur in the Inland Waters under Alternative 1, an increase of 15 over the No Action Alternative. These activities are of the same type in the same locations as described under the No Action Alternative.

Eelgrass could be present where these testing activities take place. For the same reasons as described under the No Action Alternative, and re-colonization would likely occur within a relatively short time (weeks). Therefore, there would be minimal impacts to marine vegetation with the implementation of Alternative 1 within the Inland Waters.

Western Behm Canal, Alaska

Under Alternative 1, five component system testing activities would occur in the Western Behm Canal. These activities involve the temporary placement of small anchoring devices on the seafloor.

Eelgrass could be present where these testing activities take place. Marine vegetation could be affected by the use of these anchors. However, these effects would be short term (weeks), would affect a very small portion of the area (several yards at most), and would not result in long-term changes in the distribution or abundance of these populations. Activities usually last less than a day and are localized within a small area. Given that the size of the disturbed area would be small (several yards at most) and the activities would be short term and infrequent, impacts would be minimal. In addition, the disturbed area would likely be re-colonized within a relatively short time as the disturbed sediments would not be removed, but rather re-distributed in the same location. Therefore, there would be minimal impacts to marine vegetation with the implementation of Alternative 1 in the Western Behm Canal.

3.7.3.2.3.3 Alternative 2

Training Activities

Inland Waters

Under Alternative 2, the total number of explosive training events would increase relative to the No Action Alternative, due to the additional use of 18 SWAG in Crescent Harbor and 18 SWAG in Hood Canal. The mine neutralization exercises would increase from two 1.5 lb. mine neutralization charges to three 2.5 lb. charges in Hood Canal and from two to three 2.5 lb. mine neutralization exercises in Crescent Harbor. Not every activity would include a bottom-moored mine, as some exercises involve only a floating mine shape. This level and type of activity is the same as described for Alternative 1.

In addition, 10 precision anchoring training exercises would occur at the same locations and in the same manner as described above under Alternative 1.

Eelgrass could be present at all of these locations. For the same reasons as described under the No Action Alternative, these activities would pose a negligible risk to marine vegetation. Any damage from anchors would be followed by a recovery period lasting weeks to months. Population-level impacts are unlikely because of the small, local impact areas, the frequency of training activities, and the wider geographic distribution of seagrasses in and adjacent to training areas.

Testing Activities

Offshore Area

Seven crawler UUV testing activities would occur in the Offshore Area under Alternative 2, an increase of two over the No Action Alternative. Because of the absence of marine vegetation in the surf zone area where the testing occurs, and the infrequency of testing, impacts to marine vegetation are unlikely.

Inland Waters

As shown in Table 3.7-2, 239 annual testing activities would occur in the Inland Waters under Alternative 2, an increase of 29 over the No Action Alternative. These activities are of the same type in the same locations as described under the No Action Alternative.

Eelgrass could be present where these testing activities take place. For the same reasons as described under the No Action Alternative, re-colonization would likely occur within a relatively short time. Therefore, there would be minimal impacts to marine vegetation with the implementation of Alternative 2 within the Inland Waters.

Western Behm Canal, Alaska

Under Alternative 2, 15 component system testing activities would occur in the Western Behm Canal, an increase of 10 over the No Action Alternative. These activities involve the temporary placement of small anchoring devices on the seafloor.

Eelgrass could be present where these testing activities take place. For the same reasons as described under the No Action Alternative, re-colonization would likely occur within a relatively short time. Therefore, there would be minimal impacts to marine vegetation with the implementation of Alternative 2 in the Western Behm Canal.

3.7.3.2.3.4 Substressor Impact on Marine Vegetation as Essential Fish Habitat from Seafloor Devices (Preferred Alternative)

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of seafloor devices during training and testing activities may adversely affect EFH by reducing the quality or quantity of attached macroalgae and submerged rooted vegetation that constitutes EFH or Habitat Areas of Particular Concern. Any impacts of seafloor devices on attached macroalgae or submerged rooted vegetation would be minimal and short term.

3.7.3.3 Secondary Stressors

This section analyzes potential impacts on marine vegetation exposed to stressors indirectly through changes in sediments and water quality. Section 3.1 (Sediments and Water Quality) considered the impacts on marine sediments and water quality from explosives and explosion by-products, metals, chemicals other than explosives, and other materials (marine markers, flares, chaff, targets, and miscellaneous components of other materials). The analysis determined that neither state or federal standards or guidelines for sediments nor water quality would be violated by the No Action Alternative, Alternative 1, or Alternative 2. Because of these conditions, population-level impacts on marine vegetation are likely to be inconsequential and undetectable. Therefore, because these standards and guidelines are structured to protect human health and the environment, and the proposed activities do not violate them, no indirect impacts are anticipated on marine vegetation from the training and testing activities proposed by the No Action Alternative, Alternative 1, or Alternative 2.

3.7.3.4 Summary of Potential Impacts (Combined Impacts of All Stressors) on Marine Vegetation

Activities described in this Environmental Impact Statement (EIS)/Overseas EIS that have potential impacts on vegetation are widely dispersed, and not all stressors would occur simultaneously in a given location. The stressors that have potential impacts on marine vegetation include acoustic (underwater and surface explosions) and physical disturbances or strikes (vessel and in-water devices, and military expended materials). Unlike mobile organisms, vegetation cannot flee from stressors once exposed. Marine algae are the vegetation most likely to be exposed to multiple stressors in combination because it occurs in large expanses. Discrete areas of the Study Area (mainly within offshore areas with depths greater than 26 m (85.3 ft.) in portions of range complexes and testing ranges) could experience higher levels of activity involving multiple stressors, which could result in a higher potential risk for impacts on marine algae within those areas. The potential for exposure of seagrasses and attached macroalgae to multiple stressors would be less because activities are not concentrated in coastal (areas with depths less than 26 m) distributions of these species. The combined impacts of all stressors would not be expected to affect marine vegetation populations because (1) activities involving more than one stressor are generally short in duration, (2) such activities are dispersed throughout the Study Area, and (3) activities are generally scheduled where previous activities have occurred. The aggregate effect on marine vegetation would not observably differ from existing conditions.

3.7.3.4.1 Essential Fish Habitat Determinations

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of metal, chemical, and other material contaminants during training and testing activities would have no adverse impact on marine vegetation that constitutes EFH or Habitat Areas of Particular Concern. The use of explosives and other impulse sources, vessel movement, in-water devices, military expended materials, and seafloor devices during training and testing activities may adversely affect EFH by reducing the quality and quantity of marine vegetation that constitutes EFH or Habitat Areas of Particular Concern. Individual stressor impacts on marine vegetation were either no effect or minimal and ranged in duration from temporary to long term, depending on the habitat impacted.

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REFERENCES

Anderson, D., P. Glibert and J. Burkholder. (2002). "Harmful algal blooms and eutrophication: Nutrient sources, composition, and consequences." Estuaries 25(4): 704-726.

Bailey, A., H. Berry, B. Bookheim, and D. Stevens. (1998). Probability-based estimation of nearshore habitat characteristics. Pages 580-588. In: Proceedings of Puget Sound Research '98 Conference.Puget Sound Water Quality Action Team, Olympia, WA.

Batchelder, H.P., C.A. Edwards, and T.M. Powell. (2002). Individual-based models of copepod populations in coastal upwelling regions: implications of physiologically and environmentally influenced diel vertical migration on demographic success and nearshore retention. Prog. Oceanogr., 53: 307-333.

Berry, H. and R. Ritter. (1995). Puget Sound intertidal habitat inventory 1995: Vegetation and shoreline characteristics classification methods. Olympia, Washington, Washington State Department of Resources: 30 pp.

Bisby, F. A., Roskov, Y. R., Orrell, T. M., Nicolson, D., Paglinawan, L. E., Bailly, N., Baillargeon, G. (2010). *Species 2000 & ITIS Catalogue of Life: 2010 Annual Checklist*. [Online database] Species 2000. Retrieved from http://www.catalogueoflife.org/annual-checklist/2010/browse/tree, 05 September 2010.

Boesch, D. F., Anderson, D. M., Horner, R. A., Shumway, S. E., Tester, P. A., Whitledge, T. E. (1997). Harmful Algal Blooms in Coastal Waters: Options for Prevention, Control and Mitigation. *Science for Solutions*. NOAA Coastal Ocean Program Decision Analysis Series No. 10.

Castro, P. & Huber, M. E. (2000). Marine prokaryotes, protists, fungi, and plants. In *Marine Biology* (3rd ed., pp. 83-103). McGraw-Hill.

Cembella, A. D. (2003). Chemical ecology of eukaryotic microalgae in marine ecosystems. Phycologia 42:420-447.

Center for Disease Control and Prevention. (2004). Red Tide: Harmful Algal Blooms. Retrieved from http://www.cdc.gov/hab/redtide/pdfs/about.pdf, as accessed on 29 October, 2011.

Chavez, E. (2009). 2008 San Diego Bay Eelgrass Inventory and Bathymetry Update. San Diego Unified Port District Environmental Advisory Committee. Presented by Eric Chavez, National Marine Fisheries Service. September 10, 2009.

Culbertson, J. B., Valiela, I., Pickart, M., Peacock, E. E. and Reddy, C. M. (2008). Long-term consequences of residual petroleum on salt marsh grass. *Journal of Applied Ecology, 45*(4), 1284-1292. doi: 10.1111/j.1365-2664.2008.01477.x

Dawes, C. J. (1998). *Marine Botany* (2nd ed.). New York, NY: John Wiley and Sons, Inc.

Dawes, C. J., Andorfer, J., Rose, C., Uranowski, C. and Ehringer, N. (1997). Regrowth of the seagrass Thalassia testudinum into propeller scars. *Aquatic Botany, 59*(1-2), 139-155. 10.1016/s0304-3770(97)00021-1 Retrieved from http://www.sciencedirect.com/science/article/pii/S0304377097000211

Dayton, P. K. (1985). Ecology of kelp communities. *Annual Review of Ecology and Systematics, 16*, 215-245. doi: 10.1146/annurev.es.16.110185.001243 den Hartog, C. (1970). The Seagrasses of the World. Amsterdam, The Netherlands: North-Holland Publishers.

Dethier, M.N. (1990). A Marine and Estuarine Habitat Classification System for Washington State. Washington Natural Heritage Program. Dept. Natural Resources. 56 pp. Olympia, Wash.

Dreyer, G. D. and Niering, W. A. (1995). Tidal marshes of Long Island Sound: Ecology, history and restoration. [Electronic]. *Connecticut Aboretum Bulletin, 34*, 2. Retrieved from http://www.conncoll.edu/ccrec/greennet/arbo/publications/34/frame.htm

Eissinger, A. (2009). Marine Invasive Species Identification Guide for the Puget Sound area. Puget Sound Marine Invasive Species Volunteer Monitoring Program (MISM). Nahkeeta Northwest Wildlife Services. p. 10.

Emerson, S. E. and J. B. Zedler. (1978). "Recolonization of intertidal algae: An experimental study." Marine Biology 44(4): 315-324.

Estrada, M., and D. Blasco. (1979). Two phases of the phytoplankton community in the Baja California upwelling. Limnology and Oceanography 24:1065-1080.

Foster, M.S. and D.R. Schiel. (1985). The ecology of giant kelp forests in California: A community profile. Biological Report. 85(7.2). U.S. Fish and Wildlife Service. 152 pp.

Garrison, T. (2004). *Essentials of Oceanography* (3rd ed.). Pacific Grove, CA: Brooks/Cole-Thomas Learning.

Graham, M.H. (1997). Factors determining the upper limit of giant kelp, Macrocystis pyrifera Agardh, along the Monterey Peninsula, central California, USA. Journal of Experimental Marine Biology and Ecology 218:127-1 49.

Green, E. P. and Short, F. T. (2003). *World Atlas of Seagrasses* (pp. 298). Berkeley, California: University of California Press.

Guiry, M.D. & Guiry, G.M. (2013). AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org; searched on 14 February 2013.

Harborne, A.R., P.J. Mumby, F. Micheli, C.T. Perry, C.P. Dahlgren, K.E. Holmes, & D.R. Brumbaugh (2006). The Functional Value of Caribbean Coral Reef, Seagrass and Mangrove Habitats to Ecosystem Processes. *Advances in Marine Biology Volume 50*.

Hardy, J.T. (1993). Phytoplankton. Pages 233-265. In: Ecology of the Southern California Bight. M.D. Dailey, D.J. Reish, and J.W. Anderson, eds. University of California Press. Berkeley, CA.

Hayes, M. O., Hoff, R., Michel, J., Scholz, D. and Shigenaka, G. (1992). *An Introduction to Coastal Habitats and Biological Resources for Oil Spill Response*. (Report No. HMRAD 92-4, pp. 401). Seattle, WA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Hazardous Materials Response and Assessment Division.

Hayes, P. K., El Semary, N. A. & Sanchez-Baracaldo, P. (2007). The taxonomy of cyanobacteria: Molecular insights into a difficult problem. In J. Brodie and J. Lewis (Eds.), *Unravelling the Algae: The Past, Present, and Future of Algal Systematics* (pp. 93-102). Boca Raton, FL: CRC Press.

Heck, K. L., Jr, Hays, G. & Orth, R. J. (2003). Critical evaluation of the nursery role hypothesis for seagrass meadows. *Marine Ecology Progress Series, 253*, 123-136.

Hemminga, M. and Duarte, C. (2000). Seagrasses in the human environment. In *Seagrass Ecology* (pp. 248-291). Cambridge, UK: Cambridge University Press.

Howard, V. (2008). *Spartina alterniflora*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Retreived from: http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1125, on 31 October 2011.

International Union for Conservation of Nature. (2012). IUCN Red List of Threatened Species. Version 2012.1. Retrieved from: www.iucnredlist.org, as accessed on 22 June 2012.

Iverson, R.L., H.C. Curl, and J.L. Saugen. (1974). Simulation model for wind-driven summer phytoplankton dynamics in Auke Bay, Alaska. Marine Biology 28:169-178.

Kenworthy, W. J., Durako, M. J., Fatemy, S. M. R., Valavi, H. and Thayer, G. W. (1993). Ecology of seagrasses in northeastern Saudi Arabia one year after the Gulf War oil spill. *Marine Pollution Bulletin, 27*, 213-222. doi: 10.1016/0025-326x(93)90027-h

Kudela, R.M. and Cochlan, W.P. (2000). Nitrogen and carbon uptake kinetics and the influence of irradiance for a red tide bloom off southern California. *Aquatic Microbial Ecology*, 21, 31-47.

Laffoley, D. d. A. and Grimsditch, G. (2009). Introduction D. d. A. Laffoley and G. Grimsditch (Eds.), *The management of natural coastal carbon sinks*. (pp. 1-3). Prepared by I. U. f. C. o. Nature.

Leet, W. S., Dewees, C. M., Klingbeil, R. & Larson, E. J. (Eds.) (2001). *California's Living Marine Resources: A Status Report*. (pp. 588) California Department of Fish and Game.

Lehane, L., and R. J. Lewis. (2000). Ciguatera: recent advances, but the risk remains. Int. J. Food Microbiol. 61:91-125.

Levinton, J. (2009a). Environmental impacts of industrial activities and human populations. In *Marine Biology: Function, Biodiversity, Ecology* (3rd ed., pp. 564-588). New York, NY: Oxford University Press.

Levinton, J. (2009b). Seaweeds, sea grasses, and benthic microorganisms. In *Marine Biology: Function, Biodiversity, Ecology* (3rd ed., pp. 309-320). New York: Oxford University Press.

Levinton, J. (2009c). The water column: Plankton. In *Marine Biology: Function, Biodiversity, Ecology* (3rd ed., pp. 167-186). New York: Oxford University Press.

Lindstrom, S. C. (2005). The Biogeography and Molecular Diversity of Mastocarpus papillatus (Rhodophyta, Phyllorphoraceae) in Puget Sound, the Strait of Georgia and the Strait of Juan de Fuca. Proceedings of the 2005 Puget Sound Georgia Basin Research Conference.

Mach, K. J., Hale, B. B., Denny, M. W. & Nelson, D. V. (2007). Death by small forces: a fracture and fatigue analysis of wave-swept macroalgae. Journal of Experimental Biology, 210(13), 2231-2243. 10.1242/jeb.001578 Retrieved from http://jeb.biologists.org/content/210/13/2231.abstract.

Mitsch, W. J., Gosselink, J. G., Anderson, C. J. and Zhang, L. (2009). *Wetland Ecosystems* (pp. 295). Hoboken, NJ: John Wiley & Sons, Inc.

National Centers for Coastal Ocean Science. (2010, Last updated April 2010). *Economic Impacts of Harmful Algal Blooms*. [Fact sheet] Center for Sponsored Coastal Ocean Research. Retrieved from http://www.cop.noaa.gov/stressors/extremeevents/hab/current/econimpact_08.pdf

National Marine Fisheries Service. (2002). *Final recovery plan for Johnson's seagrass (Halophia johnsonni)*. (pp. 134). Silver Spring, MD. Prepared by the Johnson's seagrass recovery team. Prepared for [NMFS] National Marine Fisheries Service.

National Oceanic and Atmospheric Administration. (2001). *Seagrasses: An Overview for Coastal Managers*. (pp. 20) NOAA Coastal Services Center.

National Oceanic and Atmospheric Administration. (2013). Harmful Algal Blooms and Hypoxia in the Pacific Coast Region. NOAA Center for Sponsored Coastal Ocean Research.

Neckles, H.A., F.T. Short, S. Barker, & B.S. Kopp. (2005). Disturbance of eelgrass *Zostera marina* by commercial mussel *Mytilus edulis* harvesting in Maine: dragging impacts and habitat recovery.

Perry, M.J., J.P. Bolger and D.C. English. (1989). Primary Production in Washington Coastal Waters. In: Coastal Oceanography of Washington and Oregon. M.R. Landry and B.M. Hickey, eds. Elsevier Applied Science. New York, NY.

Peterson, C. H. (2001). The "Exxon Valdez" oil spill in Alaska: Acute, indirect and chronic effects on the ecosystem. In A. J. Southward, P. A. Tyler, C. M. Young and L. A. Fuiman (Eds.), *Advances in Marine Biology* (Vol. 39, pp. 1-103). San Diego, CA: Academic Press. doi: 10.1016/S0065-2881(01)39008-9

Phillips, R. C. & Meñez, E. G. (1988). Seagrasses. *Smithsonian Contributions to the Marine Sciences, 34*, 104.

Puget Sound Partnership. (2013). Spartina cordgrass (*Spartina spp.*). As accessed on April 15, 2013 at http://www.psparchives.com/our_work/protect_habitat/ans/spartina.htm

Richlen, M. L. and P. S. Lobel. (2011). "Effects of depth, habitat, and water motion on the abundance and distribution of ciguatera dinoflagellates at Johnston Atoll, Pacific Ocean." Marine Ecology Progress Series 421: 51-66.

SALMON Project. (2004). Sea-Air-Land Modeling and Observing Network (SALMON) SeaWiFS Chlorophyll Concentrations. http://www.ims.uaf.edu/salmon/data/seawifs/images/southeast/2004/. Accessed July 8, 2011.

Sargent, F. J., Leary, T. J., Crewz, D. W. and Kruer, C. R. (1995). Scarring of Florida's Seagrasses: Assessment and Management Options *Technical Report*. Florida Department of Environmental Protection.

Schoener, A. and Rowe, G. T. (1970). Pelagic Sargassum and its presence among the deep-sea benthos. *Deep-Sea Research, 17*, 923-925.

Shaffer, J.A. (1998). Kelp habitats of Inland Waters of Western Washington. Puget Sound Research 98. Puget Sound Watershed Action Team, Olympia, Washington.

Smayda, T.J. (1997). What is a bloom? A commentary. Limnol. Oceanogr. 42:1132-1136.

Smith, D. (1977). A Guide to Marine Coastal Plankton and Marine Invertebrate Larvae. Kendall/Hunt Publishing Company, Dubuque, IA.

South Atlantic Fishery Management Council. (1998). Final *habitat plan for the South Atlantic region: Essential fish habitat requirements for fishery management plans of the South Atlantic Fishery Management Council*. Charleston, SC: South Atlantic Fishery Management Council.

Spalding, M., Taylor, M., Ravilious, C., Short, F. & Green, E. (2003). Global overview: The distribution and status of seagrasses. In E. P. Green and F. T. Short (Eds.), *World Atlas of Seagrasses* (pp. 5-26). Berkeley, CA: University of California Press.

Steneck, R. S., Graham, M. H., Bourque, B. J., Corbett, D., Erlandson, J. M., Estes, J. A., et al. (2002). Kelp forest ecosystems: Biodiversity, stability, resilience and future. *Environmental Conservation, 29*(4), 436-459. doi: 10.1017/S0376892902000322

Strub, P.T., C. James, A.C. Thomas, and M.R. Abbott. (1990). Seasonal and nonseasonal variability of satellite-derived surface pigment concentration in the California Current. J. Geophys. Res., 95, 11501-11530.

Sutor, M.M., T.J. Cowles, W.T. Peterson, and S.D. Pierce. (2005). Acoustic observations of finescale zooplankton distributions in the Oregon upwelling region. Deep-Sea Research II 52(1-2): 109-121.

Sze, P. (1998). Cyanobacteria. In *A Biology of the Algae* (3rd ed., pp. 21-38). McGraw-Hill.

Thomas, A. and P.T. Strub. (2001). Cross-shelf phytoplankton pigment variability in the California Current. Continental Shelf Research 21(11-12):1157-1190.

Thurman, H.V. (1997). Introductory Oceanography. 8th ed. Upper Saddle River, New Jersey: Prentice Hall.

U.S. Department of the Navy. (1988). *Final Environmental Impact Statement*. Southeast Alaska Acoustic Measurement Facility (SEAFAC). U.S. Navy.

U.S. National Response Team. (2010). *What are the Effects of Oil on Seagrass?* [Electronic Pamphlet] U.S. Environmental Protection Agency, Region IV. Retrieved from http://www.nrt.org/production/NRT/RRTHome.nsf/resources/RRTIV-Pamphlets/$File/27_RRT4_Seagrass_Pamphlet.pdf

Waaland, J.R. (1977). Common Seaweeds of the Pacific Coast. Pacific Search Press, Seattle, WA. 120pp.

Waggoner, B. & Speer, B. R. (1998, Last updated August 1998). *Introduction to the Dinoflagellata*. [Web page] University of California Museum of Paleontology. Retrieved from http://www.ucmp.berkeley.edu/protista/dinoflagellata.html, 05 September 2010.

Waite, A., P. Bienfang, and P. Harrison. (1992). Spring bloom sedimentation in a subarctic ecosystem. Marine Biology 114:131-138.

Walsh, J.J., T.E. Whitledge, J.C. Kelley, S.A. Huntsman, and R.D. Pillsbury. (1977). Further transition states of the Baja California upwelling ecosystem. Limnology and Oceanography. Vol 22(2) 264-280

Wilson, C. (2002, Last updated September 2002). *Giant Kelp (*Macrocystis pyrifera*)*. [Web page] California Department of Fish and Game. Retrieved from http://www.dfg.ca.gov/mlpa/response/kelp.pdf

Wyllie-Echeverria, S. & Ackerman, J. D. (2003). The seagrasses of the Pacific coast of North America. In E. P. Green and F. T. Short (Eds.), *World Atlas of Seagrasses* (pp. 199-206). Berkeley, CA: University of California Press.

Zaitsev, Y.P. (1971). Marine neustonology. Translation by A. Mercado. Jerusalém: Israel Program for Scientific Translations. 207 p.

Ziemann, D.A., L.D. Conquest, M. Olaizola, and P.K. Bienfang. (1991). Interannual variability in the spring phytoplankton bloom in Auke Bay, Alaska. Marine Biology 109:321-334.

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