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Environmental Impact Statement/Overseas Environmental Impact Statement

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Northwest Training and Testing Activities Draft Environmental Impact Statement/ Overseas Environmental Impact Statement

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NWTT EIS/OEIS Project Manager
Naval Facilities Engineering Command, Northwest, EV21.KK
1101 Tautog Circle
Silverdale, WA 98315

DRAFT ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT for NORTHWEST TRAINING AND TESTING ACTIVITIES

Lead Agency:	United States Department of the Navy
Cooperating Agency:	National Marine Fisheries Service United States Coast Guard
Title of the Proposed Action:	Northwest Training and Testing Activities
Designation:	Draft Environmental Impact Statement/Overseas Environmental Impact Statement

Abstract

The United States Department of the Navy (Navy) prepared this Environmental Impact Statement (EIS)/Overseas EIS (OEIS) in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code § 4321 et seq.); the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations [C.F.R.] §§ 1500 et seq.); Navy Procedures for Implementing NEPA (32 C.F.R. § 775); and Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions*. The Navy identified its need to support and conduct current, emerging, and future training and testing activities in the Northwest Training and Testing Study Area (Study Area), which is made up of air and sea space in the eastern north Pacific Ocean region, located adjacent to the Northwest coast of the United States, to include the Strait of Juan de Fuca, Puget Sound (including Hood Canal), and Western Behm Canal in southeastern Alaska. Three alternatives are analyzed in this EIS/OEIS:

- The No Action Alternative represents baseline training and testing activities as defined by existing Navy environmental planning documents, including the *Northwest Training Range Complex EIS/OEIS*, the *Naval Undersea Warfare Center Keyport Range Complex Extension EIS/OEIS,* and the *Southeast Alaska Acoustic Measurement Facility EIS*. The baseline testing activities also include other testing events that historically occur in the Study Area and have been subject to previous analysis pursuant to NEPA and EO 12114.
- Alternative 1 includes the training and testing activities addressed in the No Action Alternative, plus adjustments to types and levels of activities from the baseline as necessary to support current and planned Department of the Navy training and testing requirements.
- Alternative 2 includes all elements of Alternative 1 plus adjustments to tempo of activities. Training activities would generally remain the same as proposed under Alternative 1, while testing activities would increase, on average, about 12 percent over those in Alternative 1.

In this EIS/OEIS, the Navy analyzes potential environmental impacts that result or could result from activities under the No Action Alternative, Alternative 1, and Alternative 2. Resource areas that will be addressed include, but are not limited to, sediments and water quality, air quality, marine habitats, marine mammals, sea turtles, birds, marine vegetation, marine invertebrates, fish, cultural resources, Native American and Native Alaskan traditional resources, socioeconomic resources, and public health and safety.

Prepared by: United States Department of the Navy

Point of Contact: Kimberly Kler, Environmental Planner
Naval Facilities Engineering Command, Northwest, EV21.KK
1101 Tautog Circle, Silverdale, WA 98315 | (360) 396-0927

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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The United States (U.S.) Department of the Navy (Navy) prepared this Environmental Impact Statement (EIS)/Overseas EIS (OEIS) to assess the potential environmental impacts associated with two categories of military readiness activities: training and testing. Collectively, the at-sea areas in which these military readiness activities are proposed to occur are referred to as the Northwest Training and Testing (NWTT) Study Area (Study Area) (Figure ES-1). The Navy also prepared this EIS/OEIS to comply with the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114.

Major conflicts, terrorism, lawlessness, and natural disasters all have the potential to threaten the national security of the United States. National security, prosperity, and vital interests of the United States are increasingly tied to other nations because of the close relationships between the United States and other national economies. The Navy carries out training and testing activities to be able to protect the United States from its enemies, as well as to protect and defend the rights of the United States and its allies to move freely on the oceans. Training and testing activities that prepare the Navy to fulfill its mission to protect and defend the United States and its allies potentially impact the environment. These activities may trigger legal requirements identified in many U.S. federal environmental laws, regulations, and EOs.

After thoroughly reviewing its environmental compliance requirements for training and testing exercises at sea, the Navy instituted a policy in the year 2000 designed to comprehensively address these requirements. That policy—the Navy's At-Sea Policy—resulted, in part, in a series of comprehensive analyses of training and testing activities on U.S. at-sea range complexes and operating areas. These analyses served as the basis for the National Marine Fisheries Service (NMFS) to issue Marine Mammal Protection Act (MMPA) incidental take authorizations because of the potential effects of some training and testing activities on species protected by federal law. These analyses also served as the basis for the NMFS and U.S. Fish and Wildlife Service (USFWS) to issue Biological Opinions (BOs) and incidental take statements pursuant to the Endangered Species Act (ESA). The initial analyses for the Study Area considered in this document (*Northwest Training Range Complex Final EIS/OEIS* [U.S. Department of the Navy 2010a] and *Naval Sea Systems Command Naval Undersea Warfare Center Keyport Range Complex Extension Final EIS/OEIS* [U.S. Department of the Navy 2010b]) resulted in incidental take authorizations and incidental take statements, which begin to expire in 2015.

The present EIS/OEIS updates these analyses and supports incidental take authorizations. This EIS/OEIS also furthers compliance with the Navy's policy for comprehensive analysis by analyzing the potential environmental impacts of training and testing activities in additional areas (areas not analyzed in previous documents) where training and testing historically occur, including Navy ports and shipyards.

ES.2 PURPOSE OF AND NEED FOR PROPOSED MILITARY READINESS TRAINING AND TESTING ACTIVITIES

The purpose of the Proposed Action is to conduct training and testing activities to ensure that the Navy meets its mission, which is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is achieved in part by conducting training and testing within the Study Area.

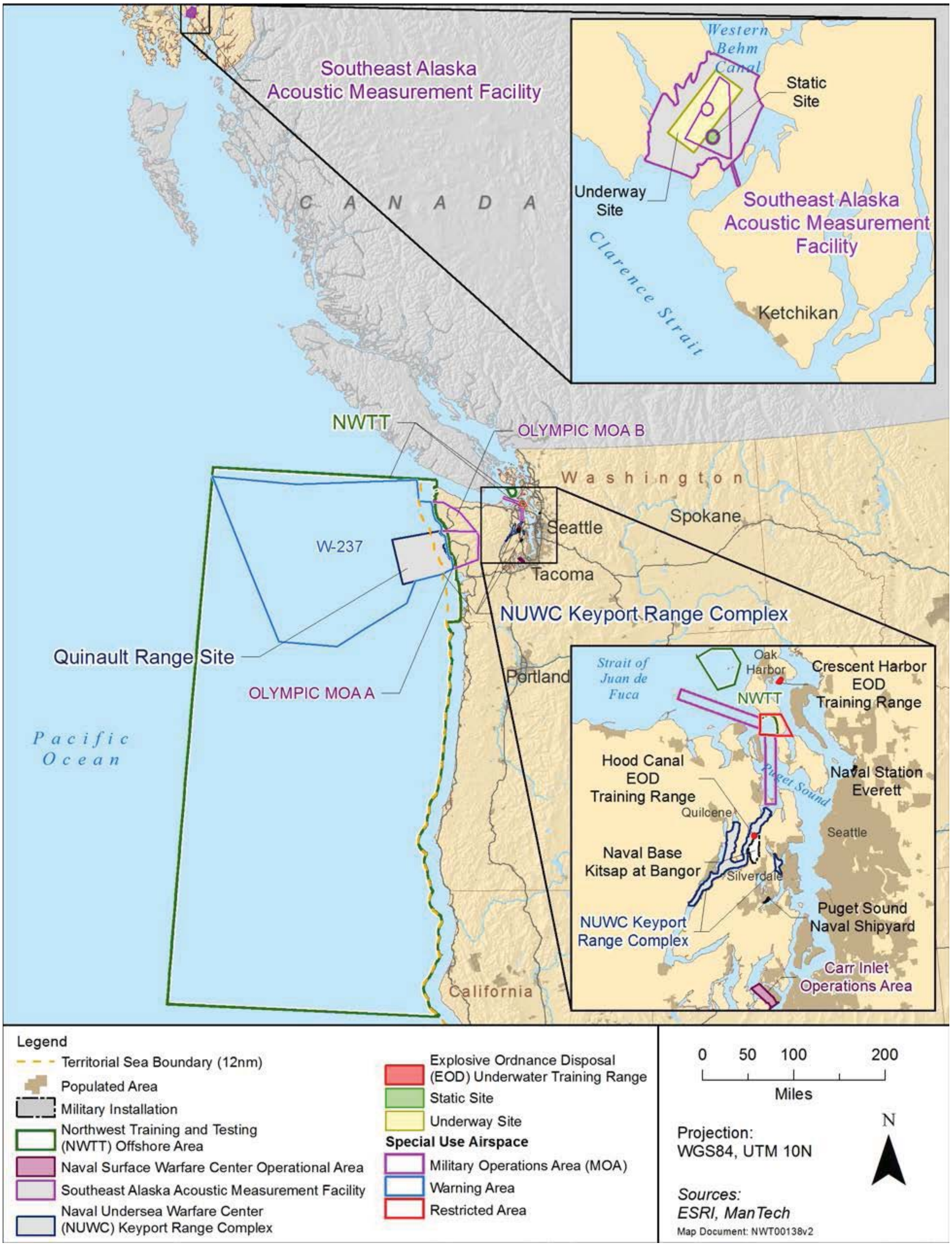

Figure ES-1: Northwest Training and Testing Study Area

ES.3 SCOPE AND CONTENT OF THE ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

In this EIS/OEIS, the Navy assessed military readiness training and testing activities that could potentially impact human and natural resources, especially marine mammals, fish, birds, sea turtles, and other marine resources. The range of alternatives includes a No Action Alternative and other reasonable courses of action. The Navy analyzed direct, indirect, cumulative, short-term, long-term, irreversible, and irretrievable impacts. The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this EIS/OEIS. The United States Coast Guard is a cooperating agency as this document assesses potential impacts from their activities that are similar to the Navy's. The NMFS is a cooperating agency because of its expertise and regulatory authority over marine resources. Additionally, this document will serve as NMFS' environmental planning documentation for the rule-making process under the MMPA.

In accordance with the Council on Environmental Quality Regulations, 40 Code of Federal Regulations (C.F.R.) § 1505.2, the Navy will issue a Record of Decision (ROD) that provides the rationale for choosing one of the alternatives. The decision will be based on factors analyzed in this EIS/OEIS, including military training and testing objectives, best available science and modeling data, potential environmental impacts, and public interest.

ES.3.1 NATIONAL ENVIRONMENTAL POLICY ACT

Federal agencies are required under NEPA to examine the environmental impacts of their proposed actions within the United States and its territories. An EIS is a detailed public document that provides an assessment of the potential effects that a major federal action might have on the human environment, which includes the natural environment. The Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with applicable laws, regulations, and executive orders. Presidential Proclamation 5928, issued 27 December 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 nautical miles (nm); however, the proclamation expressly provides that it does not extend or otherwise alter existing federal law or any associated jurisdiction, rights, legal interests, or obligations. Thus, as a matter of policy, the Navy analyzes environmental effects and actions within 12 nm (Territorial Sea as identified on Figure ES-1) under NEPA.

ES.3.2 EXECUTIVE ORDER 12114

This OEIS has been prepared in accordance with EO 12114 (44 Federal Register 1957) and in accordance with Navy regulations codified at 32 C.F.R. Part 187, *Environmental Effects Abroad of Major Department of Defense Actions*. An OEIS is required when a proposed action and alternatives have the potential to significantly harm the environment of the global commons. The global commons are defined as geographical areas outside the jurisdiction of any nation and include the oceans outside of the territorial limits (more than 12 nm from the coast) and Antarctica but do not include contiguous zones and fisheries zones of foreign nations (32 C.F.R. § 187.3). The EIS and OEIS have been combined into one document, as permitted under NEPA and EO 12114, to reduce duplication.

ES.3.3 MARINE MAMMAL PROTECTION ACT

The MMPA of 1972 (16 U.S. Code [U.S.C.] § 1361 et seq.) established, with limited exceptions, a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates "takes" of marine mammals in the global commons by vessels or persons under U.S. jurisdiction. The term "take," as defined in Section 3 (16 U.S.C. § 1362(13)) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of harassment: Level A (potential injury) and Level B (potential behavioral disturbance).

The MMPA directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if NMFS finds that the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking, other means of attaining the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the mitigation, monitoring, and reporting of such taking.

The National Defense Authorization Act of Fiscal Year 2004 (Public Law 108-136) amended the definition of harassment, removing the "specified geographic area" requirement, as well as the small numbers provision as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government consistent with Section 104(c)(3) (16 U.S.C. § 1371 et seq.). The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the Fiscal Year 2003 National Defense Authorization Act (Public Law 107-314). A "military readiness activity" is defined as "all training and operations of the Armed Forces that relate to combat" and "the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use." For military readiness activities, the relevant definition of harassment is any act that:

- injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment") or
- disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") (16 U.S.C. § 1362(18)(B)(i) and (ii)).

The Navy has prepared a consolidated request for two 5-year Letters of Authorization: one for the incidental taking of marine mammals during the conduct of training, and another for the incidental taking of marine mammals during the conduct of testing activities within the NWTT Study Area from 2015 through 2020. This EIS/OEIS has been prepared in accordance with the applicable regulations of the MMPA and will evaluate all components of the proposed training and testing activities that have the potential to incidentally take marine mammals.

ES.3.4 ENDANGERED SPECIES ACT

The ESA of 1973 (16 U.S.C. § 1531 et seq.) established protection over and conservation of threatened and endangered species and the ecosystems upon which they depend. An "endangered" species is a species in danger of extinction throughout all or a significant portion of its range. A "threatened" species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The USFWS and NMFS jointly administer the ESA and are also responsible for the listing of species (designating a species as either threatened or endangered). The ESA allows the designation of geographic areas as critical habitat for threatened or endangered species. Section 7(a)(2) requires each federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a listed species, that agency is required to consult with NMFS or USFWS, depending on which service has jurisdiction over the species (50 C.F.R. 402.14(a)). Under the terms of Section 7(b)(4) and Section 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the act provided that such taking complies with the terms and conditions of an Incidental Take Statement. The ESA applies to certain marine mammals, fish, birds, and sea turtles evaluated in this EIS/OEIS.

This EIS/OEIS analyzes potential effects to species listed under the ESA. In accordance with ESA requirements, the Navy will complete consultation under Section 7 of the ESA with NMFS and USFWS on the potential that implementation of the Proposed Action may affect listed species. With regard to NMFS jurisdiction, upon concluding Section 7 consultation, the Navy will implement protective measures identified by the Services in a BO or other consultation document. In addition, the Navy has applied for a Letters of Authorization, which are expected to impose terms and conditions that, when implemented, would make ESA Section 9 prohibitions inapplicable to covered Navy activities. With regard to USFWS jurisdiction over species present in the Study Area, the Navy will adhere to the terms of the BOs.

ES.3.5 OTHER ENVIRONMENTAL REQUIREMENTS CONSIDERED

The Navy must comply with all applicable federal environmental laws, regulations, and EOs, including, but not limited to, those listed below. Further information on Navy compliance with these and other environmental laws, regulations, and EOs can be found in Chapters 3 and 6.

- Abandoned Shipwreck Act
- Clean Air Act
- Clean Water Act
- Coastal Zone Management Act
- Endangered Species Act
- Magnuson-Stevens Fishery Conservation and Management Act
- Marine Mammal Protection Act
- Migratory Bird Treaty Act
- National Historic Preservation Act
- National Marine Sanctuaries Act
- Rivers and Harbors Act
- EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*
- EO 12962, *Recreational Fisheries*
- EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*
- EO 13089, *Coral Reef Protection*
- EO 13158, *Marine Protected Areas*
- EO 13175, *Consultation and Coordination with Indian Tribal Governments*
- EO 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*

ES.4 PUBLIC INVOLVEMENT

Under NEPA, federal agencies are required to examine the environmental effects of their proposed actions within U.S. territories. An EIS is a detailed public document that provides an assessment of the potential effects that a major federal action might have on the human environment. The Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with all applicable laws, regulations, and EOs.

The first step in the NEPA process for an EIS is to prepare a Notice of Intent to develop an EIS. The Navy published a Notice of Intent in the *Federal Register* (77 FR 11497) and several newspapers on 27 February 2012. In addition, Notice of Intent/Notice of Scoping Meeting Letters were distributed to more than 790 federal, state, and local elected officials, Native American Tribes, and government agencies. The Notice of Intent provided an overview of the proposed action and the scope of the EIS, and initiated the scoping process.

ES.4.1 SCOPING PROCESS

Scoping is an early and open process for developing the “scope” of issues to be addressed in an EIS and for identifying significant issues related to a proposed action. During scoping, the public helps define and prioritize issues through public meetings and written comments.

Nine scoping meetings were held on March 13, 14, 15, 16, 19, 20, 22, 23, and 27, 2012, in the cities of Oak Harbor, WA; Quilcene, WA; Silverdale, WA; Aberdeen, WA; Tillamook, OR; Newport, OR; Eureka, CA; Fort Bragg, CA; and Ketchikan, AK, respectively. At each scoping meeting, staffers at the welcome station greeted guests and encouraged them to sign in to be added to the project mailing list to receive future notifications. In total, 238 people signed in at the welcome table. The meetings were held in an open house format, presenting informational posters and written information, with Navy staff and project experts available to answer participants’ questions. Additionally, a digital voice recorder was available to record participants’ oral comments. The interaction during the information sessions was helpful to the Navy, providing an opportunity for communication from the public, including government representatives and non-governmental organizations.

ES.4.2 SCOPING COMMENTS

Scoping participants submitted comments to the Navy in five ways:

- Oral statements at the public meetings (as recorded by the digital voice recorder)
- Written comments at the public meetings
- Written letters (received throughout the public comment period)
- Electronic mail (received throughout the public comment period)
- Comments submitted directly on the project website (received throughout the public comment period)

In total, the Navy received 316 comments from individuals, groups, agencies, and elected officials. Table ES-1 provides a breakdown of areas of concern based on comments received during scoping. Because many of the comments addressed more than one issue, the total number of issues raised is greater than the 316 comments received. The Navy considered all scoping comments in preparing this EIS/OEIS.

Table ES-1: Public Scoping Comment Summary

Area of Concern	No. of times issue raised
Marine Mammals	225
Sound in the Water/Sonar	173
Underwater Explosions	71
Mitigation	59
Study Area/Size	57
Fish	56
Marine Habitats	45
NEPA Process/Public Participation	42
Navy Activities/Proposed Action	38
Sea Turtles	35
Birds	30
Water Quality	29
Socioeconomics/Commercial and Recreational Fishing	29
Cumulative Impacts	25
Public Health and Safety	24
Other	23
Research	20
Air Quality	18
Marine Debris	15
Terrestrial Resources	15
Noise	11
Cultural Resources/Native American Concerns	9
Access to Ocean Areas	5

Note: NEPA = National Environmental Policy Act

ES.4.3 DRAFT ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

This Draft EIS/OEIS has been prepared to assess potential impacts of the proposed action and alternatives on the environment. A Notice of Availability was published in the *Federal Register* and notices were placed in local and regional newspapers announcing the availability of the Draft EIS/OEIS. This Draft EIS/OEIS is being circulated for review and comment, and public meetings will be held in Washington, Oregon, California, and Alaska.

ES.4.4 FINAL ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT/RECORD OF DECISION

The Final EIS/OEIS (scheduled for completion in spring 2015) will address all public comments received on the Draft EIS/OEIS. Responses to public comments may include correction of data, clarifications of and modifications to analytical approaches, and inclusion of new or additional data or analyses. Finally, the decision-maker will issue a ROD no earlier than 30 days after the Final EIS/OEIS is made available to the public.

ES.5 PROPOSED ACTION AND ALTERNATIVES

Through this EIS/OEIS, the Navy will:

- Reassess the environmental impacts of Navy at-sea training and testing activities contained in three separate EISs/OEISs and various earlier environmental planning documents (i.e., Environmental Assessments and Categorical Exclusions), and consolidate these analyses into a single environmental planning document, including the following:
  - Northwest Training Range Complex (NWTRC) Final EIS/OEIS
  - Naval Sea Systems Command (NAVSEA) Naval Undersea Warfare Center (NUWC) Division, Keyport Range Complex Extension Final EIS/OEIS
  - Southeast Alaska Acoustic Measurement Facility (SEAFAC) Final EIS
- Update environmental analyses with the best available science and most current acoustic analysis methods to evaluate the potential effects of training and testing activities on the marine environment.
- Analyze the potential environmental impacts of training and testing activities in additional areas (areas not covered in previous documents) where training and testing historically occur, including Navy ports and naval shipyards.
- Update the at-sea environmental impact analyses in the previous documents to account for force structure changes for 2015–2020 and the development of supporting weapons, platforms, and systems.
- Adjust baseline training and testing activities from current levels to the level needed to support Navy training and testing requirements beginning October 2015. Adjustment will include other activities and sound sources not addressed in the previous analyses, adjusted for the 2015–2020 time frame.
- Support authorization of incidental takes of marine mammals under the MMPA and incidental takes of threatened and endangered marine species, including marine birds under the ESA.

Three alternatives are analyzed in this EIS/OEIS:

- **No Action Alternative:** Baseline training and testing activities, as defined by existing Navy environmental planning documents, including the *NWTRC EIS/OEIS*, the *NUWC Keyport Range Complex Extension EIS/OEIS,* and the *SEAFAC EIS*. The baseline activities also include other events that historically occur in the Study Area and have been subject to previous analysis pursuant to NEPA and EO 12114.
- **Alternative 1 (Preferred Alternative):** Adjustments to types and levels of activities, from the baseline as necessary to support current and planned Navy training and testing requirements. This Alternative considers:
  - modified or updated mission requirements associated with force structure changes, including those resulting from the development, testing, and ultimate introduction of new platforms (vessels and aircraft), and weapons systems into the fleet
  - new biennial training exercises conducted in the Offshore Area
  - biennial mine warfare exercises in Puget Sound in support of homeland defense
  - testing with and testing of undersea systems, subsystems, and components in Puget Sound
  - proof-of-concept testing of unique undersea hardware and fixtures
  - resumption of testing activities at the Carr Inlet Operations Area
  - pierside sonar maintenance and life cycle testing

  - sea trials in support of overhaul
  - elimination of sinking exercises in the Study Area
- **Alternative 2:** Consists of Alternative 1 plus adjustments to tempo of training and testing activities. All training activities would remain the same except for an increase in Maritime Homeland Defense training events from one every other year to one every year. The tempo of testing activities over those proposed for Alternative 1 would increase in a range between 6 percent for maintenance and miscellaneous testing events and 38 percent for all testing activities in the Western Behm Canal, Alaska. On average, most testing activities in Alternative 2 would increase about 12 percent over those in Alternative 1.

ES.6 SUMMARY OF ENVIRONMENTAL EFFECTS

Environmental effects which might result from the implementation of the Navy's Proposed Action or alternatives have been analyzed in this EIS/OEIS. Resource areas analyzed include sediments and water quality, air quality, marine habitats, marine mammals, sea turtles, birds, marine vegetation, marine invertebrates, fish, cultural resources, Native American and Alaska Native traditional resources, socioeconomic resources, and public health and safety. The Navy's analysis includes an evaluation of effects on each resource based on the stressors to that resource. The term stressor refers to an agent, condition, or other stimulus that causes stress to an organism or alters physical, socioeconomic, or cultural resources. The effects on these resources are summarized in Table ES-2. This table provides a comparison of the environmental impacts of the No Action Alternative, Alternative 1, and Alternative 2.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2

Resource Category	Summary of Impacts
Sediments and Water Quality	Stressors analyzed include explosives and explosion byproducts, metals, chemicals other than explosives, and other materials. **No Action Alternative:** Explosives and Explosion Byproducts: Impacts of explosion byproducts would be short term and local, while impacts of unconsumed explosives and metals would be long term and local. Chemical or physical changes in sediment or water quality would not exceed applicable standards, regulations, and guidelines. Metals: Impacts of metals would be long term and local. Corrosion and biological processes would reduce exposure of military expended materials to seawater, decreasing the rate of leaching, and most leached metals would bind to sediments and other organic matter. Elevated levels of metals in sediments would be restricted to a small zone around the metal. Chemicals: Impacts of chemicals other than explosives would be both short term and long term as well as local. Chemical or physical changes in sediment or water quality would not be detectable and would be within existing conditions or designated uses. Other Materials: Impacts of other materials would be short term and local. Most other materials from military expended materials would not be harmful to marine organisms and would be consumed during use. Chemical or physical changes in sediment or water quality would not be detectable. **Alternative 1:** The number of individual impacts may increase slightly under Alternative 1, but the types of impacts would be the same as the No Action Alternative. Despite the small increase, changes to sediments and water quality under Alternative 1 would be considered localized, short term, and long term. Impacts under Alternative 1 would be below applicable standards, regulations, and guidelines and would be within existing conditions or designated uses. **Alternative 2:** The number of individual impacts may increase slightly under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts would be the same as the No Action Alternative. Despite the small increase, changes to sediments and water quality under Alternative 2 would be considered localized, short term, and long term. Impacts under Alternative 2 would be below applicable standards, regulations, and guidelines and would be within existing conditions or designated uses.
Air Quality	Stressors analyzed include criteria air pollutants and hazardous air pollutants. **No Action Alternative:** Criteria Air Pollutants: Reasonably foreseeable emissions of criteria air pollutants in attainment areas from the Navy's actions would not exceed federal ambient air quality standards. Hazardous Air Pollutants: Reasonably foreseeable emissions of criteria air pollutants in maintenance areas from the Navy's actions would not exceed applicable federal *de minimis* levels. The public would not be exposed to substantial concentrations of hazardous air pollutants from the Navy's actions. **Alternative 1:** The number of individual activities may increase under Alternative 1, as would emissions of two of the six criteria air pollutants. However, emissions of four air pollutants would decrease under Alternative 1. All of the changes are relatively small and the types of impacts would be the same as the No Action Alternative. Therefore, changes to air quality under Alternative 1 would be considered minor and localized; changes to air quality from hazardous air pollutants are not expected to be detectable.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
	Alternative 2: The number of individual activities may increase under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), as would emissions of two of the six criteria air pollutants. However, emissions of four air pollutants would decrease under Alternative 2. All of the changes are relatively small and the types of impacts would be the same as the No Action Alternative. Therefore, changes to air quality under Alternative 2 would be considered minor and localized; changes to air quality from hazardous air pollutants are not expected to be detectable.
Marine Habitats	Stressors analyzed include acoustic (impulse sound sources – underwater explosions) and physical disturbance and strike (vessel and in-water device strikes, military expended materials, and seafloor devices). **No Action Alternative:** Acoustic: Most of the high-explosive military expended materials would detonate at or near the water surface. Only bottom-laid explosives could affect bottom substrate and, therefore, marine habitats. Habitat utilized for underwater detonations would primarily be soft-bottom sediment. The surface area of bottom substrate affected would be a fraction of the total training area available in the Study Area. Physical Disturbance and Strike: Items entering the ocean would not be expected to affect marine habitats because of the nature of high-energy surf in the Offshore Area, and shifting sands in the Offshore Area, Inland Waters, and the Western Behm Canal. Once on the seafloor, larger military expended material would be colonized by benthic organisms because these materials would be anchor points in the shifting bottom substrates. Smaller military expended materials would be incorporated into the bottom substrates. The surface area of bottom substrate affected would be a fraction of the total training area available in the Study Area. Pursuant to the Essential Fish Habitat (EFH) requirements of the Magnuson Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom, 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 non-living substrates that constitute EFH and Habitat Areas of Particular Concern. Essential Fish Habitat conclusions for associated marine vegetation and sedentary invertebrates are summarized in corresponding resource sections (e.g., marine vegetation, invertebrates). Impacts to the water column as EFH are summarized in corresponding resource sections (e.g., invertebrates, fish) because they are impacts on the organisms themselves. **Alternative 1:** The number of individual impacts may increase under Alternative 1, but the types of impacts would be the same as the No Action Alternative. Despite the increases, most detonations would continue to occur at or near the surface, and those that do occur on the seafloor would be located in primarily soft-bottom habitat. Changes to marine substrates could include localized disturbance of the seafloor and cratering of soft bottom sediments. Impacts on soft bottom habitats would be short term, and impacts on hard bottom would be long term. Activities under Alternative 1 would not impact the ability of marine substrates to serve their function as habitat. **Alternative 2:** The number of individual impacts may increase under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts would be the same as the No Action Alternative. Despite the increases, most detonations would continue to occur at or near the surface, and those that do occur on the seafloor would be located in primarily soft-bottom habitat. Changes to marine substrates could include localized disturbance of the seafloor and cratering of soft bottom sediments. Impacts on soft bottom habitats would be short term, and impacts on hard bottom would be long term. Activities under Alternative 2 would not impact the ability of marine substrates to serve their function as habitat.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Marine Mammals	Stressors analyzed include acoustic (sonar and other active acoustic sources; explosive (impulse) sources; weapons firing, launch, and impact noise; vessel noise; and aircraft overflight noise), energy (electromagnetic devices), physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices), entanglement (fiber optic cables and guidance wires, decelerator/parachutes), ingestion (munitions and military expended material other than munitions), and secondary stressors (sediments and water quality). **No Action Alternative:** Acoustic: Pursuant to the MMPA, the use of sonar and other non-impulse sources, and explosive (impulse) sources may result in Level A harassment or Level B harassment of certain marine mammals; the use of weapons firing, vessel noise, and aircraft noise are not expected to result in Level A or Level B harassment of any marine mammals. Pursuant to the Endangered Species Act (ESA), sonar and other active acoustic sources and explosive (impulse) sources may affect and are likely to adversely affect certain ESA-listed marine mammals; weapons firing, launch, and impact noise; vessel noise, and aircraft overflight noise may affect but are not likely to adversely affect certain ESA-listed marine mammals; and all acoustic sources would have no effect on marine mammal critical habitats. Energy: Pursuant to the MMPA, the use of electromagnetic devices is not expected to result in Level A or Level B harassment of any marine mammals. Pursuant to the ESA, the use of electromagnetic devices may affect but is not likely to adversely affect certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats. Physical Disturbance and Strike: Pursuant to the MMPA, the use of vessels may result in mortality or Level A harassment of certain marine mammal species but is not expected to result in Level B harassment. The use of in-water devices, military expended materials, and seafloor devices are not expected to result in Level A or Level B harassment of any marine mammal. Pursuant to the ESA, vessel use may affect and is likely to adversely affect certain ESA-listed species. The use of in-water devices and military expended materials may affect but is not likely to adversely affect certain marine mammal species. The use of seafloor devices would have no effect on any ESA-listed marine mammal. The use of vessels, in-water devices, military expended materials, and seafloor devices would have no effect on marine mammal critical habitats. Entanglement: Pursuant to the MMPA, the use of fiber optic cables, guidance wires, and decelerator/parachutes is not expected to result in mortality or in Level A or Level B harassment of any marine mammal. Pursuant to the ESA, the use of fiber optic cables, guidance wires, and decelerator/parachutes may affect but is not likely to adversely affect certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats. Ingestion: Pursuant to the MMPA, the potential for ingestion of all military expended materials is not expected to result in Level A or Level B harassment of any marine mammal. Pursuant to the ESA, the potential for ingestion of all military expended materials may affect, but is not likely to adversely affect certain ESA-listed species. Secondary Stressors: Pursuant to the MMPA, secondary stressors are not expected to result in Level A or Level B harassment of any marine mammal. Pursuant to the ESA, secondary stressors may affect but are not likely to adversely affect certain ESA-listed marine mammals and would have no effect on marine mammal critical habitat.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
	Alternative 1: The number of individual impacts under the No Action Alternative may increase for most species under Alternative 1, but the types of impacts, MMPA conclusions, and ESA conclusions would be the same as under the No Action Alternative. Despite the increase, impacts on marine mammals under Alternative 1 are not expected to decrease the overall fitness of any marine mammal population. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase for most species under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts, MMPA conclusions, and ESA conclusions would be the same as under the No Action Alternative. Despite the increase, impacts on marine mammals under Alternative 2 are not expected to decrease the overall fitness of any marine mammal population.
Sea Turtles	Stressors analyzed include acoustic (sonar and other active acoustic sources; underwater explosives; weapons firing, launch, and impact noise; vessel and simulated vessel noise, and aircraft noise), energy (electromagnetic devices), physical disturbance and strike (vessels and in-water devices, and military expended materials), entanglement (fiber optic cables, guidance wires, and decelerator/parachutes), ingestion (munitions and military expended materials other than munitions), and secondary (habitat, sediments, and water quality). **No Action Alternative:** <u>Acoustic</u>: Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities would have no effect on ESA-listed leatherback turtles. The use of sonar and other active acoustic sources during testing activities may affect, but is not likely to adversely affect, leatherback turtles. Underwater explosives, and vessel and aircraft noise may affect, but are not likely to adversely affect, leatherback turtles. Weapons firing, launch, and impact noise during training may affect, but is not likely to adversely affect, leatherback turtles. Weapons firing, launch, and impact noise during testing would have no effect on leatherback turtles. The use of acoustic sources would have no effect on leatherback turtle critical habitat. <u>Physical Disturbance and Strike</u>: Pursuant to the ESA, physical disturbance and strike from the use of vessels during training and testing activities may affect, and is likely to adversely affect, ESA-listed leatherback turtles. The use of in-water devices, military expended materials, and seafloor devices may affect, but is not likely to adversely affect, ESA-listed sea turtles. Physical disturbance and strike stressors would have no effect on leatherback turtle critical habitat. <u>Energy</u>: Pursuant to the ESA, the use of energy sources during training and testing activities would have no effect on ESA-listed leatherback turtles. The use of energy sources would have no effect on leatherback turtle critical habitat. <u>Entanglement</u>: Pursuant to the ESA, entanglement from the use of fiber optic cables, guidance wires, and decelerator/parachutes during training and testing activities may affect, but is not likely to adversely affect, ESA-listed leatherback turtles. Entanglement stressors would have no effect on leatherback turtle critical habitat. <u>Ingestion</u>: Pursuant to the ESA, ingestion hazards the use of munitions during training and testing activities would not affect ESA-listed leatherback turtles. The expenditure of military expended materials other than munitions during training and testing activities may affect, but is not likely to adversely affect, ESA-listed leatherback turtles. Ingestion stressors would have no effect on leatherback turtle critical habitat. <u>Secondary Stressors</u>: Pursuant to the ESA, secondary stressors may affect but are not likely to adversely affect ESA-listed sea turtles because changes in sediment, water, and air quality are not likely to be detectable, and no detectable changes in growth, survival, propagation, or population levels of sea turtles are anticipated. Secondary stressors would have no effect on leatherback turtle critical habitat.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
	Alternative 1: The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts and ESA conclusions would be the same as under the No Action Alternative. Despite the increase, impacts on sea turtles under Alternative 1 are not expected to decrease the overall fitness of any sea turtle population. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts and ESA conclusions would be the same as under the No Action Alternative. Despite the increase, impacts on sea turtles under Alternative 2 are not expected to decrease the overall fitness of any sea turtle population.
Birds	Stressors analyzed include acoustic (sonar and other active acoustic sources, underwater explosives, vessel and simulated vessel noise, and aircraft noise), physical disturbance and strike (aircraft and aerial target strikes, vessels and in-water device strikes, and military expended materials), and ingestion (munitions and military expended materials other than munitions). **No Action Alternative:** <u>Acoustic</u>: Pursuant to the ESA, the use of sonar, other active acoustic sources, and underwater explosives may affect, and is likely to adversely affect, the marbled murrelet. Vessel and simulated vessel noise from training and testing would have no effect on the marbled murrelet. Aircraft noise during training and testing may affect but is not likely to adversely affect the marbled murrelet. Acoustic sources would have no effect on critical habitat. <u>Physical Disturbance and Strike</u>: Pursuant to the ESA, physical disturbance and strike from the use of aircraft, aerial targets, vessels, in-water devices, and military expended materials for training and testing may affect but is not likely to adversely affect the marbled murrelet. Physical disturbance and strike stressors would have no effect on critical habitat. <u>Ingestion</u>: Pursuant to the ESA, ingestion hazards from the use of munitions and military expended materials other than munitions would have no effect on the marbled murrelet. Ingestion stressors would have no effect on critical habitat. Under the Migratory Bird Treaty Act (MBTA) regulations applicable to military readiness activities (50 C.F.R. Part 21), the impacts from stressors introduced during training and testing activities would not result in a significant adverse effect on migratory bird populations. Under the Bald and Golden Eagle Protection Act, the impacts from stressors introduced during training and testing activities would not result in an adverse effect on bald or golden eagles. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts, and ESA, MBTA, and Bald and Golden Eagle Protection Act conclusions would be the same as under the No Action Alternative. Despite the increase, impacts on seabirds under Alternative 1 are not expected to decrease the overall fitness of any bird population. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts, and ESA, MBTA, and Bald and Golden Eagle Protection Act conclusions would be the same as under the No Action Alternative. Despite the increase, impacts on seabirds under Alternative 2 are not expected to decrease the overall fitness of any bird population.
Marine Vegetation	Stressors analyzed include acoustic (underwater explosives) and physical disturbance and strike (vessel and in-water device strikes, military expended materials, and seafloor devices), and secondary (sediments and water quality). No ESA-listed marine vegetation species are found in the Study Area.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
	No Action Alternative: Acoustic and Physical Disturbance and Strike: Underwater explosives, 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 Stressors: 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 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. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts from acoustic stressors and physical disturbance are not expected to result in detectable changes to marine vegetation growth, survival, or propagation and are not expected to result in population-level impacts. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts from acoustic stressors and physical disturbance are not expected to result in detectable changes to marine vegetation growth, survival, or propagation and are not expected to result in population-level impacts.
Marine Invertebrates	Stressors analyzed include acoustic (sonar and other active acoustic sources, and underwater explosives), energy (electromagnetic devices), physical disturbance and strike (vessels and in-water devices, and military expended materials), entanglement (fiber optic cables, guidance wires, and decelerator/parachutes), ingestion (munitions and military expended materials other than munitions), and secondary stressors (metals and chemicals). No ESA-listed marine invertebrate species are found in the Study Area. **No Action Alternative:** Acoustic: The use of sonar and other active acoustic sources and underwater explosives is 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. Energy: The use of electromagnetic devices is 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. Physical Disturbance and Strike: Physical disturbance and strikes from the use of vessels, in-water devices, military expended materials, and seafloor devices is 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. Entanglement: Entanglement from the use of fiber optic cables and guidance wires and decelerator/parachutes is not expected to

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
	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. Ingestion: Ingestion hazards from the expenditure of munitions and military expended materials other than munitions 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. Secondary Stressors: Secondary impacts to marine invertebrates would be inconsequential and not detectable. Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of sonar and other acoustic sources, vessel noise, weapons firing noise, electromagnetic sources, vessel movement, in-water devices, and metal, chemical, or other material contaminants would have no adverse effect on sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. The use of electromagnetic sources would have minimal and temporary adverse impact to invertebrates occupying water column EFH or Habitat Areas of Particular Concern. The use of explosives, military expended materials, seafloor devices, and explosives and explosive byproduct contaminants may have an adverse effect on EFH by reducing the quality and quantity of sedentary invertebrate beds or reefs that constitute EFH or Habitat Areas of Particular Concern. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on marine invertebrates under Alternative 1 are not anticipated to result in population-level impacts. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on marine invertebrates under Alternative 2 are not anticipated to result in population-level impacts.
Fish	Stressors analyzed include acoustic (sonar and other active acoustic sources; underwater explosives; weapons firing, launch, and impact noise; vessel noise; and aircraft noise), energy (electromagnetic devices), physical disturbance and strike (vessels and in-water devices, military expended materials, and seafloor devices), entanglement (fiber optic cables, guidance wires, and decelerator/parachutes), ingestion (munitions and military expended materials other than munitions). **No Action Alternative:** Acoustic: Pursuant to the ESA, the use of sonar and other non-impulse sources during training and testing activities may affect, but is not likely to adversely affect, ESA-listed salmonid species, green sturgeon, Pacific eulachon, and rockfish species; and would have no effect on any species' critical habitat. The use of explosives and other impulse sources during training and testing activities may affect, but is not likely to adversely affect, ESA-listed salmonid species, green sturgeon, Pacific eulachon, and rockfish species; may affect, but is not likely to adversely affect, critical habitat for salmonid species and green sturgeon; and would have no effect on Pacific eulachon critical habitat. Energy: Pursuant to the ESA, the use of electromagnetic devices during training activities may affect but is not likely to adversely affect, ESA-listed salmonid species, green sturgeon, Pacific eulachon, and rockfish species; may affect, but is not likely to adversely affect, salmonid critical habitat; and would have no effect on critical habitat for Pacific eulachon and green sturgeon. Physical Disturbance and Strike: Pursuant to the ESA, the use of vessels and in-water devices may affect, but is not likely to adversely affect, ESA-listed salmonid species, green sturgeon, and Pacific eulachon species; would have no effect on rockfish

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
	species; may affect, but is not likely to adversely affect, salmonid critical habitat; and would have no effect on Pacific eulachon and green sturgeon critical habitat. The use of military expended materials would have no effect on Pacific eulachon and their associated critical habit; may affect, but is not likely to adversely affect, ESA-listed salmonid species, rockfish species, and green sturgeon; and may affect but is not likely to adversely affect salmonid and green sturgeon critical habitat. The use of seafloor devices may affect, but is not likely to adversely affect, ESA-listed salmonid species, Pacific eulachon, green sturgeon, and rockfish species; may affect, but is not likely to adversely affect salmonid and green sturgeon critical habitat; and would have no effect on any species' critical habitat. Entanglement: Pursuant to the ESA, entanglement from the use of fiber optic cables, guidance wires, and decelerator/parachutes during training and testing activities may affect but is not likely to adversely affect ESA-listed salmonid species, green sturgeon, Pacific eulachon, and rockfish species; would have no effect on Pacific eulachon critical habitat; and may affect but is not likely to adversely affect salmonid critical habitat. The use of fiber optic cables and guidance wires would have no effect on green sturgeon critical habitat. The use of parachutes may affect, but is not likely to adversely affect, green sturgeon critical habitat. Ingestion: Pursuant to the ESA, ingestion hazards from the expenditure of munitions and military expended material other than munitions during training and testing activities may affect, but is not likely to adversely affect, ESA-listed salmonid species, green sturgeon, Pacific eulachon, and rockfish species. Ingestion sources may affect, but are not likely to adversely affect, salmonid and green sturgeon critical habitat; and would have no effect on Pacific eulachon critical habitat. Secondary Stressors: Pursuant to the ESA, secondary stressors from training and testing activities would have no effect on ESA-listed salmonid species, green sturgeon, Pacific eulachon, and rockfish species; and would have no effect on salmonid, green sturgeon and Pacific eulachon critical habitat. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts and ESA conclusions would be the same as under the No Action Alternative. Despite the increase, impacts on fish under Alternative 1 are not expected to decrease the overall fitness of any fish population. **Alternative 2:** The number of individual impacts under the No Action Alternative may increase under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts and ESA conclusions would be the same as under the No Action Alternative. Despite the increase, impacts on fish under Alternative 2 are not expected to decrease the overall fitness of any fish population.
Cultural Resources	Stressors analyzed include acoustic (underwater explosions and cratering from underwater explosions) and physical disturbance and interaction (vessel interactions and use of in-water devices, deposition of military expended materials, and use of seafloor devices). **No Action Alternative:** Acoustic and physical stressors, as indicated above, would not adversely affect submerged historic resources within U.S. territorial waters in accordance with Section 106 of the National Historic Preservation Act (NHPA). The Navy previously analyzed impacts that could result from these activities and concluded that there would be either no historic properties affected or no adverse effects on historic properties. The Washington State Historic Preservation Office concurred with these findings. In accordance with Section 402 of the NHPA, no World Heritage sites would be affected. **Alternative 1:** The number of most activities under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Because of the increase in activity under Alternative 1, there could

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
	be an increased probability of disturbing submerged cultural resources depending on the location of the activity when compared to the No Action Alternative. **Alternative 2:** The number of most activities under the No Action Alternative may increase under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts would be the same as under the No Action Alternative. Because of the increase in activity under Alternative 2, there could be an increased probability of disturbing submerged cultural resources depending on the location of the activity when compared to the No Action Alternative.
Native American and Alaska Native Traditional Resources	Stressors analyzed include accessibility (limiting access to the ocean), airborne acoustics, physical disturbance and interactions (activities including seafloor devices and deposition of military expended materials) and secondary impacts from changes to the availability of marine resources. **No Action Alternative:** Impacts on Native American and Alaska Native protected tribal resources and other traditional resources would not occur because inaccessibility to areas of co-use would be temporary, use of seafloor devices could create damage or loss to Native American fishing equipment but would not affect the use of the usual and accustomed fishing grounds, and marine species' population levels would not be altered to such an extent that tribes could no longer find their target species. **Alternative 1:** The number of most activities under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Because of the increase in activity under Alternative 1, there could be an increased probability of disrupting access to co-use areas, but impacts remain unlikely. **Alternative 2:** The number of most activities under the No Action Alternative may increase under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts would be the same as under the No Action Alternative. Because of the increase in activity under Alternative 2, there could be an increased probability of disrupting access to co-use areas, but impacts remain unlikely.
Socioeconomic Resources	Stressors analyzed include accessibility (limiting access to the ocean and the air), physical disturbance and interactions (aircraft, vessels and in-water devices, and military expended materials), airborne acoustics (weapons firing, aircraft and vessel noise), and secondary impacts from changes to the availability of marine resources. **No Action Alternative:** Impacts on socioeconomic resources are not expected because: • Inaccessibility to areas of co-use would be localized and temporary. • The Navy's strict standard operating procedures would minimize physical disturbance and strikes. • Most airborne activities would occur well out to sea far from tourism and recreation locations. • Impacts to marine species are not expected. Further, there are no disproportionately high impacts or adverse effects on any low-income or minority populations. **Alternative 1:** The number of most activities under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase in activity under Alternative 1, impacts to socioeconomic resources are not expected. **Alternative 2:** The number of most activities under the No Action Alternative may increase under Alternative 2 (consisting of

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
	Alternative 1 plus additional increases in activity tempo), but the types of impacts would be the same as under the No Action Alternative. Despite the increase in activity under Alternative 2, impacts to socioeconomic resources are not expected.
Public Health and Safety	Stressors analyzed include underwater energy, in-air energy, physical interactions, and secondary impacts from sediment and water quality changes. **No Action Alternative:** Because of the Navy's standard operating procedures, impacts on public health and safety would be unlikely. Further, there are no proportionately high impacts or adverse effects on any low-income or minority populations. **Alternative 1:** The number of most activities under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase in activities under Alternative 1, Navy safety procedures would continue to prevent proposed activities being co-located with public activities. Because of the Navy's safety procedures, the potential for activities to impact public health and safety under Alternative 1 would be unlikely. **Alternative 2:** The number of most activities under the No Action Alternative may increase under Alternative 2 (consisting of Alternative 1 plus additional increases in activity tempo), but the types of impacts would be the same as under the No Action Alternative. Despite the increase in activities under Alternative 2, Navy safety procedures would continue to prevent proposed activities being co-located with public activities. Because of the Navy's safety procedures, the potential for activities to impact public health and safety under Alternative 2 would be unlikely.

Notes: C.F.R. = Code of Federal Regulations, ESA = Endangered Species Act, MMPA = Marine Mammal Protection Act, Navy = United States Department of the Navy, U.S. = United States

ES.7 CUMULATIVE IMPACTS

Marine mammals and sea turtles are the primary resources of concern for cumulative impacts analysis. Marine mammal and sea turtles species occurring in the Study Area may be impacted by multiple ongoing and future actions. Explosive detonations, non-impulse sources such as sonar, and vessel strikes under the No Action Alternative, Alternative 1, and Alternative 2 have the potential to disturb, injure, or kill marine mammals and sea turtles.

The impact on marine mammal and sea turtle species of the Navy's proposed activities is small (see Summary of Impacts on marine mammals and sea turtles in Table ES-2 above). The No Action Alternative, Alternative 1, or Alternative 2 would contribute to cumulative impacts, but the relative contribution would be small compared to other actions. Compared to the potential mortality, stranding, and injury resulting from commercial ship strikes and bycatch, entanglement, ocean pollution and other human causes, the potential for mortality, strandings, or injury resulting from Navy training and testing activities is estimated to be orders of magnitude lower (tens of animals versus hundreds of thousands of animals).

Because of the negligible impacts of the proposed action on sediments and water quality, air quality, marine habitats, birds, marine vegetation, marine invertebrates, fish, cultural resources, Native American and Alaska Native traditional resources, socioeconomic resources, and public health and safety, cumulative impacts would likewise be negligible. The No Action Alternative, Alternative 1, or Alternative 2 would also make an incremental contribution to greenhouse gas emissions, representing approximately 0.0009 percent, 0.0007 percent, and 0.0009 percent of U.S. 2010 greenhouse gas emissions, respectively.

ES.8 STANDARD OPERATING PROCEDURES, MITIGATION, AND MONITORING

Within the Study Area, the Navy implements standard operating procedures, mitigation measures, and marine species monitoring and reporting. Navy standard operating procedures have the indirect benefit of reducing potential impacts on marine resources. Mitigation measures are designed to reduce or avoid potential impacts on marine resources. Marine species monitoring efforts are designed to track compliance with take authorizations, evaluate the effectiveness of mitigation measures, and improve understanding of the impacts of training and testing activities on marine resources.

ES.8.1 STANDARD OPERATING PROCEDURES

The Navy currently employs standard operating procedures to provide for the safety of personnel and equipment, including ships and aircraft, as well as the success of the training and testing activities. In many cases there are incidental environmental, socioeconomic, and cultural benefits resulting from standard operating procedures. Standard operating procedures serve the primary purpose of providing for safety and mission success, and are implemented regardless of their secondary benefits. Because of their importance for maintaining safety and mission success, standard operating procedures have been considered as part of the Proposed Action under each alternative, and therefore are included in the environmental analyses for each resource.

ES.8.2 MITIGATION

The Navy recognizes that the Proposed Action has the potential to impact the environment. Unlike standard operating procedures, which are established for reasons other than environmental benefit, mitigation measures are modifications to the Proposed Action that are implemented for the sole purpose of reducing a specific potential environmental impact on a particular resource. These measures are being coordinated with NMFS and USFWS through the consultation and permitting processes. The ROD for this EIS/OEIS will address any additional mitigation measures that may result from ongoing regulatory processes.

Additionally, the Navy has engaged in consultation processes under the ESA with regard to listed species that may be affected by the Proposed Action described in this EIS/OEIS. For the purposes of the ESA Section 7 consultation, the mitigation measures proposed here may be considered by NMFS, and USFWS as beneficial actions taken by the Federal agency or applicant (50 C.F.R. 402.14(g)(8)). If necessary to satisfy requirements of the ESA, NMFS, and USFWS may develop an additional set of measures contained in reasonable and prudent alternatives, reasonable and prudent measures, or conservation recommendations in any BO issued for this Proposed Action.

The Navy selected mitigation measures that have been documented to be effective in reducing impacts and protecting resources, while maintaining the Navy's ability to meet mission requirements. Table ES-3 summarizes the Navy's recommended mitigation measures with currently implemented mitigation measures for each activity category also summarized in the table.

ES.8.3 MITIGATION MEASURES CONSIDERED BUT ELIMINATED

A number of possible alternative or additional mitigation measures have been suggested during the public comment periods of this or previous Navy environmental documents. In addition, through the evaluation process, some measures were deemed to either be ineffective, have an unacceptable impact on the proposed training and testing activities, or both, and will not be carried forward for further consideration.

ES.8.4 MONITORING

The Navy is committed to demonstrating environmental stewardship while executing its National Defense Mission and complying with the suite of federal environmental laws and regulations. As a complement to the Navy's commitment to avoiding and reducing impacts of the Proposed Action through mitigation, the Navy will undertake monitoring efforts to track compliance with take authorizations, help investigate the effectiveness of implemented mitigation measures, and better understand the impacts of the Proposed Action on marine resources. Taken together, mitigation and monitoring comprise the Navy's integrated approach for reducing environmental impacts from the Proposed Action. The Navy's overall monitoring approach will seek to leverage and build on existing research efforts whenever possible.

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Table ES-3: Mitigation Identification and Implementation

Mitigation Measure	Benefit	Evaluation Criteria	Implementation	Responsible Command	Date Implemented
Marine Species Awareness Training All personnel standing watch on the bridge and Lookouts will successfully complete the training before standing watch or serving as a Lookout.	To learn the procedures for searching for and recognizing the presence of marine species, including detection cues (e.g., congregating seabirds) so that potentially harmful interactions can be avoided.	Successful completion of training by all personnel standing watch and all personnel serving as Lookouts. Personnel successfully applying skills learned during training.	The multimedia training program has been made available to personnel required to take the training. Personnel have been and will continue to be required to take the training prior to standing watch and serving as Lookouts.	Officer Conducting the Exercise or Test or civilian equivalent	Ongoing
Lookouts					
Use of Four Lookouts for Underwater Detonations Mine countermeasure and neutralization activities using time delay or positive control firing devices will include the use of two to four Lookouts, depending on the size of the charge. If applicable, aircrew and divers will report sightings of marine mammals or sea turtles.	Lookouts can visually detect marine species so that potentially harmful impacts to marine mammals and sea turtles from explosives use can be avoided. Lookouts can more quickly and effectively relay sighting information so that corrective action can be taken. Support from aircrew and divers, if they are involved in the activity, will increase the probability of sightings, reducing the potential for impacts.	Annual report documenting NAVSEA testing and marine mammal observation data. Timely reporting of underwater detonations and monitoring results related to bull trout and marbled murrelets.	All Lookouts will receive marine species awareness training and will be positioned on vessels, boats, and aircraft as described in Section 5.3.1.1.1 (Training for Personnel Standing Watch and Lookouts).	Officer Conducting the Exercise or Test	Ongoing
Use of One or Two Lookouts Vessels using low-frequency active sonar or hull-mounted mid-frequency active sonar associated with ASW activities will have either one or two Lookouts, depending on the activity and size of the vessel. Mine countermeasure and neutralization activities with positive control will use two Lookouts, with one on each support vessel. If applicable, aircrew and divers will also report the presence of marine mammals or sea turtles. One Lookout may be used under certain circumstances specific in Section 5.3.1.2 (Lookouts).	Lookouts can visually detect marine species so that potentially harmful impacts to marine mammals and sea turtles from Navy sonar and explosives use can be avoided. Lookouts can more quickly and effectively relay sighting information so that corrective action can be taken. Support from aircrew and divers, if they are involved in the activity, will increase the probability of sightings, reducing the potential for impacts.				
Use of One Lookout Surface ships and aircraft conducting ASW, ASUW, or MIW activities using HFAS, non-hull mounted mid-frequency active sonar, helicopter dipping mid-frequency active sonar, anti-swimmer grenades, IEER sonobuoys, surface gunnery activities, surface missile activities, bombing activities, explosive torpedo testing, and activities using non-explosive practice munitions, will have one Lookout.	Lookouts can visually detect marine species so that potentially harmful impacts to marine mammals and sea turtles from Navy sonar, explosives, sonobuoys, gunnery rounds, missiles, explosive torpedoes, pile driving, towed systems, surface vessel propulsion, and non-explosive munitions can be avoided. Lookouts will quickly and effectively relay sighting information so that corrective action(s) can be taken.				

Table ES-3: Mitigation Identification and Implementation (continued)

Mitigation Measure	Benefit	Evaluation Criteria	Implementation	Responsible Command	Date Implemented
Mitigation Zones					
Use of a Mitigation Zone A mitigation zone is an area defined by a radius and centered on the location of a sound source or activity. The size of each mitigation zone is specific to a particular training or testing activity (e.g., sonar use or explosive use).	A mitigation zone defines the area in which Lookouts survey for marine mammals and sea turtles. Mitigation zones reduce the potential for injury to marine species.	For those activities where monitoring is required, record observations of marine mammals and sea turtles located outside of the mitigation zone and note any apparent reactions to on-going Navy activities. Observation of acute reactions may be used as an indicator that the radius of the mitigation zone needs to be increased.	Mitigation zones have been and will continue to be implemented as described in Section 5.3.2 (Mitigation Zone Procedural Measures). Lookouts are trained to conduct observations within mitigation zones of different sizes.	Officer Conducting the Exercise or Test	Ongoing
Recognize the Importance of Marine Protected Areas In general, most Armed Forces activities are exempt from the prohibitions of marine protected areas. Nevertheless, the Navy would carry out its training and testing activities in a manner that will avoid, to the maximum extent practicable and consistent with training and testing requirements, adverse impacts to National Marine Sanctuary resources.	Avoiding or minimizing impacts while operating in or near marine protected areas could result in improved health of the resources in the areas.	The Navy will report the annual hours of each type of sonar source. For hull-mounted sonar, this report shall include a depiction of the training geographically across the Study Area.	The Navy includes maps in the Protective Measures Assessment Protocol to define marine protected areas. To the greatest extent practicable, adverse impacts to these areas will be avoided.	Officer Conducting the Exercise or Test	Ongoing

Notes: ASW = Anti-Submarine Warfare, ASUW = Anti-Surface Warfare, HFAS = High-Frequency Active Sonar, IEER = Improved Extended Echo Ranging, MIW = Mine Warfare, NAVSEA = Naval Sea Systems Command, Navy = United States Department of the Navy

Consistent with the cooperating agency agreement with NMFS, mitigation and monitoring measures presented in this EIS/OEIS focus on the requirements for protection and management of marine resources. Since monitoring will be required for compliance with the Final Rule issued for the Proposed Action under the MMPA, details of the monitoring program are being developed in coordination with NMFS through the regulatory process.

The Integrated Comprehensive Monitoring Program is intended to coordinate monitoring efforts across all regions where the Navy trains and to allocate the most appropriate level and type of effort for each range complex. The current Navy monitoring program is composed of a collection of "range-specific" monitoring plans, each developed individually as part of MMPA and ESA compliance processes as environmental documentation was completed. These individual plans establish specific monitoring requirements for each range complex and are collectively intended to address the Integrated Comprehensive Monitoring Program top-level goals. A Scientific Advisory Group of leading marine mammal scientists developed recommendations that would serve as the basis for a Strategic Plan for Navy monitoring. The Strategic Plan is intended to be a primary component of the Integrated Comprehensive Monitoring Program and provide a "vision" for Navy monitoring across geographic regions—serving as guidance for determining how to most efficiently and effectively invest the marine species monitoring resources to address Integrated Comprehensive Monitoring Program top-level goals and satisfy MMPA regulatory requirements. The objective of the Strategic Plan is to continue the evolution of Navy marine species monitoring towards a single integrated program, incorporating Scientific Advisory Group recommendations, and establishing a more transparent framework for soliciting, evaluation, and implementing monitoring work across the Fleet range complexes.

ES.8.5 REPORTING

The Navy is committed to documenting and reporting relevant aspects of training and testing activities in order to reduce environmental impacts and improve future environmental assessments. Initiatives include exercise and monitoring reporting, stranding response planning, and bird strike reporting.

ES.8.6 OTHER CONSIDERATIONS

ES.8.6.1 Consistency with Other Federal, State, and Local Plans, Policies and Regulations

Based on an evaluation of consistency with statutory obligations, the Navy's proposed training and testing activities would not conflict with the objectives or requirements of applicable federal, state, regional, or local plans, policies, or legal requirements. The Navy is consulting and will continue to consult with regulatory agencies as appropriate during the planning process and prior to implementation of the Proposed Action to ensure all legal requirements are met.

ES.8.6.2 Relationship Between Short-Term Use of the Environment and Maintenance and Enhancement of Long-Term Productivity

This EIS/OEIS provides an analysis of the relationship between a project's short-term impacts on the environment and the effects that these impacts may have on the maintenance and enhancement of the long-term productivity of the affected environment. The Proposed Action may result in both short- and long-term environmental effects. However, the Proposed Action would not be expected to result in any impacts that would reduce environmental productivity, permanently narrow the range of beneficial uses of the environment, or pose long-term risks to health, safety, or the general welfare of the public.

ES.8.6.3 Irreversible or Irretrievable Commitment of Resources

For the alternatives including the Proposed Action, most resource commitments are neither irreversible nor irretrievable. Most impacts are short term and temporary or, if long lasting, are negligible. No habitat associated with threatened or endangered species would be lost as a result of implementation of the Proposed Action. No commitment of resources to construction is proposed as part of this action.

Implementation of the Proposed Action would require fuels used by aircraft and vessels. Since fixed- and rotary-wing flight and ship activities could increase, relative total fuel use could increase. Therefore, if total fuel consumption increased, this nonrenewable resource would be considered irretrievably lost. The Navy has initiated programs that are expected to greatly reduce consumption of fossil fuels and reduce greenhouse gas emissions. Included among these are Navy plans to deploy by 2016 a green strike group (a “great green fleet”) composed of nuclear vessels and ships powered by biofuel in local operations and with aircraft flying only with biofuels.

ES.8.6.4 Energy Requirements and Conservation Potential of Alternatives and Mitigation Measures

Resources that will be permanently and continually consumed by project implementation include water, electricity, natural gas, and fossil fuels; however, the amount and rate of consumption of these resources would not result in significant environmental impacts or the unnecessary, inefficient, or wasteful use of resources. Prevention of the introduction of potential contaminants is an important component of mitigation of the alternative’s adverse impacts. To the extent practicable, considerations in the prevention of introduction of potential contaminants are included.

Sustainable range management practices are in place that protect and conserve natural and cultural resources and preserve access to training areas for current and future training requirements while addressing potential encroachments that threaten to impact range and training area capabilities.

REFERENCES

U.S. Department of the Navy. (2010a). Northwest Training Range Complex (NWTRC) Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). Prepared by Naval Facilities Engineering Command Northwest.

U.S. Department of the Navy. (2010b). Naval Undersea Warfare Center (NUWC) Keyport Range Complex Extension Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). Prepared by Naval Facilities Engineering Command Northwest.

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ACRONYMS AND ABBREVIATIONS

(r$_0$)	charge radius
µg	micrograms(s)
µg/g	microgram(s)/gram
µg/L	microgram(s) per liter
µm	micrometer(s)
µPa	micropascal(s)
µPa^2-s	micropascal squared second(s)
°	degrees
AASP	Acoustic Augmentation Support Program
AAW	Anti-Air Warfare
ac.	acre(s)
ACM	Air Combat Maneuver
ACMP	Alaska Coastal Management Program
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
ATBA	Area to Be Avoided
ATCAA	Air Traffic Control Assigned Airspace
ATN	Aid to Navigation
AUTEC	Atlantic Undersea Test and Evaluation Center
AUV	Autonomous Underwater Vehicle
AWOIS	Automated Wreck and Obstruction Information System
BA	Biological Assessment
BDU	Bomb Dummy Unit
BOMBEX	Bombing Exercise
BRF	Behavioral Risk Function
BTS	Bureau of Transportation Statistics
C	Celsius
CAA	Clean Air Act
CATM	Captive Air Training Missile
CCC	California Coastal Commission
CEE	Controlled Exposure Experiment
Ce$_{HF}$	High-Frequency Cetacean Weighting Function
Ce$_{LF}$	Low Frequency Cetacean Weighting Function
Ce$_{MF}$	Mid-Frequency Cetacean Weighting Function
CEQ	Council on Environmental Quality
C.F.R.	Code of Federal Regulations
CG	Cruiser
CH$_4$	methane
cm	centimeter(s)
CMP	Coastal Management Program
CO	carbon monoxide
CO$_2$	carbon dioxide
CO$_2$Eq	carbon dioxide equivalent
CV	Coefficient of Variation
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
dB	decibel(s)
dB re 1 µPa	decibels referenced to 1 micropascal
dBA	A-weighted decibels
DBRC	Dabob Bay Range Complex
DDG	Destroyer
DDT	dichlorodiphenlytrichlorethane
DEIS	Draft Environmental Impact Statement
DICASS	Directional Command Activated Sonobuoy
DLCD	Department of Land Conservation and Development
DOC	Department of Commerce
DoD	Department of Defense
DOE (Washington State)	Department of Ecology
DOI	Department of Interior
DPS	Distinct Population Segments
D$_{Rm}$	depth of receiver (animal) in meters
DS	Doppler Sonar
DT	Developmental Testing
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFHA	Essential Fish Habitat Assessment
EIS	Environmental Impact Statement
EL	Exposure Level
EMATT	Expendable Mobile Anti-Submarine Warfare Training Target
EO	Executive Order
EOD	Explosive Ordnance Disposal
ERL	effects range–low
ERM	effects range–median
ESA	Endangered Species Act
EW	Electronic Warfare
F	Fahrenheit
FEIS	Final Environmental Impact Statement
FFG	Frigate
FL	flight level
FR	Federal Register
FRR&DP	Fleet Readiness Research and Development Program
ft.	foot/feet
ft.^{2}	square foot/feet
FTCA	Federal Tort Claims Act
g	gram(s)
G	gauss
gal.	gallon(s)
gC	gram(s) of carbon
GI	gastrointestinal
GUNEX	Gunnery Exercise
h	depth
ha	hectare(s)
HARM	High Speed Anti-Radiation Missile
HDC (1)	High Duty Cycle

HDC (2)	Harbor Defense Command
HF	high-frequency
Hz	Hertz
IEER	Improved Extended Echo Ranging
i-ENCON	Incentivized Energy Conservation
IFR	Instrument Flight Rules
in.	inch(es)
ISR	Intelligence, Surveillance, Reconnaissance
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
L	liter(s)
lb.	pound(s)
LF	low-frequency
Lmax	maximum peak sound level
LOA	Letter of Authorization
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
M	Acoustic Modems
MAC	Multistatic Active Coherent
MBTA	Migratory Bird Treaty Act
MF	mid-frequency
MFA	Mid-Frequency Active
MFAS	Mid-Frequency Active Sonar
mg	milligram(s)
mg/L	milligram(s) per liter
mg chl/m^3	milligram(s) of chlorophyll per cubic meter
mi.	mile(s)
mi.^{2}	square mile(s)
MINIROV	Miniature Remotely Operated Vehicle
ml	milliliter(s)
mm	millimeter(s)
MMPA	Marine Mammal Protection Act
MOA	Military Operations Area
MPA (1)	Maritime Patrol Aircraft
MPA (2)	Marine Protected Area
msec	millisecond(s)
MSL	Mean Sea Level
MW	Mine Warfare
MIW	Mine Warfare
N	north
N$_2$O	nitrous oxide
N/A	not applicable
NAEMO	Navy Acoustic Effects Model
NAS	Naval Air Station
NASWI	Naval Air Station Whidbey Island
NAVAIR	Naval Air Systems Command
NAVBASE	Naval Base
NAVSEA	Naval Sea Systems Command
Navy	United States Department of the Navy
NBK	Naval Base Kitsap
NEPA	National Environmental Policy Act
NEPM	Non-explosive Practice Munition
NEW	Net Explosive Weight
NHPA	National Historic Preservation Act
NKB	Naval Base Kitsap
nm	nautical mile(s)
nm^2	square nautical mile(s)
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Lab
NMSA	National Marine Sanctuaries Act
NO	nitric oxide
NO$_2$	nitrogen dioxide
NO$_x$	nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NRHP	National Register of Historic Places
NTM	Notice to Mariners
NSWCCD	Naval Surface Warfare Center, Carderock Division
NUWC	Naval Undersea Warfare Center
NWTRC	Northwest Training Range Complex
NWTT	Northwest Training and Testing
O$_3$	ozone
OBIS-SEAMAP	Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate
OCE	Officer Conducting the Exercise
OCMP	Oregon Coastal Management Program
OCNMS	Olympic Coast National Marine Sanctuary
OEIS	Overseas Environmental Impact Statement
OPAREA	Operating Area
OT	Operational Testing
oz.	ounce(s)
P	Pinger
Pa	Pascal
Pb	lead
Pa-s	Pascal seconds
PACNW	Pacific Northwest
PCAD	Population Consequences of Acoustic Disturbance
PCBs	polychlorinated biphenyls
PCE	Primary Constituent Element
PM	particulate matter
PM$_{10}$	PM ≤10 microns in diameter
PM $_{2.5}$	PM ≤2.5 microns in diameter
PMRF	Pacific Missile Range Facility
P$_O$	Otariid Pinniped Weighting Function
POPS	Project Operations
P$_P$	Phocid Pinniped Weighting Function
ppb	parts per billion
PRST	Post Refit Sea Trial

PSA	Post Shakedown Availability
psi	pounds per square inch
PSNS&IMFINST	Puget Sound Naval Shipyard and Intermediate Maintenance Facility Instruction
PSU	Practical Salinity Units
PTS	permanent threshold shift
QUTR	Quinault Underwater Tracking Range Site
R	Restricted Area
RDT&E	Research, Development, Test and Evaluation
RDX	royal demolition explosive
re	referenced to
RITA	Research and Innovative Technology Administration
RL	Received Level
rms	root mean square
RMMV	Remote Multi-Mission Vehicle
ROD	Record of Decision
ROP	Range Operating Policies and Procedures Manual
ROV	Remotely Operated Vehicle
S	south
SAR	Stock Assessment Report
SAS	Synthetic Aperture Sonar
SCUBA	Self-Contained Underwater Breathing Apparatus
SD	Swimmer Detection Sonar
SDV	Seal Delivery Vehicle
SEAFAC	Southeast Alaska Acoustic Measurement Facility
SEAL	Sea, Air, Land
sec	second(s)
SEL	Sound Exposure Level
SINKEX	Sinking Exercise
SIP	State Implementation Plan
SL	source level
SO_2	sulfur dioxide
Sonar	Sound Navigation and Ranging
SPL	Sound Pressure Level
SPLASH	Structure of Populations, Levels of Abundance, and Status of Humpbacks
SSN	Navy submarine
Study Area	NWTT Study Area
SUS	Signal Underwater Sound
SWAG	Shock Wave Action Generator
SWFSC	Southwest Fisheries Science Center
Tg	tetragram(s)
TL	transmission loss
TNT	trinitrotoluene
TOC	total organic carbon
TORP	torpedoes
TRACKEX	tracking exercise
TTS	temporary threshold shift
T-weighting	turtle-weighting
UAS	Unmanned Aerial System
UEWS	Underwater Emergency Warning System
U.S.	United States
U.S.C.	United States Code
USCG	United States Coast Guard
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USV	Unmanned Surface Vehicle
UUV	Unmanned Underwater Vehicle
VDS	Variable Depth Sonar
VFR	Visual Flight Rules
VHF	Very High Frequency
VOC	volatile organic compounds
W (1)	Warning Area
W (2)	west
yd.	yard(s)

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MASTER GLOSSARY OF TERMS

Term	Definition
Acoustics	The scientific study of sound, especially of its generation, transmission, and reception.
Action proponent	The commander, commanding officer, or civilian director of a unit, activity, or organization who initiates a proposal for action, as defined in 40 Code of Federal Regulations 1508.23, and who has command and control authority over the action once it is authorized. Commander, United States (U.S.) Pacific Fleet is the action proponent for the Northwest Training and Testing Environmental Impact Statement (EIS)/Overseas EIS (OEIS).
Active sonar	A system that detects objects by creating a sound pulse, or ping, that transmits through the water and reflects off the target, returning in the form of an echo. This is a two-way transmission (source to reflector to receiver).
Alternative	A different method for accomplishing the Proposed Action. An action alternative modifies some combination of factors affecting the location, timing, or scope of the activity while still accomplishing the purpose of the Proposed Action. The No Action Alternative provides a baseline (existing condition or historic condition) against which to compare the action alternatives, but may not necessarily fulfill the purpose of the Proposed Action.
Ambient sound	The typical or persistent environmental background sound present in the ocean.
Anadromous	Species of fish that are born in freshwater migrate to the ocean to grow into adults, and return to freshwater to spawn.
Anthropogenic sound	Acoustic energy emitted from human activities.
Anti-Submarine Warfare	Naval operations that involve detecting, tracking, and potential engagement with submarines, their supporting forces, and operating bases that demonstrate hostile intent or are declared hostile by appropriate authority.
Baleen	In some whales (see Mysticete below), the parallel rows of fibrous plates that hang from the upper jaw and are used for filter feeding.
Bathymetry	The measurement of water depth at various places in a body of water; the information derived from such measurements.
Behavioral effect	Defined in this EIS/OEIS as a variation in an animal's behavior or behavior patterns that results from an anthropogenic acoustic exposure and exceeds the normal daily variation in behavior, but which arises through normal physiological process (it occurs without an accompanying physiological effect).
Benthic	Referring to the bottom-dwelling community of organisms (i.e., plants and animals) that creep, crawl, burrow, or attach themselves to either the sea bottom or such structures as ships, buoys, and wharf pilings (e.g., crabs, clams, worms).
Biologically important activities/behaviors	Those activities or behaviors essential to the continued existence of a species, such as migration, breeding/calving, or feeding.
Biologically important area	For cetacean species with distinct migrations, areas, and time periods where they are known to concentrate for specific behaviors such as reproducing, feeding, or migrating. For other cetacean species, areas and months within which small and resident populations occupy a limited geographic extent.
Biological Opinion	A document that is the result of Endangered Species Act (ESA), Section 7 formal consultation. This document states the opinion of the Service (National Marine Fisheries Service or U.S. Fish and Wildlife Service) on whether or not a Federal action is likely to adversely affect or jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat and, if so, the Service provides recommendations to minimize or avoid adverse impacts.
Cetacean	An order of aquatic mammals such as whales, dolphins, and porpoises.

Term	Definition
Critical habitat	As defined in the ESA and used in this document, the term "critical habitat" for a threatened or endangered species means (1) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the ESA, on which are found those physical or biological features (i) essential to the conservation of the species, and (ii) that may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species.
Cumulative impact	The impact on the environment which results from adding the incremental impact of the proposed action to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes the other actions.
Decibel (dB)	A unit used to express the relative difference in power, usually between acoustic or electrical signals, equal to 10 times the common logarithm of the ratio of the two levels. Since the decibel scale is exponential and not linear, a 20 dB sound is 10 times louder than a 10 dB sound, and a 30 dB sound is 100 times louder than a 10 dB sound.
Demersal	Living at or near the bottom of a water body, but having the capacity for active swimming. Term used particularly when describing various fish species.
Distinct population segment (DPS)	As defined by the National Marine Fisheries Service, a vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species. The ESA provides for listing species, subspecies, or DPSs of vertebrate species.
Duty cycle	Duty cycle describes the portion of time that a sound source actually generates sound. It is defined as the percentage of the time during which a sound is generated over a total operational period.
Endangered species	As defined in the ESA and used in this document, any species which is in danger of extinction throughout all or a significant portion of its range.
Essential fish habitat	As defined by the Magnuson Stevens Fishery Conservation and Management Act, those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.
Exclusive Economic Zone	A maritime zone adjacent to the territorial sea that may not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.
Federal Register	The official daily publication for actions taken by the federal government, such as Rules, Proposed Rules, and Notices of federal agencies and organizations, as well as Executive Orders and other Presidential documents.
Frequency	The number of oscillations or waves per second is called the frequency of a sound, and the metric is Hertz (Hz). One Hz is equal to one oscillation per second, and 1 kilohertz (kHz) is equal to 1,000 oscillations per second.
Harassment	Under the 1994 Amendments to the Marine Mammal Protection Act (MMPA) and used in this document, harassment is statutorily defined as, any act of pursuit, torment, or annoyance which (Level A Harassment) has the potential to injure a marine mammal or marine mammal stock in the wild, or (Level B Harassment) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.
High-frequency	As defined by the U.S. Department of the Navy (Navy) and used in this document, frequencies greater than 10 kHz to 100 kHz.
Hydrophone	An underwater receiver used to detect the pressure change caused by sound in the water. That pressure is converted to electrical energy. It can then be translated to something that can be heard by the human ear. Sometimes the detected acoustic pressure is outside the human range of hearing.

Term	Definition
Impulse sound	As defined by the American National Standards Institute in *American National Standard Acoustical Terminology* and the *Handbook of Acoustical Measurements and Noise Control* (Jansen 1998), impulse sounds are sounds defined as brief, broadband, atonal, transients. Examples of impulse sounds (at least at the source) are explosions, gunshots, sonic booms, seismic airgun pulses, and pile driving strikes. These sounds are all characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a decay period that may include a period of diminishing oscillating maximal and minimal pressures. For additional information, consult Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Jr., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P.E., Richardson, W. J., Thomas, J.A, & Tyack, P. L. (2007). Marine mammal noise and exposure criteria: initial scientific recommendations. *Aquatic Mammals*, 33, 411-521.
Infauna	Animals living within the sediment.
Inland Waters	An area within the Northwest Training and Testing Study Area comprised of the Strait of Juan de Fuca and Puget Sound. See Section 2.1.2 for complete description.
In-water devices	In-water devices as discussed in this analysis are unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles, unmanned undersea vehicles, and towed devices.
Isobath	A line on a chart or map connecting points of equal depths; bathymetric contour.
Letter of Authorization (LOA)	The MMPA provides for an “incidental take” authorization (i.e., LOA) for specified activities, provided the National Marine Fisheries Service finds that the takings will have a negligible impact on marine mammal species or stocks, will not have an unmitigable adverse impact on the availability of the species or stocks for subsistence uses, and promulgates the permissible methods of taking, other means of effecting the least practicable adverse impact on species or stocks and habitat, and requirements pertaining to monitoring and reporting of such taking.” The small numbers requirement does not apply to military readiness activities.
Level A harassment	Under the 1994 Amendments to the MMPA and used in this document, level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild.
Level B harassment	Under the 1994 Amendments to the MMPA and used in this document, level B harassment includes any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered. Unlike Level A harassment, which is solely associated with physiological effects, Level B harassment is associated with both physiological and behavioral effects.
Lookout	A person assigned to stand watch, whose specific duties include observing the air and surface of the water, visually searching for any object or disturbance that may be indicative of a threat to the ship and its crew, such as debris, a periscope, surfaced submarine, or surface disturbance, or that may indicate the presence of biological resources.
Low-frequency	As defined by the Navy and used in this document, frequencies less than 1 kHz.
Masking	The obscuring of sounds of interest by interfering sounds, generally at the same frequencies.
Mid-frequency	As defined by the Navy and used in this document, frequencies from 1 kHz and 10 kHz, inclusive.

Term	Definition
Military expended materials	Those munitions, items, devices, equipment and materials which are uniquely military in nature, and are used and expended in the conduct of the military training and testing mission, such as sonobuoys, flares, chaff, drones, targets, bathymetry measuring devices and other instrumentation, communications devices, and items used as training substitutes. This definition may also include materials expended (such as propellants, weights, guidance wires) from items typically recovered, such as aerial target drones and practice torpedoes.
Military Operations Area (MOA)	Airspace with defined vertical and lateral limits established for the purpose of separating or segregating certain military training activities from instrument flight rules traffic and to identify visual flight rules traffic where these activities are conducted.
Mitigation measure	Measures that will minimize, avoid, rectify, reduce, eliminate, or compensate for significant environmental effects.
Monitoring	The Navy's efforts to track compliance with take authorizations, help evaluate the effectiveness of implemented mitigation measures, and gain a better understanding of the effects of the Proposed Action on marine resources.
Munitions (military)	All ammunition products and components produced or used by or for the U.S. Department of Defense, or the U.S. Armed Services for national defense and security, including military munitions under the control of the Department of Defense, the U.S. Coast Guard, the U.S. Department of Energy, and the National Guard.
Mysticete	Any whale of the suborder Mysticeti having plates of whalebone (baleen plates) instead of teeth. Mysticetes are filter-feeding whales, also referred to as baleen whales, such as blue, fin, gray, and humpback whales.
Noise	Unintentional byproduct of acoustic emissions (waste) such as vessel or aircraft engine noise.
Non-impulse sound	Non-impulse sounds can be tonal, broadband, or both. Some of these non-impulse sounds can be transient signals of short duration but without the essential properties of impulse sounds (e.g., rapid rise-time). Examples of sources producing non-impulse sounds include vessels; aircraft; machinery operations, such as drilling or wind turbines; and many active sonar systems. For additional information, consult Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Jr., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P.E., Richardson, W. J., Thomas, J.A, & Tyack, P. L. (2007). Marine mammal noise and exposure criteria: initial scientific recommendations. *Aquatic Mammals*, 33, 411-521.
Notice of Intent	A written notice published in the *Federal Register* that announces the intent to prepare an EIS. Also provides information about a proposed federal action, alternatives, the scoping process, and points of contact within the lead federal agency regarding the EIS.
Odontocete	Any toothed whale (without baleen plates) of the suborder Odontoceti such as sperm whales, killer whales, dolphins, and porpoises.
Offshore Area	An area within the Northwest Training and Testing Study Area comprised of part of the Pacific Ocean off the coast of Washington, Oregon, and Northern California. See Section 2.1.1 for complete description.
Onset permanent threshold shift (onset PTS)	In this EIS/OEIS, the smallest amount of PTS (onset PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset PTS is used to define the outer limit of the Level A harassment zone.
Onset temporary threshold shift (onset TTS)	In this EIS/OEIS, the smallest measurable amount of TTS (onset TTS) is taken as the best indicator for slight temporary sensory impairment. The acoustic exposure associated with onset TTS is used to define the outer limit of the portion of the Level B harassment zone attributable to physiological effects.
Operating Area (OPAREA)	A maritime area defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace.

Term	Definition
Ordnance	Explosives, chemicals, pyrotechnics, and similar stores (e.g., bombs, guns and ammunition, flares, smoke, or napalm).
Passive sonar	A sonar system for detecting or receiving acoustic energy without the system itself emitting acoustic energy.
Pelagic	The open, upper portion of marine waters rather than waters adjacent to land or near the sea floor, and the species which typically occupy this habitat.
Permanent threshold shift (PTS)	A nonrecoverable (permanent) change in the threshold of hearing due to destruction of tissues within the auditory system from exposure to high-intensity sound. PTS therefore qualifies as an injury and is classified as Level A harassment under the wording of the MMPA.
Ping	Pulse of sound created by sonar.
Pinger	A pulse generator using underwater sound transmission to relay data such as subject location. Includes range and tracking pingers.
Pinniped	Any member of the suborder (Pinnipedia) of aquatic carnivorous mammals (i.e., seals and sea lions) with all four limbs modified into flippers.
Platform	A vessel, aircraft, pier, barge, etc. from which training or test activities can be conducted.
Predation	A biological interaction where a predator organism feeds on another living organism or organisms known as prey. The act of predation results in the ecologically significant death of the prey.
Range complex	A geographically defined area that encompasses military operating areas, ranges, test facilities and other designated sites on the sea, on land, or in the airspace.
Received level	The level of sound that arrives at the receiver (such as a marine animal or a hydrophone). The received level is the source level minus the transmission losses from the sound traveling through the water.
Record of Decision (ROD)	A summary of the decision made by the action proponent (e.g., Navy) from the alternatives presented in the Final EIS. The ROD is published in the *Federal Register*.
Resonance	A phenomenon that exists when an object is vibrated at a frequency near its natural frequency of vibration—the particular frequency at which the object vibrates most readily. Several factors determine the frequency at which resonance will occur.
Restricted Area (Airspace)	Airspace where aircraft are subject to restriction due to the existence of unusual, often invisible hazards (e.g., release of ordnance) to aircraft. Some areas are under strict control of the Department of Defense (DoD) and some are shared with non military agencies.
Restricted Area (Surface)	A restricted area is a defined water area for the purpose of prohibiting or limiting public access to the area. Restricted areas generally provide security for Government property and/or protection to the public from the risks of damage or injury arising from the Government's use of that area (33 C.F.R. § 334).
Scoping	An early and open process with federal and state agencies and interested parties to identify possible alternatives and the significant issues to be addressed in an environmental planning action.
Ship	Self-propelled Navy-owned or leased surface vessel with in-water hull configuration (i.e., not a hovercraft like the LCAC [landing craft, air cushion]) and surfaced submarines; may include craft operated by uniform personnel or civilians with a bridge crew including a captain and watch personnel; operations are conducted in accordance with Navy standard operating procedures, which maximize personnel and public safety and mission success.

Term	Definition
Small boat	Self-propelled Navy-owned or leased surface craft with in-water hull configuration, short range and small capacity (e.g., rigid hull inflatable boats or commercially available boats used to support test operations); may include craft operated by uniform personnel or civilians with a pilot but not a designated bridge crew; operations are conducted in accordance with Navy standard operating procedures, which maximize personnel and public safety and mission success though procedures may be adapted for vessel size.
Sound	*Sound* is an oscillation in pressure, particle displacement, and particle velocity, as well as the auditory sensation evoked by these oscillations, although not all sound waves evoke an auditory sensation (i.e., they are outside of an animal's hearing range) (American National Standards Institute S1.1-1994).
Sound navigation and ranging (sonar)	Any anthropogenic (man-made) or animal (e.g., bats, dolphins) system that uses transmitted acoustic signals or echo returns to navigate, communicate, or determine the position and bearing of a target. There are two broad types of anthropogenic sonar: active and passive.
Sound pressure level (SPL)	The relative loudness of sounds calculated by the ratio of the sound pressures. Sound pressure level is described by taking the logarithm of the ratio of the measured sound pressure to a reference pressure. For additional information on sound pressure level, see Appendix G (Acoustic Primer).
Sound source	A source of anthropogenic acoustic energy. Sound sources proposed for use in this EIS/OEIS are grouped into "bins" or "classes," based on certain parameters such as source level, frequency, duty cycle, and beam patterns. Sounds can be generally categorized as impulse and non-impulse (see *impulse sound* and *non-impulse sound* definitions in this glossary).
Source level	The SPL of an underwater sound as measured one meter from the source.
Special Use Airspace	Airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration Order 7400.8 series).
Standard operating procedures	Standard practices employed by the Navy to provide for the safety of personnel and equipment, including vessels and aircraft, as well as the success of training and testing activities.
Submarine	Self-propelled manned vessel capable of operating when submerged; may include vessel operated by uniform personnel or civilians; when surfaced, the standard operating procedures of ships apply; when submerged the standard operating procedures for submarines apply.
Substrate	Any object or material upon which an organism grows or to which an organism is attached.
Surface Danger Zone	A danger zone is a defined water area used for target practice, bombing, rocket firing, or other especially hazardous military activities. Danger zones are established pursuant to statutory authority of the Secretary of the Army and are administered by the Army Corps of Engineers. Danger zones may be closed to the public on a full-time or intermittent basis (33 Code of Federal Regulations [C.F.R.] § 334).
Tactical Sonar	A category of sonar emitting equipment mounted on the hulls of surface ships and submarines.
Take	Defined under the MMPA as "harass, hunt, capture, kill or collect, or attempt to harass, hunt, capture, kill or collect." Defined under the ESA as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect"
Temporary threshold shift (TTS)	A short-term (temporary) change in the threshold of hearing due to stress of tissues within the auditory system from exposure to high-intensity sound. Recovery may occur within minutes, hours or days. Temporary threshold shift is less than an injury and is classified as Level B harassment under the wording of the MMPA.
Threatened species	As defined in the ESA and used in this document, any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Term	Definition
Threshold shift	A diminution in ability of an animal to detect sounds within the normal hearing range. The effect may be temporary or permanent. A threshold shift may be caused by stress or damage to tissue of the auditory system, or by masking sounds normally received by the animal.
Transmission loss	Energy losses that occur as the pressure wave, or sound, travels through a medium. The associated wave front diminishes due to the spreading of the sound over an increasingly larger volume and the absorption of some of the energy by the medium.
Unmanned device	Self-propelled devices which are remotely operated in, on, or over the water; devices may be small enough for a human to lift or as large as a rigid-hull inflatable boat, may be tethered or untethered.
Very high-frequency	As defined by the Navy and used in this document, frequencies greater than 100 kHz.
Vessel	All manned self-propelled ships, submarines, and small boats, but not unmanned devices or craft without propulsion (e.g., barges).
Warning Area	Areas of defined dimensions, extending from 3 nautical miles (nm) outward from the coast of the United States, which serve to warn nonparticipating aircraft of potential danger.

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1 Purpose and Need

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1 PURPOSE AND NEED

1.1 INTRODUCTION

Major conflicts, terrorism, lawlessness, and natural disasters all have the potential to threaten national security of the United States. National security, prosperity, and vital interests of the United States are increasingly tied to other nations because of the close relationships between the United States and other national economies. The United States (U.S.) Department of the Navy (Navy) carries out training and testing activities so it can protect the United States from its enemies, protect and defend the rights of the United States and its allies to move freely on the oceans, and provide humanitarian assistance and disaster relief to failed states. The Navy operates on the world's oceans, seas, and within coastal areas—the international maritime domain—on which 90 percent of the world's trade and two-thirds of its oil are transported. Most of the world's population also lives within a few hundred miles of an ocean.

The U.S. Congress, after World War II, established the National Command Authority to identify defense needs based on the existing and emergent situations in the United States and overseas that must be dealt with now or may be dealt with in the future. The National Command Authority, which is composed of the President, the Secretary of Defense, and their deputized alternates or successors, divides defense responsibilities among services. The heads (secretaries) of each service ensure that military personnel are trained, prepared, and equipped to meet those operational requirements.

Training and testing activities that prepare the Navy to fulfill its mission to protect and defend the United States and its allies have the potential to impact the environment. These activities may trigger legal requirements identified in various U.S. federal environmental laws, regulations, and executive orders.

The Navy, in cooperation with the U.S. Coast Guard, prepared this Environmental Impact Statement (EIS)/Overseas EIS (OEIS) to comply with the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114. The Navy also prepared this EIS/OEIS to assess the potential environmental impacts associated with the two categories of military readiness activities mentioned above: training and testing. Collectively, the at-sea areas in this EIS/OEIS are referred to as the Northwest Training and Testing (NWTT) Study Area (Study Area) (Figure 1.1-1).

Training. Navy personnel first undergo entry-level (or schoolhouse) training, which varies according to their assigned warfare community (aviation, surface warfare, submarine warfare, and special warfare) and the community's unique requirements. Personnel then train within their warfare community at sea in preparation for deployment; each warfare community has primary mission areas (areas of specialized expertise that involve multiple warfare communities) that overlap with one another, described in detail in Chapter 2 (Description of Proposed Action and Alternatives).

Testing. The Navy researches, develops, tests, and evaluates new platforms,[1] systems, and their corresponding technologies. Many tests are conducted in realistic conditions at sea and can range in scale from testing new torpedo guidance software to pierside calibration testing after a system upgrade to testing explosive sonobuoys at designated test ranges and operating areas. Testing activities may occur independently of or with training activities.

[1] Throughout this EIS/OEIS, ships and aircraft may be referred to as "platforms"; weapons, combat systems, sensors, and related equipment may be referred to as "systems."

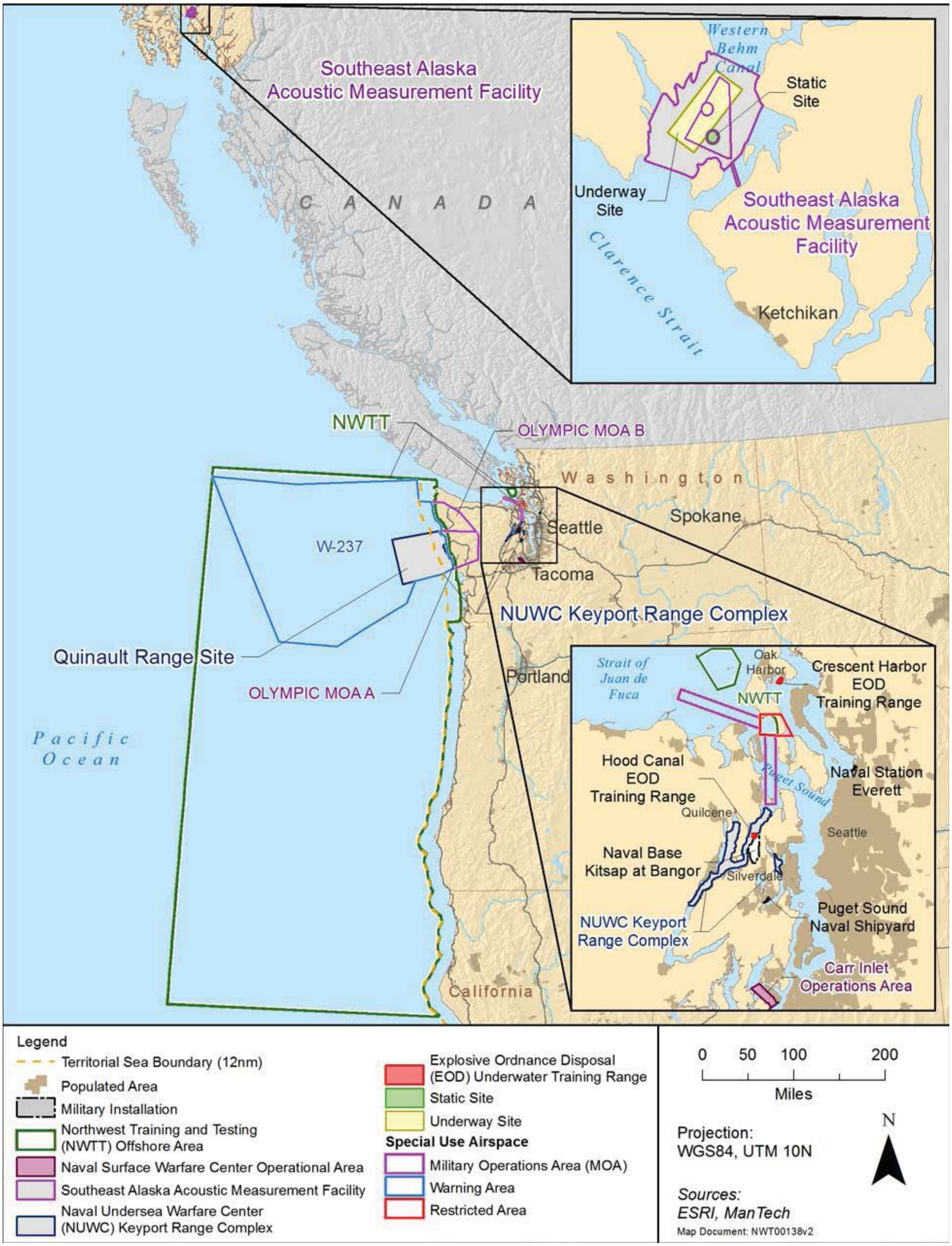

Figure 1.1-1: Northwest Training and Testing Study Area

The land areas and land activities associated with the range complexes and operating areas (OPAREAs) within the Study Area were covered in previous environmental documents (Section 1.9) and are not part of the analysis in this EIS/OEIS.

1.2 THE NAVY'S ENVIRONMENTAL COMPLIANCE AND AT-SEA POLICY

In 2000, the Navy completed a thorough review of its environmental compliance requirements for training at sea and instituted a policy designed to comprehensively address them. The policy, known as the "At-Sea Policy," directed, in part, that the Navy develop a programmatic approach to environmental compliance for exercises and training at sea for ranges and OPAREAs within its areas of responsibility (U.S. Department of the Navy 2000). Ranges affected by the "At-Sea Policy" are designated water areas and associated air space that are managed and used to conduct training or testing activities. OPAREAs affected by the policy are those ocean areas and associated air space, defined by specific geographic coordinates, used by the Navy to undertake training and testing activities (now referred to as Phase I and described below). To meet the requirements of the policy, the Navy developed the updated Concept of Operations for Phase II (described below) Environmental Planning and Compliance for Navy Military Readiness and Scientific Research Activities At Sea. The Concept of Operations laid out a plan to achieve comprehensive environmental planning and compliance for Navy training and testing activities at sea.

Phase I of the planning program. The first phase of the planning program was accomplished by the preparation and completion of individual or separate environmental planning documents for each range complex and OPAREA. The Navy prepared NEPA/EO 12114 documents (Section 1.9) for range complexes in the Northwest (as well as NEPA documents for other OPAREAs in the Study Area) that analyzed training and testing activities. Many of these range complexes and OPAREAs predate World War II and remain in use by naval forces. The previous NEPA/EO 12114 documents identified major training and testing activities, analyzed potential environmental impacts, and supported permit requests and other requirements under applicable environmental laws, regulations, and executive orders. As an example, Marine Mammal Protection Act (MMPA) incidental take authorizations (also known as "Letters of Authorization"), issued by the National Marine Fisheries Service (NMFS), were obtained for two range complexes in the Northwest and will expire in late 2015 for the Northwest Training Range Complex (NWTRC) and mid-2016 for the Naval Undersea Warfare Center (NUWC) Keyport Range Complex.

Phase II of the planning program. The second phase of the planning program will analyze the at-sea activities included in Phase I NEPA/EO 12114 documents and also will analyze additional geographic areas including, but not limited to, pierside locations, testing in Puget Sound, and operations of a test facility in Ketchikan, Alaska. The Navy will not reanalyze the portions of the NWTRC EIS/OEIS that addressed land activities because the activities occurring on land areas analyzed by the EIS/OEIS will not increase, nor will their associated impacts change, and the biological opinions prepared by the U.S. Fish and Wildlife Service (USFWS) will not be altered by the Proposed Action for this EIS/OEIS. There were no terrestrial incidental take statements prepared by the USFWS because the USFWS concurred with the Navy's determination of "Not Likely to Adversely Affect" terrestrial species. This EIS/OEIS is part of the second phase of environmental planning documents needed to support the Navy's request to obtain an incidental take authorization under the MMPA and an incidental take statement under the Endangered Species Act (ESA) from both NMFS and USFWS for marine species. The Navy is reevaluating impacts from historically conducted activities and has updated the training and testing activities based on changing operational requirements, including those associated with new platforms and systems. The Navy will use this new analysis to support incidental take authorizations under the MMPA and the ESA.

The Study Area for this EIS/OEIS consists of established sea and air portions of NWTRC, NUWC Keyport Range Complex, the Carr Inlet OPAREA, and the Southeast Alaska Acoustic Measurement Facility. In addition to these designated training and testing locations, the Study Area includes pierside locations at U.S. Navy bases where sonar (sound navigation and ranging) maintenance and testing occur, as well as inland waters that are not part of the areas listed above where training and testing may occur.

1.3 PROPOSED ACTION

The Navy's Proposed Action, described in detail in Chapter 2, is to conduct training and testing activities—to include the use of active sonar and acoustic sources, and explosives—within the Study Area (Figure 1.1-1). The Proposed Action includes pierside sonar testing conducted as part of overhaul, modernization, maintenance, and repair activities at Naval Base (NAVBASE) Kitsap Bremerton, NAVBASE Kitsap Bangor, and Naval Station Everett, all located in Washington State.

1.4 PURPOSE OF AND NEED FOR PROPOSED MILITARY READINESS TRAINING AND TESTING ACTIVITIES

The purpose of the Proposed Action is to conduct training and testing activities to ensure that the Navy meets its mission, which is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is achieved in part by conducting training and testing within the Study Area.

The following sections provide an overview of the need for military readiness training and testing activities.

> Title 10, Section 5062 of the U.S. Code provides, "The Navy shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea. It is responsible for the preparation of naval forces necessary for the effective prosecution of war except as otherwise assigned and, in accordance with integrated joint mobilization plans, for the expansion of the peacetime components of the Navy to meet the needs of war."

1.4.1 WHY THE NAVY TRAINS

Naval forces must be ready for a wide range of military operations—from large-scale conflict to maritime security and humanitarian assistance/disaster relief—to deal with the dynamic, social, political, economic, and environmental issues that occur in today's world. The Navy supports these military operations through its continuous presence on the world's oceans: the Navy can respond to a wide range of issues because, on any given day, over one-third of its ships, submarines, and aircraft are deployed overseas. Naval forces must be prepared for a broad range of capabilities—from full-scale armed conflict in a variety of different geographic areas[1] to disaster relief efforts[2]—prior to deployment on the world's oceans. To learn these capabilities, personnel must train with the equipment and systems that will achieve military objectives. The training process provides personnel with an in-depth understanding of their individual limits and capabilities; the training process also helps the testing community improve new weapon systems.

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[1] For example, Operation Iraqi Freedom in Iraq and Operation Enduring Freedom in Afghanistan; maritime security operations, including anti-piracy efforts like those in Southeast Asia and the Horn of Africa.

[2] Such as evacuation of noncombatants from American embassies under hostile conditions, as well as humanitarian assistance/disaster relief like the tsunami responses in 2005 and 2011 and Haiti's earthquake in 2009.

Modern weapons bring both unprecedented opportunity and innumerable challenges to the Navy. For example, modern (or smart) weapons are very accurate and help the Navy accomplish its mission with greater precision and far less collateral damage than in past conflicts; however, modern weapons are very complex to use. Military personnel must train regularly with these weapons to understand the capabilities, limitations, and operations of the platform or system. Modern military actions require teamwork—teamwork that includes the use of diverse equipment, vehicles, ships, and aircraft—between hundreds or thousands of people to achieve success.

Military readiness training and preparation for deployment include everything from teaching basic and specialized individual military skills to intermediate skills or small unit training. As personnel improve their skill levels and complete the basic training, they advance to intermediate and larger exercise training events, which culminate in advanced, integrated training events composed of large groups of personnel and, in some instances, joint service exercises. No major training exercises are conducted in the Study Area.

Military readiness training must be as realistic as possible to provide the experiences so important to success and survival. While simulators and synthetic training are critical elements of training—to provide early skill repetition and enhance teamwork—there is no substitute for live training in a realistic environment. The range complexes, test ranges, and OPAREAs have these realistic environments, with sufficient sea and airspace vital for safety and mission success. Just as a pilot would not be ready to fly solo after simulator training, a Navy commander would not allow military personnel to engage in real combat activities based merely on simulator training.

1.4.2 FLEET READINESS TRAINING PLAN

The Navy developed the Fleet Response Plan to ensure the constant readiness of naval forces. This plan maintains, staffs, and trains naval forces to deploy for missions. The Fleet Response Plan increases the number of personnel and vessels that can be deployed on short notice. For example, the Navy completed an unscheduled deployment of an additional aircraft carrier to the Middle East in January 2007 because of adherence to the Fleet Response Plan. Observance of the Fleet Response Plan allows the Navy to respond to global events more robustly while maintaining a structured process that ensures continuous availability of trained, ready Navy forces.

Figure 1.4-1: Fleet Readiness Training Plan

The Fleet Readiness Training Plan implements the requirements in the Fleet Response Plan. The Fleet Readiness Training Plan outlines the training activities required for military readiness that prepares Navy personnel for any conflict or operation. The Navy's building-block approach to training is cyclical and qualifies its personnel to perform their assigned missions. Training activities proceed in four phases: basic, integrated, sustainment, and maintenance, as depicted in Figure 1.4-1.

1.4.2.1 Basic Phase

The basic phase consists of training exercises performed by individual ships and aircraft; it is characterized mostly as unit-level training. Fundamental combat skills are learned and practiced during this phase. OPAREA and range support requirements for unit-level training are relatively modest compared to large-scale, major exercises. Training exercises with two or more units (ships, aircraft, or both), known as coordinated unit-level training exercises, are also included in the basic phase. These training exercises further refine the basic, fundamental skills while increasing difficulty through coordination with other units.

Access to local range complexes and OPAREAs near the locations where Sailors and Marines are stationed reduces the amount of travel time and training costs.

1.4.2.2 Integrated Phase

The integrated phase combines the units involved in the basic, coordinated unit-level training into strike groups. Strike groups are composed of multiple ships and aircraft. Strike group skills and proficiencies are developed and evaluated through major exercises. The integrated phase concludes when the strike group is certified for deployment, meaning that the strike group demonstrated the skills and proficiencies across the entire spectrum of warfare that may be needed during deployment. The integrated phase for assets homeported/homebased in the Pacific Northwest takes place primarily in the Southern California Range Complex.

Major exercises in this phase require access to large, relatively unrestricted ocean OPAREAs, multiple targets, and unique range attributes (oceanographic features, proximity to naval bases, and land-based targets).

1.4.2.3 Sustainment Phase

The strike group needs continued training activities to maintain its skills after certification for deployment in the integrated phase; these continued training activities fall within the sustainment phase. Sustainment phase activities provide strike groups additional training, as well as the ability to evaluate new and developing technologies, and to evaluate and develop new tactics.

Similar to the integrated phase, sustainment exercises require access to large, relatively unrestricted ocean OPAREAs and unique range attributes to support the scenarios.

1.4.2.4 Maintenance Phase

Naval forces enter the maintenance phase after forces return from deployment. Maintenance may involve relatively minor repair or major overhaul, depending on the system and its age. The maintenance phase also includes testing a ship's systems; these tests may take place pierside or at sea. Naval forces reenter the basic phase at the completion of the maintenance phase.

1.4.3 WHY THE NAVY TESTS

The Navy's research and acquisition community conducts military readiness activities generally classified as testing. The Navy tests ships, aircraft, weapons, combat systems, and sensors and related equipment, and it conducts scientific research activities to achieve and maintain military readiness. The fleet identifies military readiness requirements to support its mission; the Navy's research and acquisition community, including the Navy's systems commands and associated scientific research organizations, provides Navy personnel with ships, aircraft, weapons, combat systems, sensors, and related equipment. The Navy's research and acquisition community is responsible for researching, developing, testing, evaluating, acquiring, and delivering modern platforms and systems to the fleet—and supporting the systems throughout their service lives. This community is responsible for furnishing high-quality platforms, systems, and support matched to the requirements and priorities of the fleet, while providing the necessary high return on investment by the American taxpayer.

The Navy's research and acquisition community operating in the Study Area includes the following:

- The Naval Sea Systems Command, which develops, acquires, delivers, and maintains surface ships, submarines, and weapon system platforms that provide the right capability to the fleet.
- The Naval Air Systems Command, which develops, acquires, delivers, and sustains aircraft and systems with proven capability and reliability to ensure that Sailors achieve mission success.

The Navy's research and acquisition community, in cooperation with private companies, designs, tests, and builds systems and platforms to address requirements identified by the fleet. Private companies are contracted to assist the Navy in acquiring the platform, system, or upgrade. The Navy's research and acquisition community must test and evaluate the platform, system, or upgrade to validate whether it performs as expected and to determine whether it is operationally effective, suitable, survivable, and safe for its intended use by the fleet.

Testing performed by the Navy's research and acquisition community can be categorized as scientific research testing, private contractor testing, developmental testing and operational testing (including lot acceptance testing), fleet training support, follow-on test and evaluation, or maintenance and repair testing. Fleet training events often offer the most suitable environment for testing a system because training events are designed to accurately replicate operational conditions. System tests, therefore, are often embedded in training events such that it would be difficult for an observer to differentiate the two activities.

- **Scientific research testing.** The Navy's research and acquisition community conducts scientific research to evaluate emerging threats or technology enhancement before developing a new system. As an example, testing might occur on a current weapon system to determine if a newly developed technology would improve system accuracy or enhance safety to personnel.
- **Private contractor testing.** Contractors are often required to conduct performance and specification tests before delivering a system or platform to the Navy. These tests may be conducted on a Navy range, in a Navy OPAREA, or seaward of ranges and OPAREAs; these tests are sometimes done with fleet training activities.
- **Developmental testing.** A series of tests is conducted by specialized Navy units to evaluate a platform or system's performance characteristics and to ensure that it meets all required specifications.
- **Operational testing.** A platform or system is evaluated as it would be used by the fleet to test particular systems in the operating environment.
- **Fleet training support.** Systems that are still under development may be integrated on ships or aircraft for testing. If training has not been developed for use of a particular system, the Navy's systems commands may support the fleet by providing training on the operation, maintenance, and repair of the system during developmental testing activities.
- **Follow-on test and evaluation.** This phase occurs when a platform receives a new system, after a significant upgrade to an existing system, or when the system failed to meet contractual performance specifications during previous testing. Tests similar to those conducted during the

developmental testing or operational testing phase are conducted again, as needed, to ensure that the modified or new system meets performance requirements and does not conflict with existing platform systems and subsystems.

- **Maintenance and repair testing.** Following periodic maintenance, overhaul, modernization, or repair of systems, testing of the systems may be required to assess performance. These testing activities may be conducted at shipyards or Navy piers.

Preparatory checks of a platform or system to be tested are often made before actual testing to ensure that the platform or system is operating properly. This preparatory check is similar to checking the wipers and brakes on a car before taking a trip. These checks are done to ensure that everything is operating properly before expending the often considerable resources involved in conducting a full-scale test. Pierside platform and systems checks are conducted during ship maintenance activities and are essential to ensure safe operation of the platform or system at sea.

The Navy uses different testing methods, including computer simulation and analysis, throughout the development of platforms and systems. Although simulation is a key component in the development of platforms and systems, it cannot provide information on how a platform or system will perform, or whether it will meet performance and other specification requirements, in the environment in which it is intended to operate without comparison to actual performance data. For this reason, platforms and systems must undergo at-sea testing at some point in the development process. Navy platforms and systems must be tested and evaluated within the broadest range of operating conditions available (e.g., bathymetry, topography, geography) because Navy personnel must be capable of performing missions within the wide range of operating conditions that exist worldwide. Furthermore, Navy personnel must be assured that platforms and systems will meet performance specifications in the real-world environment in which they will be operated.

1.5 OVERVIEW AND STRATEGIC IMPORTANCE OF EXISTING RANGE COMPLEXES AND TESTING RANGES

The Navy has historically used areas in the Study Area for training and testing. The Navy has grouped areas used for a common purpose into “range complexes.” A range complex may include adjacent areas of sea space, undersea space, land ranges, and overlying airspace designated for military training and testing activities. Range complexes provide controlled and safe environments where military ship, submarine, and aircraft crews can train in realistic conditions. The combination of ranges, OPAREAs, inland waters, and pierside testing sites is critical to realistic training and testing, which allows electronics on the range to capture data on the effectiveness of tactics and equipment—data that provide a feedback mechanism for training and testing evaluations.

The range complexes and testing ranges analyzed in this EIS/OEIS have each existed for decades, some dating back to the 1910s. Range use and infrastructure have developed over time as training and testing requirements in support of modern warfare have evolved. The Navy has not proposed and is not proposing to create new range complexes, OPAREAs, or testing ranges.

The proximity of the NWTT range complexes to naval homeports is strategically important to the Navy because the close access allows efficient execution of training activities and non-training maintenance functions. The proximity of training to homeports also ensures that Sailors and Marines do not have to routinely travel far from their families. For example, the areas of western Washington encompassing Kitsap County, Island County, and Everett are home to thousands of military families. The Navy is required to track and, where possible, limit the amount of time Sailors and Marines spend deployed away from home. Less time away from home is critical to military readiness, morale, and retention. The proximity of the testing ranges to technical centers of expertise (e.g., NUWC Keyport) is crucial to the successful completion of testing activities. The proximate availability of the NWTT range complexes is critical to Navy efforts in these areas.

A summary of the Study Area is provided below. Detailed information on the range complexes and testing ranges included in the Study Area can be found in Section 2.1 (Description of the Northwest Training and Testing Study Area).

Northwest Training Range Complex. The NWTRC encompasses land (not analyzed in this EIS/OEIS), air, and sea areas that extend westward into the Pacific Ocean from the Strait of Juan de Fuca to 130 degrees west longitude (approximately 250 nautical miles [nm]), and southerly parallel to the coasts of Washington, Oregon, and northern California (approximately 510 nm) (see Figure 1.1-1).

Naval Undersea Warfare Center Division, Keyport Range Complex. The NUWC Division Keyport Range Complex is composed of the Keyport Range Site, Dabob Bay Range Complex Site, and Quinault Range Site. The Keyport Range Site is within Kitsap County and includes portions of Port Orchard Reach (also known as Port Orchard Narrows) and the southern tip of Liberty Bay. The Dabob Bay Range Complex Site is in Hood Canal and Dabob Bay and is within Jefferson, Mason, and Kitsap counties. The Quinault Range Site is off the coast of Jefferson and Grays Harbor Counties; it is within the Pacific Northwest Ocean Surface/Subsurface OPAREA and also includes a surf zone area at Pacific Beach, WA.

Southeast Alaska Acoustic Measurement Facility. The Southeast Alaska Acoustic Measurement Facility consists of three major functional components: (1) the Back Island Operations Center and supporting facilities on shore (not analyzed in this EIS/OEIS), (2) the Underway Measurement Site, and (3) the Static Site. These components are distributed within five restricted areas (see Figure 1.1-1).

Carr Inlet Operations Area. The Carr Inlet Operations Area is a 12-square-nautical-mile area between Fox and McNeil Islands in the southern end of Puget Sound, west of Tacoma. The area has been used for acoustic testing and for research, development, test, and evaluation activities. There is no permanent instrumentation or land infrastructure in place or required for the testing proposed for the Carr Inlet OPAREA.

Pierside Testing Facilities. The Navy conducts some testing at or near Navy piers. Most of this testing is sonar maintenance and testing while ships are in port. These piers within the Study Area are all within Puget Sound and include NAVBASE Kitsap Bremerton in Sinclair Inlet, NAVBASE Kitsap Bangor Waterfront in Hood Canal, and Naval Station Everett in Possession Sound.

1.6 THE ENVIRONMENTAL PLANNING PROCESS

The National Environmental Policy Act of 1969 requires federal agencies to examine the environmental impacts of their proposed actions within the United States and its territories. An EIS is a detailed public document that assesses the potential effects that a major federal action might have on the human environment. The Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with applicable laws, regulations, and executive orders.

1.6.1 NATIONAL ENVIRONMENTAL POLICY ACT REQUIREMENTS

The first step in the NEPA process (Figure 1.6-1) for an EIS is to prepare a Notice of Intent to develop an EIS. The Notice of Intent was published in the *Federal Register* on 27 February 2011 and provides an overview of the proposed action and the scope of the EIS. The Notice of Intent is also the first step in engaging the public.

Scoping is an early and open process for developing the scope of issues to be addressed in an EIS and for identifying significant issues related to a proposed action. The scoping process for an EIS is initiated by publication of the Notice of Intent in the *Federal Register* and local newspapers. During scoping, the public helps define and prioritize issues through public meetings and written comments. Details of the public participation process, including comments received for this EIS/OEIS, are available in Appendix E.

After the scoping process, a Draft EIS (DEIS) is prepared to assess the potential impacts of the proposed action and alternatives on the environment. When completed, a Notice of Availability is published in the *Federal Register* and notices are placed in local or regional newspapers announcing the availability of the DEIS. The DEIS is circulated for review and comment; public meetings are also held.

The Final EIS (FEIS) addresses all public comments received on the DEIS. Responses to public comments may include correction of data, clarifications of and modifications to analytical approaches, and inclusion of new or additional data or analyses.

Finally, the decision-maker will issue a Record of Decision, no earlier than 30 days after a FEIS is made available to the public.

Figure 1.6-1: National Environmental Policy Act Process

1.6.2 EXECUTIVE ORDER 12114

Executive Order 12114, *Environmental Impacts Abroad of Major Federal Actions*, directs federal agencies to provide for informed environmental decision-making for major federal actions outside the United States and its territories. Presidential Proclamation 5928, issued 27 December 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 nm; however, the proclamation expressly provides that it does not extend or otherwise alter existing federal law or any associated jurisdiction, rights, legal interests, or obligations. Thus, as a matter of policy, the Navy analyzes environmental effects and actions within 12 nm under NEPA (an EIS) and those effects occurring beyond 12 nm under the provisions of EO 12114 (an OEIS).

1.6.3 OTHER ENVIRONMENTAL REQUIREMENTS CONSIDERED

The Navy must comply with all applicable federal environmental laws, regulations, and executive orders, including, but not limited to, those listed below. Further information can be found in Chapter 3 (Affected Environment and Environmental Consequences) and Chapter 6 (Additional Regulatory Considerations).

- Abandoned Shipwreck Act
- Antiquities Act
- Clean Air Act
- Clean Water Act

- Coastal Zone Management Act
- Endangered Species Act
- Magnuson-Stevens Fishery Conservation and Management Act
- Marine Mammal Protection Act
- Migratory Bird Treaty Act
- National Historic Preservation Act
- National Marine Sanctuaries Act
- Rivers and Harbors Act
- EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*
- EO 12962, *Recreational Fisheries*
- EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*
- EO 13089, *Coral Reef Protection*
- EO 13158, *Marine Protected Areas*
- EO 13175, *Consultation and Coordination with Indian Tribal Governments*
- EO 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*

1.7 SCOPE AND CONTENT

In this EIS/OEIS, the Navy assesses military readiness training and testing activities that could potentially impact human and natural resources, especially marine mammals, sea turtles, and other marine resources. The range of alternatives includes the No Action Alternative and other reasonable courses of action. In this EIS/OEIS, the Navy analyzes direct, indirect, cumulative, short-term, long-term, irreversible, and irretrievable impacts. The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this EIS/OEIS. The United States Coast Guard is a cooperating agency because this document assesses potential impacts from its activities that are similar to the Navy's. The NMFS is a cooperating agency because of its expertise and regulatory authority over marine resources. Additionally, this document will serve as the NMFS's NEPA documentation for the rule-making process under the MMPA.

In accordance with Council on Environmental Quality Regulations, 40 Code of Federal Regulations § 1505.2, the Navy will issue a Record of Decision that provides the rationale for choosing one of the alternatives. The decision will be based on factors analyzed in this EIS/OEIS, including military training and testing objectives, best available science and modeling data, potential environmental impacts, and public interest.

1.8 ORGANIZATION OF THIS ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

To meet the need for decision-making, this EIS/OEIS is organized as follows:

- Chapter 1 describes the purpose of and need for the Proposed Action.
- Chapter 2 describes the Proposed Action, alternatives considered but eliminated, and alternatives to be carried forward for analysis (including the preferred alternative).
- Chapter 3 describes the existing conditions of the affected environment and analyzes the potential impacts of the training and testing activities in each alternative.
- Chapter 4 describes the analysis of cumulative impacts, which are the impacts of the Proposed Action when added to past, present, and reasonably foreseeable future actions.

- Chapter 5 describes the measures the Navy evaluated that could mitigate impacts to the environment.
- Chapter 6 describes other considerations required by NEPA and describes how the Navy complies with other federal, state, and local plans, policies, and regulations.
- Chapter 7 is a list of the EIS/OEIS preparers.
- References are provided at the end of each section.
- Appendices provide technical information that supports the EIS/OEIS analyses and its conclusions.

1.9 RELATED ENVIRONMENTAL DOCUMENTS

The progression of NEPA/EO 12114 documentation for Navy activities has developed from planning individual range complex exercises and testing events to theater assessment planning that spans multiple years and covers multiple range complexes. The following documents are referenced in this EIS/OEIS where appropriate:

- *Final Environmental Impact Statement for Introduction of the P-8A Multi-Mission Maritime Aircraft into the U.S. Navy Fleet* (March 2009)
- *Final Environmental Assessment for Replacement of EA-6B Aircraft with EA-18G Aircraft at Naval Air Station Whidbey Island, Washington* (January 2005)
- *Final Environmental Assessment and Finding of No Significant Impact for the Transition of Expeditionary EA-6B Prowler Squadrons to EA-18G Growler at Naval Air Station Whidbey Island, Oak Harbor, Washington* (November 2012)
- *Supplemental Environmental Impact Statement for Surveillance Towed Array Sensor System Low-Frequency Active (SURTASS LFA) Sonar* (April 2007)
- *Northwest Training Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statement* (September 2010)
- *Final Environmental Impact Statement/Overseas Environmental Impact Statement NAVSEA NUWC Keyport Range Complex Extension* (May 2010)
- *Southeast Alaska Acoustic Measurement Facility (SEAFAC), Behm Canal, Ketchikan Gateway Borough: Environmental Impact Statement* (1988)

The following U.S. Coast Guard documents are also referenced in this EIS/OEIS where appropriate:

- *Final Environmental Impact Statement on U.S. Coast Guard Pacific Area Operations: Districts 11 and 13, U.S. Coast Guard* (April 2010)
- *Final Programmatic Environmental Assessment (PEA) for the Nationwide Use of High Frequency (HF) and Ultra High Frequency (UHF) Sound Navigation and Ranging (SONAR) Technology, U.S. Coast Guard* (November 2013)

REFERENCES

U.S. Department of the Navy. (2000). *Compliance with Environmental Requirements in the Conduct of Naval Exercises or Training at Sea*. (11 pages). Prepared by The Under Secretary of the Navy.

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2 Description of Proposed Action and Alternatives

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2 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

The United States (U.S.) Department of the Navy's (Navy's) Proposed Action is to conduct training and testing activities primarily within existing range complexes, operating areas (OPAREAs), and testing ranges located in the Pacific Northwest of the United States, to include the Strait of Juan de Fuca, Puget Sound, and the Western Behm Canal in southeastern Alaska. Navy training and testing activities may include the use of impulse (e.g., explosives[1]) and non-impulse sources (e.g., active sonar) within the Study Area. The Proposed Action also includes pierside maintenance and sonar testing within the Study Area.

Through this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), the Navy will:

- Reassess the environmental impacts of Navy at-sea training and testing activities contained in three separate EIS/OEISs and various earlier environmental planning documents, and consolidate these analyses into a single environmental planning document, including the following:
    - Northwest Training Range Complex (NWTRC) Final EIS/OEIS (U.S. Department of the Navy 2010a)
    - Naval Sea Systems Command (NAVSEA) Naval Undersea Warfare Center (NUWC) Keyport Range Complex Extension Final EIS/OEIS (U.S. Department of the Navy 2010b)
    - Southeast Alaska Acoustic Measurement Facility (SEAFAC) Final EIS (U.S. Department of the Navy 1988)
- Update environmental analyses with the best available science and most current acoustic analysis methods to evaluate the potential effects of training and testing activities on the marine environment.
- Analyze the potential environmental impacts of training and testing activities in additional areas (areas not analyzed in previous documents) where training and testing historically occur, including Navy ports and shipyards.
- Update the at-sea environmental impact analyses in the previous documents to account for planned force structure changes for 2015–2020 and the development of supporting weapons, platforms, and systems.
- Adjust baseline training and testing activities from current levels to the level needed to support Navy training and testing requirements beginning October 2015 to include other activities and sound sources not addressed in the previous analyses.
- Support authorization of incidental takes of marine mammals under the Marine Mammal Protection Act (MMPA) and incidental takes of threatened and endangered species under the Endangered Species Act (ESA).

In this chapter, the Navy will build upon the purpose and need to train and test by describing the Study Area and identifying the primary mission areas under which these activities are conducted. Each warfare community conducts activities that uniquely contribute to the success of a primary mission area. Each primary mission area requires unique skills, sensors, weapons, and technologies to accomplish the mission. For example, in the primary mission area of anti-submarine warfare, surface, submarine, and aviation communities each utilize different skills, sensors, and weapons to locate, track, and eliminate submarine threats. The testing community contributes to the success of anti-submarine warfare by anticipating and identifying technologies and systems that respond to the needs of the warfare

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[1] The terms 'explosive' and 'high explosive' will be used interchangeably throughout the document.

communities. As each warfare community develops its basic skills and integrates them into combined units and strike groups, the problems of communication, coordination and planning, and movement and positioning of naval forces and targeting/delivery of weapons become increasingly complex. This complexity creates a need for coordinated training and testing between the fleets and systems commands.

In order to address the activities needed to accomplish training and testing in this EIS/OEIS, the Navy has broken down each training and testing activity into basic components that are analyzed for their potential environmental impacts. The training and testing activities are captured in the tables and discussion that follows. Additionally, Chapter 2 provides detailed discussion of how the training and testing activities occur and the platforms, weapons, and systems that are required to complete the activities.

Chapter 2 is organized into eight sections.

- Section 2.1 outlines the area where these training and testing activities would occur.
- Section 2.2 outlines the primary mission areas, which are how training and testing activities are categorized.
- Section 2.3 provides information on the sonar systems, ordnance and munitions, and targets utilized during training and testing activities.
- Section 2.4 outlines the proposed training and testing activities.
- Section 2.5 outlines the process to develop the alternatives to the Proposed Action.
- Sections 2.6, 2.7, and 2.8 outline the No Action and Action Alternatives proposed in this EIS/OEIS.

The proposed activities are complex and therefore the Navy has prepared several appendices that provide a greater level of detail. These appendices will be referenced in the appropriate chapters.

2.1 DESCRIPTION OF THE NORTHWEST TRAINING AND TESTING STUDY AREA

The Northwest Training and Testing (NWTT) Study Area (Study Area) is composed of established maritime operating and warning areas in the eastern north Pacific Ocean region, to include the Strait of Juan de Fuca, Puget Sound, and Western Behm Canal in southeastern Alaska. The area includes air and water space within and outside Washington state waters, and outside state waters of Oregon and Northern California. The Study Area includes four existing range complexes and facilities: the NWTRC, the Keyport Range Complex, Carr Inlet Operations Area, and SEAFAC. In addition to these range complexes, the Study Area also includes Navy pierside locations where sonar maintenance and testing occurs as part of overhaul, modernization, maintenance, and repair activities at Navy piers at Naval Base (NAVBASE) Kitsap Bremerton, NAVBASE Kitsap Bangor, and Naval Station Everett.

The Study Area for this EIS/OEIS consists of established sea and air portions of NWTRC, NUWC Keyport Range Complex, SEAFAC, and the Carr Inlet OPAREA. It includes Navy training and testing range complexes, OPAREAs, testing facilities, and select Navy pierside locations. A range complex is a designated set of specifically bounded geographic areas that encompasses a water component (above and below the surface), and may encompass airspace and a land component where training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occurs. Range complexes include established OPAREAs, Restricted Areas (RAs), and special use airspace (SUA), which may be further divided to provide better control of the area and events for safety reasons.

- **OPAREA:** A maritime area defined by geographic coordinates with defined surface and subsurface areas and associated SUA, OPAREAs may include the following:
  - **Surface Danger Zones:** A danger zone is a defined water area used for target practice, bombing, rocket firing, or other especially hazardous military activities. Danger zones are established pursuant to statutory authority of the Secretary of the Army and are administered by the Army Corps of Engineers. Danger zones may be closed to the public on a full-time or intermittent basis (33 Code of Federal Regulations [C.F.R.] Part 334).
  - **Restricted Areas:** A restricted area is a defined water area for the purpose of prohibiting or limiting public access to the area. Restricted areas generally provide security for Government property and/or protection to the public from the risks of damage or injury arising from the Government's use of that area (33 C.F.R. Part 334).
- **Special Use Airspace:** Airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration Order 7400.8 series). SUA found in the Study Area includes the following:
  - **Restricted Areas:** Airspace where aircraft are subject to restriction due to the existence of unusual, often invisible hazards (e.g., release of ordnance) to aircraft. Some areas are under strict control of the Department of Defense and some are shared with non-military agencies (14 C.F.R. Part 73, Subpart B).
  - **Military Operations Areas (MOAs):** Airspace with defined vertical and lateral limits established for the purpose of separating or segregating certain military training activities from instrument flight rules (IFR) traffic and to identify visual flight rules (VFR) traffic where these activities are conducted.
  - **Warning Area:** Areas of defined dimensions, extending from 3 nautical miles (nm) outward from the coast of the United States, which serve to warn nonparticipating aircraft of potential danger.
- **Special Activity Airspace/Airspace Assigned by Air Traffic Control:** Air Traffic Control Assigned Airspace (ATCAA) is that airspace of defined vertical/lateral limits, assigned by Air Traffic Control, for the purpose of providing air traffic segregation between the specified activity being conducted within the assigned airspace and other IFR traffic. ATCAAs are assigned by the Federal Aviation Administration and are not SUA.

The Study Area includes only the at-sea components of the training and testing areas and facilities. For this EIS/OEIS, the term “at-sea” applies to the Pacific Ocean, the Strait of Juan de Fuca, the Puget Sound, the Western Behm Canal in Alaska, and select pierside locations, where those areas are within the Study Area, and Explosive Ordnance Disposal (EOD) underwater training ranges within the range complex at Crescent Harbor and Hood Canal. The land resources affected by use of the Olympic MOAs A and B will be evaluated as they are directly impacted by overflights for at-sea activities. The remaining land-based portions of the range complex are addressed in previous National Environmental Policy Act (NEPA) documentation, and that analysis remains valid. The previous NEPA analysis remains valid because both the Proposed Action and the conditions related to land areas in this analysis are the same as analyzed in previous NEPA documents. These land areas are not subject to reauthorization under the MMPA or ESA, and therefore are not a part of the Study Area or this EIS analysis. The Study Area is depicted in Figure 2.1-1.

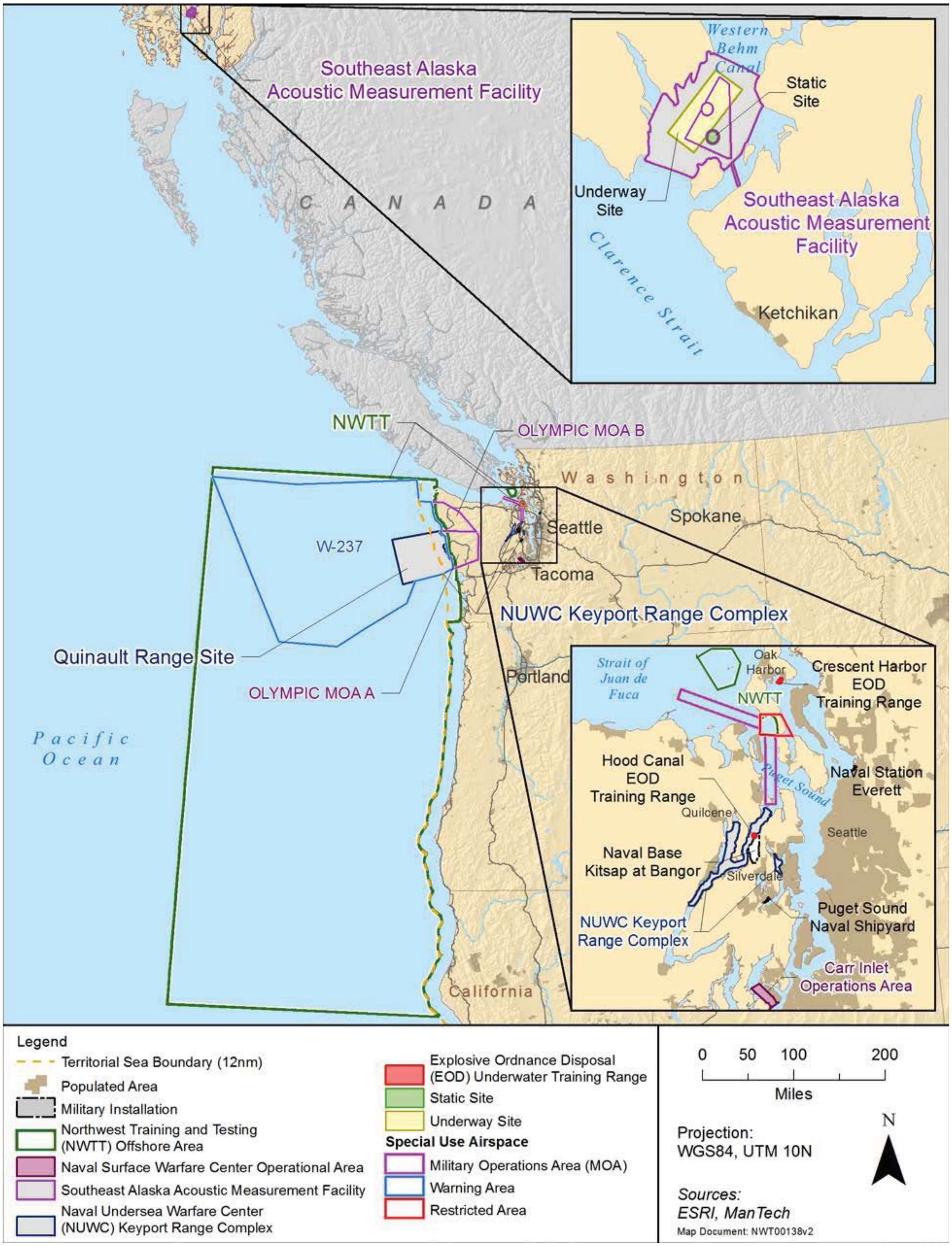

Figure 2.1-1: Northwest Training and Testing Study Area

Military activities in the Study Area occur (1) on the ocean surface, (2) beneath the ocean surface, and (3) in the air. To aid in the description of the ranges covered in the NWTT EIS/OEIS, the ranges are divided into three distinct geographic and functional subdivisions. All of the training and testing activities proposed in this EIS/OEIS would occur in one or more of these three range subdivisions:

- The Offshore Area
- The Inland Waters
- Western Behm Canal, Alaska

2.1.1 DESCRIPTION OF THE OFFSHORE AREA

The offshore area of the Study Area includes air, surface, and subsurface operating areas extending generally west from the coastline of Washington, Oregon, and Northern California for a distance of approximately 250 nm into international waters. At Washington, the eastern boundary of the Offshore Area abuts the coastline; at Oregon and northern California, the boundary lies 12 nm off the coastline. These components are described below and depicted in Figure 2.1-2.

2.1.1.1 Air Space

The SUA in the Offshore Area is comprised of Warning Area 237 (W-237), which extends westward off the coast of Northern Washington State and is divided into nine sub-areas (A–H and J). The eastern boundary of W-237 lies 3 nm off the coast of Washington. The floor of W-237 extends to the ocean surface, and the ceiling of the airspace varies between 27,000 feet (ft.) (8,200 meters [m]) in areas E, H, and J; 50,000 ft. (15,200 m) in areas A and B; and unlimited in areas C, D, F, and G.

The Olympic MOA overlay both land (the Olympic Peninsula) and sea (extending to 3 nm off the coast of Washington into the Pacific Ocean). The MOA lower limit is 6,000 ft. (1,800 m) above mean sea level but not below 1,200 ft. above ground level, and the upper limit is up to but not including 18,000 ft. (5,500 m), with a total area coverage of 1,614 square nautical miles (nm^2).

Above the Olympic MOA is the Olympic ATCAA, which has a floor coinciding with the Olympic MOA ceiling. The ATCAA has an upper limit of 35,000 ft. (10,700 m).

For this EIS/OEIS, the Olympic MOA and the Olympic ATCAA are components of the Offshore Area.

2.1.1.2 Sea and Undersea Space

The Offshore Area includes sea and undersea space approximately 510 nm in length from the northern boundary at the mouth of the Strait of Juan de Fuca to the southern boundary at 40 degrees (°) north (N) latitude, and 250 nm in length from the coastline to the western boundary at 130° west (W) longitude. The southern boundary of 40° N latitude corresponds to the northern boundary of Mendocino County in Northern California. Total surface area of the Offshore Area is approximately 121,000 nm^2. While the Offshore Area extends to the shoreline throughout its length along the Washington coast, it excludes that portion from the coastline of Oregon and Northern California out to 12 nm at sea.

Commander Submarine Force, U.S. Pacific Fleet Pearl Harbor uses this water space as transit lanes for U.S. submarines. The sea space is ample for all levels of Navy training, and its location is ideal for ships, submarines, and aircraft based in the Pacific Northwest. The size of the area and its extension south off the coast of Northern California provides valuable training and testing space for ships and submarines transiting between the Pacific Northwest and Southern California.

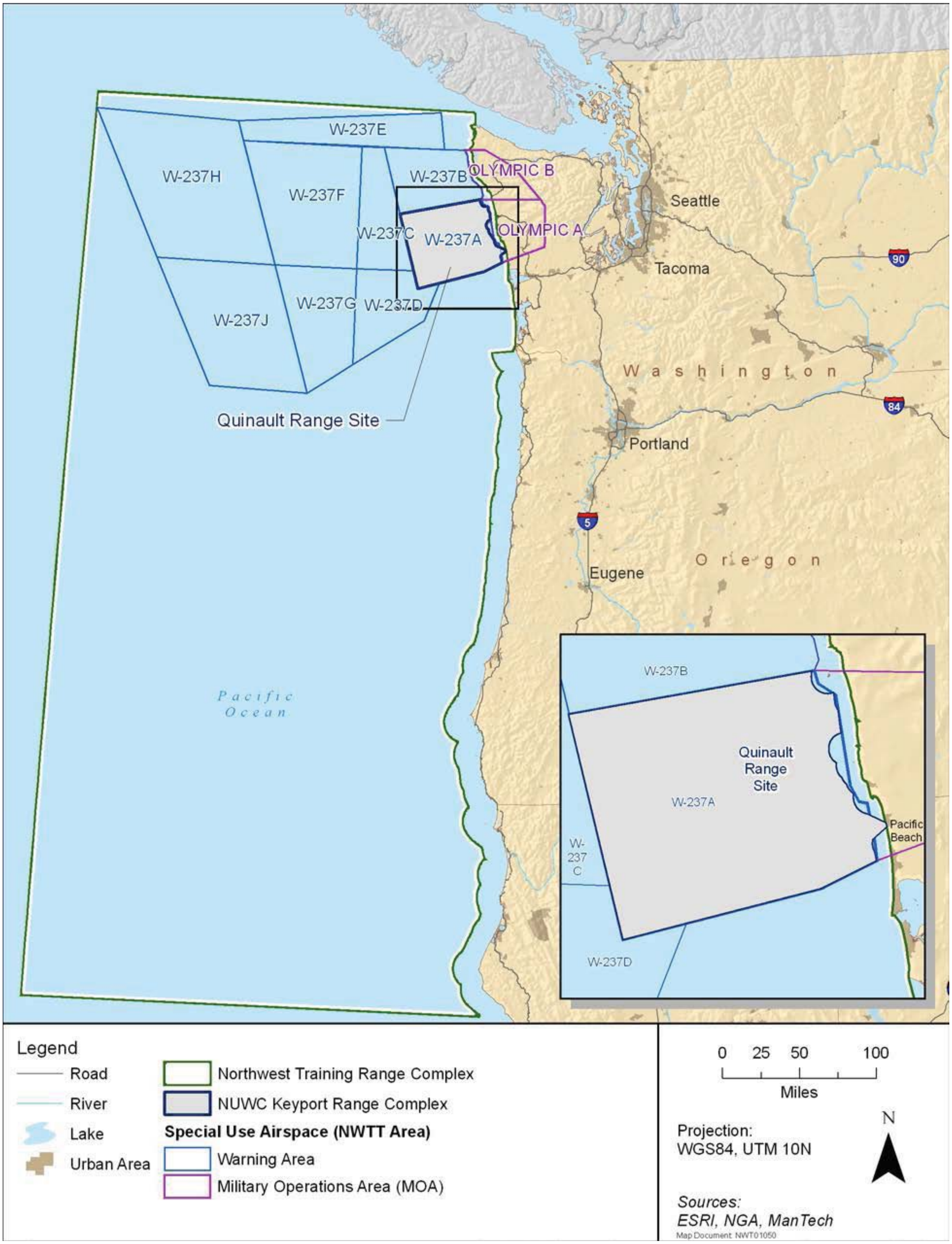

Figure 2.1-2: Offshore Area of the Northwest Training and Testing Study Area

Within the boundaries of the Offshore Area lies the Quinault Range Site (see Figure 2.1-2), a defined area of sea space where training and testing is conducted. The Quinault Range Site coincides with the boundaries of W-237A and also includes a surf zone component. The surf zone component extends north to south 5 nm along the eastern boundary of W-237A, extends approximately 3 nm to shore along the mean lower low water line, and encompasses 1 mile (mi.) (1.6 kilometers [km]) of shoreline at Pacific Beach, Washington. Surf-zone activities would be conducted from an area on the shore and seaward.

2.1.2 DESCRIPTION OF THE INLAND WATERS

The Inland Waters includes air, sea, and undersea space inland of the coastline, from buoy "J" at 48° 29.6 minutes N, 125° W, eastward to include all waters of the Strait of Juan de Fuca and the Puget Sound. None of this area extends into Oregon or California. Within the Inland Waters are specific geographic components in which training and testing occur. The Inland Waters and its component areas are described below and depicted in Figure 2.1-3.

2.1.2.1 Air Space

Restricted Area 6701 (R-6701, Admiralty Bay) is a Restricted Area over Admiralty Bay, Washington, with a lower limit at the ocean surface and an upper limit of 5,000 ft. This airspace covers a total area of 56 nm^2.

Chinook A and B MOAs are 56 nm^2 of airspace south and west of Admiralty Bay (Figure 2.1-3). The Chinook MOAs extend from 300 ft. to 5,000 ft. above the ocean surface.

2.1.2.2 Sea and Undersea Space

2.1.2.2.1 Explosive Ordnance Disposal Ranges

Two active EOD ranges are located in the Inland Waters at the following locations, as depicted by Figure 2.1-3:

- NAVBASE Kitsap Bangor – Hood Canal EOD Range
- Naval Air Station Whidbey Island – Crescent Harbor EOD Range

The sites are also used for swimmer training in Mine Countermeasures. Currently, charges at the site near Crescent Harbor are limited to two annual events of 2.5 pounds (lb.) (1.1 kilograms [kg]) Net Explosive Weight (NEW) charge size and at Hood Canal are limited to two events of 1.5 lb. (0.7 kg) NEW charge size in accordance with the NWTRC EIS MMPA 2010 Letter of Authorization.

2.1.2.2.2 Surface and Subsurface Testing Sites

There are three geographically distinct range sites in the Inland Waters where the Navy conducts surface and subsurface testing and some limited training. The Keyport Range Site is located in Kitsap County and includes portions of Liberty Bay and Port Orchard Reach (also known as Port Orchard Narrows). The Dabob Bay Range Complex (DBRC) Site is located in Hood Canal, in Jefferson, Kitsap, and Mason counties. The Carr Inlet OPAREA is located in southern Puget Sound.

The Keyport Range Site is located adjacent to Naval Undersea Warfare Center Keyport, providing approximately 3.2 nm^2 for underwater testing, including in-shore shallow water sites and a shallow lagoon to support integrated undersea warfare systems and vehicle maintenance and engineering activities. Water depth at the Keyport Range Site is less than 100 ft. (30.5 m). Underwater tracking of

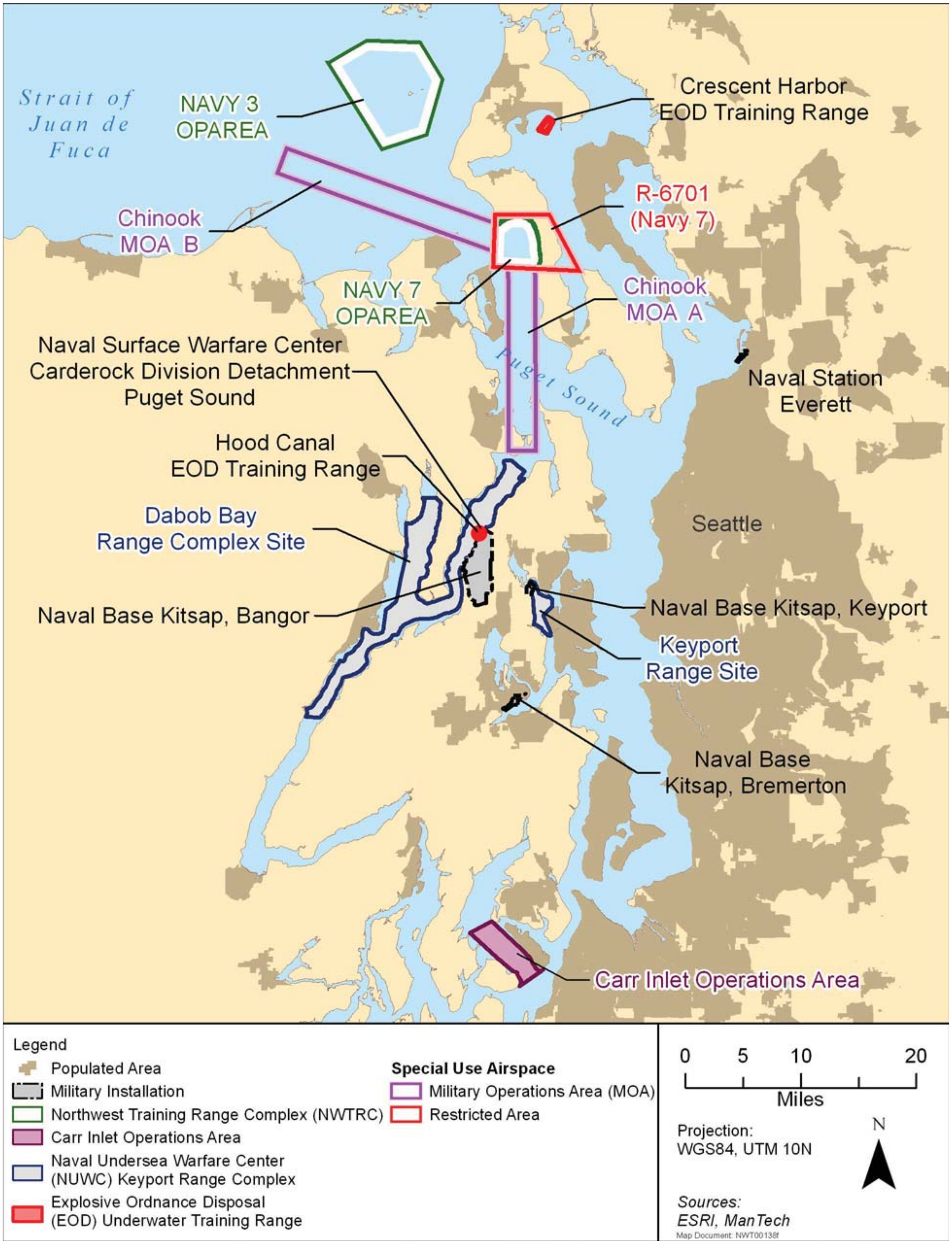

Figure 2.1-3: Inland Waters of the Northwest Training and Testing Study Area

test activities can be accomplished by using temporary or portable range equipment. The Navy has conducted underwater testing at the Keyport Range Site since 1914.

The DBRC Site includes Dabob Bay and Hood Canal from 1 mi. (1.6 km) south of the Hood Canal Bridge to the Hamma Hamma River, a total area of approximately 45.7 nm^2. The Navy has conducted underwater testing at the DBRC Site since 1956, beginning with a control center at Whitney Point. The control center was subsequently moved to Zelatched Point.

Dabob Bay is a deep-water area in Jefferson County approximately 14.5 nm^2 in size, which contains an acoustic tracking range. The acoustic tracking space within the range is approximately 7.3 nm by 1.3 nm (9 nm^2) with a maximum depth of 600 ft. (182.9 m). The Dabob Bay tracking range, the only component of the DBRC Site with extensive acoustic monitoring instrumentation installed on the seafloor, provides for object tracking, communications, passive sensing, and target simulation. Many activities conducted within Dabob Bay are supported by land-based facilities at Zelatched Point.

The Carr Inlet OPAREA is a quiet deep-water inland range approximately 12 nm^2 in size. It is located in an arm of water between Key Peninsula and Gig Harbor Peninsula. Its southern end is connected to the southern basin of Puget Sound. Northward, it separates McNeil Island and Fox Island as well as the peninsulas of Key and Gig Harbor. The acoustic tracking space within the range is approximately 6 nm by 2 nm with a maximum depth of 545 ft. (166 m). The Navy previously performed underwater acoustic testing at Carr Inlet from the 1950s through 2009, when activities were relocated to Naval Surface Warfare Center, Carderock Division (NSWCCD) at NAVBASE Kitsap Bangor. While no permanently installed structures are present in the Carr Inlet OPAREA, the waterway remains a Naval Restricted Area (33 C.F.R. § 334.1250).

2.1.2.2.3 Pierside Testing Facilities

In addition to the training and testing ranges, at which most of the training and testing assessed in this document occurs, the Navy conducts some testing at or near Navy piers. Most of this testing is sonar maintenance and testing while ships are in port for maintenance or system re-fitting. These piers within the Study Area are all within Puget Sound and include NAVBASE Kitsap Bremerton in Sinclair Inlet, NAVBASE Kitsap Bangor Waterfront in Hood Canal, and Naval Station Everett (see Figure 2.1-3).

2.1.2.2.4 Navy Surface Operations Areas

In addition to the areas mentioned above, there are two surface and subsurface operations areas used for Navy training and testing within the Inland Waters. Navy 3 OPAREA is a surface and subsurface area off the west coast of northern Whidbey Island. Navy 7 OPAREA is the surface and subsurface area that lies beneath R-6701. This area covers a total area of 56 nm^2.

2.1.3 DESCRIPTION OF THE WESTERN BEHM CANAL, ALASKA

The Western Behm Canal is located in Southeast Alaska, near the city of Ketchikan, Alaska. SEAFAC is located in the Western Behm Canal and covers an area of 48 nm^2. The U.S. Navy has been conducting testing activities at SEAFAC since 1992. The facility replaced the Santa Cruz Acoustic Range Facility in Southern California and is now the location for some acoustic testing previously conducted at the Naval Surface Warfare Center (NSWC) Carr Inlet Acoustic Range in Washington State.

Bottom-moored acoustic measurement arrays are located in the middle of the site. These instrumented arrays are established for measuring vessel signatures when a vessel is underway (underway site) and is at rest and moored (static site). The instruments are passive arrays of hydrophones sensing the acoustic signature of the vessels (i.e., the sounds emitted when sonar units are not in operation). Hydrophones on the arrays pick up noise in the water and transmit it to shore facilities, where the data are processed. SEAFAC's sensitive and well-positioned acoustic measurement equipment provides the ability to listen to and record the radiated signature of submarines, as well as other submerged manned and unmanned vehicles, selected National Oceanic and Atmospheric Administration surface vessels, and cruise ships.

The sensors at SEAFAC are passive and measure radiated noise in the water, such as machinery on submarines and other underwater vessels. SEAFAC does not use tactical mid-frequency active sonar (MFAS). Active acoustic sources are used for communications, range calibration, and to provide position information for units operating submerged on the range.

SEAFAC is comprised of land-based facilities and in-water assets. The land-based facilities located within 5.5 acres on Back Island are not a part of the Study Area and Navy activities occurring in this location will be or have been addressed under separate NEPA documentation. The in-water assets include two sites: the underway site and the static site. These assets and the operational area of SEAFAC are located in five restricted areas. The underway site arrays are in Area 1. The static site is in Area 2. All associated underwater cabling and other devices associated with the underway site are located in Area 3. Area 4 provides a corridor for utility power and a phone cable. Area 5 is an operational area to allow for safe passage of local vessel traffic. Notifications of invoking restriction of Area 5 occur at least 72 hours prior to SEAFAC operations in accordance with 33 C.F.R. § 334.1275. This notification is accomplished through notices to mariners and press releases to concerned organizations. During test periods, all vessels entering Area 5 are requested to contact SEAFAC to coordinate safe passage through the area. Area 5 defines the SEAFAC Study Area boundary, which is comprised only of the in-water area and excludes the land-based supporting facilities and operations. These areas are all depicted in Figure 2.1-4.

The SEAFAC at-sea areas are:

- Restricted Areas 1 through 5. The five restricted areas are located within Western Behm Canal. The main purposes of the restricted areas are to provide for vessel and public safety, lessen acoustic encroachment from non-participating vessels, and prohibit certain activities that could damage SEAFAC's sensitive in-water acoustic instruments and associated cables. Area 5 encompasses the entire SEAFAC operations area.
- Underway Measurement Site. The underway measurement site is in the center of Western Behm Canal and is 5,000 yards (yd.) (4,572 m) wide and 12,000 yd. (10,973 m) long. The acoustic arrays are located at the center of this area (Area 1).
- Static Site. The static site is approximately 2 nm northwest of Back Island. During testing, a vessel is tethered between two surface barges. In most scenarios, the vessel submerges to conduct acoustic measurements. The static site is located at the center of Area 2.
- Area 3 and Area 4. These restricted areas provide protection to underwater cables and bottom-mounted equipment they encompass.

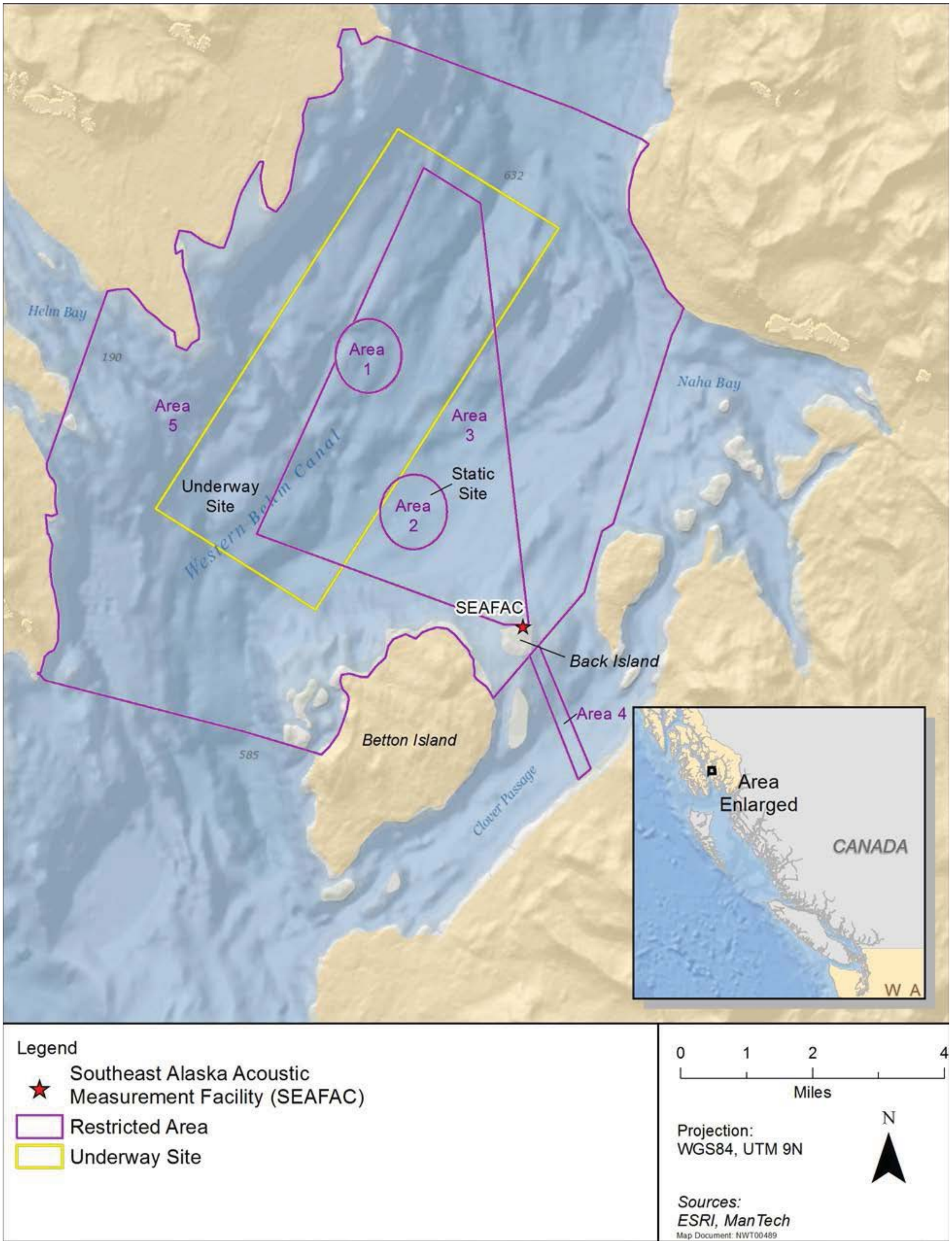

Figure 2.1-4: Western Behm Canal, Alaska and the Southeast Alaska Acoustic Measurement Facility

2.2 PRIMARY MISSION AREAS

The Navy categorizes training activities into functional warfare areas called primary mission areas. Training activities fall into the following six primary mission areas:

- Anti-Air Warfare
- Anti-Surface Warfare
- Anti-Submarine Warfare
- Electronic Warfare
- Mine Warfare
- Naval Special Warfare

Most training activities addressed in this EIS/OEIS are categorized under one of these primary mission areas; those activities that do not fall within one of these areas are in a separate category. Each warfare community (surface, subsurface, aviation, and special warfare) may train in some or all of these primary mission areas. The research and acquisition community also categorizes some, but not all, of its testing activities under these primary mission areas.

The sonar, ordnance, munitions, and targets used in the training and testing activities are described in Section 2.3 (Descriptions of Sonar, Ordnance/Munitions, Targets, and Other Systems Employed in Northwest Training and Testing Activities). A short description of individual training and testing activities, as well the sonar and ordnance used and military expended materials is provided in Tables 2.4-1 through 2.4-3 (Section 2.4, Proposed Activities). More detailed descriptions of the training and testing activities are provided in Appendix A (Navy Activities Descriptions).

2.2.1 ANTI-AIR WARFARE

The mission of anti-air warfare is to destroy or reduce enemy air and missile threats (including unmanned airborne threats) and serves two purposes: to protect U.S. forces from attacks from the air and to gain air superiority. Anti-air warfare also includes providing U.S. forces with adequate attack warnings, while denying hostile forces the ability to gather intelligence about U.S. forces.

Aircraft conduct anti-air warfare through radar search, detection, identification, and engagement of airborne threats—generally by firing anti-air missiles or cannon fire. Surface ships conduct anti-air warfare through an array of modern anti-aircraft weapon systems such as aircraft detecting radar, naval guns linked to radar-directed fire-control systems, surface-to-air missile systems, and radar-controlled cannons for close-in point defense. Impacts from anti-air warfare activities conducted over land were analyzed in previous documents and remain valid.

Testing of anti-air warfare systems is required to ensure the equipment is fully functional under the conditions in which it will be used. Tests may be conducted on radar and other early-warning detection and tracking systems, new guns or gun rounds, and missiles. Testing of these systems may be conducted on new ships and aircraft and on existing ships and aircraft following maintenance, repair, or modification. For some systems, tests are conducted periodically to assess operability. Additionally, tests may be conducted in support of scientific research to assess new and emerging technologies. Testing events are often integrated into training activities and in most cases the systems are used in the same manner in which they are used for fleet training activities.

2.2.2 ANTI-SURFACE WARFARE

The mission of anti-surface warfare is to defend against enemy ships or boats. In the conduct of anti-surface warfare, aircraft use cannons, air-launched cruise missiles or other precision-guided munitions; ships employ torpedoes, naval guns, and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles.

Anti-surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile or exercise torpedo launch events.

Testing of weapons used in anti-surface warfare is conducted to develop new technologies and to assess weapon performance and operability with new systems and platforms, such as unmanned systems. Tests include various air-to-surface guns and missiles, surface-to-surface guns and missiles, and bombing tests. Testing events may be integrated into training activities to test aircraft or aircraft systems in the delivery of ordnance on a surface target. In most cases the tested systems are used in the same manner in which they are used for fleet training activities.

Also, included in this mission area is a Sinking Exercise (SINKEX). Rarely conducted in the Pacific Northwest and last held in 2007, a SINKEX provides a valuable training opportunity for air, surface, and subsurface units to conduct a live fire exercise on a ship that has been environmentally cleaned in accordance with Environmental Protection Agency requirements. Future SINKEX events are not included in Alternatives 1 or 2 of this EIS/OEIS.

2.2.3 ANTI-SUBMARINE WARFARE

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine threats to surface forces. Anti-submarine warfare is based on the principle of a layered defense of surveillance and attack aircraft, ships, and submarines all searching for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack hostile submarine threats.

Anti-submarine warfare training addresses basic skills such as detection and classification of submarines, distinguishing between sounds made by enemy submarines and those of friendly submarines, ships, and marine life. More advanced, integrated anti-submarine warfare training exercises are conducted in coordinated, at-sea training events involving submarines, ships, and aircraft. This training integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using either exercise torpedoes or simulated weapons.

Testing of anti-submarine warfare systems is conducted to develop new technologies and assess weapon performance and operability with new systems and platforms, such as unmanned systems. Testing uses ships, submarines, and aircraft to demonstrate capabilities of torpedoes, missiles, countermeasure systems, and underwater surveillance and communications systems. Torpedo development, testing, and refinement are critical to successful anti-submarine warfare. At-sea sonar testing ensures systems are fully functional in an open-ocean environment prior to delivery to the fleet for operational use. Anti-submarine warfare systems on fixed wing aircraft and helicopters (including dipping sonar) are tested to evaluate the ability to search and track a submarine or similar target. Sonobuoys deployed from surface vessels and aircraft are tested to verify the integrity and performance of a group, or lot, of sonobuoys in advance of delivery to the fleet for operational use. The sensors and systems on board helicopters and maritime patrol aircraft are tested to ensure that tracking systems perform to specifications and meet operational requirements. Tests may be conducted as part of a large-scale fleet training event involving submarines, ships, fixed-wing aircraft, and helicopters. These integrated training events offer opportunities to conduct research and acquisition activities and to train aircrew in the use of new or newly enhanced systems during a large-scale, complex exercise.

2.2.4 ELECTRONIC WARFARE

The mission of electronic warfare is to degrade the enemy's ability to use their electronic systems, such as communication systems and radar, to confuse or deny them the ability to defend their forces and assets. Electronic warfare is also used to recognize an emerging threat and counter an enemy's attempt to degrade the electronic capabilities of the Navy.

Typical electronic warfare activities include threat avoidance training, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices to defeat tracking and communications systems. Impacts of overland air activities were analyzed in previous documents and remain valid.

Testing of electronic warfare systems is conducted to improve the capabilities of systems and ensure compatibility with new systems. Testing involves the use of aircraft, surface ships, and submarine crews to evaluate the effectiveness of electronic systems. Typical electronic warfare testing activities include the use of airborne and surface electronic jamming devices and chaff and flares to defeat tracking and communications systems. Chaff tests evaluate newly developed or enhanced chaff, chaff dispensing equipment, or modified aircraft systems' use against chaff deployment. Flare tests evaluate deployment performance and crew competency with newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems' use against flare deployment.

2.2.5 MINE WARFARE

The mission of mine warfare is to detect, and avoid or neutralize (disable) mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying to gain control of or deny the enemy access to sea space. Naval mines can be laid by ships (including purpose-built minelayers), submarines or aircraft.

Mine warfare training includes exercises in which ships, aircraft, submarines, underwater vehicles, or marine mammal detection systems search for mines. Personnel train to destroy or disable mines by attaching and detonating underwater explosives to the mine. Other neutralization techniques involve impacting the mine with a bullet-like projectile or intentionally triggering the mine to detonate.

Testing and development of mine warfare systems is conducted to improve sonar, laser, and magnetic detectors intended to hunt, locate, and record the positions of mines for avoidance or subsequent neutralization. Mine warfare testing and development falls into two primary categories: mine detection and classification, and mine countermeasure and neutralization. Mine detection and classification testing involves the use of air, surface, and subsurface vessels and uses sonar, including towed and side scan sonar, mine countermeasure systems, and unmanned vehicles to support mine detection and classification testing. These mine detection systems are generally helicopter-based and are sometimes used in conjunction with a mine neutralization system. Mine countermeasure and neutralization testing includes the use of air, surface, and subsurface units and uses tracking devices, countermeasure and neutralization systems, and general purpose bombs to evaluate the effectiveness of neutralizing mine threats. Most neutralization tests use mine shapes, or non-explosive practice mines, to evaluate a new or enhanced capability. During an airborne neutralization test, a previously located mine is destroyed or rendered nonfunctional using a helicopter based system that may involve the firing of a projectile or the deployment of a towed neutralization system. A small percentage of mine warfare tests require the use of high-explosive mines to evaluate and confirm the ability of the system to neutralize a high-explosive mine under operational conditions. The majority of mine warfare systems are currently deployed by ships and helicopters; however, future mine warfare missions will increasingly rely on unmanned vehicles. Tests may also be conducted in support of scientific research to support these new technologies.

2.2.6 NAVAL SPECIAL WARFARE

The mission of naval special warfare is to conduct unconventional warfare, direct action, combat terrorism, special reconnaissance, information warfare, security assistance, counter-drug operations, and recovery of personnel from hostile situations. Naval special warfare operations are highly specialized and require continual and intense training.

Testing is conducted on both conventional and unconventional weapons used by naval special warfare units, including testing of submersible vehicles capable of inserting and extracting personnel or payloads into denied areas from strategic distances, active acoustic devices, underwater communications systems, and underwater demolition technologies. Doppler sonar and side scan sonar are tested for their ability to be used during extraction and insertion missions.

Naval special warfare units are required to utilize a combination of specialized training, equipment, and tactics, including insertion and extraction operations using decelerator/parachutes, submerged vehicles, rubber and rigid hull boats, and helicopters; boat-to-shore and boat-to-boat gunnery; underwater demolition training; reconnaissance; and small arms training. However, no land-based activities, to include those of the naval special warfare community, are analyzed in this EIS/OEIS.

2.2.6.2 Other Training Activities

Other training is conducted in the Study Area that falls outside of the primary mission areas, but supports overall readiness.

Anti-terrorism/Force-protection training will occur as small boat attacks against moored ships at one of the Navy's piers inside Puget Sound.

Aircraft crews and operators of unmanned aircraft systems gather information using various sensors and electronic systems for the purpose of Intelligence, Surveillance, and Reconnaissance.

Also, operator training is necessary for the maintenance of ship and submarine sonar at piers and at-sea.

2.3 DESCRIPTIONS OF SONAR, ORDNANCE/MUNITIONS, TARGETS, AND OTHER SYSTEMS EMPLOYED IN NORTHWEST TRAINING AND TESTING ACTIVITIES

The Navy uses a variety of sensors, platforms, weapons, and other devices, including those used to ensure the safety of Sailors and Marines, to meet its mission. Training and testing with these systems may introduce acoustic (sound) energy and expended materials into the environment. The potential environmental impacts of these activities will be analyzed in Chapter 3 of this EIS/OEIS. This section presents and organizes sonar systems, ordnance, munitions, targets, and other systems in a manner intended to facilitate understanding of both the activities and the analysis of the environmental effects of their use that is later described in Chapter 3 of this EIS/OEIS.

2.3.1 SONAR AND OTHER ACOUSTIC SOURCES

What is Sonar?

Sonar, originally an acronym for "SOund Navigation And Ranging," is a technique that uses underwater sound to navigate, communicate, or detect underwater objects (the term sonar is also used for the equipment used to generate and receive sound). There are two basic types of sonar: active and passive.

Active sonar emits sound waves that travel through the water, reflect off objects, and return to the receiver. Active sonar is used to determine the distance to an underwater object by calculating the speed of sound in water and the time for the sound wave to travel to the object and back. For example, active sonar systems are used to track targets or to aid in navigation of the vessel by identifying known ocean floor features. Some whales, dolphins, and bats use echolocation, a similar technique, to identify their surroundings and to locate prey.

Passive sonar systems use underwater microphones (hydrophones) to receive underwater sounds. The advantage of passive sonar is that it places no sound in the water, and thus does not reveal the location of the listening vessel. Passive sonar can indicate the presence, character, and direction of ships and submarines; however, passive sonar, as a tool for detecting submarines, is increasingly ineffective as modern submarines become quieter. Passive sonar has no potential acoustic impact on the environment and, therefore, is not discussed further or analyzed within this EIS/OEIS.

All sounds, including sonar, are categorized by frequency. For this EIS/OEIS, active sonar is categorized into four frequency ranges: low-frequency, mid-frequency, high-frequency, and very high-frequency.

- Low-frequency active sonar emits sounds at frequencies less than 1 kilohertz (kHz). Low-frequency active sonar is useful for detecting objects at great distances because low-frequency sounds do not dissipate as rapidly as higher frequency sounds.[2]
- Mid-frequency active sonar emits sound at frequencies from 1 to 10 kHz. Mid-frequency active sonar is the Navy's primary tool for detecting and identifying submarines. Active sonar in this frequency range provides a valuable combination of range and target accuracy.
- High-frequency active sonar emits sound at frequencies greater than 10 kHz, up to 100 kHz. High-frequency sounds dissipate rapidly and have a small effective range; however, high-frequency sounds provide higher resolution of objects and it is useful at detecting and identifying smaller objects such as sea mines.
- Very high-frequency sources are those that operate above 100 kHz but below 200 kHz. These sources dissipate rapidly and have a small effective range, and may be used for such purposes as bottom mapping.

Modern sonar technology includes a variety of sonar sensor and processing systems. In concept, the simplest active sonar emits sound waves, or "pings," sent out in multiple directions and the sound waves then reflect off of the target object in multiple directions (Figure 2.3-1). The sonar source calculates the time it takes for the reflected sound waves to return; this calculation determines the distance to the target object. More sophisticated active sonar systems emit a ping and then rapidly scan

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[2] Surveillance Towed Array Sensor System (SURTASS) Low-Frequency Active (LFA). LFA sonar, which may be used in the Study Area, is not among the sources analyzed in this document. The potential environmental impacts from use of SURTASS LFA are analyzed in separate analyses under the National Environmental Policy Act.

or listen to the sound waves in a specific area. This provides both distance to the target and directional information. Even more advanced sonar systems use multiple receivers to listen to echoes from several directions simultaneously and provide efficient detection of both direction and distance. It should be noted that active sonar is rarely used continuously throughout the listed activities. In addition, when sonar is in use, the sonar ”pings” occur at intervals, referred to as a duty cycle, and the signals themselves are very short in duration. For example, sonar that emits a 1-second ping every 10 seconds has a 10 percent duty cycle.

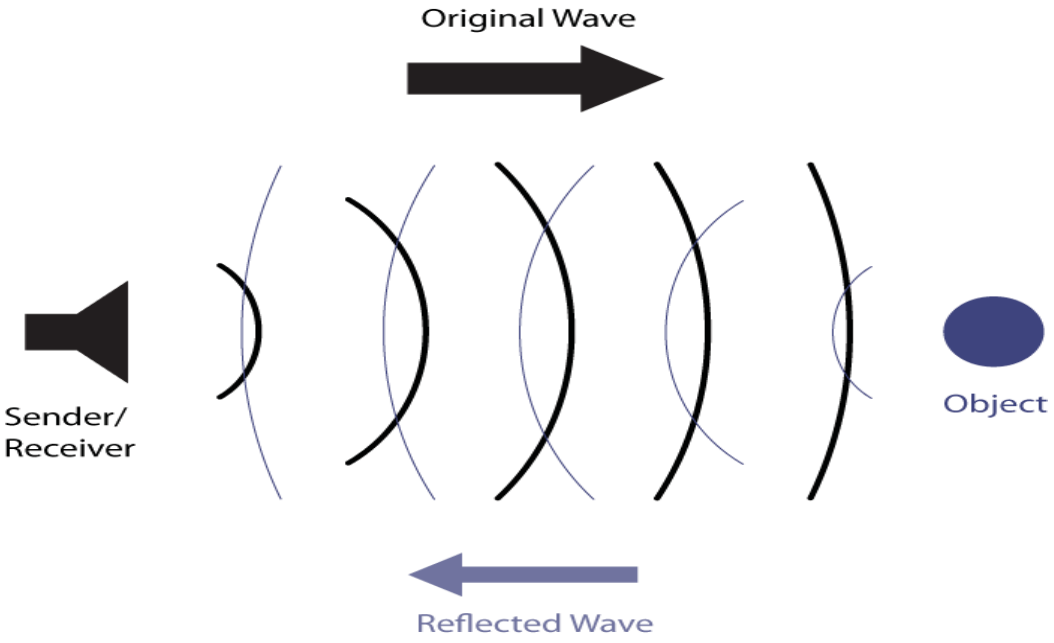

Figure 2.3-1: Principle of Active Sonar

Source: ManTech SRS, 2008

The Navy utilizes sonar systems and other acoustic sensors in support of a variety of mission requirements. Primary uses include the detection of and defense against submarines (anti-submarine warfare) and mines (mine warfare), safe navigation and effective communications, and oceanographic surveys.

Anti-Submarine Warfare. Systems used in anti-submarine warfare include hull-mounted sonar, torpedoes, and acoustic countermeasure devices. These systems are employed from a variety of platforms (surface ships, submarines, helicopters, and fixed-wing aircraft). Surface ships conducting anti-submarine warfare are typically equipped with hull-mounted sonar (passive and active) for the detection of submarines. Helicopters use dipping sonar or sonobuoys (passive and active) to locate submarines (or submarine targets during training and testing exercises). Fixed-wing aircraft deploy both active and passive expendable sonobuoys to assist in detecting and tracking submarines. Submarines are equipped with hull-mounted sonar to detect, localize, and track other submarines and surface ships. Submarines primarily use passive sonar. There are also unmanned vehicles currently under development that will be used to deploy anti-submarine warfare systems.

Anti-submarine warfare activities often use mid-frequency (i.e., 1–10 kHz) active sonar, though low-frequency and high-frequency active sonar systems are also used for specialized purposes. The Navy is currently developing and testing sonar systems that may utilize lower frequencies and longer duty cycles—albeit at lower source levels. However, these new systems would become operational only if they significantly increase the Navy's ability to detect and identify quiet submarine threats.

The types of sonar systems and acoustic sensors used during anti-submarine warfare sonar training and testing exercises include the following:

- **Surface Ship Sonar Systems.** A variety of surface ships operate hull-mounted MFAS during training exercises and testing activities (Figure 2.3-2). Typically, only cruisers, destroyers, and frigates have surface ship sonar systems.

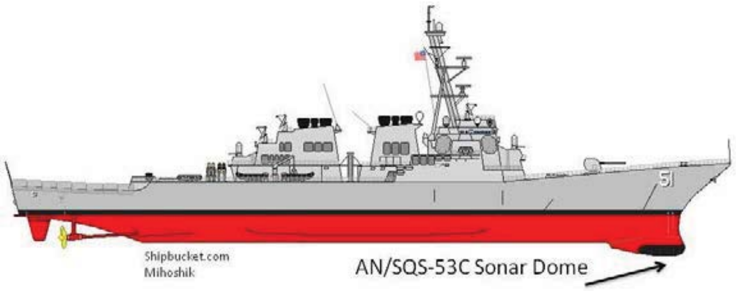

Figure 2.3-2: Guided Missile Destroyer with AN/SQS-53 Sonar

- **Submarine Sonar Systems.** Submarines are equipped with hull-mounted mid-frequency and high-frequency active sonar used to detect and target enemy submarines and surface ships (Figure 2.3-3). A submarine's mission relies on its stealth; therefore, a submarine uses its active sonar sparingly because each sound emission gives away the submarine's location.

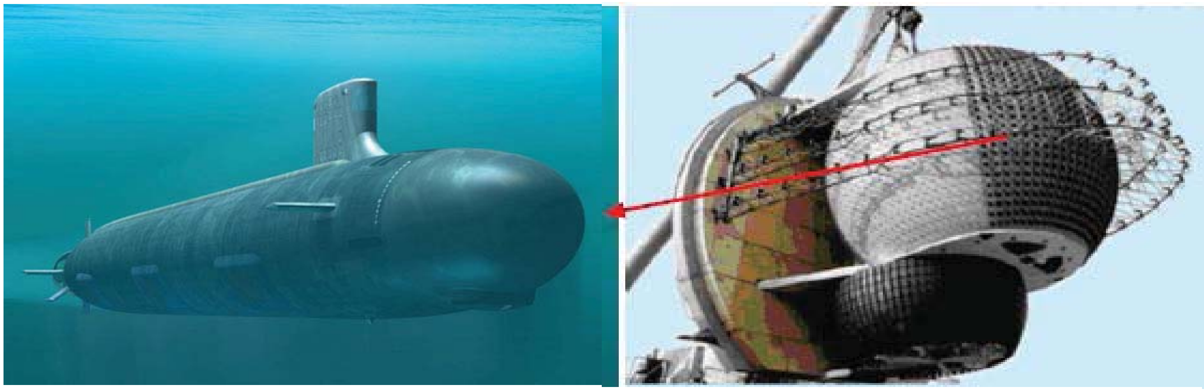

Figure 2.3-3: Submarine AN/BQQ-10 Active Sonar Array

- **Aircraft Sonar Systems.** Aircraft sonar systems include**:**
  - **Sonobuoys.** Sonobuoys are expendable devices that contain a radio transmitter and a hydrophone. The sounds collected by the sonobuoy are transmitted back to the aircraft for analysis. Sonobuoys use either active or passive sonar and allow for short and long-range detection of surface ships and submarines. These systems are deployed by both helicopter and fixed-wing patrol aircraft (Figure 2.3-4).

DICASS Sonobuoy

Loading sonobuoys on to aircraft

Figure 2.3-4: Sonobuoys

- **Dipping Sonar.** Dipping sonar systems include recoverable devices lowered into the water via cable from manned and unmanned helicopters. The sonar detects underwater targets and determines the distance and movement of the target relative to the position of the helicopter (Figure 2.3-5).

Figure 2.3-5: Dipping Sonar

- **Exercise Torpedoes.** Torpedoes are equipped with sonar that helps the torpedoes find their targets. To understand how and when this torpedo sonar is used, the following description is provided. Surface ships, aircraft, and submarines primarily use torpedoes in anti-submarine warfare (Figure 2.3-6). Recoverable, non-explosive torpedoes, categorized as either lightweight or heavyweight, are used during training and testing. Heavyweight torpedoes use a guidance system to operate the torpedo autonomously or remotely through an attached wire (guidance wire). The autonomous guidance systems operate either passively (listening for sounds generated by the target) or actively (pinging to search for the target). Torpedo training in the Study Area is mostly simulated—solid masses that approximate the weight and shape of a torpedo are fired, rather than fully functional torpedoes. Testing in the Study Area mostly uses fully functional, non-explosive exercise torpedoes.

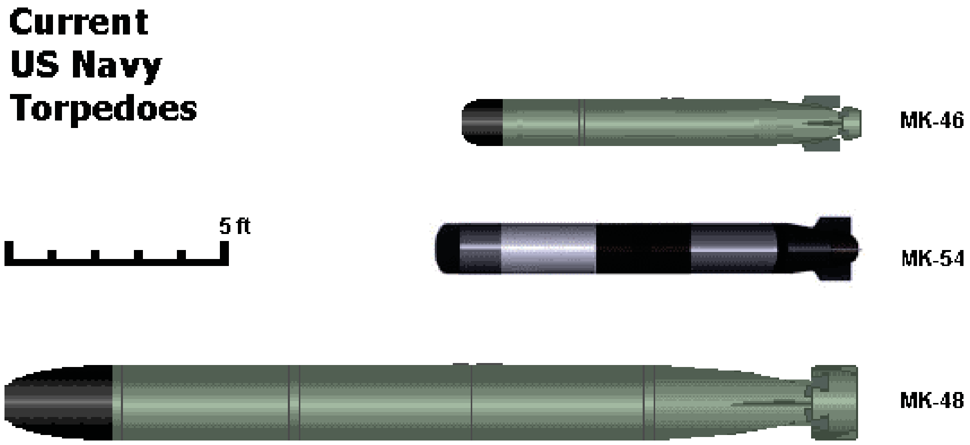

Figure 2.3-6: Navy Torpedoes

- **Acoustic Countermeasures.** Countermeasure devices are towed or free-floating and use acoustics either to avoid threats such as incoming torpedoes by masking vessel signatures or creating false targets, or to provide early detection of and timely response to threats. Countermeasures are either expendable or recoverable (Figure 2.3-7).

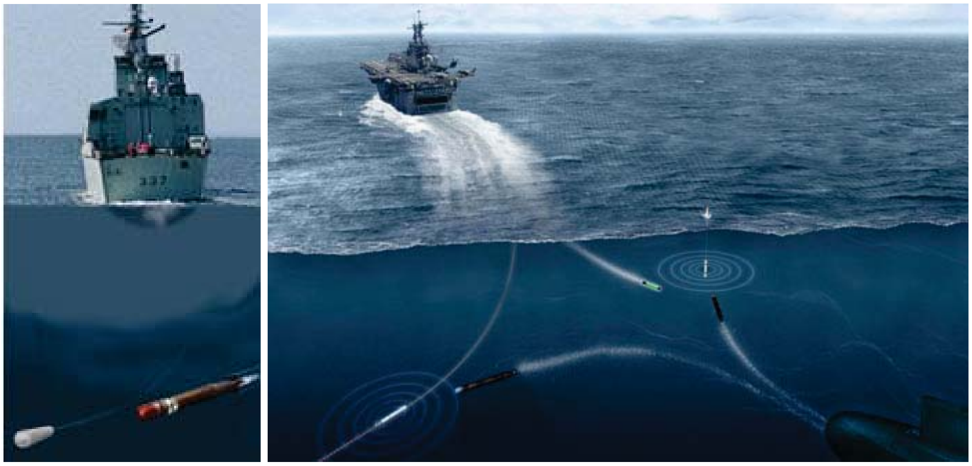

Figure 2.3-7: Acoustic Countermeasures

- **Anti-Submarine Warfare Training Targets.** Anti-submarine warfare training targets (Figure 2.3-8) are autonomous undersea vehicles that are used to simulate target submarines. The training targets are equipped with one or more of the following devices: (1) acoustic projectors emitting sounds to simulate submarine machinery or engine noise, (2) echo repeaters to simulate the characteristics of the echo of a sonar signal reflected from a submarine, and (3) magnetic sources that mimic those of a submarine.

Figure 2.3-8: Anti-Submarine Warfare Training Targets

Mine Warfare. Mine warfare training and testing activities use a variety of different sonar systems that are typically high-frequency and very high-frequency. These sonar systems (Figure 2.3-9) are used to detect, locate, and characterize moored and bottom mines. The majority of mine warfare sonar systems can be deployed by more than one platform (e.g., helicopter, unmanned underwater vehicle (UUV), submarine, or surface ship) and may be interchangeable among platforms. Surface ships and submarines use sonar to detect mines and objects and minesweeping ships use a specialized variable-depth mine detection and classification high-frequency active sonar system to detect mines.

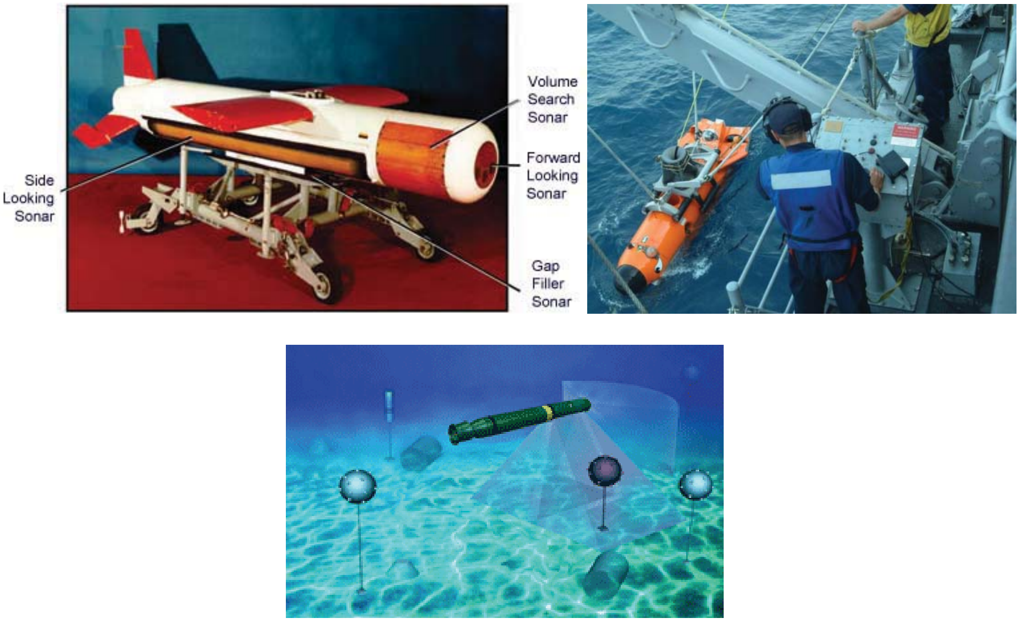

Figure 2.3-9: Mine Warfare Systems

Safety, Navigation, Communications, and Oceanographic Systems. Naval ships, submarines, and unmanned vehicles rely on equipment and instrumentation that uses active sonar during both routine operations and training and testing events. Sonar systems are used to gauge water depth; detect and map objects, navigational hazards, and the ocean floor; and transmit communication signals.

Other Acoustic Sensors. The Navy uses a variety of other acoustic sensors to protect ships anchored or at the pier, as well as shore facilities. These systems detect potentially hostile swimmers, broadcast warnings to alert Navy divers of potential hazards, and gather information regarding ocean characteristics (ocean currents, wave measurements). Both active and passive systems are used and they are generally stationary systems in Navy harbors and piers. Navy marine mammals (Atlantic bottlenose dolphins [*Tursiops truncatus*] and California sea lions [*Zalophus californianus*]) are also used to detect hostile swimmers around Navy facilities. A trained animal is deployed under behavioral control of a handler to find an intruding swimmer. Upon finding the 'target' of the search, the animal returns to the boat and alerts the animal handlers and the animals are given a localization marker or leg cuff that they attach to the intruder. Swimmers that have been marked with a leg cuff are reeled-in by security support boat personnel via a line attached to the cuff.

2.3.2 ORDNANCE/MUNITIONS

Most ordnance and munitions used during training events fall into three basic categories: projectiles, missiles, and bombs. Ordnance can be further defined by their NEW, which is the actual weight in pounds of the explosive substance without the packaging, casings, bullets, etc. Net explosive weight also includes the trinitrotoluene (TNT) equivalent of energetic material, which is the standard measure of strength of bombs and other explosives. For example, a 2,000 lb. (907.2 kg) bomb may have anywhere from 600 to 1,000 lb. (272.2 to 453.6 kg) of NEW.

Projectiles. Projectiles are fired during gunnery exercises from a variety of weapons, including pistols and rifles to large-caliber turret mounted guns on the decks of Navy ships. Projectiles can be either high-explosive munitions (e.g., certain cannon shells) or non-explosive practice munitions (e.g., rifle/pistol bullets). Explosive rounds can be fused to either explode on impact or in the air (i.e., just prior to impact). For purposes of analysis, the EIS/OEIS breaks down projectiles into the three following categories:

- **Small-Caliber Projectiles.** Includes projectiles up to 0.50 caliber (approximately 0.5-inch [in.] [1.3-centimeter {cm}] diameter). Small-caliber projectiles (e.g., bullets), are primarily fired from pistols, rifles, and machine guns (Figure 2.3-10). Most small-caliber projectiles are fired during training events for an individual Sailor to become or remain proficient.

Figure 2.3-10: Shipboard Small Arms Training

- **Medium-Caliber Projectiles.** These projectiles are larger than .50 caliber, but smaller than 57 millimeters (mm) (approximately 2.25 in. [5.7 cm] diameter). The most common size medium-caliber projectiles are 20 mm, 25 mm (Figure 2.3-11), and 40 mm. Medium-caliber projectiles are fired from machine guns operated by one to two crewmen and mounted on the deck of a ship, wing-mounted guns on aircraft, and fully automated guns mounted on ships for defense against missile attack. Medium-caliber projectiles also include 40 mm grenades, which can be fired from hand-held grenade launchers or crew-served deck-mounted guns. Medium-caliber projectiles can be non-explosive practice munitions or high-explosive projectiles. High-explosive projectiles are usually fused to detonate on impact; however, advanced high-explosive projectiles can detonate based on time, distance, or proximity to a target.

Figure 2.3-11: Shipboard Medium-Caliber Projectiles

- **Large-Caliber Projectiles.** These includes projectiles 57 mm and larger. The largest projectile currently in service has a 5 in. (12.7 cm) diameter (Figure 2.3-12), but larger weapons are under development. The most widely used large-caliber projectiles are 57 mm, 76 mm, and 5 in. (12.7 cm). The most common 5 in. (12.7 cm) projectile is approximately 26 in. (66 cm) long and weighs 70 lb. (31.7 kg). Large-caliber projectiles are fired exclusively from turret mounted guns located on ship decks and can be used to fire on surface ships and boats, in defense against missiles and aircraft, and against land-based targets. Large-caliber projectiles can be non-explosive practice munitions or high-explosive munitions. High-explosive projectiles can detonate on impact or in the air.

Figure 2.3-12: Large-Caliber Projectile Use (5-Inch)

Missiles. Missiles are rocket or jet-propelled munitions used to attack ships, aircraft, and land-based targets, as well as defend ships against other missiles. Guidance systems and advanced fusing technology ensure that missiles reliably impact on or detonate near their intended target. Missiles are categorized according to their intended target, as described below, and can be further classified according to NEW. Rockets are included within the category of missiles.

- **Anti-Air Missiles.** Anti-air missiles are fired from aircraft and ships against enemy aircraft and incoming missiles (Figure 2.3-13). Anti-air missiles are configured to explode near, or on impact with, their intended target. Missiles are the primary ship-based defense against incoming missiles.

Figure 2.3-13: Rolling Airframe Missile (left), Air-to-Air Missile (right)

- **Anti-Surface Missiles.** Anti-surface missiles are fired from aircraft, ships, and submarines against surface ships (Figure 2.3-14). Anti-surface missiles are typically configured to detonate on impact.

Figure 2.3-14: Anti-Surface Missile Fired from MH-60 Helicopter

- **Strike Missiles.** Strike missiles are fired from aircraft, ships, and submarines against land-based targets. Strike missiles are typically configured to detonate on impact, or near their intended target. The AGM-88 High-speed Anti-Radiation Missile, which is used to destroy enemy radar sites, is an example of a strike missile that is used during at-sea training, and is fired at a seaborne target that replicates a land-based radar site.

Bombs. Bombs are unpowered munitions dropped from aircraft on land and water targets. The majority of bombs used during training and testing in the Study Area are non-explosive. However, explosive munitions are occasionally used for proficiency inspections and testing requirements. Bombs are in two categories: general-purpose bombs and subscale practice bombs. Similar to missiles, bombs are further classified according to the NEW of the bomb.

- **General Purpose Bombs.** General-purpose bombs (Figure 2.3-15) consist of precision-guided and unguided full-scale bombs, ranging in size from 250 to 2,000 lb. (113 to 907 kg). Common bomb nomenclature used includes MK-80 series, which is the Navy's standard model; Guided Bomb Units and Joint Direct Attack Munitions, which are precision-guided (including laser-guided) bombs; and the Joint Standoff weapon, which is a long-range "glider" precision weapon. General purpose bombs can be either non-explosive practice munitions or high-explosive.

Figure 2.3-15: Loading General Purpose Bombs

- **Subscale Bombs.** Subscale bombs (Figure 2.3-16) are non-explosive practice munitions containing a spotting (smoke) charge to aid in scoring the accuracy of hitting the target during training and testing activities. Subscale bombs are 25 lb. (11.3 kg) and less and are steel constructed.

Figure 2.3-16: Subscale Bombs for Training

Other Munitions. There are other munitions and ordnance used in naval at-sea training and testing events that do not fit into one of the above categories, and are discussed below:

- **Demolition Charges.** Divers place explosive charges in the marine environment during some training activities. These activities may include the use of timed charges, in which the charge is placed, a timer is started, and the charge detonates at the set time. Munitions of up to 2.5 lb. (1.13 kg) blocks of C-4 plastic explosive with the necessary detonators and cords are used to support mine neutralization, demolition, and other warfare activities. All demolition charges are further classified according to the NEW of the charge.

- **Torpedoes.** Explosive torpedoes are used in designated locations in the Offshore Area of the Study Area. See Table 2.8-1 and Table 2.8-2 for activity locations. Non-explosive torpedoes are also used in testing activities (Table 2.8-2). For non-explosive torpedo tests, the warhead section has been replaced with recording and tracking instrumentation to determine the test success or failure. Test torpedoes are recovered for completion of test evaluation.

2.3.3 TARGETS

Training and testing require an assortment of realistic and challenging targets. Targets vary from items as simple and ordinary as an empty steel drum, used for small-caliber weapons training from the deck of a ship, to sophisticated, unmanned aerial drones used in air defense training. For this EIS/OEIS, targets are organized by warfare area.

- **Anti-Air Warfare Targets.** Anti-air warfare targets, tow target systems, and aerial targets are used in training and testing events that involve detection, tracking, defending against, and attacking enemy missiles and aircraft. Aerial towed target systems include textile (nylon banner) and rigid (fiberglass shapes) towed targets used for gunnery events. Parachute flares are used as air-to-air missile targets. Manned high-performance aircraft may be used as targets—to test ship and aircraft defensive systems and procedures—without the actual firing of munitions.

Figure 2.3-17: Anti-Air Warfare Targets

- **Anti-Surface Warfare Targets.** Stationary and towed targets are used as anti-surface warfare targets during gunnery events. Targets include floating steel drums, inflatable shapes or surface target balloons (e.g., Killer Tomato™, Figure 2.3-18), and towed sleds. Most targets are recovered after use; the exceptions being floating steel drums, which sink, and some parts of other targets that are hit by gunnery rounds and detach from the main body of the target.

Figure 2.3-18: Deploying a "Killer Tomato™" Floating Target

- **Anti-Submarine Warfare Targets.** Anti-submarine warfare uses multiple types of targets including the following:
  - **Submarines.** Submarines may act as tracking and detection targets during training and testing events.
  - **Motorized Autonomous Targets.** Motorized autonomous targets simulate the acoustic and magnetic characteristics of a submarine, providing realism for exercises when a submarine is not available. These mobile targets resemble torpedoes, with some models designed for recovery and reuse, while other models are expendable.
  - **Stationary Artificial Targets.** Stationary targets either resemble submarine hulls or are simulated systems with acoustic properties of enemy submarines. These targets either rest on the sea floor or are suspended at varying depths in the water column.

2.3.4 DEFENSIVE COUNTERMEASURES

Naval forces depend on effective defensive countermeasures to protect against missile and torpedo attack. Defensive countermeasures are devices designed to confuse, distract, and confound precision-guided munitions. Defensive countermeasures are in three basic categories:

- **Chaff.** Chaff consists of reflective, aluminum-coated glass fibers used to obscure ships and aircraft from radar guided systems. The chaff fibers are approximately the thickness of a human hair (generally 25.4 microns in diameter) and range in length from 0.3 to 2 in. (0.8 to 5.1 cm). Chaff fibers, which are stored in canisters, are either dispensed from aircraft or fired into the air from the decks of surface ships when an attack is imminent. The glass fibers create a radar cloud which acts to mask the position of the ship or aircraft.

- **Flares.** Flares are pyrotechnic devices used to defend against heat-seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft's engines. Similar to chaff, flares are also dispensed from aircraft and fired from ships.
- **Acoustic Countermeasures.** Acoustic countermeasures are used by surface ships and submarines to defend against torpedo attack. Acoustic countermeasures are either released from ships and submarines, or towed at a distance behind the ship, and may generate acoustic signals either mechanically or electronically.

2.3.5 MINE WARFARE SYSTEMS

Mine warfare systems are in two broad categories: mine detection and mine neutralization.

Mine Detection Systems. Mine detection systems are used to locate, classify, and map suspected mines. Once located, the mines can either be neutralized or avoided. These systems are specialized to either locate mines on the surface, in the water column, or on the sea floor.

- **Towed or Hull-Mounted Mine Detection Systems.** These detection systems use acoustic and laser or video sensors to locate and classify suspect mines (Figure 2.3-19). Helicopters, ships, and unmanned vehicles are used for towed systems, which can rapidly assess large areas.

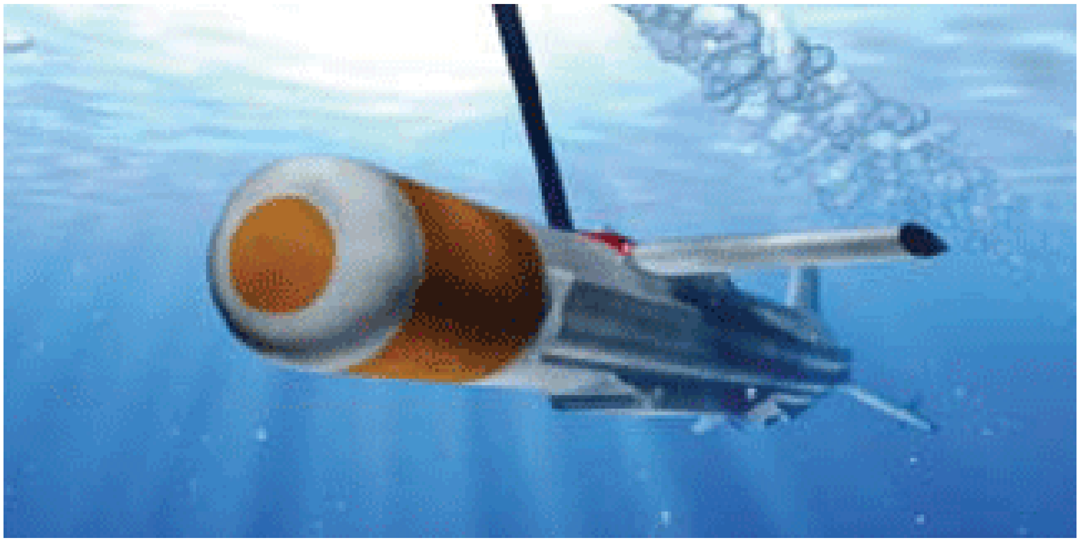

Figure 2.3-19: Towed Mine Detection System

- **Airborne Laser Mine Detection Systems.** Airborne laser detection systems work in concert with neutralization systems (Figure 2.3-20). The detection system initially locates mines and a neutralization system is then used to relocate and neutralize the mine.

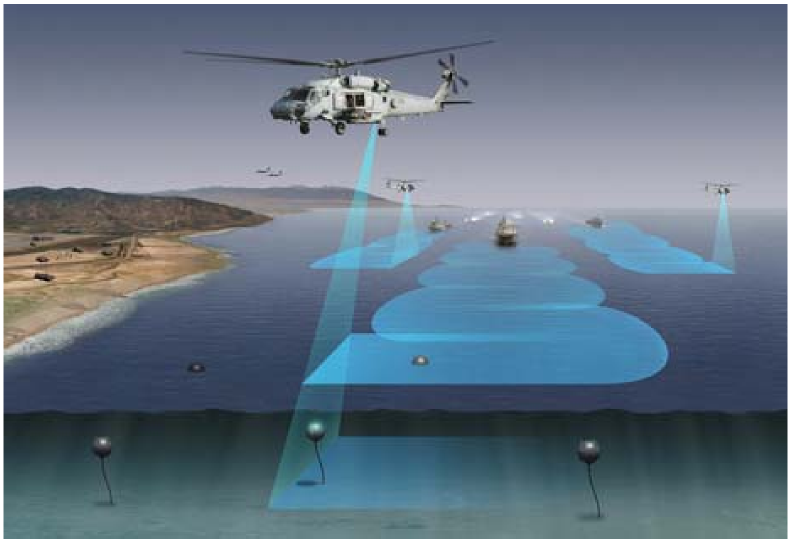

Figure 2.3-20: Airborne Laser Mine Detection System in Operation

- **Unmanned/Remotely Operated Vehicles.** These in-water vehicles use acoustic and video or lasers to locate and classify mines. Unmanned/remotely operated vehicles provide unique mine warfare capabilities in nearshore littoral areas, surf zones, ports, and channels.
- **Marine Mammal System.** Navy personnel and Navy marine mammals work together to detect specified underwater objects. The Navy deploys trained bottlenose dolphins and California sea lions as part of the marine mammal mine-hunting and object-recovery system.

Mine Neutralization Systems. These systems disrupt, disable, or detonate mines to clear ports and shipping lanes, as well as littoral, surf, and beach areas in support of naval amphibious operations. Mine neutralization systems can clear individual mines or a large number of mines quickly.

- **Towed Influence Mine Sweep Systems.** These systems use towed equipment that mimic a particular ship's magnetic and acoustic signature triggering the mine and causing it to explode (Figure 2.3-21).

Figure 2.3-21: Organic and Surface Influence Sweep

- **Towed Mechanical Mine Sweeping Systems.** These systems tow a sweep wire to snag the line that attaches a moored mine to its anchor and then uses a series of cables and cutters to sever those lines. Once these lines are cut, the mines float to the surface where Sailors can neutralize the mines.
- **Unmanned/Remotely Operated Mine Neutralization Systems.** Surface ships and helicopters operate these systems, which place explosive charges near or directly against mines to destroy the mine (Figure 2.3-22).

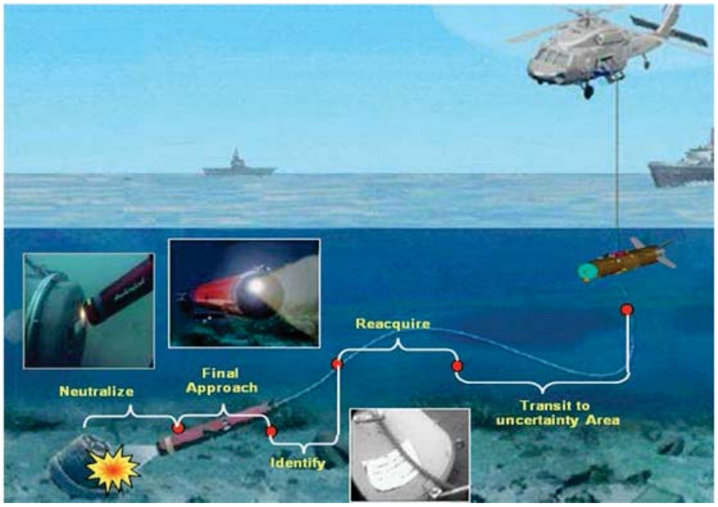

Figure 2.3-22: Airborne Mine Neutralization System

- **Projectiles.** Small- and medium-caliber projectiles, fired from surface ships or hovering helicopters, are used to neutralize floating and near-surface mines.
- **Diver Emplaced Explosive Charges.** Operating from small craft, divers emplace explosive charges near or on mines to destroy the mine or disrupt its ability to function. One of the explosive charges used is a Shock Wave Action Generator (SWAG). The SWAG is composed of a cylindrical steel tube, 3 in. long and 1 in. wide, containing approximately 0.033 lb. of explosives. The single explosive charge is highly focused. Divers place a single SWAG on the mine that is located mid-water column, within water depths of 10–20 ft.

2.3.6 MILITARY EXPENDED MATERIALS

Navy training and testing events may introduce or expend various items, such as non-explosive munitions and targets, into the marine environment as a direct result of using these items for their intended purpose. However, during many testing events, recovery of test materials is a priority in order to evaluate the effectiveness and components of the system. In addition to the items described below, some accessory materials—related to the carriage or release of these items—may be released. These materials, referred to as military expended materials, are not recovered, and potentially result in environmental impacts that are analyzed in detail in Chapter 3 of this EIS/OEIS.

Military expended materials analyzed in this document include, but are not limited to, the following:

- **Sonobuoys.** Decelerator/parachutes, which separate from the sonobuoy after water entry, and the sonobuoys themselves are expended during sonobuoy use.

  - Training: During training activities, Marine Patrol Aircraft drop sonobuoys during Anti-submarine warfare exercises. Various types and numbers of buoys are launched during a training event. The sonobuoys (and decelerator/parachutes) are not recovered and are designed to sink to the bottom of the sea following use.
  - Testing: During testing activities, sonobuoys could be dropped from aircraft or launched from a craft or pier. If dropped in the open ocean, sonobuoys and decelerator/parachutes would not be expected to be recovered; however, testing activities in inshore waters may result in the sonobuoy being recovered for further analysis.
- **Torpedo Launch Accessories.**
  - Training: Training with live torpedoes would occur in the Study Area only during a SINKEX. Explosive-filled torpedoes would expend torpedo fragments, as well as materials such as decelerator/parachutes used with air-dropped torpedoes, guidance wire used with submarine-launched torpedoes, and ballast weights. The baseline training activities in the No Action Alternative include training events that historically occur in the Study Area and have been subject to previous analysis pursuant to NEPA and Executive Order (EO) 12114. SINKEX remains in the No Action Alternative; however, SINKEX is no longer proposed in the Study Area in Alternatives 1 and 2.
  - Testing: Torpedoes used in the Study Area for testing purposes can be either explosive or non-explosive. Explosive torpedoes are used only in the Offshore Area of the Study Area. The non-explosive torpedoes are recovered to be reused and evaluated for performance. However, materials such as decelerator/parachutes used with air-dropped torpedoes, guidance wire used with some submarine-launched torpedoes, and ballast weights may be expended. In addition to the materials described for non-explosive torpedoes, explosive torpedoes would expend torpedo fragments.
- **Projectiles and Bombs.**
  - Training: Projectiles, bombs, or fragments from explosive projectiles and bombs are expended during training exercises. These items are primarily constructed of lead (most small-caliber projectiles) or steel (medium- and large-caliber projectiles and all bombs).
  - Testing: No testing of projectiles or bombs occurs in the Study Area.
- **Missiles.**
  - Training: The Navy primarily uses non-explosive missiles for training in designated areas in the Study Area. Explosive missiles are rarely used in training. Explosive filled missiles would expend missile fragments; propellant and any explosive material involved is consumed during firing and detonation. Explosive missiles are used for training within the Study Area under the No Action Alternative and are proposed for use during training under Alternative 1 and Alternative 2.
  - Testing: The Navy primarily uses non-explosive missiles for testing in designated areas in the Study Area. Explosive missiles are rarely used in testing. Explosive missiles would expend missile fragments, propellant, and any explosive material not consumed during firing and detonation.
- **Countermeasures.**
  - Training: Countermeasures (acoustic, chaff, flares) are expended as a result of training exercises, with the exception of towed acoustic countermeasures.
  - Testing: Acoustic countermeasure materials used during testing events may be recovered for test evaluation.

- **Targets.**
    - Training: Some targets are designed to be expended; other targets, such as aerial drones and remote-controlled boats, are recovered for re-use. Targets struck with ordnance will release target fragments.
    - Testing: The Navy conducts testing in which targets are used as described for training. In addition, the Navy may test the targets themselves. Targets are tested in the Study Area and typically retrieved. Stationary targets used during testing (e.g., mine shapes) are anchored on the sea bottom and are intended for recovery. However, there may be cases when the targets may not be recoverable and would be expended.
- **Unmanned Underwater Vehicle Accessories.**
    - Training: UUV systems are meant to be recovered for continued operational use and do not expend any materials.
    - Testing: UUV system tests may involve the release of expended materials such as ballast drop weights or other components; however, some tests require no expended materials to be released.
- **Unmanned Surface Vehicles (USVs).**
    - Training: USV systems are meant to be recovered for continued operational use and do not expend any materials.
    - Testing: USV systems are meant to be recovered for system analysis and do not expend any materials.
- **Unmanned Aircraft Systems (UASs).**
    - Training: UASs are meant to be recovered for continued operational use and do not expend any materials.
    - Testing: UASs are meant to be recovered for system analysis and do not expend any materials.

2.4 PROPOSED ACTIVITIES

The Navy has been conducting training and testing activities in the Study Area for decades, with some activities dating back to at least the early 1900s. The tempo and types of training and testing activities have fluctuated because of the introduction of new technologies, the evolving nature of international events, advances in war fighting doctrine and procedures, and force structure (organization of ships, submarines, aircraft, weapons, and Sailors) changes. Such developments influence the frequency, duration, intensity, and location of required training and testing activities. The Navy analyzed many training and testing activities in the Study Area in the Tactical Training Theater Assessment and Planning Program Phase I documents cited in Chapter 1 (Purpose and Need). This EIS/OEIS (Phase II) accounts for those factors that cause training and testing fluctuations and reflects refined proposed activities in two ways. First, the array of activities proposed for the Study Area anticipates planned adjustments to tempo and types of activities dictated by military readiness requirements. Second, alternatives in this EIS/OEIS include additional training and testing activities that historically occur.

2.4.1 PROPOSED TRAINING ACTIVITIES

The training activities proposed by the Navy are described in Table 2.4-1. The table is organized according to primary mission areas and includes the activity name and a short description. Appendix A (Navy Activities Descriptions) has more detailed descriptions of the activities.

Table 2.4-1: Representative Training Activities

Activity Name	Activity Description
Anti-Air Warfare (AAW)	
Air Combat Maneuver (ACM)	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	Aircrews defend against threat aircraft with missiles.
Gunnery Exercise (Surface-to-Air) (GUNEX [S-A])	Surface ship crews defend against threat aircraft or missiles with guns.
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	Surface ship crews defend against threat missiles and aircraft with missiles.
Anti-Surface Warfare (ASUW)	
Gunnery Exercise (Surface-to-Surface) – Ship (GUNEX [S-S] – Ship)	Ship crews engage surface targets with ship's small-, medium-, and large-caliber guns. Some of the small- and medium-caliber gunnery exercises analyzed include those conducted by the U.S. Coast Guard.
Gunnery Exercise (Surface-to-Surface) – Boat (GUNEX [S-S] – Boat)	Small boat crews engage surface targets with small- and medium-caliber weapons. Only blank rounds are fired.
Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Fixed-wing aircrews simulate firing precision-guided missiles, using captive air training missiles against surface targets. Some activities include firing a missile with a high-explosive warhead.
Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircrews deliver bombs against surface targets.
Sinking Exercise (SINKEX)	Aircraft, ship, and submarine crews deliver ordnance on a seaborne target, usually a deactivated ship, which is deliberately sunk using multiple weapon systems.
Anti-Submarine Warfare (ASW)	
Tracking Exercise – Submarine (TRACKEX – Sub)	Submarine crews search for, detect, and track submarines and surface ships.
Tracking Exercise – Surface (TRACKEX – Surface)	Surface ship crews search for, detect, and track submarines.
Tracking Exercise – Helicopter (TRACKEX – Helo)	Helicopter crews search for, detect, and track submarines.
Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – MPA)	Maritime patrol aircraft crews employ sonobuoys to search for, detect, and track submarines.
Tracking Exercise – Maritime Patrol Aircraft (Extended Echo Ranging Sonobuoys)	Maritime patrol aircraft crews search for, detect and track submarines using explosive source sonobuoys or multistatic active coherent system.

Table 2.4-1: Representative Training Activities (continued)

Activity Name	Activity Description
Electronic Warfare (EW)	
Electronic Warfare Operations (EW OPS)	Aircraft, surface ship, and submarine crews attempt to control portions of the electromagnetic spectrum used by enemy systems to degrade or deny the enemy's ability to take defensive or offensive actions.
Mine Warfare (MIW)	
Mine Neutralization – Explosive Ordnance Disposal (EOD)	Personnel disable threat mines. Explosive charges may be used.
Submarine Mine Exercise	Submarine crews practice detecting non-explosive training mine shapes in a designated area.
Civilian Port Defense	Civilian Port Defense exercises are naval mine warfare activities conducted at various ports and harbors, in support of maritime homeland defense/security.
Naval Special Warfare (NSW)	
Personnel Insertion/Extraction – Submersible	Military personnel train for covert insertion and extraction into target areas using submersibles.
Personnel Insertion/Extraction – Non-Submersible	Military personnel train for covert insertion and extraction into target areas using rotary wing aircraft, fixed-wing aircraft (insertion only), or small boats.
Other Training Activities	
Precision Anchoring	Releasing of anchors in designated locations.
Small Boat Attack	Small boat crews engage pierside surface targets with small-caliber weapons. Only blank rounds are fired.
Intelligence, Surveillance, and Reconnaissance (ISR)	Aircraft crews and unmanned aircraft systems conduct searches and gather intelligence using visual, optical, acoustic, and electronic systems.
Search and Rescue	Helicopter crews conduct helicopter insertion and extraction.
Surface Ship Sonar Maintenance	Maintenance of sonar systems occurs while the ships are moored and at sea.
Submarine Sonar Maintenance	Maintenance of sonar systems occurs while the submarines are moored and at sea.

2.4.2 PROPOSED TESTING ACTIVITIES

The Navy's research and acquisition community engages in a broad spectrum of testing activities in support of the fleet. These activities include, but are not limited to, basic and applied scientific research and technology development; testing, evaluation, and maintenance of systems (missiles, radar, and sonar), and platforms (surface ships, submarines, and aircraft); and acquisition of systems and platforms to support Navy missions and give a technological edge over adversaries.

The individual commands within the research and acquisition community included in this EIS/OEIS are:

- Naval Sea Systems Command (NAVSEA). Within NAVSEA are the following field activities:
    - Naval Undersea Warfare Center (NUWC) Division, Keyport

  - Naval Surface Warfare Center, Carderock Division (NSWCCD), Detachment Puget Sound
  - NSWCCD Southeast Alaska Acoustic Measurement Facility (SEAFAC)
  - Puget Sound Naval Shipyard and Intermediate Maintenance Facility
  - Various NAVSEA program office-sponsored testing activities
- Naval Air Systems Command (NAVAIR)

The Navy operates in an ever-changing strategic, tactical, funding, and time-constrained environment. Testing activities occur in response to emerging science or fleet operational needs. Following identification of future needs, new systems are developed or existing systems are modified. These systems—whether new or modifications of existing systems—must be tested in the field to ensure they meet fleet needs and requirements. Accordingly, generic descriptions of some of these activities are the best that can be articulated in a long-term, comprehensive document, like this EIS/OEIS.

Some testing activities are similar to training activities conducted by the fleet. For example, both the fleet and the research and acquisition community fire “test” torpedoes. While the firing of a torpedo might look identical to an observer, the difference is in the purpose of the firing. The fleet might fire the torpedo to practice the procedures for such a firing, whereas the research and acquisition community might be assessing a new torpedo guidance technology or ensuring that the torpedo meets performance specifications and operational requirements. These differences may result in different impact analyses and potential mitigations for the activity.

2.4.2.1 Naval Sea Systems Command Testing Events

Naval Sea Systems Command is responsible for engineering, building, buying, and maintaining the Navy's ships and submarines and associated combat systems. Naval Sea Systems Command has two types of warfare centers: NUWC and NSWC.

Naval Undersea Warfare Center provides fleet readiness support for submarines, surface ships, torpedoes, mines, land attack systems, and fleet training systems. Naval Sea Systems Command has several field activities operating out of Naval Base Kitsap, including NUWC Division Keyport, NSWC Carderock Division Detachment Puget Sound, and Puget Sound Naval Shipyard and Intermediate Maintenance Facility. Naval Surface Warfare Center Carderock Division Detachment Puget Sound also operates the SEAFAC facility in Alaska.

Each major category of NAVSEA activities in the Study Area is described below. Naval Undersea Warfare Center Division Keyport and NSWC Carderock Division Detachment Puget Sound activities are grouped together in the discussion below to simplify review due to the diversity of activity types and locations they work in. Puget Sound Naval Shipyard and Intermediate Facility activities are grouped with the general activities conducted by NAVSEA. Numerous test activities and technical evaluations, in support of NAVSEA’s systems development mission, often occur in conjunction with fleet activities within the Study Area.

2.4.2.1.2 Naval Undersea Warfare Center Division, Keyport Testing Activities

Naval Undersea Warfare Center Division, Keyport’s mission is to provide advanced technical capabilities for test and evaluation, in-service engineering, maintenance and industrial base support, fleet material readiness, and obsolescence management for undersea warfare. Naval Undersea Warfare Center Division, Keyport has historically provided facilities and capabilities to support testing of torpedoes, other unmanned vehicles, submarine readiness, diver training, and similar activities that are critical to the success of undersea warfare. Range support requirements for such activities include testing, training, and evaluation of system capabilities such as guidance, control, and sensor accuracy in multiple marine environments (e.g., differing depths, salinity levels, sea states) and in surrogate and simulated war-fighting environments. Technological advancements in the materials, instrumentation, guidance systems, and tactical capabilities of manned and unmanned vehicles continue to evolve in parallel with emerging national security priorities and threat assessments. However, NUWC Division, Keyport does not utilize explosives in any testing scenarios.

2.4.2.1.3 Naval Surface Warfare Center, Carderock Division, Detachment Puget Sound Testing Activities

Naval Surface Warfare Center Carderock Division Detachment Puget Sound provides research, development, test and evaluation (RDT&E), analysis, acquisition support, in-service engineering, logistics and integration of surface and undersea vehicles and associated systems; develops and applies science and technology associated with naval architecture and marine engineering; and provides support to the maritime industry (e.g., NAVSEA, Research Laboratories, and other commercial, academic, and private research entities).

The NSWCCD Detachment Puget Sound testing activities are aligned with its mission to provide RDT&E, analysis, acquisition support, in-service engineering, logistics and integration of surface and undersea vehicles and associated systems; develop and apply science and technology associated with naval architecture and marine engineering; and provide support to the maritime industry. Activities and support include engineering, technical, operations, diving, and logistics required for the RDT&E associated with:

- Advanced Technology Concepts, Engineering, and Proofing
- Experimental Underwater Vehicles, Systems, Subsystems, and Components
- Specialized Underwater Systems, Equipment, Tools, and Hardware
- Acoustic Data Acquisition, Analysis, and Measurement Systems (required to measure U.S. Navy Acoustic Signatures)

These activities can be categorized as two major types: System, Subsystem, and Component Acoustic Testing; and Proof-of-Concept Testing. System, Subsystem, and Component Acoustic Testing would occur in inland waters and at-sea environments to obtain static and short-distance operational performance and acoustic measurements. Development testing and training would also be exercised under this test category to validate equipment development and to provide operator training. Typical activity descriptions for each major category are provided below.

2.4.2.1.4 Naval Surface Warfare Center, Carderock Division, Southeast Alaska Acoustic Measurement Facility Testing Activities

Naval Surface Warfare Center, Carderock Division, SEAFAC conducts high-fidelity passive acoustic signature measurements of submarines and ships. The SEAFAC site includes hydrophone arrays and data collection and processing systems for real-time data analysis and signature evaluation.

As the Navy's primary acoustic engineering measurement facility in the Pacific, SEAFAC provides the capability to perform RDT&E analyses to determine the sources of radiated acoustic noise, to assess vulnerability, and to develop quieting measures.

2.4.2.1.5 Naval Sea Systems Command Program Office Sponsored Testing Activities

Naval Sea Systems Command also conducts tests that are not associated with NUWC Keyport or NSWCCD. Some of these activities are conducted in conjunction with fleet activities in the Offshore Area off the coast of Washington, Oregon, and northern California, and some occur at Navy piers at NAVBASE Kitsap Bremerton, NAVBASE Kitsap Bangor, and Naval Station Everett. Tests within this category include, but are not limited to, anti-surface warfare, anti-submarine warfare, mine warfare, and force protection (maintaining security of Navy facilities, ships, submarines, and aircraft).

Table 2.4-2 provides descriptions of the NAVSEA activities included in the Proposed Action.

Table 2.4-2: Representative Naval Sea Systems Command Testing Activities

Activity Name		Activity Description
Naval Undersea Warfare Center Division, Keyport		
Torpedo Testing	Torpedo Non-Explosive Testing	Test of a non-explosive torpedo against a target.
Autonomous and Non-Autonomous Vehicles	Unmanned Underwater Vehicle Testing	UUVs are autonomous or remotely operated vehicles with a variety of different payloads used for various purposes.
	Unmanned Aircraft System	UASs are remotely piloted or self-piloted (i.e., preprogrammed flight pattern) aircraft that include fixed-wing, rotary-wing, and other vertical takeoff vehicles. They can carry cameras, sensors, communications equipment, or other payloads.
	Unmanned Surface Vehicle Testing	USVs are primarily autonomous systems designed to augment current and future platforms to help deter maritime threats. They employ a variety of sensors designed to extend the reach of manned ships.
Fleet Training Support	Cold Water Training	Fleet training for divers in a cold water environment and other diver training related to Navy divers supporting range operations.
	Post-Refit Sea Trial	Following periodic maintenance or repairs, sea trials are conducted to evaluate submarine propulsion, sonar systems, and other mechanical tests.
	Anti-Submarine Warfare Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines or other training targets.
Maintenance and Miscellaneous	Side Scan/Multibeam	Side Scan/Multibeam systems associated with a vessel or UUV are tested to ensure they can detect, classify, and localize targets in a real world environment.
	Non-Acoustic Tests	These tests involve non-acoustic sensors. Non-acoustic sensors may also gather other forms of environmental data.
Acoustic Component Test	Countermeasures Testing	Includes testing of two types of countermeasures: those that emit active acoustic energy of varying frequencies into the water to mimic the characteristics of a target so that the actual threat or target remains undetected; and those that would detect, localize, track, and attack incoming weapons.
	Acoustic Test Facility	Various acoustic component testing and calibration is conducted in a controlled experimental environment based on periodicity and is also conducted on modified, upgraded, and experimental devices.

Table 2.4-2: Representative Naval Sea Systems Command Testing Activities (continued)

Activity Name		Activity Description
Naval Undersea Warfare Center Division, Keyport (continued)		
Acoustic Component Test (continued)	Pierside Integrated Swimmer Defense	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and engage swimmer and diver threats in harbor environments.
Naval Surface Warfare Center, Carderock Division Detachment Puget Sound		
System, Subsystem and Component Testing	Pierside Acoustic Testing	Operating AUV, ROV, UUV, submersibles/Concepts and Prototypes (including experimental vehicles, systems, equipment, tools and hardware) underwater in a static or dynamic condition within 500 yd. of an instrumented platform moored pierside.
	Performance Testing At-Sea	Operating AUV, ROV, UUV, submersibles/Concepts and Prototypes underwater at sea. Systems will be exercised to obtain operational performance measurements of all subsystems and components used for navigation and mission objectives.
	Development Training and Testing	Operating AUV, ROV, UUV, submersibles/Concepts and Prototypes underwater at Sea. Systems will be exercised to validate development and to provide operator familiarization and training with all subsystems and components used for navigation and mission objectives.
Proof of Concept Testing		Design, fabrication and installation of unique hardware and towing configurations in support of various surface and underwater demonstrations as proof-of-concept.
Naval Surface Warfare Center, Carderock Division, Southeast Alaska Acoustic Measurement Facility		
Surface Vessel Acoustic Measurement		Conduct acoustic trial measurements of surface vessels
Underwater Vessel Acoustic Measurement		Conduct acoustic trial measurements of underwater vessels
Underwater Vessel Hydrodynamic Performance Measurement		Conduct hydrodynamic performance trial measurements
Cold-water Training		Involves Navy personnel conducting insertion training in cold-water conditions. The training may include ingress and egress from subsurface vessels and small surface craft.
Component System Testing		Conduct testing on individual components of new defense acquisition systems
Countermeasures Testing		Conduct engineering and acceptance testing of countermeasures
Electromagnetic Measurement		Conduct new construction, post-PSA, and life cycle electromagnetic measurements
Measurement System Repair & Replacement		Conduct repairs, replacements and calibration of acoustic measurement systems
Project Operations (POPS)		Support testing of fleet assets
Target Strength Trial		Asset moored to static site. Acoustic projectors and receive arrays will be rotated around asset. Broadband waveforms will be transmitted. Underwater tracking system would be utilized to monitor relative positions.

Table 2.4-2: Representative Naval Sea Systems Command Testing Activities (continued)

Activity Name		Activity Description
Additional Naval Sea Systems Command Testing Activities		
Life Cycle Activities	Pierside Sonar Testing	Pierside testing of submarine and surface ship sonar systems occurs periodically following major maintenance periods and for routine maintenance.
Shipboard Protection Systems and Swimmer Defense Testing	Pierside Integrated Swimmer Defense	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and engage swimmer and diver threats in harbor environments.
Unmanned Vehicle Testing	Unmanned Vehicle Development and Payload Testing	Vehicle development involves the production and upgrade of new unmanned platforms on which to attach various payloads used for different purposes.
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing	Torpedo Testing	Air, surface, or submarine crews employ explosive torpedoes against artificial targets.
	Torpedo Non-Explosive Testing	Air, surface, or submarine crews employ non-explosive torpedoes against submarines or surface vessels.
	Countermeasure Testing	Countermeasure testing involves the testing of systems that would detect, localize, track, and attack incoming weapons.
New Ship Construction	Anti-Submarine Warfare Mission Package Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines.

Notes: AUV = Autonomous Underwater Vehicle, ROV = Remotely Operated Vehicle, UAS = Unmanned Aircraft System, USV = Unmanned Surface Vehicle, UUV = Unmanned Underwater Vehicle, PSA = Post Shakedown Availability (also known as post-delivery maintenance work)

2.4.2.2 Naval Air Systems Command Testing Events

Naval Air Systems Command testing events generally fall into the primary mission areas used by the fleets. Naval Air Systems Command events include, but are not limited to, the testing of new aircraft platforms, weapons, and systems before those platforms, weapons and systems are integrated into the fleet.

Many platforms (e.g., the P-8A) and systems (e.g., sonobuoys) currently being tested by NAVAIR will ultimately be integrated into fleet training activities. Training with systems and platforms transferred to the fleet within the timeframe of this document are analyzed in the training sections of this EIS/OEIS. This section only addresses NAVAIR’s testing activities.

As all NAVAIR testing activities in the Study Area are similar to training events, it would be difficult for an observer to discern between the two types of activities. A comparison of NAVAIR's testing activities (Table 2.4-3) and the fleet's training activities (see Table 2.4-1) highlights the commonalities between the two.

Table 2.4-3: Representative Naval Air Systems Command Testing Activities

Activity Name	Activity Description
Anti-Submarine Warfare (ASW)	
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (ASW TRACKEX – MPA) (Directional Command Activated Sonobuoy System [DICASS])	All NAVAIR ASW testing activities are similar to the training event ASW TRACKEX – MPA. This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the DICASS.
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Mutistatic Active Coherent [MAC])	This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the MAC sonobuoy system.
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Sound Underwater Signal [SUS])	This test evaluates the sensors and systems used by maritime patrol aircraft to communicate with submarines using any of the family of SUS systems.
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Improved Extended Echo Ranging [IEER])	This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the IEER sonobuoy system.
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (High Duty Cycle [HDC])	This test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines using the HDC sonobuoy system.
Electronic Warfare (EW)	
Flare Test	Flare tests evaluate newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems against flare deployment. Tests may also train pilots and aircrew in the use of newly developed or modified flare deployment systems. Flare tests are often conducted with other test events, and are not typically conducted as standalone tests.

Note: NAVAIR = Naval Air Systems Command

2.5 ALTERNATIVES DEVELOPMENT

The identification, consideration, and analysis of alternatives are important aspects of the NEPA process and contribute to the goal of objective decision-making. The Council on Environmental Quality (CEQ) requires and provides guidance on the development of alternatives. The regulations require the decision maker to consider the environmental effects of the proposed action and a range of alternatives (including the No Action Alternative) to the proposed action (40 C.F.R. § 1502.14). The range of alternatives include reasonable alternatives, which must be rigorously and objectively explored, as well as other alternatives that were considered but eliminated from detailed study. To be reasonable, an alternative must meet the stated purpose of and need for the proposed action. An EIS must explore all reasonable mitigation measures for a proposed action. Mitigation measures are discussed in Chapter 3 of this EIS/OEIS in connection with affected resources, and are also addressed in Chapter 5.

The purpose of including a No Action Alternative in environmental impact analyses is to ensure that agencies compare the potential impacts of the proposed action to the potential impacts of maintaining the status quo.

The Navy developed the alternatives considered in this EIS/OEIS after careful assessment by subject matter experts, including military units and commands that utilize the ranges, military range management professionals, and Navy environmental managers and scientists.

2.5.1 ALTERNATIVES ELIMINATED FROM FURTHER CONSIDERATION

Alternatives eliminated from further consideration are described in Sections 2.5.1.1 to 2.5.1.4. The Navy determined that these alternatives did not meet the purpose and need for the Proposed Action after a thorough consideration of each.

2.5.1.1 Alternative Locations

The Navy's use of training and testing ranges has evolved over the decades because these geographic areas provide variable bathymetries and testing challenges to simulate potential operational scenarios. While some unit level training and some testing activities may require only one training element (air space, sea space, or undersea space), more advanced training and testing events may require a combination of air, surface, and undersea space as well as access to shore facilities. The ability to utilize the diverse and multi-dimensional capabilities of each range complex allows the Navy to develop and maintain high levels of readiness. No other locations match the attributes found in the NWTT range complexes, which are as follows:

- Proximity of multiple training and testing range complexes in the Pacific Northwest to each other.
- Proximity to the homeports of Navy Region Northwest commands, ships, submarines, schools, and aircraft units stationed there.
- Proximity to shore-based facilities and infrastructure, and the logistical support provided for testing activities.
- Proximity to military families, in light of the readiness benefits derived from minimizing the length of time Sailors spend deployed away from home.
- Presence of unique in-water testing facilities, which include instrumented deep-water and inshore range areas within the protected waters of Puget Sound, Washington, and Western Behm Canal near Ketchikan, Alaska, that offer unique training and testing capabilities not available elsewhere in the Pacific.
- Environmental conditions (e.g., bathymetry, topography, and weather) that maximize the training realism and testing effectiveness.
- Specialized locations that have been used by the Navy over the past 100 years have resulted in a detailed knowledge of the environment to understand the variables such as tide, current, temperature, and salinity in these field conditions.

The uniquely interrelated nature of the component parts to the range complexes located within the Study Area provides the training and testing support needed for complex military activities. There is no other set of integrated ranges in the Pacific Northwest that affords this level of operational support for local range users. There are no other potential locations where OPAREAs, undersea terrain and ranges, in-shore waters, and military airspace combine to provide the venues necessary for the training and testing realism and effectiveness required to train and certify naval forces for combat operations and conduct testing under the required conditions.

2.5.1.2 Reduced Training and Testing

Title 10 Section 5062 of the U.S. Code provides: "The Navy shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea." Reduction or cessation of training and testing would prevent the Navy from meeting its Title 10 requirements and adequately preparing naval forces for operations at sea ranging from disaster relief to armed conflict.

2.5.1.3 Alternative with Temporal or Geographic Constraints within the Study Area

Alternatives considered under the NEPA process may include mitigation measures. This assumes however, that appropriate mitigations can be developed before a detailed analysis of the impacts from the alternatives and compliance with other federal laws occurs. Analysis of military training and testing activities involves compliance with several federal laws including the MMPA and the ESA. These laws require that the Navy complete complex and lengthy permitting processes, which include applying the best available science to develop mitigations. The best available science is reviewed and identified during the course of the permitting and NEPA/EO 12114 processes. Consequently, in order to allow for potential mitigation measures to be more fully developed as part of the detailed NEPA/EO 12114 analysis and further refined and informed by applicable permitting processes, the Navy did not identify and carry forward for analysis any separate alternatives with pre-determined geographic or temporal restrictions. Rather, Chapter 5 of this EIS/OEIS contains a detailed discussion of potential mitigation measures that were evaluated. Based on the analysis in Chapter 3, the MMPA and ESA permitting processes, and other required regulatory consultations, practical science-based mitigation measures, including temporal or geographic constraints within the Study Area, may be implemented under either action alternative.

2.5.1.4 Simulated Training and Testing

The Navy currently uses computer simulation for training and testing whenever possible (e.g., command and control exercises are conducted without operational forces); however, there are significant limitations and its use cannot completely substitute live training or testing. Therefore, simulation as an alternative that replaces training and testing in the field does not meet the purpose of and need for the Proposed Action and has been eliminated from detailed study.

2.5.1.4.1 Simulated Training

The Navy continues to research new ways to provide realistic training through simulation, but there are limits to the realism that technology can presently provide. Unlike live training, computer-based training does not provide the requisite level of realism necessary to attain combat readiness. Simulation cannot replicate the inherent high-stress environment and complexity of the coordination needed to combine multiple military assets and personnel into a single fighting unit. Most notably, simulation cannot mimic dynamic environments involving numerous forces or accurately model the behavior of sound in complex training media such as the marine environment.

Today's simulation technology does not permit anti-submarine warfare training with the degree of fidelity required to maintain proficiency. While simulators are used for the basic training of sonar technicians, they are of limited utility beyond basic training. A simulator cannot match the dynamic nature of the environment, such as bathymetry and sound propagation properties, or the training activities involving several units with multiple crews interacting in a variety of acoustic environments. Moreover, it is imperative that crews achieve competence and gain confidence in their ability to use their equipment.

Sonar operators must train regularly and frequently to develop and maintain the skills necessary to master the process of identifying underwater threats in the complex subsurface environment. Sole reliance on simulation would deny service members the ability to develop battle-ready proficiency in the employment of active sonar in the following specific areas:

- Bottom bounce and other environmental conditions. Sound hitting the ocean floor (bottom bounce) reacts differently depending on the bottom type and depth. Likewise, sound passing through changing currents, eddies, or across changes in ocean temperature, pressure, or salinity is also affected. These are extremely complex to simulate, and are a common challenge in actual combat situations.
- Mutual sonar interference. When multiple sonar sources are operating in the vicinity of each other, interference due to similarities in frequency can occur. Again, this is a complex variable that must be recognized by sonar operators, but is difficult to simulate with any degree of fidelity.
- Interplay between ship and submarine target. Ship crews, from the sonar operator to the ship's Captain, must react to the changing tactical situation with a real, thinking adversary (a Navy submarine for training purposes). Training in actual conditions with actual submarine targets provides a challenge that cannot be duplicated through simulation.
- Interplay between anti-submarine warfare teams in the strike group. Similar to the interplay required between ships and submarine targets, a ship's crew must react to all changes in the tactical situation, including changes from cooperating ships, submarines, and aircraft.

Computer simulation can provide familiarity and complement live training; however, it cannot provide the fidelity and level of training necessary to prepare naval forces for deployment. Therefore, the alternative of substituting simulation for live training fails to meet the purpose of and need for the Proposed Action and was eliminated from detailed study.

2.5.1.4.2 Simulated Testing

As described in Section 1.4.3, the Navy conducts testing activities to collect scientific data; investigate, develop, and evaluate new technologies; and to support the acquisition and life cycle management of platforms and systems used by the warfighters. Throughout the life cycle of platforms and systems, from performing basic research to procurement of the platform or system, the Navy uses a number of different testing methods, including computer simulation, when appropriate. The Navy cannot use or rely exclusively on simulation when performing a number of specific testing activities, including collection of scientific data; verifying contractual requirements; and assessing performance criteria, specifications, and operational capabilities.

The Navy collects scientific data that can only be obtained from direct measurements of the marine environment to support scientific research associated with the development of new platforms and systems. A full understanding of how waves in the ocean move, for example, can only be fully understood by collecting information on waves. This type of direct scientific observation and measurement of the environment is vital to developing simulation capabilities by faithfully replicating environmental conditions.

As the acquisition authorities for the Navy, the Systems Commands are responsible for administering large contracts for the Navy's procurement of platforms and systems. These contracts include performance criteria and specifications that must be verified to assure that the Navy accepts platforms and systems that support the warfighter's needs. Although simulation is a key component in platform and systems development, it does not adequately provide information on how a system will perform or whether or not it will be able to meet performance and other specification requirements because of the complexity of the technologies in development and the marine environments in which they will operate. For this reason, at some point in the development process, platforms and systems must undergo at-sea or in-flight testing. For example, a new jet airplane design can be tested in a wind tunnel that simulates flight to assess elements like maneuverability, but eventually a prototype must be constructed and flown to confirm the wind tunnel data.

Furthermore, the Navy is required by law to operationally test major platforms, systems, and components of these platforms and systems in realistic combat conditions before full-scale production can occur. Under Title 10 of the U.S. Code, this operational testing cannot be based exclusively on computer modeling or simulation. At-sea testing provides the critical information on operability and supportability needed by the Navy to make decisions on the procurement of platforms and systems, ensuring that what is purchased performs as expected and that tax dollars are not wasted. This testing requirement is also critical to protecting the warfighters who depend on these technologies to execute their mission with minimal risk to them.

This alternative—substitution of simulation for live testing—fails to meet the purpose of and need for the Proposed Action and was therefore eliminated from detailed study.

2.5.2 ALTERNATIVES CARRIED FORWARD

Three alternatives are analyzed in this EIS/OEIS:

- **No Action Alternative:** Baseline training and testing activities, as defined by existing Navy environmental planning documents, including the *NWTRC EIS/OEIS* (U.S. Department of the Navy 2010a), the NAVSEA *NUWC Keyport Range Complex Extension EIS/OEIS* (U.S. Department of the Navy 2010b), and the *SEAFAC EIS* (U.S. Department of the Navy 1988). The baseline testing activities also include other testing events that historically occur in the Study Area and have been subject to previous analysis pursuant to NEPA and EO 12114.
- **Alternative 1 (Preferred Alternative):** Adjustments to types and levels of activities, from the baseline as necessary to support current and planned Navy training and testing requirements. This Alternative considers:
  - modified or updated mission requirements associated with force structure changes, including those resulting from the development, testing, and ultimate introduction of new platforms (vessels and aircraft), and weapons systems into the fleet
  - new biennial training exercises conducted in the Offshore Area
  - biennial mine warfare exercises in Puget Sound in support of homeland defense
  - training with and testing of undersea systems, subsystems, and components in Puget Sound
  - proof-of-concept testing of unique undersea hardware and fixtures
  - resumption of testing activities at the Carr Inlet Operations Area
  - pierside sonar maintenance and life cycle testing
  - sea trials in support of overhaul
- **Alternative 2:** Consists of Alternative 1 plus adjustments to tempo of training and testing. All training activities would remain the same except for an increase in Civilian Port Defense training events from one every other year to one every year. The tempo of testing activities over those proposed for Alternative 1 would increase in a range between 6 percent for maintenance and miscellaneous testing events and 38 percent for all testing activities in the Western Behm Canal, Alaska. On average most testing activities in Alternative 2 would increase about 12 percent over those in Alternative 1.

Each of the alternatives is discussed in Sections 2.6 through 2.8.

2.6 NO ACTION ALTERNATIVE: CURRENT MILITARY READINESS WITHIN THE NORTHWEST TRAINING AND TESTING STUDY AREA

The CEQ regulations require that a range of alternatives to the proposed action, including a No Action Alternative, be developed for analysis. The No Action Alternative serves as a baseline description from which to compare the potential impacts of the proposed action. The CEQ provides two interpretations of the No Action Alternative, depending on the proposed action. One interpretation would mean the proposed activity would not take place, and the resulting environmental effects from taking no action would be compared with the effects of taking the proposed action. For example, this interpretation would be used if the proposed action was the construction of a facility. The second interpretation, which applies to this EIS/OEIS, allows the No Action Alternative to be thought of in terms of continuing with the present course of action until that action is changed. The No Action Alternative for this EIS/OEIS would continue currently conducted training and testing activities (baseline activities) and force structure (personnel, weapons, and assets) requirements as defined by existing Navy environmental planning documents.

The No Action Alternative represents those training and testing activities and events as set forth in previously completed Navy environmental planning documents (*Northwest Training Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statement* [September 2010]; *Final Environmental Impact Statement/Overseas Environmental Impact Statement NAVSEA NUWC Keyport Range Complex Extension* [May 2010]; *Southeast Alaska Acoustic Measurement Facility* [SEAFAC], *Behm Canal, Ketchikan Gateway Borough: Environmental Impact Statement* [1988]). However, the No Action Alternative would fail to meet the purpose of and need for the Proposed Action because it would not allow the Navy to meet future training and testing requirements necessary to achieve and maintain fleet readiness. For example, the baseline activities do not account for changes in force structure requirements, the introduction of new or upgraded weapons and platforms, and the training and testing required for proficiency with these systems.

2.7 ALTERNATIVE 1: ADJUSTMENTS TO THE BASELINE AND ADDITIONAL WEAPONS, PLATFORMS, AND SYSTEMS

Alternative 1 would consist of the No Action Alternative, with adjustments to location, type, and tempo of training and testing activities, which includes the addition of platforms and systems. These changes are necessary to accommodate force structure changes, which include the relocation of submarines, vessels, aircraft, and personnel. As forces are moved within the existing Navy structure, training needs will necessarily change as the location of forces change. Force structure changes, often related to changes in threats, also affect testing requirements that require additional or new testing. These adjustments can also result from the development and introduction of new submarines, vessels, aircraft, and weapon systems.

This EIS/OEIS contains analyses of areas where Navy training and testing would continue as in the past, but were not considered in previous environmental analyses. This is not an expansion of any range site where the Navy trains and tests but is simply an expansion of the Study Area to be analyzed. Previous EIS/OEISs were developed for individual range complexes and individual activities.

The Navy is combining and analyzing range complexes, facilities, and activities in the Northwest within one comprehensive EIS/OEIS that provides for a more integrated analysis of activities as described in Section 2.7.1 (Proposed Adjustments to Baseline Training Activities) and Section 2.7.2 (Proposed Adjustments to Baseline Testing Activities). All of the changes in Alternative 1 reflect adjustments to the

No Action Alternative baseline activities that are necessary to support all current and proposed Navy at-sea training and testing activities.

2.7.1 PROPOSED ADJUSTMENTS TO BASELINE TRAINING ACTIVITIES

The proposed adjustments to baseline levels and types of training categorized by primary mission areas are as follows:

2.7.1.1 Anti-Air Warfare

- The Navy would increase the tempo of air combat maneuver training from 160 events per year to 550 events per year due to the introduction of locally based EA-18G aircraft.

2.7.1.2 Anti-Surface Warfare

- The Navy has recently homeported a Maritime Expeditionary Security Squadron unit at Naval Air Station Whidbey Island. The unit consists only of personnel, with no patrol craft physically assigned. The Maritime Expeditionary Security Squadron's primary mission is force protection conducted through fleet support with operations around the world. Anti-terrorism and force protection missions include harbor and homeland defense, coastal surveillance, and other special missions. These security forces' training activities will be included in this EIS/OEIS, which include the addition of four annual gunnery exercise events firing small-caliber blank rounds from small boats in Puget Sound.
- Small- and medium-caliber gunnery exercises conducted by U.S. Coast Guard ships and crews are included in Alternative 1. This would result in an increase of 4,200 small-caliber (7.62 mm and .50 caliber) rounds and an increase of 910 medium-caliber (25 mm) rounds. Of the medium-caliber rounds fired, 130 would be high explosive rounds, with the remaining 780 non-explosive practice munitions. All Coast Guard gunnery exercises would be conducted in the Offshore Area.
- SINKEXs include the use of explosive weapons such as gunnery rounds, missiles, bombs, and torpedoes against a full size ship target until the target sinks. Although not a frequent occurrence in this Study Area (the most recent SINKEX in the Pacific Northwest was in 2005), this exercise was included and analyzed in the 2010 NWTRC EIS/OEIS (U.S. Department of the Navy 2010a). However, the Navy has determined these exercises are no longer likely to occur in the Study Area and therefore has removed them from consideration in this analysis.

2.7.1.3 Anti-Submarine Warfare

- The Navy would conduct four new helicopter tracking exercises, not previously analyzed or conducted in the Study Area.
- The Navy would increase surface ship sonar activity by 32 hours, from 108 hours of annual use in the No Action Alternative, to 140 annual hours under Alternative 1. The number of proposed surface tracking exercises would remain the same at 65, all located in the Offshore Area.
- The Navy is expected to begin replacing frigate class of ships stationed in the Pacific Northwest with ships of the destroyer class. Destroyers use a more powerful sonar than the frigates they will be replacing, so for estimating environmental impacts under Alternative 1, the Navy will consider every use of surface ship sonar to be from the more powerful sonar type. Previously, under the No Action Alternative, approximately 40 percent of all sonar hours were modeled as this more powerful sonar.

- While the Navy would reduce the number of annual extended echo ranging sonobuoy training events from 54 down to 15, the number of sonobuoys proposed to be used remains generally unchanged.

2.7.1.4 Electronic Warfare

- Under Alternative 1, the Navy proposes an increase in Electronic Warfare training from 2,900 events per year to 5,000 events per year with the proposed increase of additional electronic threat emitters in the Study Area.

2.7.1.5 Mine Warfare

- The Navy has a harbor and homeland defense mission to include Mine Warfare. The Naval Mine and Antisubmarine Warfare Command is required to conduct annual Mine Warfare exercises in ports on the west coast of the United States. The conduct of the Mine Warfare Exercise with its various air, surface, and EOD units training activities will be included in the EIS/OEIS. Under Alternative 1, the Navy will analyze potential effects of biennial mine warfare exercises (total of three within a 5-year period) conducted by visiting Mine Interdiction Warfare units beginning in 2015 and recurring in 2017 and 2019.
- Support mine warfare requirements with the addition of six new annual SWAG training activities (see Section 2.3.5, Mine Warfare Systems) (three each at Crescent Harbor and Hood Canal EOD Ranges).
- Support the increase of EOD mine neutralization training at Crescent Harbor EOD Range from two to three 2.5 lb. charges annually.
- Support the increase of EOD mine neutralization training at Hood Canal EOD Range in both frequency of training and in the charge size (from two 1.5 lb. charges to three 2.5 lb. charges annually).
- Support submarine crew training with the addition of eight new mine detection activities in the Offshore Area.

2.7.1.6 Other Training

- The Navy conducts precision anchoring training within the Inland Waters of Puget Sound. These training activities will be analyzed under Alternative 1.
- The Navy would conduct annual anti-terrorism/force protection training exercises in which small boat attacks would be simulated against Navy ships docked at Naval Station Everett, NAVBASE Kitsap Bangor, or NAVBASE Kitsap Bremerton. These exercises would include the firing of small-caliber blank rounds only.
- Increase levels of Insertion, Surveillance, and Extraction training, from 100 to 200 events per year.
- Conduct 13 annual events of moored surface ship sonar maintenance.
- Conduct 22 annual events of moored submarine sonar maintenance.

2.7.2 PROPOSED ADJUSTMENTS TO BASELINE TESTING ACTIVITIES

The proposed adjustments to baseline levels and types of testing are as follows:

2.7.2.1 Naval Sea Systems Command Testing Activities

- Increase tempo of torpedo non-explosive testing events from 54 to 61 per year.

- Increase tempo of autonomous and non-autonomous vehicle testing events from 148 to 231 per year.
- Increase tempo of fleet training/support events from 99 to 122 per year.
- Increase tempo of maintenance and miscellaneous testing events from 157 to 169 per year.
- Increase tempo of acoustic component testing events from 256 to 281 per year.
- Inclusion of 186 annual testing activities in the Inland Waters that historically occur but have not been previously analyzed (proof of concept testing and system, subsystem, and component testing).
- Some of these 186 annual testing activities would be conducted in Carr Inlet within the Inland Waters (proof of concept testing and system, subsystem, and component testing).
- Addition of 14 new testing activities in the Western Behm Canal, Alaska (cold water training, countermeasures testing, electromagnetic measurement, project operations, and target strength trial).
- Increase of 18 (from 28 to 46) annual existing testing activities in the Western Behm Canal, Alaska (surface and underwater vessel acoustic measurement, underwater vessel hydrodynamic performance measurement, component system testing, and measurement system repair and replacement).
- Inclusion of 68 pierside testing activities in the Inland Waters that historically occur but have not been previously analyzed (sonar testing and integrated swimmer defense).
- Conduct 17 new testing activities in the Inland Waters (unmanned vehicle development and payload testing, and countermeasure testing).
- Conduct 22 new testing activities in the Offshore Area (torpedo testing, countermeasure testing, and anti-submarine warfare mission package testing).

2.7.2.2 Naval Air Systems Command Testing Activities

- Conduct 54 new buoy testing activities per year in the Offshore Area.
- Conduct some of those 54 new activities as high-altitude buoy testing.
- Conduct 10 flare testing activities in the Offshore Area using 600 flares.

2.7.3 PROPOSED ADDITIONAL PLATFORMS AND SYSTEMS

The following is a representative list of additional training platforms, weapons and systems analyzed. The ships and aircraft will not be an addition to the fleet but rather replace older ships and aircraft that are decommissioned and removed from the inventory.

2.7.3.1 Aircraft

F-35 Joint Strike Fighter

The F-35 Joint Strike Fighter Lightning II aircraft will replace older model F/A-18s and complement the Navy's F/A-18E/F. The F-35 is projected to make up about one-third of the Navy's strike fighter inventory by 2020. The Marine Corps will have a variant of the F-35 with a short takeoff, vertical landing capability that is planned to replace the AV-8B and F/A-18C/D aircraft. The Navy variant for aircraft carrier use is scheduled for delivery in 2015. The F-35 will operate similarly to the aircraft it replaces or complements. It will operate in the same areas and will be used in the same training exercises such as air-to-surface and air-to-air missile exercises, bombing exercises, and any other exercises where fixed-wing aircraft are used in training. No new activities will result from the introduction of the F-35. Although no Joint Strike Fighters are expected to be homebased in the Northwest, Joint Strike Fighter training could be done by transient aircraft to the Study Area.

P-8A Multi-Mission Maritime Aircraft

The P-8A is a modified Boeing 737-800ERX that brings together a highly reliable airframe and turbo fan jet engine with fully connected, state-of-the-art sensors, and command and control systems. This combination of airframe and systems dramatically improves the ASW and ASUW capabilities over the current P-3 aircraft it is designed to replace. The P-3 Orion, a turboprop driven, modified Lockheed L-188 Electra, has been in service since November 1959 [P-3A] and August 1969 [P-3C]. For more information about the P-3C replacement, see Chapter 4 (Section 4.3.4.16, P-8A Multi-Mission Aircraft).

2.7.3.2 Ships

CVN-21 Aircraft Carrier (Gerald R. Ford Class)

The CVN-21 Program is designing the replacement for the Nimitz class carriers. The new aircraft carriers' capabilities will be similar to those of the carriers they will replace, and it will train in the same OPAREAs as the predecessor aircraft carriers. The first aircraft carrier (CVN 78) is expected to be delivered in 2015. No new activities will result from the introduction of the CVN 21 class of aircraft carriers.

DDG 1000 Multi-Mission Destroyer (Zumwalt Class)

Developed under the DD(X) destroyer program, Zumwalt (DDG 1000) is the lead ship of a class of next-generation multi-mission destroyers tailored for land attack and littoral dominance. DDG 1000 will operate similarly to the existing Arleigh Burke class of destroyers; however, it will provide greater capability in the near-shore sea space and will train more in that environment. Its onboard weapons and systems will include a 155 mm advanced gun system to replace the 5 in. (12.7 cm) gun system on current destroyers. This gun system will fire a new projectile (see Long Range Land Attack Projectile below) at greater distances.

The DDG 1000 will also be equipped with two new sonar systems; the AN/SQS-60 hull-mounted mid-frequency sonar, and the AN/SQS-61 hull-mounted high-frequency sonar.

The first ship of this class is expected to be delivered in 2016. This class will join the fleets and conduct training alongside existing DDG classes of ships. The introduction of DDG 1000 class would require an increase in training allowances for exercises currently being conducted by existing DDG class ships.

2.7.3.3 Unmanned Underwater Vehicle Systems

In addition to UUVs that are currently in service, new systems will be developed and enter fleet service that will support several high-priority missions including:
(1) intelligence, surveillance, and reconnaissance; (2) mine countermeasures; (3) anti-submarine warfare; (4) oceanography; (5) communication/navigation network nodes; (6) payload delivery; (7) information operations; and (8) time critical strike.

2.7.3.4 Unmanned Surface Vehicle Systems

Similar to UUVs, some USVs are currently in service and new systems will be developed and enter fleet service to support a variety of missions. Although the exact systems are not known, they share the basic USV traits described as follows. All USVs are primarily autonomous systems designed to augment current and future platforms to help deter maritime threats. They will employ a variety of sensors designed to extend the reach of manned ships.

2.7.3.5 Unmanned Aircraft Systems

Unmanned aircraft systems are currently in use in the Study Area and include aerial vehicles that operate as intelligence, search, and reconnaissance sensors or as armed combat air systems. New systems will be developed and enter fleet service. While the exact systems are not known, their basic function is expected to remain the same. The UAS is operated from ground stations manned by a four-person crew, including an air vehicle operator, a mission commander, and two sensor operators.

Broad Area Maritime Surveillance

The Broad Area Maritime Surveillance system is a complementary system to the P-8A aircraft, providing maritime reconnaissance support to the Navy. It will be equipped with electro-optical/infrared sensors, can remain on station for 30 hours, and fly at approximately 60,000 ft. (18,288 m).

2.7.3.6 Missiles/Rockets/Bombs

The Navy will develop, test, and train with improved weapons, including missiles, rockets, and bombs. Most developments involve changes in the sensors and guidance systems associated with these weapons, while the warheads generally remain unchanged. For missiles and rockets, improvements in propulsion, combined with improvements in sensor capability, may extend the maximum range of some weapons.

AGM-154 Joint Standoff Weapon

The Joint Standoff Weapon is a missile able to be launched at increased standoff distances, using global positioning system and inertial navigation for guidance. All Joint Standoff Weapon variants share a common body but can be configured for use against a variety of targets, including moving maritime targets. This would be integrated into anti-surface warfare exercises.

AGM-84 Anti-ship Missile (Harpoon)

The Harpoon, first deployed in 1985, is an all-weather, over-the-horizon, anti-ship missile system. It has a low-level, sea-skimming cruise trajectory, active radar guidance and is designed like a warhead.

It has been upgraded over the years and is now available as the Harpoon Block II and will be outfitted on the new P-8A Multi-Mission Maritime Aircraft.

2.7.3.7 Other Systems

Additional new capabilities include systems that support or are components of an aircraft, ship, unmanned system, or weapon. The examples that follow include modular ship systems, sonar systems, and command, communication and control systems.

High Altitude Anti-Submarine Warfare

High altitude anti-submarine warfare integrates new and modifies existing sensors to enhance fixed wing aircraft capability to conduct anti-submarine warfare at high altitudes. Sonobuoy modifications include integrating global positioning system for precise sonobuoy positional information and a digital uplink/downlink for radio frequency interference management. New sensors include a meteorological sensing device (dropsonde) for sensing atmospheric conditions from the aircraft altitude to the surface.

High Duty Cycle Sonar

High Duty Cycle Sonar technology provides improved detection performance and improved detection and classification decision time. This technology will be implemented as an alteration to the existing AN/SQQ-89A(V)15 surface ship combat system and the Littoral Combat Ship anti-submarine warfare mission package.

Littoral Combat Ship Variable Depth Sonar

The variable depth sonar system is a mid-frequency sonar system that will be towed by the Littoral Combat Ship and integrated into the Littoral Combat Ship anti-submarine warfare mission package.

SQS-60 and SQS-61 Sonar

The AN/SQS-60 and 61 are integrated hull-mounted sonar components of the DDG 1000 Zumwalt class destroyer. The SQS-60 is a mid-frequency active sonar and the SQS-61 is a high-frequency active sonar, both of which would be operated similarly to the current AN/SQS 53 and 56 sonar.

Commercial Side-Scan Sonar

This is any high-frequency side scan sonar system for detecting and classifying objects on the sea bottom.

Littoral Battlespace Sensing, Fusion and Integration Program

The Littoral Battlespace Sensing, Fusion and Integration program is the Navy's principal Intelligence Preparation of the Environment enabler. This capability is composed of ocean gliders and autonomous undersea vehicles. Gliders are two-man-portable, long-endurance (weeks to months), buoyancy driven vehicles that provide a low-cost, semi-autonomous, and highly persistent means to sample and characterize the ocean water column properties at spatial and temporal resolutions not otherwise possible using survey vessels or tactical units alone. Autonomous undersea vehicles are larger, shorter endurance (hours to days), conventionally powered (typically electric motor) vehicles that will increase the spatial extent and resolution of the bathymetry, imagery data, conductivity, temperature and depth data, and optical data collected by existing ships.

2.8 ALTERNATIVE 2: INCLUDES ALTERNATIVE 1 PLUS INCREASED TEMPO OF TRAINING AND TESTING ACTIVITIES

Alternative 2 consists of all activities that would occur under Alternative 1 plus adjustments to type and tempo of training and testing. All training activities would remain the same except for an increase in Civilian Port Defense training events from one every other year to one every year. The tempo of testing activities over those proposed for Alternative 1 would increase in a range between 6 percent for maintenance and miscellaneous testing events and 38 percent for all testing activities in the Western Behm Canal, Alaska. On average, most testing activities in Alternative 2 would increase about 12 percent over those in Alternative 1.

This alternative allows for potential budget changes, strategic necessity, inclusion of an alternative testing site, and future training and testing requirements. Tables 2.8-1 through 2.8-3 provide a summary of the training and testing activities to be analyzed under the No Action Alternative, Alternative 1, and

Alternative 2. Locations identified within these tables represent the areas where events are typically scheduled to be conducted. Generally, the range complex is identified, but for some activities, smaller areas within the range are identified. Cells under the "Ordnance" column are shaded gray if that activity includes the use of explosives.

2.8.1 PROPOSED ADJUSTMENTS TO ALTERNATIVE 1 TRAINING ACTIVITIES

The proposed adjustments to Alternative 1 levels and types of training are as follows:

2.8.1.1 Mine Warfare

- Increase the Civilian Port Defense exercise frequency from biennial to an annual event.

2.8.2 PROPOSED ADJUSTMENTS TO ALTERNATIVE 1 TESTING ACTIVITIES

The proposed adjustment to Alternative 1 levels and types of testing is as follows:

2.8.2.1 Naval Sea Systems Command Testing Activities

- Increase tempo of torpedo non-explosive testing events from 61 to 68 per year.
- Increase tempo of autonomous and non-autonomous vehicle testing events from 231 to 261 per year.
- Increase tempo of fleet training/support events from 122 to 139 per year.
- Increase tempo of maintenance and miscellaneous testing events from 169 to 179 per year.
- Increase tempo of acoustic component testing events from 281 to 306 per year.
- Increase tempo of system, subsystem, and component testing activities from 156 to 174 per year.
- Increase tempo of proof of concept testing activities from 30 to 34 per year.
- Increase tempo of all testing activities from 60 to 83 per year in the Western Behm Canal, Alaska.
- Increase tempo of all NAVSEA testing activities from 107 to 133 per year.

2.8.2.2 Naval Air Systems Command Testing Activities

- Increase tempo of new buoy testing activities from 54 activities with 510 buoys, to 59 activities with 561 buoys.
- Increase tempo of flare testing activities from 10 events with 600 flares, to 11 events with 660 flares per year.

Table 2.8-1: Baseline and Proposed Training Activities

Range Activity	Location	No Action Alternative		Alternative 1		Alternative 2	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Anti-Air Warfare							
Air Combat Maneuver (ACM)	Offshore Area (W-237)	160	None	550	None	550	None
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	Offshore Area (W-237)	24	30 (AIM-7/9/120) 15 HE warheads	24	30 (AIM-7/9/120) 15 HE warheads	24	30 (AIM-7/9/120) 15 HE warheads
Gunnery Exercise (Surface-to-Air) (GUNEX [S-A])	Offshore Area (W-237)	160	310 large-caliber rounds (230 HE) 16,000 medium-caliber rounds (6,320 HE)	160	310 large-caliber rounds (230 HE) 16,000 medium-caliber rounds (6,320 HE)	160	310 large-caliber rounds (230 HE) 16,000 medium-caliber rounds (6,320 HE)
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	Offshore Area (W-237)	4	8 HE warheads	4	8 HE warheads	4	8 HE warheads
Anti-Surface Warfare (ASUW)							
Gunnery Exercise (Surface-to-Surface) – Ship (GUNEX [S-S] – Ship)	Offshore Area	180	117,000 small-caliber rounds 32,760 medium-caliber rounds (48 HE) 2,880 large-caliber rounds (160 HE)	200	121,200 small-caliber rounds 33,670 medium-caliber rounds (178 HE) 2,880 large-caliber rounds (160 HE)	200	121,200 small-caliber rounds 33,670 medium-caliber rounds (178 HE) 2,880 large-caliber rounds (160 HE)
Gunnery Exercise (Surface-to-Surface) – Boat (GUNEX [S-S] – Boat)	Inland Waters (Crescent Harbor)	0	None	4	1,500 small-caliber, all blanks	4	1,500 small-caliber, all blanks
Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Offshore Area (W-237)	2	All non-firing Captive Air Training Missiles	4	4 HE Missiles	4	4 HE Missiles
Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Offshore Area (W-237)	30	10 HE Bombs 110 NEPM Bombs	30	10 HE Bombs 110 NEPM Bombs	30	10 HE Bombs 110 NEPM Bombs

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	Location	No Action Alternative		Alternative 1		Alternative 2	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Anti-Surface Warfare (ASUW) (continued)							
Sinking Exercise (SINKEX)	Offshore Area	2	24 HE Bombs 22 HE Missiles 80 HE large-caliber rounds 2 MK-48 HE	0	None	0	None
Anti-Submarine Warfare (ASW)							
Tracking Exercise – Submarine (TRACKEX – Sub)	Offshore Area	100	None	100	None	100	None
Tracking Exercise – Surface (TRACKEX – Surface)	Offshore Area	65	None	65	None	65	None
Tracking Exercise – Helicopter (TRACKEX – Helo)	Offshore Area	0	None	4	None	4	None
Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – MPA)	Offshore Area	210	None	300	None	300	None
Tracking Exercise – Maritime Patrol (Extended Echo Ranging Sonobuoys)	Offshore Area	54	150 IEER or SSQ-125 sonobuoys	17	150 IEER and 20 SSQ-125 sonobuoys	17	150 IEER and 20 SSQ-125 sonobuoys
Electronic Warfare (EW)							
Electronic Warfare Operations (EW OPS)	Offshore Area	2,900 (aircraft) 275 (ship)	None	5,000 (aircraft) 275 (ship)	None	5,000 (aircraft) 275 (ship)	None

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	Location	No Action Alternative		Alternative 1		Alternative 2	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Mine Warfare (MIW)							
Mine Neutralization – Explosive Ordnance Disposal (EOD)	Crescent Harbor EOD Training Range	2	two 2.5 lb. charges	3	three 2.5 lb. charges	3	three 2.5 lb. charges
				3	18 SWAG	3	18 SWAG
	Hood Canal EOD Training Range	2	two 1.5 lb. charges	3	three 2.5 lb. charges	3	three 2.5 lb. charges
				3	18 SWAG	3	18 SWAG
Submarine Mine Exercise	Offshore Area	0	None	8	None	8	None
Civilian Port Defense	Inland Waters	0	n/a	Every other year (three in 5 years)	None	1	None
Naval Special Warfare (NSW)							
Personnel Insertion/Extraction – Submersible	Inland Waters	35	None	35	None	35	None
Personnel Insertion/Extraction – Non-Submersible	Inland Waters (Crescent Harbor)	120	None	120	None	120	None
Other							
Precision Anchoring	Inland Waters (Naval Station Everett, Indian Island)	Not Previously Analyzed	None	10	None	10	None
Small Boat Attack	Naval Station Everett NAVBASE Kitsap Bangor NAVBASE Kitsap Bremerton	0	None	1	3,000 small-caliber rounds (all blanks)	1	3,000 small-caliber rounds (all blanks)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	Location	No Action Alternative		Alternative 1		Alternative 2	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Other (continued)							
Intelligence, Surveillance, Reconnaissance (ISR)	Offshore Area	100	None	200	None	200	None
Search and Rescue	Crescent Harbor, Navy 7 Olympic MOA	180	None	180	None	180	None
Surface Ship Sonar Maintenance	NAVBASE Kitsap Bremerton, Naval Station Everett, and Offshore Area	0	None	13	None	13	None
Submarine Sonar Maintenance	NAVBASE Kitsap Bangor, NAVBASE Kitsap Bremerton, and Offshore Area	0	None	22	None	22	None

Notes: HE = High Explosive, IEER = Improved Extended Echo Ranging, lb. = pound(s), MOA = Military Operations Area, NAVBASE = Naval Base, NEPM = Non-explosive Practice Munition, SWAG = Shock Wave Action Generator, W-237 = Warning Area 237

Table 2.8-2: Baseline and Proposed Naval Sea Systems Command Testing Activities

Range Activity		Location	No Action Alternative		Alternative 1		Alternative 2	
			No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Naval Undersea Warfare Center, Keyport Testing Activities								
Torpedo Testing	Torpedo Non-Explosive Testing	Offshore Area (QRS)	16	96 NEPM torpedoes	20	102 NEPM torpedoes	24	106 NEPM torpedoes
		Inland Waters (DBRC Site)	38	180 NEPM torpedoes	41	189 NEPM torpedoes	44	198 NEPM torpedoes
Autonomous and Non-Autonomous Vehicles	Unmanned Underwater Vehicle Testing	Inland Waters (DBRC Site, Keyport Range Site)	140	128 NEPM torpedoes	151	135 NEPM torpedoes	161	141 NEPM torpedoes
	Unmanned Aircraft System	Offshore Area (QRS)	2	None	20	None	25	None
		Inland Waters (DBRC Site)	2	None	20	None	25	None
	Unmanned Surface Vehicle	Offshore Area (QRS)	2	None	20	None	25	None
		Inland Waters (DBRC Site, Keyport Range Site)	2	None	20	None	25	None
Fleet Training/Support	Cold Water Training	Offshore Area (QRS)	15	None	20	None	25	None
		Inland Waters (DBRC Site, Keyport Range Site)	50	None	65	None	75	None
	Post-Refit Sea Trial	Inland Waters (DBRC Site)	30	None	32	None	33	None
	Anti-Submarine Warfare (ASW) Testing	Offshore Area (QRS)	4	None	5	None	6	None

Table 2.8-2: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity		Location	No Action Alternative		Alternative 1		Alternative 2	
			No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Naval Undersea Warfare Center, Keyport Testing Activities (continued)								
Maintenance and Miscellaneous	Side Scan/Multibeam Sonar	Inland Waters (DBRC Site, Keyport Range Site)	50	None	54	None	56	None
	Non-Acoustic Tests	Offshore Area (QRS)	5	None	6	None	7	None
		Inland Waters (DBRC Site, Keyport Range Site)	70	None	74	None	78	None
Acoustic Component Test	Countermeasures Testing	Offshore Area (QRS)	5	None	6	None	7	None
		Inland Waters (DBRC Site, Keyport Range Site)	55	None	61	None	67	None
	Acoustic Test Facility	Inland Waters (DBRC Site, Keyport Range Site)	160	None	176	None	192	None
	Pierside Integrated Swimmer Defense	Inland Waters (DBRC Site, Keyport Range Site)	36	None	38	None	40	None

Table 2.8-2: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity		Location	No Action Alternative		Alternative 1		Alternative 2	
			No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Naval Surface Warfare Center, Carderock Division Detachment Puget Sound								
System, Subsystem and Component Testing	Pierside Acoustic Testing	Inland Waters NAVBASE Kitsap Bangor	Not Previously Analyzed	None	60	None	68	None
	Performance Testing At Sea	Inland Waters (DBRC Site, Carr Inlet)	Not Previously Analyzed	None	60	None	66	None
	Development Training and Testing	Inland Waters (DBRC Site, Carr Inlet)	Not Previously Analyzed	None	36	None	40	None
Proof of Concept Testing		Inland Waters (DBRC Site, Carr Inlet)	Not Previously Analyzed	n/a	30	None	34	None
Naval Surface Warfare Center, Carderock Division, Southeast Alaska Acoustic Measurement Facility								
Surface Vessel Acoustic Measurement		Western Behm Canal, AK	7	None	12	None	16	None
Underwater Vessel Acoustic Measurement		Western Behm Canal, AK	17	None	26	None	32	None
Underwater Vessel Hydrodynamic Performance Measurement		Western Behm Canal, AK	2	None	3	None	5	None
Cold Water Training		Western Behm Canal, AK	0	None	1	None	2	None
Component System Testing		Western Behm Canal, AK	1	None	4	None	6	None
Countermeasures Testing		Western Behm Canal, AK	0	None	4	None	6	None
Electromagnetic Measurement		Western Behm Canal, AK	0	None	5	None	6	None

Table 2.8-2: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity		Location	No Action Alternative		Alternative 1		Alternative 2	
			No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Naval Surface Warfare Center, Carderock Division, Southeast Alaska Acoustic Measurement Facility (continued)								
Measurement System Repair & Replacement		Western Behm Canal, AK	1	None	1	None	2	None
Project Operations (POPS)		Western Behm Canal, AK	0	None	3	None	6	None
Target Strength Trial		Western Behm Canal, AK	0	None	1	None	2	None
Additional Naval Sea Systems Command Testing Activities								
Life Cycle Activities	Pierside Sonar Testing	Inland Waters (Naval Station Everett, NAVBASE Kitsap Bangor, NAVBASE Kitsap Bremerton)	Not Previously Analyzed	n/a	67	None	76	None
Shipboard Protection Systems and Swimmer Defense Testing	Pierside Integrated Swimmer Defense	Inland Waters (Keyport Range Site)	Not Previously Analyzed	n/a	1	None	2	None
Unmanned Vehicle Testing	Unmanned Vehicle Development and Payload Testing	Inland Waters (DBRC Site, Keyport Range Site)	0	None	4	None	6	None

Table 2.8-2: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity		Location	No Action Alternative		Alternative 1		Alternative 2	
			No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Additional Naval Sea Systems Command Testing Activities (continued)								
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing	Torpedo (Explosive) Testing	Offshore Area	0	None	3	6 HE torpedoes 6 NEPM torpedoes	4	8 HE torpedoes 8 NEPM torpedoes
	Torpedo (Non-explosive) Testing	Offshore Area	0	None	3	18 NEPM torpedoes	4	24 NEPM torpedoes
	Countermeasure Testing	Inland Waters (DBRC Range Site, Pierside Naval Station Everett	0	None	13	81 NEPM torpedoes	20	89 NEPM torpedoes
		Offshore Area (QRS)	0	None	8	123 NEPM torpedoes	12	181 NEPM torpedoes
New Ship Construction	ASW Mission Package Testing	Offshore Area	0	None	8	None	9	None

Notes: DBRC = Dabob Bay Range Complex, HE = High Explosive, NAVBASE = Naval Base, NEPM = Non-explosive Practice Munition, QRS = Quinault Range Site

Table 2.8-3: Baseline and Proposed Naval Air Systems Command Testing Activities

Range Activity	Location	No Action Alternative		Alternative 1		Alternative 2	
		No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)	No. of events (per year)	Ordnance (Number per year)
Anti-Submarine Warfare (ASW)							
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (DICASS)	Offshore Area	0	None	28	170 DICASS sonobuoys	31	187 DICASS sonobuoys
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (MAC)	Offshore Area	0	None	14	170 MAC sonobuoys	15	187 MAC sonobuoys
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (SUS)	Offshore Area	0	None	5	72 Impulse SUS buoys (e.g., MK-61, MK-64, MK-82) 12 Non-impulse SUS buoys (e.g., MK-84)	5	79 Impulse SUS buoys (e.g., MK-61, MK-64, MK-82) 13 Non-impulse SUS buoys (e.g., MK-84)
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (IEER)	Offshore Area	0	None	6	70 IEER sonobuoy detonations	7	77 IEER sonobuoy detonations
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (HDC)	Offshore Area	0	None	1	16 HDC sonobuoys	1	18 HDC sonobuoys
Electronic Warfare (EW)							
Flare Test	Offshore Area	0	None	10	600 flares	11	660 flares

Notes: All of the following are types of sonobuoys to be tested: DICASS = Directional Command Activated Sonobuoy System; HDC = High Duty Cycle; IEER = Improved Extended Echo Ranging; MAC = Multi Static Active Coherent; n/a = Not Applicable; SUS = Signal, Underwater Sound (e.g., MK-61, MK-64, MK-82, and MK-84)

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3 General Approach to Analysis

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3 GENERAL APPROACH TO ANALYSIS

3.0 INTRODUCTION

This chapter describes existing environmental conditions in the Northwest Training and Testing (NWTT) Study Area (Study Area) and analyzes impacts on resources from the Proposed Action, described in Chapter 2 (Description of Proposed Action and Alternatives). The Study Area is described in Section 2.1 (Description of the Northwest Training and Testing Study Area) and depicted in Figure 2.1-1. Because of the size of the Study Area and the broad range of United States (U.S.) Department of the Navy (Navy) training and testing activities in the Proposed Action (Tables 2.8-1 through 2.8-3), this chapter is very lengthy. Therefore, Section 3.0 addresses issues that apply to many or all of the resources. The resource sections (Sections 3.1 through 3.13) refer back to subsections in Section 3.0 for the general information contained herein.

Section 3.0.1 (Regulatory Framework) presents the regulatory framework on which this Environmental Impact Statement (EIS)/Overseas EIS (OEIS) is based. It briefly describes each law, executive order, and directive used to develop the analysis. Other laws and regulations that may apply to this EIS/OEIS, but that were not specifically used in the analysis, are listed in Chapter 6 (Additional Regulatory Considerations). Section 3.0.2 (Data Sources and Best Available Data) lists the sources of data used in the analysis. Many of the terms used throughout this chapter have specific meanings for this context and are defined in the Glossary at the front of the EIS/OEIS.

The Study Area covers a broad range of ecosystems where Navy training and testing is proposed, so Section 3.0.3 (Ecological Characterization of the Northwest Training and Testing Study Area) describes areas known as large marine ecosystems and open ocean areas. This section presents information on ocean bathymetry, which has general applicability to the resources analyzed.

One of the major issues addressed in this EIS/OEIS is the effects of sound in the water on biological resources. The topic of sound in the water can be very complicated to the general reader, so Section 3.0.4 (Introduction to Acoustics) presents a primer on sound in water and in air. The primer explains how sound propagates through air and water; defines terms used in the analysis; and describes the physical properties of sound, metrics used to characterize sound exposure, and frequencies of sound produced during Navy training and testing activities.

Section 3.0.5 (Overall Approach to Analysis) describes a general approach to the analysis. It identifies the resources considered for the analysis, as well as those resources eliminated from further consideration. Each Navy training and testing activity was examined to determine how it could stress each environmental resource; these stressors were grouped into categories for ease of presentation, and the stressor categories are associated with training and testing activities. A detailed description of each stressor category is contained in Section 3.0.5.3 (Identification of Stressors for Analysis). Descriptions of stressors that apply to only one resource are found in the associated resource section.

The sections following 3.0 analyze each resource independently. The physical resources (sediments and water quality, and air quality) are presented first (Sections 3.1 and 3.2, respectively). Any potential impacts on these resources were considered as potential secondary stressors on the remaining resources to be described: marine habitats, marine mammals, sea turtles, birds, marine vegetation, marine invertebrates, and fish (Sections 3.3 through 3.9). Following the biological resource sections are human resource sections: cultural, Native American and Alaska Native traditional resources, socioeconomics, and public health and safety (Sections 3.10 through 3.13).

3.0.1 REGULATORY FRAMEWORK

In accordance with the Council on Environmental Quality (CEQ) regulations for implementing the requirements of the National Environmental Policy Act (NEPA), other planning and environmental review procedures are integrated to the fullest extent possible. This section provides a brief overview of the primary federal statutes (3.0.1.1), executive orders (3.0.1.2), and guidance (3.0.1.3) that form the regulatory framework for the resource evaluations. This section also describes how each applies to the analysis of environmental consequences. Chapter 6 (Additional Regulatory Considerations) provides a summary listing and status of compliance with the applicable environmental laws, regulations, and executive orders that were considered in preparing this EIS/OEIS (including those that may be secondary considerations in the resource evaluations). More detailed information on the regulatory framework, including other statutes not listed here, may be presented as necessary in each resource section. More detailed discussions of selected regulations are included below to provide insight into the criteria used in the analyses.

3.0.1.1 Federal Statutes

This section provides a brief overview of the primary federal statutes that form the regulatory framework for the resource evaluations. This section also describes how each applies to the analysis of environmental consequences.

Abandoned Shipwreck Act

The 1997 Abandoned Shipwreck Act (43 United States Code [U.S.C.] §§ 2101–2106) asserts the federal government's title to any abandoned shipwreck that meets criteria for inclusion in the National Register of Historic Places. Abandoned shipwreck means any shipwreck to which title has voluntarily been given up by the owner with the intent of never claiming a right or interest in the vessel in the future and without vesting ownership in any other person. Such shipwrecks ordinarily are treated as being abandoned after 30 days from the sinking. States manage the wrecks and allow public access to the sites while preserving the historical and environmental integrity of the site for scientific investigation.

Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act (16 U.S.C. § 668–668(d)), enacted in 1940, and amended several times since then, prohibits anyone, without a permit issued by the Secretary of the Interior, from "taking" bald eagles, including their parts, nests, or eggs. The Act provides criminal penalties for persons who "take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any bald eagle ... [or any golden eagle], alive or dead, or any part, nest, or egg thereof." The Act defines "take" as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb."

Clean Air Act

The purpose of the Clean Air Act (42 U.S.C. § 7401 et seq.) is to protect and enhance the quality of the nation’s air resources to promote the public health and welfare and the productive capacity of its population. To fulfill the act’s purpose, federal agencies classify air basins according to their attainment status under the National Ambient Air Quality Standards (40 Code of Federal Regulations [C.F.R.] Part 50) and regulate emissions of criteria pollutants and air toxins to protect the public health and welfare. Non-criteria air pollutants that can affect human health are categorized as hazardous air pollutants under Section 112 of the Clean Air Act. The U.S. Environmental Protection Agency (USEPA) identified 188 hazardous air pollutants such as benzene, perchloroethylene, and methylene chloride.
Section 176(c)(1) of the Clean Air Act, commonly known as the General Conformity Rule, requires

federal agencies to ensure that their actions conform to applicable implementation plans for achieving and maintaining the National Ambient Air Quality Standards for criteria pollutants.

Clean Water Act

The Clean Water Act (33 U.S.C. § 1251 et seq.) regulates discharges of pollutants in surface waters of the United States. Section 403 of the Clean Water Act provides for the protection of ocean waters (waters of the territorial seas, the contiguous zone, and the high seas beyond the contiguous zone) from point-source discharges. Under Section 403(a), the USEPA or an authorized state agency may issue a permit for an ocean discharge only if the discharge complies with Clean Water Act guidelines for protection of marine waters. For this NWTT EIS/OEIS, discharges incidental to the normal operation of Navy ships are not part of the Proposed Action and were not included in the analysis.

Endangered Species Act

The Endangered Species Act (ESA) of 1973 (16 U.S.C. § 1531 et seq.) established protection over and conservation of threatened and endangered species and the ecosystems upon which they depend. An “endangered” species is a species in danger of extinction throughout all or a significant portion of its range. A “threatened” species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) jointly administer the ESA and are also responsible for the listing of species (designating a species as either threatened or endangered). The ESA allows the designation of geographic areas as critical habitat for threatened or endangered species. Section 7(a)(2) requires each federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action “may affect” a listed species, that agency is required to consult with NMFS or USFWS, depending on which Service has jurisdiction over the species (50 C.F.R. § 402.14(a)).

Magnuson-Stevens Fishery Conservation and Management Act and Sustainable Fisheries Act

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. § 1801 et seq.) enacted in 1976 and amended by the Sustainable Fisheries Act in 1996, mandates identification and conservation of essential fish habitat. Essential fish habitat is defined as those waters and substrates necessary (required to support a sustainable fishery and the federally managed species) to fish for spawning, breeding, feeding, or growth to maturity (i.e., full life cycle). These waters include aquatic areas and their associated physical, chemical, and biological properties used by fish, and may include areas historically used by fish. Substrate types include sediment, hard bottom, structures underlying the waters, and associated biological communities. Federal agencies are required to consult with NMFS and to prepare an essential fish habitat assessment if potential adverse effects on essential fish habitat are anticipated from their activities.

Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. § 1361 et seq.) established, with limited exceptions, a moratorium on the “taking” of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates “takes” of marine mammals in the global commons (that is, the high seas) by vessels or persons under U.S. jurisdiction. The term “take,” as defined in Section 3 (16 U.S.C. § 1362(13)) of the MMPA, means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.” “Harassment” was further defined in the 1994 amendments to the

MMPA, which provided two levels of harassment: Level A (potential injury) and Level B (potential behavioral disturbance).

The MMPA directs the Secretary of Commerce (Secretary) to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens or agencies who engage in a specified activity (other than commercial fishing) within a specified geographical region if NMFS finds that the taking will have a negligible impact on the species or stock(s), and will not have an unmitigatable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the mitigation, monitoring, and reporting of such taking.

The National Defense Authorization Act of Fiscal Year 2004 (Public Law 108-136) amended the definition of harassment, removed the “specified geographic area” requirement, and removed the small numbers provision as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government consistent with Section 104(c)(3) (16 U.S.C. § 1374(c)(3)). The Fiscal Year 2004 National Defense Authorization Act adopted the definition of “military readiness activity” as set forth in the Fiscal Year 2003 National Defense Authorization Act (Public Law 107-314). A “military readiness activity” is defined as “all training and operations of the Armed Forces that relate to combat” and “the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use.” For military readiness activities, the relevant definition of harassment is any act that:

- injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild (“Level A harassment”) or
- disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered (“Level B harassment”) (16 U.S.C. § 1362(18)(B)(i) and (ii)).

The Navy has prepared a consolidated request for two five-year Letters of Authorization; one for the incidental taking of marine mammals during the conduct of training and another for the incidental taking of marine mammals during the conduct of testing activities within the NWTT Study Area from 2015 through 2020. This EIS/OEIS has been prepared in accordance with the applicable regulations of the MMPA and ESA and will evaluate all components of the proposed training and testing activities that have the potential to incidentally take marine mammals or may affect ESA-listed species or critical habitat.

Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 (16 U.S.C. § 703 et seq.) and the Migratory Bird Conservation Act (16 U.S.C. §§ 715–715d, 715e, 715f–715r) of 18 February 1929, are the primary laws in the United States established to conserve migratory birds. The Migratory Bird Treaty Act prohibits the taking, killing, or possessing of migratory birds or the parts, nests, or eggs of such birds, unless permitted by regulation.

The 2003 National Defense Authorization Act provides that the Armed Forces may take migratory birds incidental to military readiness activities provided that, for those ongoing or proposed activities that the Armed Forces determine may result in a significant adverse effect on a population of a migratory bird species, the Armed Forces confers and cooperates with the Service to develop and implement appropriate conservation measures to minimize or mitigate such significant adverse effects (50 C.F.R. § 21.15).

National Environmental Policy Act

The Navy prepared this EIS/OEIS in accordance with the President's CEQ regulations implementing NEPA (40 C.F.R. §§ 1500–1508). NEPA (42 U.S.C. §§ 4321–4347) requires federal agencies to prepare an EIS for a proposed action with the potential to significantly affect the quality of the human environment, disclose significant environmental impacts, inform decision makers and the public of the reasonable alternatives to the proposed action, and consider comments to the EIS. Based on Presidential Proclamation 5928, issued 27 December 1988, impacts on oceans areas that lie within 12 nautical miles (nm) of land (U.S. territory) are subject to analysis under NEPA.

National Historic Preservation Act

The National Historic Preservation Act (NHPA) of 1966 (16 U.S.C. § 470 et seq.) establishes preservation as a national policy and directs the federal government to provide leadership in preserving, restoring, and maintaining the historic and cultural environment. Section 106 of the NHPA requires federal agencies to take into account the effects of their undertakings on historic properties, and affords the Advisory Council on Historic Preservation a reasonable opportunity to comment. The National Historic Preservation Act created the National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices to help protect each state's historical and archaeological resources. Section 110 of the National Historic Preservation Act requires federal agencies to assume responsibility for the preservation of historic properties owned or controlled by them; to identify, evaluate, and nominate all properties that qualify for the National Register; and to protect historic properties. The NHPA applies to cultural resources evaluated in this EIS/OEIS.

3.0.1.2 Executive Orders

Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*

This OEIS has been prepared in accordance with Executive Order (EO) 12114 (44 Federal Register [FR] 1957) and Navy implementing regulations in 32 C.F.R. Part 187, *Environmental Effects Abroad of Major Department of Defense Actions*. An OEIS is required when a proposed action and alternatives have the potential to significantly harm the environment of the global commons. The global commons are defined as geographical areas outside the jurisdiction of any nation and include the oceans outside of the territorial limits (more than 12 nm from the coast) and Antarctica but do not include contiguous zones and fisheries zones of foreign nations (32 C.F.R. § 187.3). As used in EO 12114, "environment" means the natural and physical environment and excludes social, economic, and other environments. The EIS and OEIS have been combined into one document, as permitted under NEPA and EO 12114, to reduce duplication.

Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments*

EO 13175 (77 FR 71479) was signed on 6 November 2000 and applies to new agency regulations with Tribal Implications. Tribal Implications are defined as having substantial direct effects on one or more Indian tribes, on the relationship between the federal government and Indian tribes, or on the distribution of power and responsibilities between the federal government and Indian tribes. Agencies were also directed not to enact regulations that would place a financial burden on tribal governments unless the federal government would pay for those costs, or unless the tribal government has at least had an opportunity to demonstrate the estimated financial burden with a report if the federal government does not provide the funding. Federal agencies were also directed not to establish new rules that would preempt tribal law unless the tribal government had been given an opportunity to be consulted early in the rulemaking process and also had an opportunity to file an impact statement on how the proposed regulation would preempt tribal law.

Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*

EO 13514 (74 FR 52117) was signed in October 2009 to establish an integrated strategy toward sustainability in the federal government and to make reduction of greenhouse gas emissions a priority for federal agencies. The Department of Defense (DoD) developed a Strategic Sustainability Performance Plan that identifies performance-based goals and subgoals, provides a method to meet the goals (including investment strategies), and outlines a plan for reporting on performance. The Strategic Sustainability Performance Plan is included in the analyses in this EIS/OEIS.

Executive Order 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*

EO 13547 (75 FR 43023) was issued in 2010. It is a comprehensive national policy for the stewardship of the ocean, our coasts, and the Great Lakes. This order adopts the recommendations of the Interagency Ocean Policy Task Force and directs executive agencies to implement the recommendations under the guidance of a National Ocean Council. This order establishes a national policy to

- ensure the protection, maintenance, and restoration of the health of ocean, coastal, and Great Lakes ecosystems and resources;
- enhance the sustainability of ocean and coastal economies, preserve our maritime heritage,
- support sustainable uses and access;
- provide for adaptive management to enhance our understanding of and capacity to respond to climate change and ocean acidification; and
- coordinate with our national security and foreign policy interests.

3.0.1.3 Guidance

Department of Defense and Navy Directives and Instructions

Several military communications are included in this EIS/OEIS that establish policy or a plan to govern an action, conduct, or procedure. For example, DoD Directive 4540.1, *Use of Airspace by U.S. Military Aircraft and Firings over the High Seas*, specifies procedures for conducting aircraft maneuvers and for firing missiles and projectiles. Each range complex and test range has its own manual; however, many of the components are similar.

3.0.2 DATA SOURCES AND BEST AVAILABLE DATA

The Navy used the best available data and information to compile the environmental baseline and environmental consequences evaluated in Chapter 3. In accordance with NEPA, the Administrative Procedure Act of 1946 (5 U.S.C. §§ 551–559), and EO 12114, best available data accepted by the appropriate regulatory and scientific communities were used in the analyses of potential impacts on resources.

Literature searches of journals, books, periodicals, bulletins, and other technical reports were conducted in preparation of this EIS/OEIS. Searches included general queries in the resource areas evaluated to document the environmental baseline and specific queries to support analysis of environmental consequences. A wide range of primary literature was used in preparing this EIS/OEIS from federal agencies such as NMFS, the USEPA, international organizations including the United Nations Educational Scientific and Cultural Organization, state agencies, and nonprofit and non-governmental organizations.

Internet searches were conducted, and websites were evaluated for credibility of the source, quality of the information, and relevance of the content to ensure use of the best available information in this document.

3.0.2.1 Geographical Information Systems Data

Table 3.0-1 lists sources of non-Navy Geographical Information System data used in Chapter 3 figures.

Table 3.0-1: Sources of Non-Navy Geographic Information System Data Used to Generate Figures in Chapter 3

Feature/Layer	Applicable Figures	Data Source References
Bathymetry and Ocean Base Map	3.0-1, 3.0-2, 3.0-3, 3.0-4	General Bathymetric Chart of the Oceans 2010
Sea Surface Temperature	3.0-4	Sea Surface Temperature from NASA 2011
National Register of Historic Places Eligible or Listed Resources/Sovereign Immunity, Shipwrecks	3.10-1, 3.10-2, 3.10-3, 3.10-4, 3.10-5	National Oceanographic and Atmospheric Administration’s Automated Wreck and Obstruction Information System 2002; Google Earth 2010
Navigable Waterways	3.11-1	Research and Innovative Technology Administration's Bureau of Transportation Statistics 2007

3.0.2.2 Navy Integrated Comprehensive Monitoring Program

Since 2006, the Navy, as well as non-Navy marine mammal scientists and research institutions, has conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where the Navy has been training and testing and where it proposes to continue these activities. Data collected from Navy monitoring, scientific research findings, and annual reports provided to NMFS may inform the analysis of impacts on marine mammals for a variety of reasons, including species distribution, habitat use, and evaluation of potential responses to Navy activities. Monitoring is performed using various methods, including visual surveys from surface vessels and aircraft and passive acoustics. Navy monitoring can generally be divided into two types of efforts: (1) collecting long-term data on distribution, abundance, and habitat use patterns within Navy activity areas; and (2) collecting data during individual training or testing activities. Monitoring efforts during anti-submarine warfare and explosive events focus on observing individual animals in the vicinity of the event and documenting behavior and any observable responses. Although these monitoring events are very localized and short term, over time they will provide valuable information to support the impact analysis.

Most of the training and testing activities the Navy is proposing for the next 5 years are similar if not identical to activities that have been occurring in the same locations for decades. For example, the mid-frequency anti-submarine warfare sonar system on the cruisers, destroyers, and frigates has the same sonar system components in the water as those first deployed in the 1970s. While the signal analysis and computing processes onboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed. Therefore, the history of past marine mammal observations, research, and monitoring reports remain applicable to the analysis of effects from the proposed future training and testing activities.

3.0.2.2.1 Relevant Data From the Northwest Training and Testing Study Area

In the NWTT Study Area, there have been no Major Training Events and training and testing events are small in scope. For the NWTT Study Area, there have been three annual exercise reports and three monitoring reports (see U.S. Department of the Navy 2011a, 2011b, 2012a, 2012b, 2013a, 2013b, 2013c) submitted to NMFS since issuance of the current (2010) authorization under the MMPA. Research undertaken and completed by Navy in the Pacific Northwest includes the following:

- Deployment of autonomous passive acoustic monitoring buoys (High-frequency Acoustic Recording Package)
- Analysis of 10,617 hours of passive acoustic data
- Deployment of satellite tracking tags on fin and humpback whales off the Washington coast by Cascadia Research Collective in cooperation with Washington Department of Fish and Wildlife
- Tagging of gray whales off Oregon and Northern California by researchers at Oregon State University (beginning in 2013)
- Surveys of pinniped at Puget Sound Navy installations (Everett, Bangor, Bremerton)
- Marine mammal small boat line transect surveys in Hood Canal and Dabob Bay
- Aerial pinniped haul-out surveys (beginning in 2013)
- Monitoring of Explosive Ordinance Demolition/Underwater Detonation training

Based on this research; monitoring before, during, and after training and testing events since 2006; and the reports that have been submitted to and reviewed by NMFS, the Navy's assessment is that it is unlikely there will be impacts to populations of marine mammals having any long-term consequences as a result of the proposed continuation of training and testing in the ocean areas historically used by the Navy.

This assessment of likelihood is based on four indicators from areas in the Pacific where Navy training and testing has been ongoing for decades: (1) evidence suggesting or documenting increases in the numbers of marine mammals present, (2) examples of documented presence and site fidelity of species and long-term residence by individual animals of some species, (3) use of training and testing areas for breeding and nursing activities, and (4) 6 years of comprehensive monitoring data indicating a lack of any observable effects to marine mammal populations as a result of Navy training and testing activities.[1]

3.0.2.3 Marine Species Density Database

A quantitative analysis of impacts on a species requires data on the abundance and concentration of the species population in the potentially impacted area. The most appropriate metric for this type of analysis is density, which is the number of animals present per unit area.

Estimating marine species density requires significant effort to collect and analyze data to produce a usable estimate. NMFS is the primary agency responsible for estimating marine mammal and sea turtle density within the U.S. Exclusive Economic Zone. Other independent researchers often publish density data for key species in specific areas of interest. For example, pinniped abundance data in the Northwest is gathered by the Washington Department of Fish and Wildlife. Within most of the world's oceans, although some survey effort may have been completed, the required amount of surveys has not been conducted to allow density estimation. To approximate distribution and abundance of species for areas or seasons that have not been surveyed, the Habitat Suitability Index or Relative Environmental Suitability model is used to estimate occurrence based on modeled relationships of where the animals are sighted and the associated environmental variables (i.e., depth, sea surface temperature, etc.).

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[1] Monitoring of Navy activities began in July 2006 as a requirement under issuance of an Incidental Harassment Authorization by NMFS for the Rim of the Pacific exercise and has continued to the present for training events in the HRC and SOCAL as well as other monitoring as part of the coordinated efforts under the Navy's ICMP developed in coordination with NMFS and others.

There is no single source of density data for every area of the world, species, and season because of the fiscal costs, resources, and effort involved in providing survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the Study Area, the Navy compiled data from several sources. To compile and structure the most appropriate database of marine species density data, the Navy developed a protocol to select the best available data sources based on species, area, and time (season). Refer to the NWTT EIS web site (https://nwtteis.com) for a technical report (U.S. Department of the Navy 2014) describing in detail the process the Navy used to create the marine species density database. The resulting Geographic Information System database includes seasonal density estimates for every marine mammal and sea turtle species present within the Study Area.

3.0.3 ECOLOGICAL CHARACTERIZATION OF THE NORTHWEST TRAINING AND TESTING STUDY AREA

Navy activities in the marine environment predominately occur within established Navy use areas (Offshore Area, Inland Waters, and Western Behm Canal, Alaska), which include range complexes, test ranges, ports, and pierside locations.

This section provides a description of the bathymetry (water depth) of the Study Area. Given that the bathymetry of an area reflects the topography (surface features) of the seafloor, it is an important factor for understanding the potential impacts of Navy training and testing activities on the seafloor, the propagation of underwater sound, and species diversity. Table 3.0-2 provides a description of the bathymetry of Navy training and testing areas within each large marine ecosystem. Large marine ecosystems are “relatively large areas of ocean space of approximately 200,000 square kilometers (km^2) or greater, adjacent to the continents in coastal waters where primary productivity is generally higher than in open ocean areas” (National Oceanic Atmospheric Administration 2013).

Table 3.0-2: Summary of Bathymetric Features within the Large Marine Ecosystem of the Study Area

Range/Component	Description	General Bathymetry[1,2]
Offshore Area (California Current Large Marine Ecosystem)		
Pacific Northwest Ocean Surface/Subsurface OPAREA	Located from the Strait of Juan de Fuca to approximately 50 nm south of Eureka, California, and from the coast line of Washington, Oregon, and California westward to 130° west longitude.	Varying continental shelf width. Cascadia Abyssal Plain. Steep continental slope. Numerous seamounts, escarpments, canyons, and basins characterize the bathymetry of the OPAREA.
Quinault Range Site*	The Quinault Range site is collocated with W-237A and additionally has a shore surf zone of a mile at Pacific Beach Washington.	The continental shelf is narrow and ranges in width from 8 to 40 mi. (12.9 to 64.4 km). The Juan de Fuca and Quinault canyons reside within the shelf, and the continental slope has a steep upper portion and a gently sloping lower portion, grading into the Cascadia Basin.

Table 3.0-2: Summary of Bathymetric Features within the Large Marine Ecosystem of the Study Area (continued)

Range/Component	Description	General Bathymetry[1,2]
Inland Waters (Puget Sound)		
Keyport Range Site*	Located adjacent to the Naval Undersea Warfare Center Keyport.	Water depth at the Keyport Range Site is less than 100 ft. (30.5 m). This range provides approximately 3.2 nm^2 of shallow underwater testing area, and a shallow lagoon.
Dabob Bay Range Complex Site*	This site is located in Dabob Bay and the Hood Canal, as well as the connecting waters between the bay and the canal. The southern boundary extends to the Hamma Hamma River, and the northern boundary is 1 nm south of the Hood Canal Bridge (Highway 104).	Maximum depth in the Dabob Bay is 600 ft. (183 m). The deep water range in Dabob Bay is approximately 14.5 nm^2, and has hard walls with a mud bottom. The Hood Canal contains two deep-water operating areas with an average depth of 200 ft. (61 m). The portion of the Hood Canal that connects Dabob Bay with Hood Canal has a water depth of typically greater than 300 ft. (91.4 m). The total area of the Dabob Bay Range Complex Site is approximately 45.7 nm^2.
Carr Inlet OPAREA	Located in southern Puget Sound, the Carr Inlet OPAREA is an arm of water between Key Peninsula and Gig Harbor Peninsula. The southern end is connected to the southern basin of Puget Sound. Northward, it separates McNeil Island and Fox Island, as well as the peninsulas of Key and Gig Harbor.	The OPAREA is a deeper-water inland test site, approximately 12 nm^2 in size. The maximum depth of the OPAREA is 545 ft. (166 m).
Western Behm Canal, Alaska (Gulf of Alaska Large Marine Ecosystem)		
Southeast Alaska Acoustic Measurement Facility	Located in the Western Behm Canal near Ketchikan, Alaska and covers an area of 48 nm^2.	The canal is a deep (> 2,000 ft. [> 610 m] in some areas), protected fjord containing two moraines, the end moraine and lateral moraine.

* Naval Sea Systems Command Undersea Warfare Center Keyport Range Complex

[1] U.S. Department of the Navy 2010

[2] National Oceanic and Atmospheric Administration 2001. National Oceanic and Atmospheric Administration Nautical Charts were also reviewed to determine depth ranges at specific locations. Some “pierside activities” listed as taking place at these locations actually take place away from the coastal areas and are located inside ranges.

Notes: ° = degrees, ft. = feet, km = kilometers, m = meters, mi. = miles, MOA = Military Operations Area, nm^2 = square nautical miles, OPAREA = Operating Area

Source: U.S.Department of the Navy 2007, Naval Sea Systems Command Naval Undersea Warfare Center Keyport Range Complex Final Rule (76 FR 20257)

3.0.3.1 Bathymetry of the Offshore Area

Bathymetric features of the Offshore Area portion of the Study Area include the shoreline along the Washington coast, a continental shelf, a continental slope, a rise, and a deep seafloor (Figure 3.0-1). The Offshore Area is located where the edge of the North American continental plate meets and overrides the Juan de Fuca oceanic plate. The tectonic activities here, as well as periods of glaciations, erosion, and deposition, created the mountains, canyons, fjords, and coastal lowlands that are characteristic of the range complex (Melbourne and Webb 2003, McGregor and Offield 1986). The deepest basins were created in the North Puget Sound in and around the San Juan Islands, from past glaciation events. The

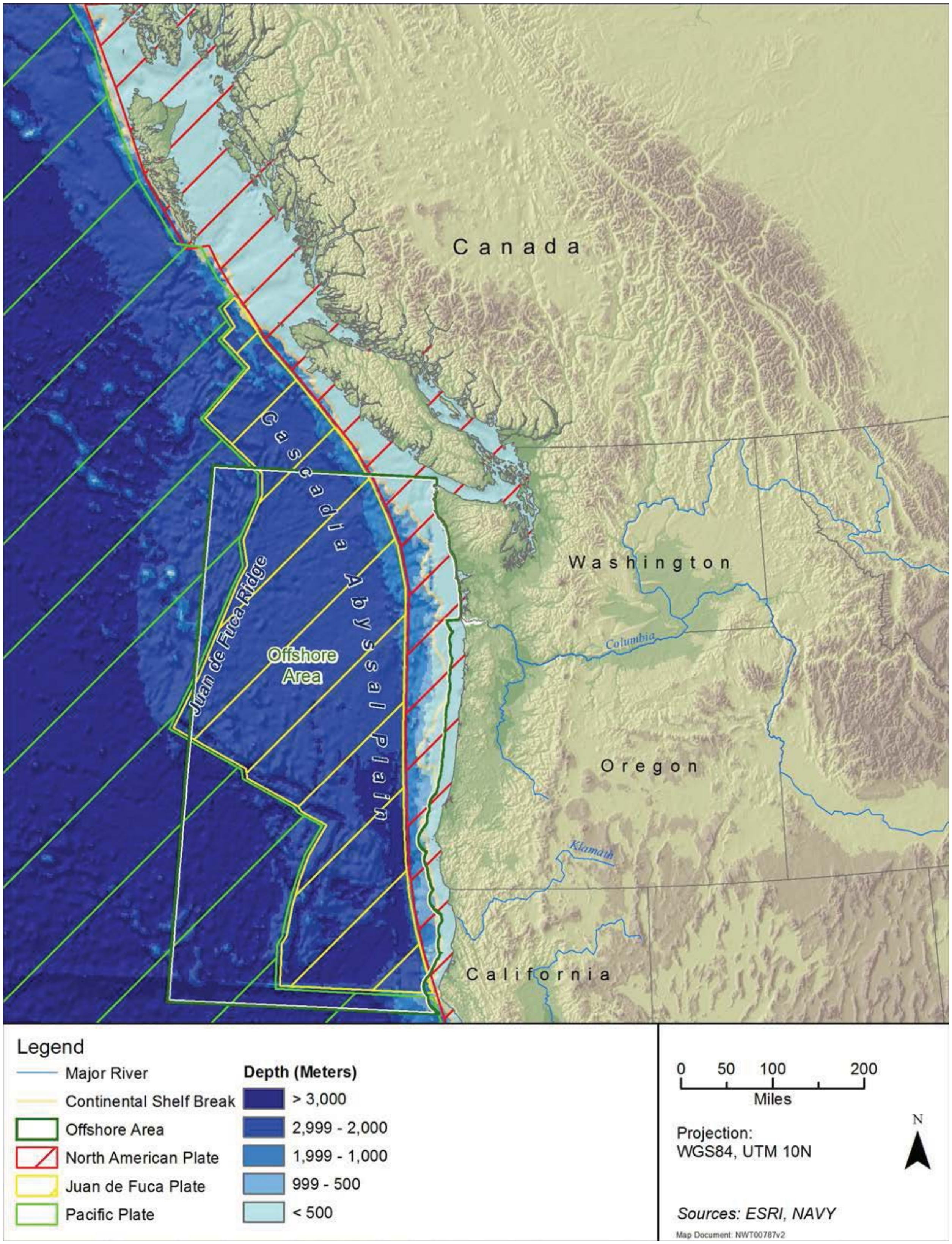

Figure 3.0-1: Bathymetry of the Offshore Area of the Northwest Training and Testing Study Area

tectonic activity around the continental margin of the Offshore Area has created a fairly narrow continental shelf, only about 15–50 miles (mi.) (24.1–80.5 kilometers [km]) wide. The shelf is widest along the Washington coast, and becomes narrower along Oregon and northern California. Water depths along the shelf are generally less than 650 feet (ft.) (198.1 meters [m]), and the bottom is mostly flat due to sediment accumulation (Shepard and Emery 1941, Strickland and Chasan 1989).

The Juan de Fuca Ridge and Gorda Ridge are where the floor of the Pacific Ocean is spreading apart and forming new ocean crust. The Juan de Fuca Ridge is approximately 300 mi. (483 km) long and rises from 1,300 to 3,300 ft. (400 to 1,000 m) above the surrounding abyssal plains (Kulm and Fowler 1974, Kulm et al. 1986, Porter et al. 2000). The Gorda Ridge is smaller and located south of the Juan de Fuca Ridge. They both have localized volcanic activity, lava flows, and hot springs that provide good conditions for deep-sea habitats (Fox and Dziak 1998). Seamounts are isolated mountains that rise from 3,000 to 10,000 ft. (914 to 3,048 m) above the surrounding ocean bottom. Seamounts are numerous in the Pacific Ocean and found dispersed throughout the Study Area.

The continental shelf along the Pacific Northwest Coast is cut by many deep submarine canyons oriented perpendicular to the shore (Strickland and Chasan 1989). Submarine canyons have steep walls, winding valleys, narrow V-shaped cross-sections, steps, and considerable irregularity along the sea floor (Kennett 1982, Thurman 1997). They represent the flooded remains of terrestrial canyons that were cut by large rivers. The floors of the submarine canyons are primarily mud with isolated sandy patches. Turbidity currents associated with submarine canyons transport sediment to the deep sea, forming sediment fans where they open to the abyssal plain (Thurman 1997).

The Cascadia Abyssal Plain off the Pacific Northwest Coast is a flat area of the deep ocean floor between the foot of a continental slope and the Juan de Fuca Ridge to the west. Depths are between 7,300 and 18,150 ft. (2,225 to 5,532 m). The plain is blanketed by fine grained sediments, mainly clay and silt.

3.0.3.2 Bathymetry of the Puget Sound

The Puget Sound (Figure 3.0-2) is just one half of a 17,000 km^2 ecosystem called the Salish Sea. Puget Sound is on the American side of the border, while the Salish Sea is on the Canadian side. For most of the Puget Sound area, seafloor features such as bedrock types (e.g., sedimentary, metamorphic, volcanic, and granitic rocks), structures (e.g., faults, folds, scours, and landslides), and bedforms of unconsolidated sediments are found throughout the inland basin. More detailed information about selected specific areas within the Puget Sound can be found in Table 3.0-3.

3.0.3.2.1 Bathymetry of the Western Behm Canal, Alaska

The Western Behm Canal is located about 13 air mi. north-northwest of Ketchikan, Alaska. The Behm Canal is a large, deep, protected fjord carved out of bedrock by glacial action (Figure 3.0-3). The western portion is about 60 mi. (96.6 km) in length and has a mean width of 3 mi. (4.83 km). Some areas of the fjord have depths exceeding 2,000 ft. (610 m). There are two types of moraines, an end moraine and a lateral moraine.

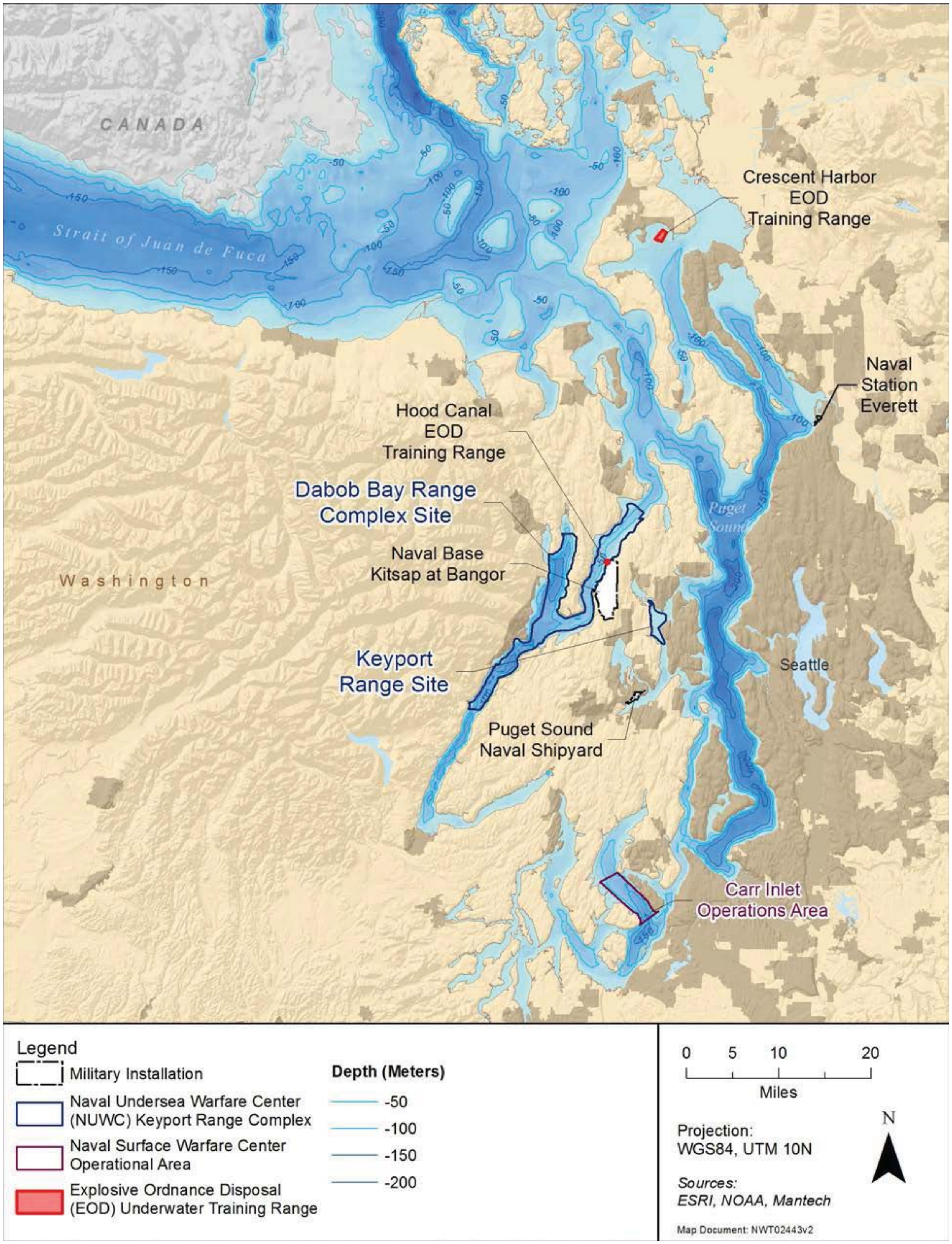

Figure 3.0-2: Bathymetry of the Puget Sound in the Northwest Training and Testing Study Area

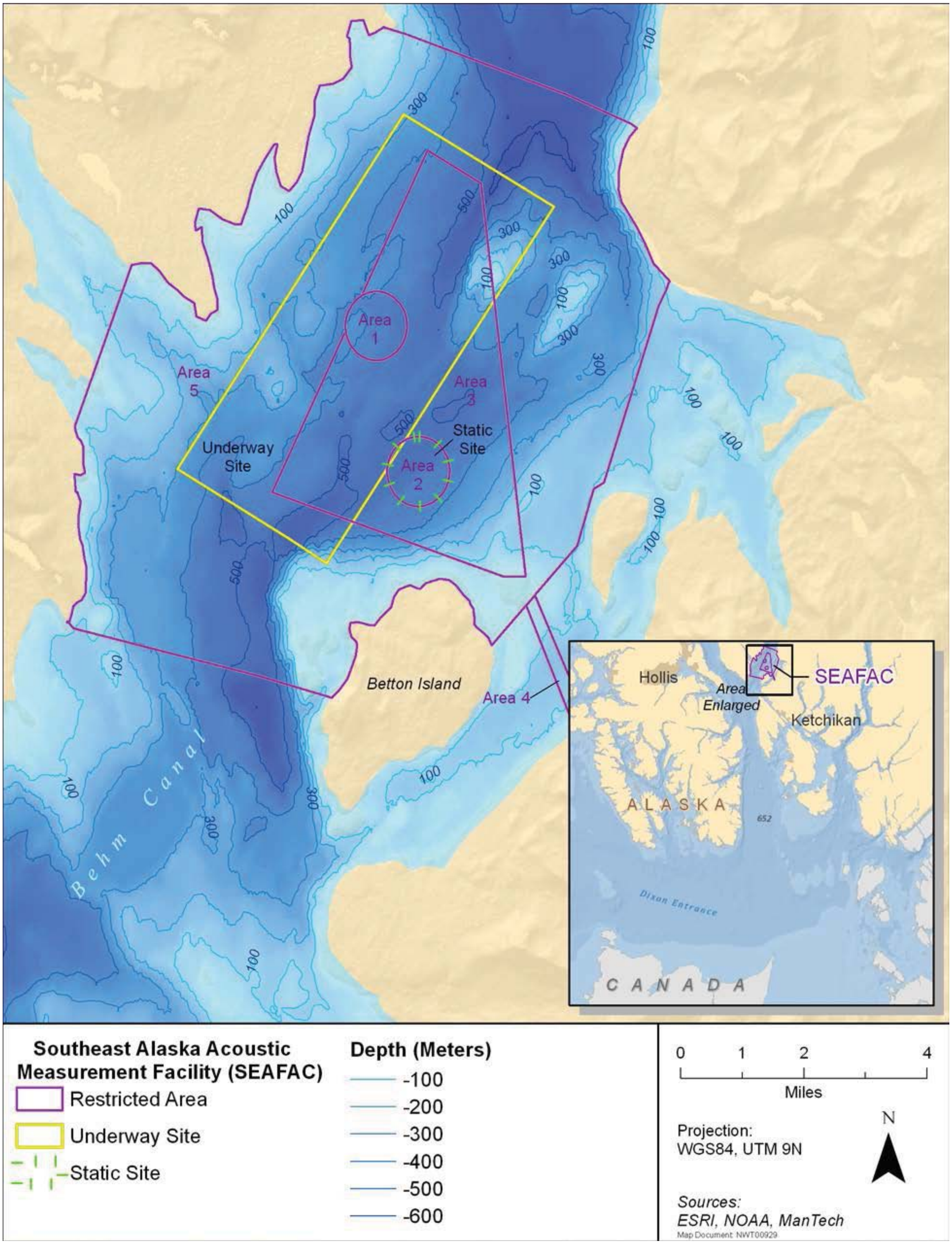

Figure 3.0-3: Bathymetry of the Southeast Alaska Acoustic Measurement Facility

The end moraine feature in Behm fjord is the bathymetric sill lying at the entrance to western Behm Canal. This bathymetric sill has a narrow groove approximately 1.5 nm wide occurring between 600 and 900 ft. (183 and 274 m). This structure acts as a boundary to physical mixing of the water column in Western Behm Canal (U.S. Department of the Navy 2011c). The seafloor of the Behm Canal consists of large grain sizes (shell, gravel, sand) to mixed sizes (clayey sand, sandy silt) to finer-grained sizes (inorganic silt, gray clay) to hard exposed bedrock. Sand is found along the coastline beaches, and gas-charged seafloor sediments have also been reported.

3.0.4 INTRODUCTION TO ACOUSTICS

This section introduces basic acoustic principles and terminology describing how sound travels or "propagates" in air and water. These terms and concepts are used when analyzing potential impacts due to acoustic sources and explosives used during naval training and testing. This section briefly explains the transmission of sound, and defines acoustical terms, abbreviations, and units of measurement. Finally, it discusses the various sources of underwater sound, including physical, biological, and anthropogenic sounds. A more complete and more technical introduction to acoustics is provided in Appendix G (Acoustic Primer).

3.0.4.1 Terminology/Glossary

Definitions and terminology can be found in the Master Glossary of Terms at the beginning of the EIS/OEIS. *Sound* is an oscillation in pressure, particle displacement, and particle velocity, as well as the auditory sensation evoked by these oscillations, although not all sound waves evoke an auditory sensation (i.e., they are outside of an animal's hearing range) (American National Standards Institute 1994). Sound may be described in terms of both physical and subjective attributes. Physical attributes may be directly measured. Subjective (or sensory) attributes cannot be directly measured and require a listener to make a judgment about the sound. Physical attributes of a sound at a particular point are obtained by measuring pressure changes as sound waves pass. The following material provides a short description of some of the basic parameters of sound.

3.0.4.1.1 Particle Motion and Sound Pressure

Sound is produced when a medium (air or water in this analysis) is set into motion, often by a vibrating object within the medium. As the object vibrates, its motion is transmitted to adjacent particles of the medium. The motion of these particles is transmitted to adjacent particles, and so on. As the sound wave travels through the medium, the individual particles of the medium oscillate about their original positions but do not actually move with the sound wave. The result is a mechanical disturbance (the "sound wave") that propagates away from the source. The measurable properties of a sound are the pressure oscillations of the sound wave and the velocity, displacement amplitude, and direction of particle movements. The basic unit of sound pressure is the Pascal (Pa) ($1 \text{ Pa} = 1.45 \times 10^{-4}$ pounds per square inch), although the most commonly encountered unit is the micropascal (μPa) ($1 \text{ μPa} = 1 \times 10^{-6}$ Pa).

Animals with an eardrum or similar structure directly detect the pressure component of sound. Some marine fish also have specializations to detect pressure changes. Certain animals (e.g., most invertebrates and some marine fish) likely cannot detect sound pressure, only the particle motion component of sound. Because particle motion is most detectable near a sound source and at lower frequencies, this difference in acoustic energy sensing mechanisms limits the range at which these animals can detect most sound sources analyzed in this document.

3.0.4.1.2 Frequency

The number of oscillations or waves per second is called the frequency of the sound, and the metric is Hertz (Hz). One Hz is equal to one oscillation per second, and 1 kilohertz (kHz) is equal to 1,000 oscillations per second. The inverse of the frequency is the period or duration of one acoustic wave.

Frequency is the physical attribute most closely associated with the subjective attribute “pitch”; the higher the frequency, the higher the pitch. Human hearing generally spans the frequency range from 20 Hz to 20 kHz. The pitch based on these frequencies is subjectively “low” (at 20 Hz) or “high” (at 20 kHz).

In this document, sounds are generally described as either low- (less than 1 kHz), mid- (1 kHz–10 kHz), high- (greater than 10 kHz–100 kHz), or very high- (greater than 100 kHz) frequency. Hearing ranges of marine animals (e.g., fish, birds, and marine mammals) are quite varied and are species-dependent. For example, some fish can hear sounds below 100 Hz and some species of marine mammals have hearing capabilities that extend above 100 kHz. Discussions of sound or sound propagation and potential impacts must therefore focus not only on the sound pressure, but the composite frequency of the noise and the species considered.

3.0.4.1.3 Duty Cycle

Duty cycle describes the portion of time that a sound source actually generates sound. It is defined as the percentage of the time during which a sound is generated over a total operational period. For example, if a sound navigation and ranging (sonar) source produces a 1-second ping once every 10 seconds, the duty cycle is 10 percent. Duty cycles vary among different acoustic sources; in general, a low duty cycle is 20 percent or less and a high duty cycle is 80 percent or higher.

3.0.4.1.4 Loudness and Auditory Weighting Functions

Sound levels are normally expressed in decibels (dB), a commonly misunderstood term. Although the term decibel always means the same thing, decibels may be calculated in several ways, and the explanations of each can quickly become both highly technical and confusing.

Auditory weighting functions are a method common in human hearing risk analysis to account for differences in hearing sensitivity at various frequencies. This concept can be applied to other species as well. When used in analyzing the impacts of sound on an animal, auditory weighting functions adjust received sound levels to emphasize ranges of best hearing and de-emphasize ranges of less or no sensitivity. A-weighted sound levels, often seen in units of “dBA,” (A-weighted decibels) are frequency-weighted to account for the sensitivity of the human ear to a barely audible sound. Many measurements of sound in air appear as A-weighted decibels in the literature because the intent of the authors is often to assess noise impacts on humans.

Because mammalian ears can detect large pressure ranges, and humans judge the relative loudness of sounds by the ratio of the sound pressures (a logarithmic behavior), sound pressure level is described by taking the logarithm of the ratio of the sound pressure to a reference pressure (American National Standards Institute 1994). Use of a logarithmic scale compresses the wide range of pressure values into a more usable numerical scale. The softest audible sound has a power of about 0.000000000001 watt/square meter (m^2), and the threshold of pain is around 1 watt/m^2. With the advantage of the logarithmic scale, this ratio is efficiently described as 120 dB.

For human hearing in air, a sound 10 times more powerful than the smallest audible sound (near-total silence) is 10 dB. A sound 100 times more powerful than near-total silence is 20 dB. A sound 1,000 times more powerful than near-total silence is 30 dB. Table 3.0-3 compares common sounds to their approximate decibel rating.

Table 3.0-3: Source Levels of Common In-Air Sounds

Source	Source Level (dB re 20 µPa)
Near total silence	0 dB
Whisper	15 dB
Normal conversation	60 dB
Lawnmower	90 dB
Car horn	110 dB
Rock concert	120 dB
Firecracker (50 mg of black gunpowder)	120 dB (peak)
Gunshot	140 dB (peak)

Notes: dB = decibel(s), db re 20 µPa = decibel referenced to 20 micropascals, mg = milligrams

Table 3.0-4 lists common underwater sounds and their source levels. Because seawater is a very efficient medium for the transmission of sound, there is a significant difference between transmission of sound in water and transmission of sound in air. It is important to note that, because of the difference in the media in which the sound is traveling (water vs. air), the same absolute pressures would result in different dB values for each medium. Different reference units are used for sounds in air and sounds in water, making side-by-side comparisons meaningless. Consider the 120 dB firecracker from Table 3.0-3 (using the in-air reference value of 20 µPa) and the same firecracker with a 206 dB in-water value from Table 3.0-4 (using a reference value of 1 µPa).

Table 3.0-4: Source Levels of Common Underwater Sounds

Source	Source Level (dB re 1 µPa at 1 m)
Ice breaker ship	193[1]
Large tanker	186[1]
Seismic airgun array (32 guns)	259 (peak)[1]
Dolphin whistles	125–173[1]
Dolphin clicks	194–219[2]
Humpback whale song	144–174[3]
Snapping shrimp	183–189[4]
Firecracker (50 mg of black gunpowder)	206 (peak)
Sperm whale click	236[5]
Naval mid-frequency active sonar (SQS-53)	235
Lightning strike	260[6]
Seafloor volcanic eruption	255[7]

[1] Richardson et al. 1995, [2] Rasmussen et al. 2002, [3] Payne and Payne 1985; Thompson et al. 1979, [4] Au and Banks 1998, [5] Levenson 1974; Watkins 1980, [6] Hill 1985, [7] Northrop 1974

Notes: dB re 1 µPa at 1 m = decibels referenced to 1 micropascal at 1 meter, mg = milligrams

3.0.4.1.5 Underwater Sound and Regulatory Thresholds

As the federal regulator responsible for the protection of marine mammals, NMFS has worked with the Navy as a cooperating agency in the development of thresholds used for this analysis for underwater sound exposure to marine mammals and sea turtles pursuant to the requirements of the MMPA and ESA. The development of these criteria is described in detail in Finneran and Jenkins (2012). In short, regulatory thresholds for marine mammals and sea turtles that now use frequency weighted thresholds parallel those developed for human occupational safety and health noise exposure guidelines. The human standards rely on frequency-weighted sound level (dB) thresholds that emphasize the middle of the frequency range where average human hearing is more sensitive and de-emphasize the frequencies at either end of the spectrum where human hearing is not as sensitive; the thresholds for marine mammals and sea turtles do the same. Since there are differences in the hearing ranges of many marine mammal species and sea turtles, auditory weighting functions have been created for each functional hearing group wherein all species of a group are assumed to have similar hearing abilities. These groups are: (1) Low-frequency cetaceans—all of the mysticetes, (2) Mid-frequency cetaceans—most delphinid species, (3) High-frequency cetaceans—the porpoises, (4) Phocid seals, (5) Otariid seals, (6) Sea otter, (7) Polar bear, and (8) Sirenians—manatees and dugongs.

3.0.4.2 Categories of Sound

3.0.4.2.1 Signal Versus Noise

When sound is purposely created to convey information, communicate, or obtain information about the environment, it is often referred to as a signal. Examples of sounds that could be considered signals are sonar pings, marine mammal vocalizations and echolocations, tones used in hearing experiments, and small sonobuoy explosions used for submarine detection.

Noise is undesired sound (American National Standards Institute 1994). Sounds produced by naval aircraft and vessel propulsion are considered noise because they represent possible inefficiencies and increased detectability, both of which are undesirable. Whether a sound is noise often depends on the receiver (i.e., the animal or system that detects the sound). For example, small explosives and sonar used to generate sounds that can locate an enemy submarine produce signals that are useful to sailors engaged in anti-submarine warfare but are assumed to be noise when detected by marine mammals.

Noise also refers to all sound sources that may interfere with detection of a signal (background noise) and the combination of all sounds at a particular location (ambient noise) (American National Standards Institute 1994).

3.0.4.2.2 Impulse versus Non-Impulse Sounds

Sounds may be categorized as impulse or non-impulse. Impulse sounds feature a very rapid increase to high pressures, followed by a rapid return to the static pressure. Impulse sounds are often produced by processes involving a rapid release of energy or mechanical impacts (Hamernik and Hsueh 1991). Non-impulse sounds lack the rapid rise time and can have longer durations than impulse sounds. Non-impulse sound can be continuous or intermittent. Figure 3.0-4 provides examples of impulse and non-impulse underwater sound sources. This figure is for illustration only, and not indicative of the sources analyzed in this NWTT EIS/OEIS.

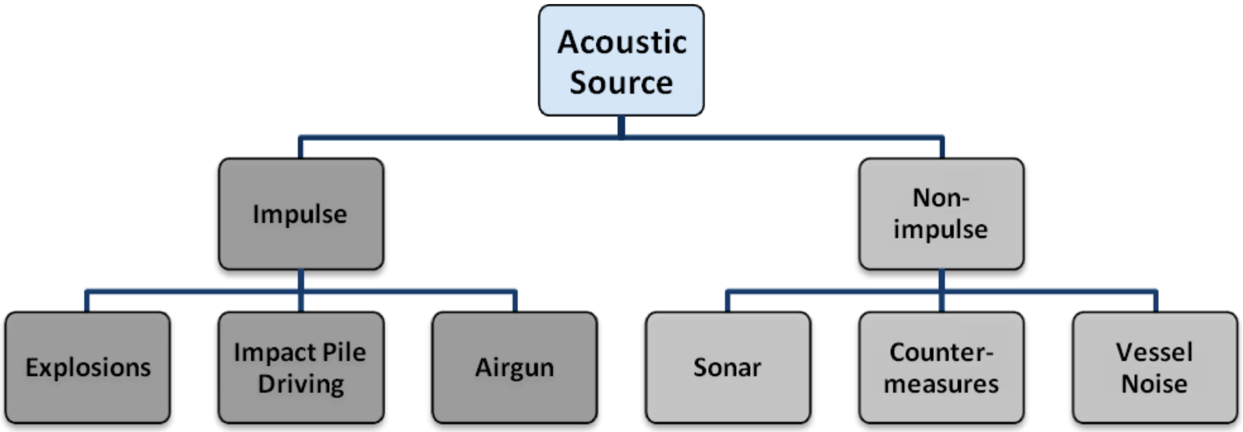

Figure 3.0-4: Examples of Impulse and Non-Impulse Acoustic Sources

3.0.4.2.3 Classification of Acoustic and Explosive Sources

In order to better organize and facilitate the analysis of approximately 300 individual sources of underwater acoustic sound or explosive energy, a series of source classifications, or source bins, were developed. The use of source classification bins provides the following benefits:

- provides the ability for new sensors or munitions to be covered under existing regulatory authorizations, as long as those sources fall within the parameters of a "bin"
- simplifies the source utilization data collection and reporting requirements anticipated under the MMPA
- ensures a conservative approach to all impacts estimates, as all sources within a given class are modeled as the loudest source (lowest frequency, highest source level, longest duty cycle, or largest net explosive weight) within that bin
- allows analysis to be conducted in a more efficient manner, without any compromise of analytical results
- provides a framework to support the reallocation of source usage (hours/count) between different source bins, within certain limitations of the Navy's regulatory compliance parameters (i.e., MMPA Letter of Authorization and ESA Biological Opinion); this flexibility is required to support evolving Navy training and testing requirements, which are linked to real world events

There are two primary types of source classes: impulse and non-impulse. A description of each source classification is provided in Table 3.0-5 and Table 3.0-6. Impulsive bins are based on the net explosive weight of the munitions or explosive devices or the source level for air and water guns. Non-impulsive acoustic sources are grouped into bins based on the frequency,[2] source level,[3] and, when warranted, the application in which the source would be used. The following factors further describe the considerations associated with the development of non-impulsive source bins:

- Frequency of the non-impulsive source:

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[2] Bins are based on the typical center frequency of the source. Although harmonics may be present, those harmonics would be several decibels lower than the primary frequency.

[3] Source decibel levels are expressed in terms of sound pressure level and are values given in decibels referenced to one micropascal at one meter.

  - Low-frequency sources operate below 1 kHz
  - Mid-frequency sources operate at and above 1 kHz, up to and including 10 kHz
  - High-frequency sources operate above 10 kHz, up to and including 100 kHz
  - Very high-frequency sources operate above 100 kHz but below 200 kHz
- Source level of the non-impulse source:
  - Greater than 160 dB, but less than 180 dB
  - Equal to 180 dB and up to 200 dB
  - Greater than 200 dB
- Application in which the source would be used.
  - How a sensor is employed supports how the sensor's acoustic emissions are analyzed
  - Factors considered include pulse length (time source is on); beam pattern (whether sound is emitted as a narrow, focused beam or, as with most explosives, in all directions); and duty cycle (how often or how many times a transmission occurs in a given time period during an event)

Table 3.0-5: Sonar and Other Active Acoustic Sources Quantitatively Analyzed

Source Class Category	Source Class	Description
Low-Frequency (LF): Sources that produce low-frequency (less than 1 kHz) signals	LF4	Low-frequency sources equal to 180 dB and up to 200 dB
	LF5	Low-frequency sources less than 180 dB
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1 to 10 kHz) signals	MF1	Hull-mounted surface ship sonar (e.g., AN/SQS-53C and AN/SQS-60)
	MF2	Hull-mounted surface ship sonar (e.g., AN/SQS-56)
	MF3	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonar (e.g., AN/AQS-22 and AN/AQS-13)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF6	Active underwater sound signal devices (e.g., MK-84)
	MF8	Active sources (greater than 200 dB)
	MF9	Active sources (equal to 180 dB and up to 200 dB)
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	MF11	Hull-mounted surface ship sonar with an active duty cycle greater than 80%
	MF12	High duty cycle – variable depth sonar
High-Frequency (HF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 100 kHz) signals	HF1	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	HF3	Hull-mounted submarine sonar (classified)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF5	Active sources (greater than 200 dB)
	HF6	Active sources (equal to 180 dB and up to 200 dB)
Very High-Frequency (VHF): Tactical and non-tactical sources that produce signals greater than 100 kHz but less than 200 kHz	VHF2	Active sources with a frequency greater than 100 kHz, up to 200 kHz with a source level less than 200 dB

Table 3-0.5: Sonar and Other Active Acoustic Sources Quantitatively Analyzed (continued)

Source Class Category	Source Class	Description
Anti-Submarine Warfare (ASW): Tactical sources such as active sonobuoys and acoustic countermeasures systems used during the conduct of ASW training and testing activities	ASW1	Mid-frequency Deep Water Active Distributed System (DWADS)
	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125) – sources analyzed by number of items (sonobuoys)
	ASW2H	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125) – Sources that are analyzed by hours
	ASW3	Mid-frequency towed active acoustic countermeasure systems (e.g., AN/SLQ-25)
	ASW4	Mid-frequency expendable active acoustic device countermeasures (e.g., MK-3)
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK-46, MK-54)
	TORP2	Heavyweight torpedo (e.g., MK-48, electric vehicles)
Acoustic Modems (M): Systems used to transmit data acoustically through the water	M3	Mid-frequency acoustic modems and similar sources (up to 210 dB) (e.g., UEWS, ATN)
Swimmer Detection Sonar (SD): Systems used to detect divers and submerged swimmers	SD1	High-frequency sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security.
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS2	High-frequency UUV (e.g., UUV payloads)

Notes: (1) Refer to Table 3.0-7 for those sources excluded from quantitative analysis. (2) For this NWTT EIS/OEIS, HF5 consists of only one source; the modeling was conducted specifically for that source. (3) ATN = aid to navigation, dB = decibels, DICASS = Directional Command Activated Sonobuoy System, kHz = kilohertz, UEWS = underwater emergency warning system, UUV = unmanned underwater vehicle, VDS = variable depth sonar

Table 3.0-6: Training and Testing Explosive Source Classes

Source Class	Example Ordnance	Net Explosive Weight (pounds [lb.])
E1	Medium-caliber projectiles	0.1–0.25
E3	Large-caliber projectiles	> 0.5–2.5
E4	Improved Extended Echo Ranging Sonobuoy	> 2.5–5.0
E5	5-inch projectiles	> 5–10
E8	MK-46 Torpedo	> 60–100
E10	Air-to-surface missile	> 250–500
E11	MK-48 Torpedo	> 500–650
E12	2,000 lb. Bomb	> 650–1,000

3.0.4.2.3.1 Sources Qualitatively Analyzed

There are in-water active acoustic sources with narrow beam widths, downward directed transmissions, short pulse lengths, frequencies above known hearing ranges, low source levels, or some combination of these factors, that are not anticipated to result in takes of protected species and, therefore, are not required to be quantitatively analyzed. These sources will be categorized as *de minimis* sources and will be qualitatively analyzed to reach the appropriate determinations under NEPA, the MMPA, and the ESA. When used during routine training and testing activities, and in a typical environment, *de minimis* sources generally meet one or more of the following criteria:

- Acoustic source classes listed in Table 3.0-6 (actual source parameters listed in the classified bin list)
- Acoustic sources that transmit primarily above 200 kHz
- Sources operated with source levels of 160 dB (dB referenced to [re] 1 µPa) or less

The types of sources with source levels less than 160 dB are typically hand held sonar, range pingers, transponders, and acoustic communication devices. Assuming spherical spreading for a 160 dB source, the sound will attenuate to less than 140 dB within 33 ft. (10 m), and less than 120 dB within 330 ft. (100 m) of the source. Using the behavioral risk function equation:

$$R = \frac{1 - \left(\frac{L - B}{K}\right)^{-A}}{1 - \left(\frac{L - B}{K}\right)^{-2A}}$$

R=risk (0–1.0)
L=received level (RL) in dB (140 dB)
B=basement RL in dB (120 dB)
K=RL increment above basement with 50 percent risk (45 dB)
A=risk transition sharpness

For odontocetes, pinnipeds, manatees, sea otters, and polar bears, A=10; therefore, R=0.0003, or 0.03 percent risk. For mysticetes, A=8; therefore, R=0.0015, or 0.15 percent risk.

Therefore:

- For all marine mammals subject to a behavioral risk function, these sources will not significantly increase the number of potential exposures as determined by the effects criteria.
- For beaked whales, the range to 140 dB behavioral threshold from a 160 dB source is 10 m (32.8 ft.). The likelihood of any potential effect is low because of the small affected area and the relative low density of beaked whales.
- For harbor porpoises, there will be a 100 m (328.1 ft.) zone from a 160 dB source to 120 dB behavioral threshold. Based on the above discussion and the extremely short propagation ranges to 120 dB, the potential for exposures that would result in changes to behavioral patterns to an extent where those patterns are abandoned or significantly altered is unlikely.
- For sea turtles, the behavioral threshold of 175 dB is above the 160 dB source level, and therefore no behavioral effect would be expected.
- Additionally, for all of the above calculations, absorption of sound in water is not a consideration, but would increase the actual transmission losses and further reduce the low potential for exposures.

3.0.4.2.3.2 Source Classes Qualitatively Analyzed

An entire source bin, or some sources from a bin, may be excluded from quantitative analysis (Table 3.0-7) within the scope of this EIS/OEIS if one or more of the following criteria are met:

- The source is expected to result in responses which are short term and inconsequential based on system acoustic characteristics (i.e., short pulse length, narrow beamwidth, downward directed beam, etc.) and manner of system operation.
- The sources are determined to meet the criteria specified in Section 3.0.4.2.3.1. (Sources Qualitatively Analyzed) or Table 3.0-7.
- Bins contain sources needed for safe operation and navigation.

Sources that meet these criteria will be qualitatively analyzed in Table 3.0-7 to determine the appropriate determinations under NEPA, MMPA, and ESA.

Shock Wave Action Generator (SWAG) explosives contain 0.033 pound (lb.) of explosive and acoustic impacts will not be analyzed in a quantitative manner for impacts to marine species due to the low level of explosive contained in the device. Although SWAG will be analyzed only qualitatively for potential impacts to marine mammals, the zone of impact from SWAG use will be calculated to determine a zone of potential take with regard to ESA-protected birds and fish.

Table 3.0-7: Source Classes Excluded from Quantitative Analysis

Source Class Category	Source Class	Justification
Doppler Sonar/Speed Logs (DS) Navigation equipment, downward focused, narrow beamwidth, HF/VHF spectrum utilizing very short pulse length pulses.	DS2, DS3, DS4	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler or pinger given their characteristics (e.g., narrow downward-directed beam), which is focused directly beneath the platform. Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources.
Fathometers (FA) High-frequency sources used to determine water depth	FA1–FA4	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler or pinger given their characteristics (e.g., narrow downward-directed beam). Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources. Fathometers use a downward-directed, narrowly focused beam directly below the vessel (typically much less than 30 degrees), using a short pulse length (less than 10 msec). Use of fathometers is required for safe operation of Navy vessels.
Hand-held Sonar (HHS) High-frequency sonar devices used by Navy divers for object location	HHS1	Hand-held sonar generates very high frequency sound at low power levels, short pulse lengths, and narrow beam widths. Because output from these sound sources would attenuate to below any current threshold for marine species at a very short range, and they are under positive control of the diver on which direction the sonar is pointed, marine species reactions are not likely. No additional quantitative modeling is required for marine species that might encounter these sound sources.

Table 3.0-7: Source Classes Excluded from Quantitative Analysis (continued)

Source Class Category	Source Class	Description
Imaging Sonar (IMS) HF or VHF, very short pulse lengths, narrow bandwidths. IMS1 is a side scan sonar (HF/VHF, narrow beams, downward directed). IMS2 is representative of a downward looking source, narrow beam, and operates above 180 kHz (basically a fathometer).	IMS1, IMS2	These side scan sonar operate in a very high frequency range (over 120 kHz) relative to marine mammal hearing (Richardson et al. 1995; Southall et al. 2007). The frequency range from these side scan sonar is beyond the hearing range of mysticetes (baleen whales), pinnipeds, manatees, and sea turtles, and, therefore, not expected to affect these species in the Study Area. The frequency range from these side scan sonar falls within the upper end of odontocete (toothed whale) hearing spectrum (Richardson et al. 1995), which means that they are not perceived as loud acoustic signals with frequencies below 120 kHz by these animals. Therefore, these marine species may be less likely to react to these types of systems in a biologically significant way. Further, in addition to spreading loss for acoustic propagation in the water column, high-frequency acoustic energies are more quickly absorbed through the water column than sounds with lower frequencies (Urick 1983). Additionally, these systems are generally operated in the vicinity of the sea floor, thus reducing the sound potential of exposure even more. Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the imaging sonar given their characteristics (e.g., narrow downward-directed beam and short pulse length (generally 20 msec). Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources.
High Frequency Acoustic Modems and Tracking Pingers (M, P)	M2, P1, P2, P3, P4	Acoustic modems and tracking pingers operate at frequencies between 2 and 170 kHz, have low duty cycles (single pings in some cases), short pulse lengths (typically 20 msec), and relatively low source levels. Marine species are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics as described above. Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for animals that might encounter these sound sources.
Acoustic Releases (R) Systems that transmit active acoustic signals to release a bottom-mounted object from its housing in order to retrieve the device at the surface	R1, R2, R3	Acoustic releases operate at mid- and high-frequencies. Since these types of devices are only used to retrieve bottom mounted devices, they typically transmit only a single ping. Marine species are expected to exhibit no more than short-term and inconsequential responses to these sound sources given that any sound emitted is extremely short in duration. Such reactions are not considered to constitute “taking” and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources.
Side Scan Sonar (SSS) Sonar that use active acoustic signals to produce high-resolution images of the seafloor	SSS1, SSS2, SSS3	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics such as a downward-directed beam and using short pulse lengths (less than 20 msec). Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources.

Notes: dB = decibel, HF = high frequency, kHz = kilohertz, m = meters, msec = milliseconds, NWTT = Northwest Training and Testing, VHF = very high frequency

3.0.5 OVERALL APPROACH TO ANALYSIS

The approach to analysis follows these steps:

- Identification of resources for analysis

- Resource-specific impacts analysis for individual stressors[4]
- Resource-specific impacts analysis for multiple stressors
- Examination of potential population-level impacts
- Cumulative impacts analysis
- Consideration of mitigations to reduce identified potential impacts

Navy training and testing activities in the Proposed Action are comprised of multiple components that may cause stress on a resource. Appendix F includes tables (Tables F-1 and F-2) that indicate these components by activity. For example, one component of a missile exercise (surface-to-air) is vessel movement. The potential stressors are categorized by the way in which they may affect the environment in Table 3.0-8; stressors are listed under the resource areas in which they can cause an effect. A single activity may result in multiple stressors (e.g., a torpedo test may involve water quality stressors from torpedo exhaust, physical disturbance and strike stressors from an object moving through the water, and acoustic stressors from the guidance system operation). A summary of which stressors result from the activity types being analyzed in this document is given in Table 3.0-9. Not all stressors affect every resource, nor do all proposed Navy activities produce all stressors.

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

First, a preliminary analysis was conducted to determine the environmental resources potentially impacted and associated stressors. Secondly, each resource was analyzed for potential impacts of individual stressors, followed by an analysis of the combined impacts of all stressors related to the Proposed Action. A cumulative impact analysis was conducted to evaluate the incremental impact of the Proposed Action when added to other past, present, and reasonably foreseeable future actions. The cumulative impacts analysis is provided in Chapter 4. Mitigation measures are discussed in detail in Chapter 5.

In this phased approach, the initial analyses were used to develop each subsequent step so the analyses focused on relevant issues (defined during scoping) that warranted the most attention. The systematic nature of this approach allowed the Proposed Action with the associated stressors and potential impacts to be effectively tracked throughout the process. This approach provided a comprehensive analysis of applicable stressors and potential impacts. Each step is described in more detail below.

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[4] The term “stressor” is broadly used in this document to refer to an agent, condition, or other stimulus that causes stress to an organism or alters physical, socioeconomic, or cultural resources.

Table 3.0-8: List of Stressors Analyzed

Components and Stressors for Physical Resources	
Sediments and Water Quality	
Explosives and explosive byproducts	Chemicals other than explosives
Metals	Other materials
Air Quality	
Criteria pollutants	Hazardous air pollutants
Components and Stressors for Biological Resources	
Acoustic Stressors	
Sonar and other active sources	Vessel noise
Explosives	Aircraft noise
Weapons firing, launch, and impact noise	
Energy Stressors	
Electromagnetic devices	
Physical Disturbance and Strike Stressors	
Aircraft and aerial targets	Military expended materials
Vessels	Seafloor devices
In-water devices	
Entanglement Stressors	
Fiber optic cables and guidance wires	Parachutes
Ingestion Stressors	
Military expended materials from munitions	
Military expended materials other than munitions	
Secondary Stressors	
Habitat (sediments and water quality; air quality)	
Prey availability	
Components and Stressors for Human Resources	
Cultural Resources Stressors	
Acoustic	
Physical disturbance and strike	
Native American and Alaska Native Stressors/Socioeconomic Stressors	
Accessibility	
Airborne acoustics	
Physical disturbance and strike	
Secondary impacts from availability of resources	
Public Health and Safety Stressors	
Underwater energy	
In-air energy	
Physical interactions	
Secondary stressors (sediments and water quality)	

Table 3.0-9: Stressors by Training Category (Warfare Area) and Testing Category

Training/ Testing Category	Acoustic Stressors	Energy Stressors	Physical Disturbance and Strike Stressors	Entanglement Stressors	Ingestion Stressors	Air Quality	Sediments and Water Quality	Cultural Resources Stressors	Socioeconomics Stressors	Public Health & Safety Stressors
Training Category										
Anti-Air Warfare	✓		✓	✓	✓	✓	✓	✓	✓	✓
Anti-Surface Warfare	✓		✓	✓	✓	✓	✓	✓	✓	✓
Anti-Submarine Warfare	✓		✓	✓	✓	✓	✓	✓	✓	✓
Electronic Warfare	✓		✓			✓		✓	✓	✓
Mine Warfare	✓	✓	✓		✓	✓	✓	✓	✓	✓
Naval Special Warfare	✓		✓			✓	✓		✓	
Other Training Activities	✓		✓			✓			✓	
Testing Category										
Torpedo Testing	✓		✓	✓		✓	✓		✓	✓
Autonomous and Non-Autonomous Vehicles	✓		✓			✓			✓	
Fleet Training Support	✓		✓	✓		✓				
Maintenance and Miscellaneous	✓		✓			✓			✓	
Acoustic Component Test	✓		✓						✓	
System, Subsystem, and Component Testing	✓		✓			✓				
Proof-of-Concept Testing	✓		✓			✓				
Acoustic Measurement Tests	✓		✓			✓	✓	✓		
Life Cycle Activities	✓									
Shipboard Protection Systems and Swimmer Defense Testing	✓									
ASUW/ASW Testing	✓		✓	✓	✓	✓	✓		✓	✓
New Ship Construction	✓		✓	✓		✓				
NAVAIR ASW Testing Activities	✓		✓	✓	✓	✓	✓			
NAVAIR EW Testing Activities	✓		✓		✓	✓	✓			

Notes: ASUW = Anti-Surface Warfare, ASW = Anti-Submarine Warfare, NAVAIR = Naval Air Systems Command, EW = Electronic Warfare

3.0.5.1 Resources and Issues Evaluated in this Document

Physical resources and issues evaluated include marine sediments, marine water quality, and air quality. Biological resources (including threatened and endangered species) evaluated include marine habitats, marine mammals, sea turtles, birds, marine vegetation, marine invertebrates, and fish. Human resources evaluated in this EIS/OEIS include cultural resources, socioeconomics, and public health and safety. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, was considered, but was not included in a section to itself. Environmental justice issues are analyzed in Section 3.11 (Native American and Alaska Native Traditional Resources) and Section 3.12 (Socioeconomic Resources). Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, is considered in Section 3.13 (Public Health and Safety).

3.0.5.2 Resources and Issues Eliminated from Further Consideration

Resources and issues considered but not carried forward for further consideration include land use, demographics, and terrestrial resources. Land use and terrestrial resources were eliminated from further consideration because the in-water activities in the Proposed Action would not be relevant to land use issues and no new actions are being proposed that would indirectly affect land use or terrestrial resources. Demographics were eliminated from further consideration because implementation of the Proposed Action would not result in a change in the demographics within the Study Area of the counties of the coastal states that abut the Study Area. Terrestrial resources were eliminated from further consideration because all of the proposed activities occur in or over the ocean or inland waters.

3.0.5.3 Identification of Stressors for Analysis

The proposed training and testing activities were evaluated to identify specific components that could act as stressors (see Table 3.0-8) by having direct or indirect impacts on the environment. This evaluation included identification of the spatial variation of the identified stressors. The warfare areas and testing categories, along with their associated stressors, are identified previously in Table 3.0-9. Matrices were prepared to identify associations between stressors, resources, training and testing activities, warfare and testing areas, range complexes, and alternatives. The following subsections describe the stressors in more detail. Each description contains a list of activities in which the stressor may occur. Refer to Appendix F for more information on stressors associated with each training and testing activity. Resources that may occur or are known to occur within the Study Area and that may be exposed to the identified stressors are also listed in Appendix F. Stressors for physical resources (sediment and water quality, air quality) and human resources (cultural resources, socioeconomic resources, and public health and safety) are described in their respective sections of Chapter 3.

A preliminary analysis based on scoping, previous NEPA analyses, and opinions of subject matter experts identified the stressor/resource interactions that warrant further analysis in the EIS/OEIS. Stressor/resource interactions that were determined to have negligible or no impacts were eliminated from analysis in the EIS/OEIS.

3.0.5.3.1 Acoustic Stressors

This section describes the characteristics of sounds produced during naval training and testing and the relative magnitude and location of these acoustic sources and activities:

- Sonar and other active acoustic sources
- Explosives
- Weapons firing, launch, and impact noise
- Vessel noise
- Aircraft overflight noise

This provides the basis for analysis of impulse and non-impulse acoustic impacts to resources in the remainder of Chapter 3. For additional details on the properties of acoustics, see Section 3.0.4 (Introduction to Acoustics).

3.0.5.3.1.1 Sonar and Other Active Acoustic Sources

Table 3.0-10 presents the hours of operation proposed under each alternative for the source bins that are quantitatively analyzed for impacts (see Section 3.0.4.2.3, Classification of Acoustic and Explosive Sources).

Table 3.0-10: Training and Testing Sonar and Other Active Acoustic Sources Quantitatively Analyzed in the Northwest Training and Testing Study Area

For Annual Training and Testing Activities								
Source Class Category	Source Class	Units	Annual Hours					
			No Action Alternative		Alternative 1		Alternative 2	
			Training	Testing	Training	Testing	Training	Testing
Low-Frequency (LF) Sources that produce signals less than 1 kHz	LF4	Hours	0	78	0	110	0	120
	LF5	Hours	0	0	0	71	0	83
Mid-Frequency (MF) Tactical and nontactical sources that produce signals from 1 to 10 kHz	MF1	Hours	44	0	166	0	166	0
	MF2	Hours	64	0	0	0	0	0
	MF3	Hours	0	0	70	161	70	177
	MF4	Hours	0	0	4	10	4	11
	MF5	Items	880	60	896	273	896	297
	MF6	Items	0	0	0	12	0	13
	MF8	Hours	0	14	0	40	0	44
	MF9	Hours	0	128	0	1,183	0	1,337
	MF10	Hours	0	95	0	1,156	0	1,639
	MF11	Hours	0	0	16	34	16	35
	MF12	Hours	0	0	0	24	0	26
High-Frequency (HF) Tactical and nontactical sources that produce signals greater than 10 kHz but less than 180 kHz	HF1	Hours	16	0	48	161	48	177
	HF3	Hours	0	0	0	145	0	191
	HF4	Hours	0	0	384	0	384	0
	HF5	Hours	0	0	0	360	0	396
	HF6	Hours	180	416	192	2,099	192	2,658
Very High-Frequency (VHF): Tactical and non-tactical sources that produce signals greater than 100 kHz but less than 200 kHz	VHF2	Hours	0	32	0	35	0	38

Table 3.0-10: Training and Testing Acoustic Sources Quantitatively Analyzed in the Northwest Training and Testing Study Area (continued)

For Annual Training and Testing Activities								
Source Class Category	Source Class	Units	Annual Hours					
			No Action Alternative		Alternative 1		Alternative 2	
			Training	Testing	Training	Testing	Training	Testing
Anti-Submarine Warfare (ASW) Tactical sources used during anti-submarine warfare training and testing activities	ASW1	Hours	0	0	0	16	0	18
	ASW2[1]	Hours	0	0	0	64	0	72
	ASW2[1]	Items	150	0	20	170	20	187
	ASW3	Hours	0	4	78	444	78	488
	ASW4	Items	0	1,088	0	1,182	0	1,277
Acoustic Modems (M) Transmit data acoustically through the water	M3	Hours	0	430	0	1,519	0	1,656
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	TORP1	Items	0	136	0	315	0	342
	TORP2	Items	0	268	0	299	0	319
Swimmer Detection Sonar (SD) Used to detect divers and submerged swimmers	SD1	Hours	0	274	0	757	0	830
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS2	Hours	0	613	0	798	0	853

[1] The ASW2 bin contains sources that are analyzed by hours and some that are analyzed by count. There is no overlap of the numbers in the two rows.

Underwater sound propagation is highly dependent upon environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity. The sound received at a particular location will be different than near the source due to the interaction of many factors, including propagation loss; how the sound is reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation (Appendix G, Acoustic Primer).

The following sections will provide more details regarding the use of specific active acoustic sources.

Anti-Submarine Warfare Sonar

Sonar used in ASW is deployed on many platforms and is operated in various ways. Anti-submarine warfare active sonar is usually mid-frequency (1–10 kHz) because mid-frequency sound balances sufficient resolution to identify targets and distance within which threats can be identified.

- Ship tactical hull-mounted sonar contributes a small portion of overall non-impulse sound in the Study Area. Duty cycle can vary from about a ping per minute to continuously active. Sonar can be wide-ranging in a search mode or highly directional in a track mode.
- A submarine's mission revolves around its stealth; therefore, a submarine's mid-frequency sonar is used infrequently because its use would also reveal a submarine's location.
- Aircraft-deployed, mid-frequency, ASW systems include omnidirectional dipping sonar (deployed by helicopters) and omnidirectional sonobuoys (deployed from various aircraft), which have a typical duty cycle of several pings per minute.
- Acoustic countermeasures that continuously emulate broadband vessel sound or other vessel acoustic signatures may be deployed by ships and submarines during training. Acoustic decoy testing also occurs in the Study Area and is not limited to use from ships and submarines.
- Torpedoes use directional high-frequency sonar when approaching and locking onto a target. Practice targets emulate the sound signatures of submarines or respond to received signals.

Mine Warfare Sonar

Sonar used to locate mines and other small objects is typically high frequency, which provides higher resolution. Mine detection sonar is deployed at variable depths on moving platforms to sweep a suspect mined area (towed by ships, helicopters, submarines, or unmanned underwater vehicles). Mine detection sonar use would be concentrated in areas where practice mines are deployed, typically in water depths less than 600 ft. (183 m). Most events usually occur over a limited area and are completed in less than 1 day, often within a few hours.

Use of Sonar During Training and Testing

Most sonar and other active acoustic sources associated with training or testing activities originate from a single unit (ship, submarine, aircraft, or other platform) employing a single active sonar source in addition to sound sources used for communication, navigation, and measuring oceanographic conditions. These events usually occur over a limited area and are completed in less than 24 hours, often within a few hours.

3.0.5.3.1.2 Explosives

Explosive detonations during training and testing activities are associated with high-explosive ordnance, including bombs, missiles, and naval gun shells; torpedoes, demolition charges, and explosive sonobuoys. Some detonations would occur in the air or near the water's surface. Detonations associated with torpedoes and explosive sonobuoys would occur in the water column; demolition charges could occur near the surface, in the water column, or near the ocean bottom. Most detonations would occur in waters greater than 200 ft. (61 m) in depth, and greater than 3 nm from shore, although mine warfare (MIW), demolition, and some testing detonations could occur in shallow water close to shore. Detonations associated with ASW would typically occur in waters greater than 600 ft. (183 m) depth. The numbers of in-water explosions in each explosive source class proposed under each alternative are shown in Table 3.0-11.

Explosives in the water introduce loud, impulse, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: (1) the weight of the explosive warhead, (2) the type of explosive material, and (3) the detonation depth.

Table 3.0-11: Explosives for Training and Testing Activities in the Northwest Training and Testing Study Area

Explosives	Location	Training Activities			Testing Activities		
		No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Shock Wave Action Generator (< 0.1 lb. NEW)	Offshore Area	0	0	0	0	0	0
	Inland Waters	0	36	36	0	0	0
	Behm Canal	0	0	0	0	0	0
	Total	**0**	**36**	**36**	**0**	**0**	**0**
E1 (0.1–0.25 lb. NEW)	Offshore Area	0	48	48	0	0	0
	Inland Waters	0	0	0	0	0	0
	Behm Canal	0	0	0	0	0	0
	Total	**0**	**48**	**48**	**0**	**0**	**0**
E3 (> 0.5 lb– 2.5 lb. NEW)	Offshore Area	0	0	0	0	72	79
	Inland Waters	4	6	6	0	0	0
	Behm Canal	0	0	0	0	0	0
	Total	**4**	**6**	**6**	**0**	**72**	**79**
E4 (>2.5–6 lb. NEW)	Offshore Area	150	150	150	0	70	77
	Inland Waters	0	0	0	0	0	0
	Behm Canal	0	0	0	0	0	0
	Total	**150**	**150**	**150**	**0**	**70**	**77**
E5 (> 6–10 lb. NEW)	Offshore Area	40	80	80	0	0	0
	Inland Waters	0	0	0	0	0	0
	Behm Canal	0	0	0	0	0	0
	Total	**40**	**80**	**80**	**0**	**0**	**0**
E8 (> 60– 100 lb. NEW)	Offshore Area	2	0	0	0	3	4
	Inland Waters	0	0	0	0	0	0
	Behm Canal	0	0	0	0	0	0
	Total	**2**	**0**	**0**	**0**	**3**	**4**
E10 (> 250– 500 lb. NEW)	Offshore Area	0	4	4	0	0	0
	Inland Waters	0	0	0	0	0	0
	Behm Canal	0	0	0	0	0	0
	Total	**0**	**4**	**4**	**0**	**0**	**0**
E11 (> 500– 650 lb. NEW)	Offshore Area	2	0	0	0	3	4
	Inland Waters	0	0	0	0	0	0
	Behm Canal	0	0	0	0	0	0
	Total	**2**	**0**	**0**	**0**	**3**	**4**
E12 (> 650– 1,000 lb. NEW)	Offshore Area	16	10	10	0	0	0
	Inland Waters	0	0	0	0	0	0
	Behm Canal	0	0	0	0	0	0
	Total	**16**	**10**	**10**	**0**	**0**	**0**

Notes: lb. = pound(s), NEW = Net Explosive Weight

The net explosive weight, the explosive power of a charge expressed as the equivalent weight of trinitrotoluene, accounts for the first two parameters. The properties of explosive detonations are discussed in Section 3.0.4 (Introduction to Acoustics). Table 3.0-6 shows the depths at which representative explosive source classes are assumed to detonate underwater for purposes of analysis.

Explosive events would consist of a single explosion or multiple explosions. During training, all high-explosive bombs would be detonated near the surface over deep water. Bombs with high-explosive ordnance would be fused to detonate on contact with the water. Other detonations would occur near but above the surface upon impact with a target; these detonations are conservatively assumed to occur at a depth of 3.3 ft. (1 m) for purposes of analysis. Detonations of projectiles during anti-air warfare would occur far above the water surface.

Since most explosive sources used in military activities are munitions that detonate essentially upon impact, the effective source depths are quite shallow and, therefore, the surface-image interference effect can be pronounced (see Appendix G, Acoustic Primer). This effect would reduce peak pressures and potential impacts near the water surface.

3.0.5.3.1.3 Weapons Firing, Launch, and Impact Noise

Noise associated with weapons firing and the impact of non-explosive practice munitions could happen at any location within the Offshore Area but generally would occur at locations greater than 12 nm from shore for safety reasons.

The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated by firing the gun (muzzle blast), vibration from the blast propagating through a ship's hull, and sonic booms generated by the projectile flying through the air (Table 3.0-12). Missiles and targets would produce noise during launch. In addition, the impact of non-explosive practice munitions on the water surface can introduce another impulse noise into the water.

Table 3.0-12: Representative Weapons Noise Characteristics

Noise Source	Sound Level
In-Water	
Naval Gunfire Muzzle Noise (5 in./54-caliber)	Approximately 200 dB re 1 μPa directly under gun muzzle at 5 ft. (1.5 m) below the water surface[1]
Airborne	
Naval Gunfire Muzzle Noise (5 in./54-caliber)	178 dB re 20 μPa directly below the gun muzzle above the water surface[1]
Hellfire Missile Launch from Aircraft	149 dB re 20 μPa at 15 ft. (4.5 m)[2]
7.62-millimeter M-60 Machine Gun	90 dBA re 20 μPa at 50 ft. (15 m)[3]
0.50-caliber Machine Gun	98 dBA re 20 μPa at 50 ft. (15 m)[3]

[1] Yagla and Stiegler 2003
[2] U.S Department of the Army 1999
[3] Investigative Science and Engineering, Inc. 1997
Notes: μPa = micropascals; db = decibels; dBA = decibels, A-weighted; ft. = feet; in. = inches; m = meters; re = referenced to

Naval Gunfire Noise

In-air sound levels of several Navy weapons have been measured (see Table 3.0-12), including a 5-inch (in.) gun, 7.62-millimeter (mm) machine gun, 0.50-caliber machine gun, and a Hellfire missile. Firing a ship deck gun produces a muzzle blast in air that propagates away from the muzzle in all directions, including toward the water surface. As explained in Appendix G (Acoustic Primer), most sound enters the water in a narrow cone beneath the sound source (within 13 degrees [°] of vertical). In-water sound levels were measured during the muzzle blast of a 5 in. deck-mounted gun, the largest caliber gun currently used in proposed Navy activities. The highest sound level in the water (on average 200 dB re 1 µPa measured 5 ft. [1.5 m] below the surface) was obtained when the gun was fired at the lowest angle, placing the blast closest to the water surface (U.S. Department of the Navy 2000; Yagla and Stiegler 2003). The average impulse at that location was 19.6 Pascal-second. The corresponding average peak in-air pressure was 178 dB re 20 µPa, measured at the water surface below the firing point.

Gunfire also sends energy through the ship structure, into the water, and away from the ship. This effect was investigated in conjunction with the measurement of 5 in. gun blasts described above. The energy transmitted through the ship to the water for a typical round was about 6 percent of that from the air blast impinging on the water. Therefore, sound transmitted from the gun through the hull into the water is a minimal component of overall weapons firing noise.

The projectile shock wave in air by a shell in flight at supersonic speeds propagates in a cone (generally about 65°) behind the projectile in the direction of fire (Pater 1981). Measurements of a 5 in. projectile shock wave ranged from 140 to 147 dB re 20 µPa taken at the surface at 0.59 nm distance from the firing location and 10° off the line of fire for safety (approximately 623 ft. [190 m] from the shell's trajectory). Sound level intensity decreases with increased distance from the firing location and increased angle from the line of fire (Pater 1981). Like sound from the gun firing blast, sound waves from a projectile in flight would enter the water primarily in a narrow cone beneath the sound source. The region of underwater sound influence from a single traveling shell would be relatively narrow, the duration of sound influence would be brief at any point, and sound level would diminish as the shell gains altitude and loses speed. Multiple, rapid gun firings would occur from a single firing point toward a target area. Vessels participating in gunfire activities would maintain enough forward motion to maintain steerage, normally at speeds of a few knots. Acoustic impacts from weapons firing would often be concentrated in space and duration.

Launch Noise

Missiles and some air targets can be rocket or jet propelled. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket. It rapidly fades as the missile or target reaches optimal thrust conditions and the missile or target reaches a downrange distance where the booster burns out and the sustainer engine continues. Launch noise level for the Hellfire missile, which is launched from aircraft, is about 149 dB re 20 µPa at 14.8 ft. (4.5 m) (U.S. Department of the Army 1999).

Non- Explosive Munitions Impact Noise

Large-caliber non-explosive projectiles, non-explosive bombs, and intact missiles and targets could produce a large impulse upon impact with the water surface (McLennan 1997). Sounds of this type are produced by the kinetic energy transfer of the object with the target surface and are highly localized to the area of disturbance. Sound associated with impact events is typically of low frequency (less than 250 Hz) and of brief duration.

3.0.5.3.1.4 Vessel Noise

Naval vessels (including ships, small craft, and submarines) produce low-frequency, broadband underwater sound. In the West Coast Exclusive Economic Zone, Navy ships contribute approximately 1 percent of the broadband noise generated by large military and non-military vessels. The vast majority (89 percent) of broadband noise is produced by non-military foreign flagged vessels. Overall, naval traffic is often a minor component of total vessel traffic (Mintz and Filadelfo 2011; Mintz and Parker 2006).

Exposure to vessel noise would be greatest in the areas of highest naval vessel traffic. In an attempt to determine traffic patterns for Navy and non-Navy vessels, a review by the Center for Naval Analysis (Mintz and Parker 2006) was conducted on commercial vessels, coastal shipping patterns, and Navy vessels. Commercial and non-Navy traffic, which included cargo vessels, bulk carriers, passenger vessels, and oil tankers (all over 65 ft. [20 m] in length), was heaviest near the Strait of Juan de Fuca and the Columbia River mouth, and could be seen in the east to west and north to south international shipping lanes (Figure 3.0-5).

Radiated noise from Navy ships ranges over several orders of magnitude. The quietest Navy warships radiate much less broadband noise than a typical fishing vessel, while the loudest Navy ships are almost on par with large oil tankers (Mintz and Filadelfo 2011). For comparison, a typical commercial cargo vessel radiates broadband noise at a source level around 172 dB re 1 µPa and a typical fishing vessel radiates noise at a source level of about 158 dB re 1 µPa (Richardson et al. 1995; Urick 1983). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below about 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies. (Richardson et al. 1995; Urick 1983).

Anti-submarine warfare platforms (such as destroyers and cruisers) and submarines make up a large part of Navy traffic but contribute little noise to the overall sound budget of the oceans as these vessels are designed to be quiet to minimize detection. These platforms are much quieter than Navy oil tankers, for example, which have a smaller presence but contribute substantially more broadband noise than ASW platforms (Mintz and Filadelfo 2011). Sound produced by vessels will typically increase with speed. During training or testing, speeds of most larger naval vessels generally range from 10 to 15 knots; however, ships will, on occasion, operate at higher speeds within their specific operational capabilities.

A variety of smaller craft, such as service vessels for routine testing activities, would be operating within the Study Area. These small craft types, sizes, and speeds vary, but in general, they will emit higher-frequency noise than larger ships.

While commercial traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Navy traffic is episodic in the ocean. Training and testing activities within the Study Area typically consist of a single vessel involved in unit-level activity for a few hours, or one or two small boats conducting testing. Navy vessels do contribute to the overall ambient noise in inland waters near Navy ports, although their contribution to the overall noise in these environments is minimal because these areas typically have large amounts of commercial and recreational vessel traffic.

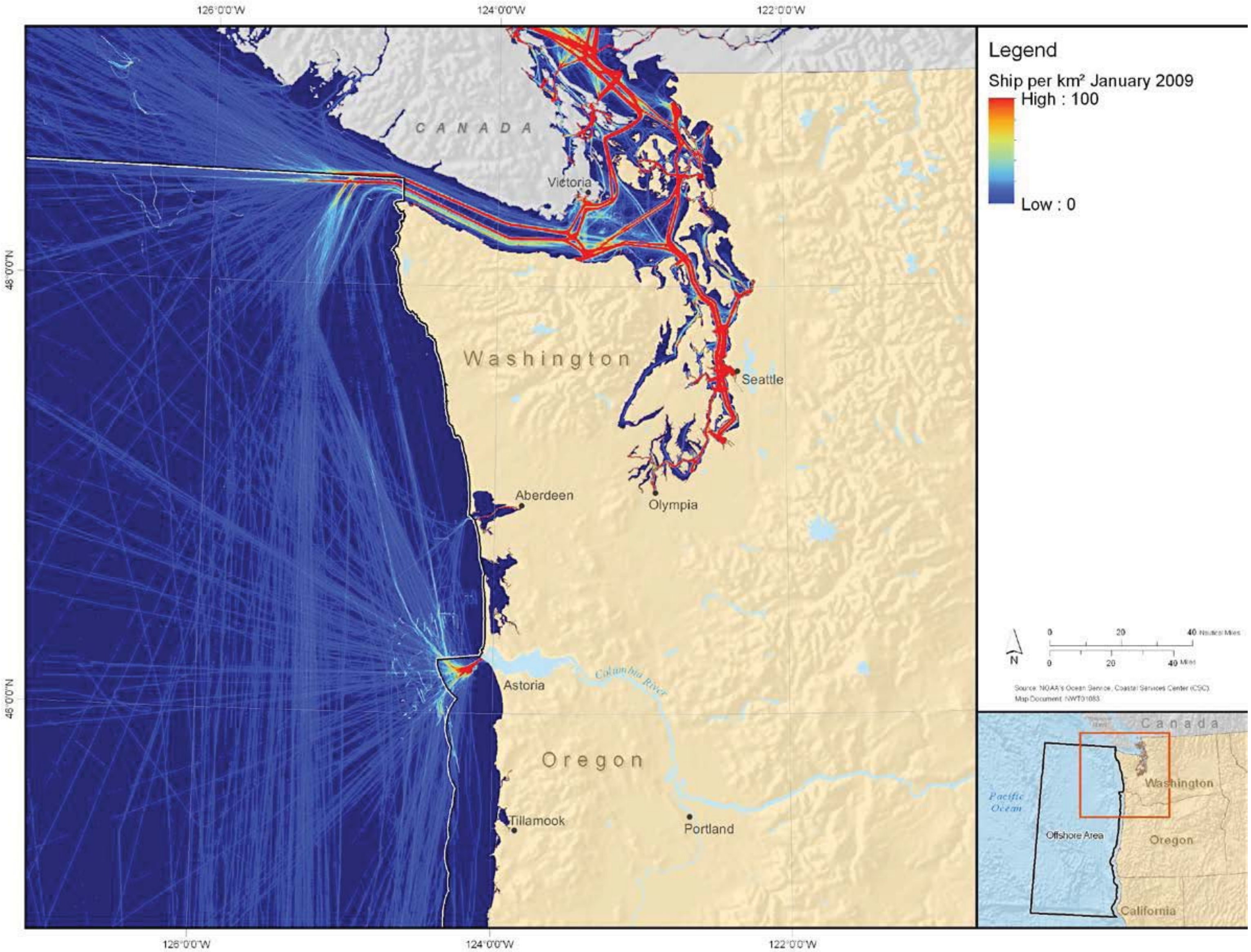

Figure 3.0-5: Average Ship Traffic Density in the Pacific Northwest, January 2009

3.0.5.3.1.5 Aircraft Overflight Noise

Fixed- and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area, contributing both airborne and underwater sound to the ocean environment. Aircraft used in training and testing generally have reciprocating, turboprop, or jet engines. Motors, propellers, and rotors produce the most noise, with some noise contributed by aerodynamic turbulence. Aircraft sounds have more energy at lower frequencies. Takeoffs and landings occur at established airfields as well as on vessels at sea throughout the Study Area. Most aircraft noise would be produced around air stations in the range complexes. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location.

Fixed-Wing Aircraft

Noise generated by fixed-wing aircraft is transient in nature and extremely variable in intensity. Most fixed-wing aircraft sorties would occur above 3,000 ft. (914 m). Air combat maneuver altitudes generally range from 5,000 to 30,000 ft. (1.5 to 9.1 km) and typical airspeeds range from very low (less than 100 knots) to high subsonic (greater than 600 knots). Sound exposure levels at the sea surface from most air combat maneuver overflights are expected to be less than 85 dBA (based on an FA-18 aircraft flying at an altitude of 5,000 ft. [1,524 m] and at a subsonic airspeed [400 knots]) (U.S. Department of the Navy 2009). Exposure to fixed-wing aircraft noise would be brief (seconds) as an aircraft quickly passes overhead.

Helicopters

Noise generated from helicopters is transient in nature and extremely variable in intensity. In general, helicopters produce lower-frequency sounds and vibration at a higher intensity than fixed-wing aircraft (Richardson et al. 1995). Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz. Helicopters often radiate more sound forward than backward. The underwater noise produced is generally brief when compared with the duration of audibility in the air.

Helicopter unit level training in the Study Area is infrequent, and consists of single-aircraft sorties over water that start and end at an air station, although flights may occur from ships at sea. Individual flights typically last about 2–4 hours. Some events require low-altitude flights over a defined area, such as mine countermeasure activities deploying towed systems. Helicopter sorties associated with mine countermeasures would occur at altitudes as low as 75–100 ft. (23–30 m). Likewise, in some ASW events, a dipping sonar is deployed from a line suspended from a helicopter hovering at low altitudes over the water.

Underwater Transmission of Aircraft Noise

Sound generated in air is transmitted to water primarily in a narrow area directly below the aircraft (Appendix G, Acoustic Primer). A sound wave propagating from an aircraft must enter the water at an angle of incidence of 13° or less from the vertical for the wave to continue propagating under the water's surface. At greater angles of incidence, the water surface acts as an effective reflector of the sound wave and allows very little penetration of the wave below the water (Urick 1983). Water depth and bottom conditions strongly influence propagation and levels of underwater noise from passing aircraft. For low-altitude flights, sound levels reaching the water surface would be higher, but the transmission area would be smaller. As an aircraft gains altitude, sound reaching the water surface diminishes, but the possible transmission area increases. Estimates of underwater sound pressure level are provided for representative aircraft in Table 3.0-13.

Table 3.0-13: Representative Aircraft Sound Characteristics

Noise Source	Sound Level
In-Water	
F/A-18 Subsonic at 1,000 ft. (300 m) Altitude	148 dB re 1 μPa at 6 ft. (2 m) below water surface[1]
F/A-18 Subsonic at 10,000 ft. (3,000 m) Altitude	128 dB re 1 μPa at 6 ft. (2 m) below water surface[1]
H-60 Helicopter Hovering at 50 ft. (15 m) Altitude	Approximately 125 dB re 1 μPa at 3 ft. (1 m) below water surface
Airborne	
Jet Aircraft under Military Power	144 dBA re 20 μPa at 50 ft. (15 m) from source[2]
Jet Aircraft under Afterburner	148 dBA re 20 μPa at 50 ft. (15 m) from source[2]
H-60 Helicopter Hovering	90 dBA re 20 μPa at 50 ft. (15 m) from source[3]

[1] Eller and Cavanagh 2000
[2] U.S. Department of the Navy 2009
[3] Bousman and Kufeld 2005
Notes: μPa = micropascal(s); dB = decibels; dBA = decibels, A-weighted; ft. = feet; m = meter(s); re = referenced to

Underwater sound from aircraft overflights has been modeled for some airframes. Eller and Cavanagh (2000) modeled underwater sound pressure level as a function of time at various depths (2, 10, and 50 m) for F/A-18 Hornet aircraft subsonic overflights (250 knots) at various altitudes (984.2, 3,280.8, and 9,842.4 ft. [300, 1,000, and 3,000 m]). For the worst modeled case of an F/A-18 at the lowest altitude (984.2 ft. [300 m]), the sound level at 6.6 ft. (2 m) below the surface peaked at 152 dB re 1 μPa, and the sound level at 164.0 ft. (50 m) below the surface peaked at 148 dB re 1 μPa. When F/A-18 flight was modeled at 9,842.4 ft. (3,000 m) altitude, peak sound level at 6.6 ft. (2 m) depth dropped to 128 dB re 1 μPa.

Sonic Booms

An intense but infrequent type of aircraft noise is the sonic boom, produced when an aircraft exceeds the speed of sound. Supersonic aircraft flights are usually limited to altitudes above 30,000 ft. (9,100 m) or locations more than 30 nm from shore. Several factors influence sonic booms: weight, size, shape of aircraft or vehicle; altitude; flight paths; and atmospheric conditions. A larger and heavier aircraft must displace more air and create more lift to sustain flight, compared with small, light aircraft. Therefore, larger aircraft create sonic booms that are stronger and louder than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the stronger the shock waves (U.S. Department of the Navy 2007).

Of all the factors influencing sonic booms, increasing altitude is the most effective method of reducing sonic boom intensity. The width of the boom “carpet” or area exposed to sonic boom beneath an aircraft is about 1 mi. (1.6 km) for each 1,000 ft. (305 m) of altitude. For example, an aircraft flying supersonic straight and level at 50,000 ft. (15,240 m) can produce a sonic boom carpet about 50 mi. (80.5 km) wide. The sonic boom, however, would not be uniform, and its intensity at the water surface would decrease with greater aircraft altitude. Maximum intensity is directly beneath the aircraft and decreases as the lateral distance from the flight path increases until shock waves refract away from the ground and the sonic boom attenuates. The lateral spreading of the sonic boom depends only on altitude, speed, and the atmosphere and is independent of the vehicle’s shape, size, and weight. The ratio of the aircraft length to maximum cross-sectional area also influences the intensity of the sonic boom. The longer and more slender the aircraft, the weaker the shock waves. The wider and more blunt the aircraft, the stronger the shock waves can be (U.S. Department of the Navy 2007).

F/A-18 Hornet supersonic flight was modeled to obtain peak sound pressure levels and energy flux density at the water surface and at depth (Laney and Cavanagh 2000). These results are shown in Table 3.0-14.

Table 3.0-14: Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight

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

[1] Mach number equals aircraft speed divided by the speed of sound

Notes: µPa = micropascal, µPa^2-s = squared micropascal-second, dB = decibel, km = kilometer, m = meter, re = referenced to

3.0.5.3.2 Energy Stressors

This section describes the characteristics of energy introduced into the water through naval training and testing and the relative magnitude and location of these activities to provide the basis for analysis of potential electromagnetic and laser impacts to resources in the remainder of Chapter 3.

3.0.5.3.2.1 Electromagnetic

Electromagnetic energy emitted from magnetic influence mine neutralization systems is analyzed in this document. The training and testing activities that involve the use of magnetic influence mine neutralization systems are detailed in Table 3.0-15.

Table 3.0-15: Annual Number and Location of Electromagnetic Energy Events

Activity Area	Training			Testing		
	No Action	Alternative 1	Alternative 2	No Action	Alternative 1	Alternative 2
Inland Waters	0	See Note	1	0	0	0
Total	**0**	**See Note**	**1**	**0**	**0**	**0**

Note: This event occurs once every 2 years under Alternative 1.

The majority of devices involved in the activities described above include towed or unmanned MIW systems that simply mimic the electromagnetic signature of a vessel passing through the water. None of the devices include any type of electromagnetic "pulse." An example of a representative device is the Organic Airborne and Surface Influence Sweep that would be used by a MH-60S helicopter at sea. The Organic Airborne and Surface Influence Sweep is towed from a forward flying helicopter and works by emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The sound and electromagnetic signature cause nearby mines to detonate.

Generally, voltage used to power these systems is around 30 volts relative to seawater. This amount of voltage is comparable to two automobile batteries. Since saltwater is an excellent conductor, only very moderate voltages of 35 volts (capped at 55 volts) are required to generate the current. These small levels represent no danger of electrocution in the marine environment, because the difference in electric charge is very low in saltwater.

The static magnetic field generated by the electromagnetic devices is of relatively minute strength. Typically, the maximum magnetic field generated would be approximately 23 gauss (G). This level of electromagnetic density is very low compared to magnetic fields generated by other everyday items. The magnetic field generated is between the levels of a refrigerator magnet (150–200 G) and a standard household can opener (up to 4 G at 4 in.). The strength of the electromagnetic field decreases quickly away from the cable. The magnetic field generated at a distance of 13.12 ft. (4 m) from the source is comparable to the earth's magnetic field, which is approximately 0.5 G. The strength of the field at just under 26 ft. (8 m) is only 40 percent of the earth's field, and only 10 percent at 79 ft. (24 m). At a radius of 656 ft. (200 m) the magnetic field would be approximately 0.002 G (U.S. Department of the Navy 2005).

3.0.5.3.2.2 Lasers

Laser devices can be organized into two categories: (1) low energy lasers and (2) high energy lasers. Low energy lasers are used to illuminate or designate targets, to guide weapons, and to detect or classify mines. High energy lasers are used as weapons to disable surface targets. No high energy lasers would be used in the Study Area as part of the Proposed Action and are not discussed further.

Low Energy Lasers

Within the category of low energy lasers, the highest potential level of exposure would be from an airborne laser beam directed at the ocean's surface. An assessment on the use of low energy lasers by the Navy determined that low energy lasers, including those involved in the training and testing activities in this EIS/OEIS, have an extremely low potential to impact marine biological resources (Swope 2010). The assessment determined that the maximum potential for laser exposure is at the ocean's surface, where laser intensity is greatest (Swope 2010). As the laser penetrates the water, 96 percent of a laser beam is absorbed, scattered, or otherwise lost (Ulrich 2004). Based on the parameters of the low energy lasers and the behavior and life history of major biological groups, it was determined the greatest potential for impact would be to the eye of a marine mammal or sea turtle. However, an animal's eye would have to be exposed to a direct laser beam for at least 10 seconds or longer to sustain damage. Swope (2010) assessed the potential for damage based on species specific eye/vision parameters and the anticipated output from low energy lasers and determined that no animals were predicted to incur damage. Therefore, low energy lasers are not analyzed further in this document as a stressor to biological resources.

3.0.5.3.3 Physical Disturbance and Strike Stressors

This section describes the characteristics of physical disturbance and strike stressors from Navy training and testing activities. It also describes the relative magnitude and location of these activities to provide the basis for analyzing the potential physical disturbance and strike impacts to resources in the remainder of Chapter 3. The following sources of physical disturbance and strike stressors will be described:

- Vessels
- In-water devices
- Military expended material
- Seafloor devices

- Aircraft strikes

3.0.5.3.3.1 Vessels

Vessels used as part of the Proposed Action include ships (e.g., aircraft carriers, surface combatants, surfaced submarines), submarines (submerged), and small boats (e.g., support craft, rigid hull inflatable boats). Table 3.0-16 provides examples of the types of vessels, length, and speeds used in both training and testing activities. The U.S. Navy Fact Files on the World Wide Web provide the latest information on the quantity and specifications of the vessels operated by the Navy.

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

Type	Example(s)	Length	Typical Operating Speed	Max Speed
Aircraft Carrier	Aircraft Carrier	> 980 ft. > 300 m	10–15 knots	30+ knots
Surface Combatant	Cruisers, Destroyers, Frigates, Littoral Combat Ships	330–660 ft. 100–200 m	10–15 knots	30+ knots
Support Craft/Other	Range Support Craft; Combat Rubber Raiding Craft; Landing Craft, Mechanized; Landing Craft, Utility; Submarine Tenders; Yard Patrol Craft; Barge	16–150 ft. 5–45 m	Variable	20 knots
Support Craft/Other – Specialized High Speed	Patrol Coastal Ships, Rigid Hull Inflatable Boat	65–130 ft. 20–40 m	Variable	50+ knots
Submarines	Fleet Ballistic Missile Submarines, Attack Submarines, Guided Missile Submarines	330–660 ft. 100–200 m	8–13 knots	20+ knots

Notes: ft. = feet, m = meters

Navy ships generally operate at speeds in the range of 10–15 knots, and submarines generally operate at speeds in the range of 8–13 knots. Small craft (for purposes of this discussion, less than 40 ft. [12 m] in length), which are all support craft, have much more variable speeds (dependent on the mission). While these speeds are representative of most events, some vessels need to operate outside of these parameters. For example, to produce the required relative wind speed over the flight deck, an aircraft carrier vessel group engaged in flight operations must adjust its speed through the water accordingly. Conversely, there are other instances such as launch and recovery of a small rigid hull inflatable boat, vessel boarding, search, and seizure training events or retrieval of a target when vessels would be dead in the water or moving slowly ahead to maintain steerage.

The number of Navy vessels in the Study Area at any given time varies and is dependent on local training or testing requirements. Most activities include either one or two vessels and may last from a few hours up to an entire day. Vessel movement as part of the Proposed Action would be widely dispersed throughout the Study Area, but more concentrated in portions of the Study Area near ports, naval installations, range complexes and testing ranges.

Table 3.0-17 provides the estimated number of events that include the use of vessels for each alternative. The location and hours of Navy vessel usage for training and testing are most dependent upon the locations of Navy ports, piers and established at-sea training and testing areas. These areas have not appreciably changed in the last decade and are not expected to change in the foreseeable future.

Table 3.0-17: Annual Number of Events Including Vessel Movement by Location

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Offshore Area	996	1,096	1,096	37	138	162
Inland Waters	4	28	28	337	582	640
Western Behm Canal	0	0	0	28	60	83
Total (All Areas)	**1,000**	**1,124**	**1,124**	**402**	**780**	**885**

While these estimates provide the average distribution of vessels, actual locations and hours of Navy vessel usage are dependent upon mission requirements, deployment schedules, annual budgets, and other unpredictable factors. Consequently, vessel use can be highly variable. The difference between the No Action Alternative and Alternatives 1 and 2 includes an increase in the number of many activities. Because multiple activities usually occur from the same vessel, the increased activities would not necessarily result in an increase in vessel use or transit. The concentration of activities and the manner in which the Navy uses vessels to accomplish its training and testing activities is likely to remain consistent with the range of variability observed over the last decade. Consequently, the Navy is not proposing appreciable changes in the levels, frequency, or locations where vessels have been used over the last decade.

3.0.5.3.3.2 In-Water Devices

In-water devices as discussed in this analysis are unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles, unmanned undersea vehicles, and towed devices. These devices are self-propelled or towed through the water from a variety of platforms, including helicopters and surface ships. In-water devices are generally smaller than most Navy vessels ranging from several inches to about 49.2 ft. (15 m). See Table 3.0-18 for a range of in-water devices used.

These devices can operate anywhere from the water surface to near the seafloor. Certain devices do not have a realistic potential to strike living marine resources because they either move slowly through the water column (e.g., gliders and oceanographic sensors) or are closely monitored by observers manning the towing platform (e.g., most towed devices). Because of their size and potential operating speed, in-water devices that operate in a manner with the potential to strike living marine resources are the Unmanned Surface Vehicles.

Table 3.0-18: Representative Types, Sizes, and Speeds of In-Water Devices

Type	Example(s)	Length	Typical Operating Speed
Towed Device	AQS Systems; Improved Surface Tow Target; Towed SONAR System; MK-103, MK-104 and MK-105 Minesweeping Systems; OASIS, Orion, Shallow Water Intermediate Search System, Towed Pinger Locator 30	< 10 m	10–40 knots
Unmanned Undersea Vehicle	Acoustic Mine Targeting System, AMNS, AN-ASQ Systems, Archerfish Common Neutralizer, Crawlers, CURV 21, Deep Drone 8000, Deep Submergence Rescue Vehicle, Gliders, EMATTs, Light and Heavy Weight Torpedoes, Magnum ROV, Manned Portables, MINIROVs, MK 30 ASW Targets, RMMV, Remote Minehunting System, Unmanned Influence Sweep	< 15 m	1–15 knots
Unmanned Surface Vehicle	Various surface test vehicles	< 10 m	1–15 knots

Notes: (1) AQS Systems are a family of helicopter deployed sonar systems used for underwater mine or submarine detection. AN-ASQ Systems are a family of helicopter deployed underwater mine neutralization systems. (2) AMNS = Airborne Mine Neutralization System, EMATT = Expendable Mobile Anti-Submarine Warfare Training Target, m = meters, MINIROV = Miniature Remotely Operated Vehicle, RMMV = Remote Multi-Mission Vehicle, ROV = Remotely Operated Vehicle

Table 3.0-19 provides estimates of relative in-water device use and location, for each of the alternatives. These are based on the estimated number of events that include the use of in-water devices for each alternative. While these estimates provide the average distribution of in-water devices, actual locations and hours of Navy in-water device usage are dependent upon military training and testing requirements, deployment schedules, annual budgets and other unpredictable factors.

Table 3.0-19: Annual Number and Location of Events Including In-Water Devices

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Offshore Area	429	484	484	40	154	183
Inland Waters	0	1[1]	1	379	648	716
Total (All Areas)	**429**	**485**	**485**	**419**	**802**	**899**

[1] This event occurs once every 2 years under Alternative 1.

3.0.5.3.3.3 Military Expended Material

Military expended materials include: (1) all sizes of non-explosive practice munitions (Table 3.0-20); (2) fragments from high explosive munitions (Table 3.0-21); and (3) expended materials other than ordnance, such as sonobuoys, torpedo and unmanned underwater vehicle accessories, expendable targets (Table 3.0-22) and unrecovered aircraft stores (fuel tanks, carriages, dispensers, racks, or similar types of support systems on aircraft).

Table 3.0-20: Number and Location of Non-Explosive Practice Munitions Expended Annually

Location	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Bombs						
Offshore Area	110	110	110	0	0	0
Missiles						
Offshore Area	15	15	15	0	0	0
Large-Caliber Projectiles						
Offshore Area	2,800	2,800	2,800	0	0	0
Medium-Caliber Projectiles						
Offshore Area	42,392	43,172	43,172	0	0	0
Small-Caliber Projectiles						
Offshore Area	117,000	121,200	121,200	0	0	0
Sonobuoys (includes Sound Underwater Signal buoys)						
Offshore Area	8,208	8,208	8,208	200	1,000	1,097
Inland Waters	0	0	0	6	6	6
Marine Markers						
Offshore Area	240	334	334	0	190	210

Table 3.0-21: Annual Number and Location of High-Explosives that May Result in Fragments

Location	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Torpedoes						
Offshore Area	2	0	0	0	6	8
Sonobuoys						
Offshore Area	150	150	150	0	142	156
Bombs						
Offshore Area	34	10	10	0	0	0
Missiles						
Offshore Area	45	27	27	0	0	0
Large-Caliber Projectiles						
Offshore Area	470	390	390	0	0	0
Medium-Caliber Projectiles						
Offshore Area	6,368	6,498	6,498	0	0	0
Underwater Detonations						
Inland Waters	4	42	42	0	0	0

Table 3.0-22: Number and Location of Targets Expended Annually

Location	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Sub-surface Targets						
Offshore Area	126	130	130	14	90	102
Inland Waters	0	0	0	8	9	11
Surface Targets						
Offshore Area	210	210	210	0	0	0
Air Targets						
Offshore Area	28	28	28	0	0	0
Mine Shapes						
Inland Waters	4	42	42	0	0	0
Ship Hulk						
Offshore Area	2	0	0	0	0	0

While disturbance or strike from any material as it falls through the water column is possible, it is not likely because the object will slow in velocity as it sinks toward the bottom and can be avoided by highly mobile organisms. For living marine resources in the water column, the discussion of military expended material strikes focuses on the potential of a strike at the surface of the water. The effect of materials settling on the bottom will be discussed as an alteration of the bottom substrate and associated organisms (i.e., invertebrates and vegetation).

3.0.5.3.3.4 Seafloor Devices

Seafloor devices represent items used during training or testing activities that are deployed onto the seafloor. These items include moored mine shapes, anchors, bottom placed instruments, and robotic vehicles referred to as “crawlers.” Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile organisms. The effect of devices on the bottom will be discussed as an alteration of the seafloor and associated living resources (i.e., invertebrates and vegetation).

The location and number of events including seafloor devices are summarized in Table 3.0-23.

Table 3.0-23: Annual Number and Location of Events Including Seafloor Devices

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Offshore Area	0	0	0	5	6	7
Inland Waters	2	16	16	210	225	239
Western Behm Canal	0	0	0	0	5	15

3.0.5.3.3.5 Aircraft Strikes

Aircraft involved in Navy training and testing activities are separated into three categories: (1) fixed-wing aircraft, (2) rotary-wing aircraft, and (3) unmanned aircraft systems. Fixed-wing aircraft include, but are not limited to, planes such as P-3, P-8, E/A-6B, E/A-18G, and F-35. Rotary-wing aircraft are generally helicopters, such as MH-60. Unmanned aircraft systems include a variety of platforms, including but not limited to, the Small Tactical Unmanned Aircraft System—Tier II, Broad Area Maritime Surveillance unmanned aircraft, Fire Scout Vertical Take-off and Landing Unmanned Aerial Vehicle, and the Unmanned Combat Air System. Aircraft strikes are only applicable to birds.

The location and number of events including aircraft movement is summarized in Table 3.0-24.

Table 3.0-24: Annual Number and Location of Events Including Aircraft Movement

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Offshore Area[1]	3,826	6,471	6,471	2	74	84
Inland Waters[2]	124	127	127	2	20	25

[1] All Offshore Area aircraft activities are fixed wing except for 4 each in Alternative 1 and Alternative 2.

[2] All Inland Waters aircraft activities are fixed wing.

3.0.5.3.4 Entanglement Stressors

This section describes the entanglement stressors introduced into the water through naval training and testing and the relative magnitude and location of these activities to provide the basis for analysis of potential impacts to resources in the remainder of Chapter 3. To assess the entanglement risk of materials expended during training and testing, the Navy examined the characteristics of these items (such as size and rigidity) for their potential to entangle marine animals. For a constituent of military expended materials to entangle a marine animal, it must be long enough to wrap around the appendages of marine animals. Another critical factor is rigidity; the item must be flexible enough to wrap around appendages or bodies. This analysis includes the potential impacts from the following two types of military expended materials:

- fiber optic cables and guidance wires
- decelerator/parachutes

Unlike typical fishing nets and lines, the Navy's equipment is not designed for trapping or entanglement purposes. The Navy deploys equipment designed for military purposes and strives to reduce the risk of accidental entanglement posed by any item it releases into the sea.

3.0.5.3.4.1 Fiber Optic Cables and Guidance Wires

Fiber Optic Cables

Fiber optic cables are flexible, durable, and abrasion or chemical-resistant, and the physical characteristics of the fiber optic material render the cable brittle and easily broken when kinked, twisted, or bent sharply (i.e., looped). The cables are often designed with controlled buoyancy to minimize the cable's effect on vehicle movement. The fiber optic cable would be suspended within the water column during the activity, and then be expended to sink to the sea floor.

The estimated location and number of expended fiber optic cables are detailed below in Table 3.0-25.

Table 3.0-25: Number and Location of Fiber Optic Cables and Guidance Wires Expended Annually During Training and Testing

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Offshore Area	2	0	0	16	20	24
Inland Waters	0	1	1	105	122	133

Guidance Wires

Wires expended during Navy training and testing activities are guidance wires from heavy-weight torpedoes and tube-launched, optically tracked, wire guided missiles. Guidance wires are used to help the firing platform control and steer the torpedo or missile. They trail behind the torpedo or missile as it moves through the water or air. The guidance wire is released from the firing platform and the torpedo or tube-launched, optically tracked, wire guided missile and sinks to the ocean floor.

The torpedo guidance wire is a single-strand, thin gauge, coated copper alloy. The tensile breaking strength of the wire is a maximum of 42 lb. (19 kilograms [kg]) and can be broken by hand (Environmental Sciences Group 2005), contrasting with the rope or lines associated with commercial fishing towed gear (trawls), stationary gear (traps), or entanglement gear (gillnets) that utilize lines with substantially higher (up to 500–2,000 lb. [227–907 kg]) breaking strength as their “weak links” to minimize entanglement of marine animals (National Marine Fisheries Service 2008). While guidance wires can coil after use (Environmental Sciences Group 2005), the physical characteristics of the wire prevent it from tangling, unlike the monofilament fishing lines and polypropylene ropes identified in the literature (U.S. Department of the Navy 1996). Torpedo guidance wire sinks at an estimated rate of 0.7 ft. (0.2 m) per second.

The tube-launched, optically tracked, wire guided missile system has two thin (5.75 mils or 0.146 mm diameter) wires. Two wire dispensers containing several thousand meters each of single-strand wire with a minimum tensile strength of 10 lb. are mounted on the rear of the missile. The length of wire dispensed would generally be equal to the distance the missile travels to impact the target and any undispensed wire would be contained in the dispensers upon impact. While degradation rates for the wire may vary because of changing environmental conditions in seawater, assuming a sequential failure or degradation of the enamel coating (degradation time is about 2 months), the copper plating (degradation time is about 1.5–25 months), and the carbon-steel core (degradation time is about 8–18 months), degradation of the tube-launched, optically tracked, wire guided missile guide wire would take 12–45 months.

3.0.5.3.4.2 Parachutes

Aircraft-launched sonobuoys, lightweight torpedoes (such as the MK 46 and MK 54), illumination flares, and targets use nylon decelerator/parachutes ranging in size from 18 to 48 in. (46 to 122 centimeters [cm]) in diameter. The majority of expended decelerator/parachutes are cruciform decelerators associated with sonobuoys, which are relatively small (see Figure 3.0-6), and have short attachment lines. Decelerator/parachutes are made of cloth and nylon, and many have weights attached to the lines for rapid sinking. At water impact, the decelerator/parachute assembly is expended, and it sinks away from the unit. The decelerator/parachute assembly may remain at the surface for 5–15 seconds before the decelerator/parachute and its housing sink to the seafloor, where it becomes flattened (Environmental Sciences Group 2005). Some decelerator/parachutes are weighted with metal clips that facilitate their descent to the seafloor. Once settled on the bottom the canopy may temporarily billow if bottom currents are present.

Figure 3.0-6: Sonobuoy Launch Depicting the Relative Size of a Decelerator/Parachute

The estimated number of decelerator/parachutes and locations where they would be expended are detailed below in Table 3.0-26.

Table 3.0-26: Annual Number and Location of Expended Decelerator/Parachutes

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Offshore Area	8,382	8,382	8,382	17	1,229	1,351
Inland Waters	0	0	0	4	4	5

3.0.5.3.5 Ingestion Stressors

This section describes the ingestion stressors introduced into the water through naval training and testing and the relative magnitude and location of these activities to provide the basis for analysis of potential impacts to resources in the remainder of Chapter 3. To assess the ingestion risk of materials expended during training and testing, the Navy examined the characteristics of these items (such as buoyancy and size) for their potential to be ingested by marine animals in the Study Area. The Navy expends the following types of materials that could become ingestion stressors during training and testing in the Study Area:

- Non-explosive practice munitions (small- and medium-caliber)
- Fragments from high-explosive munitions
- Military expended materials other than munitions

Solid metal materials, such as small-caliber projectiles, or fragments from high-explosive munitions, sink rapidly to the seafloor. Lighter items may be caught in currents and gyres or entangled in floating

Sargassum or kelp and could remain in the water column for hours to weeks or indefinitely before sinking (e.g., plastic end caps or pistons).

3.0.5.3.5.1 Non-Explosive Practice Munitions

Only small- or medium-caliber projectiles would be small enough for marine animals to ingest. This would vary depending on the resource and will be discussed in more detail within each resource section. Small- and medium-caliber projectiles include all sizes up to and including those that are 2.25 in. (57 mm) in diameter. These solid metal materials would quickly move through the water column and settle to the sea floor.

The overall number of expended small- and medium-caliber non-explosive practice munitions and locations where they occur can be found above in Table 3.0-20.

3.0.5.3.5.2 Fragments from High-Explosive Munitions

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

Types of high-explosive munitions that can result in fragments include demolition charges, grenades, projectiles, missiles, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the net explosive weight and munition type; however, typical sizes of fragments are unknown. These solid metal materials would quickly sink through the water column and settle to the seafloor.

The overall number of high-explosive munitions that may result in fragments, and the locations where they occur were detailed above in Table 3.0-21.

3.0.5.3.5.3 Military Expended Materials Other Than Munitions

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

Target-Related Materials

At-sea targets are usually remotely-operated airborne, surface, or subsurface traveling units, most of which are designed to be recovered for reuse. However, if they are used during activities that utilize high-explosives then they may result in fragments. Expendable targets that may result in fragments would include air-launched decoys, surface targets (such as marine markers, paraflares, cardboard boxes, and 10 ft. [3.05 m] diameter red balloons), and mine shapes. Most target fragments would sink quickly to the seafloor. Floating material, such as Styrofoam, may be lost from target boats and remain at the surface for some time (see Section 2.3.3 for additional information on targets). Only targets that may result in smaller fragments are included in the analyses of ingestion potential.

The number and location per year of targets used during training and testing activities with the potential to result in small fragments were detailed above in Table 3.0-22.

Chaff

Chaff consists of reflective, aluminum-coated glass fibers used to obscure ships and aircraft from radar-guided systems. Chaff, which is stored in canisters, is either dispensed from aircraft or fired into the air from the decks of surface ships when an attack is imminent. The glass fibers create a radar cloud that mask the position of the ship or aircraft. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (U.S. Air Force 1997). Chaff is released or dispensed in cartridges or projectiles that contain millions of fibers. When deployed, a diffuse cloud of fibers is formed that is undetectable to the human eye. Chaff is a very light material, similar to fine human hair. It can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (U.S. Air Force 1997; Arfsten et al. 2002). Doppler radar has tracked chaff plumes containing approximately 900 grams of chaff drifting 200 mi. (322 km) from the point of release, with the plume covering greater than 400 cubic miles (1,667 cubic kilometers) (Arfsten et al. 2002).

The chaff concentrations that marine animals could be exposed to following release of multiple cartridges (e.g., following a single day of training) is difficult to accurately estimate because it depends on several variable factors. First, specific release points are not recorded and tend to be random, and chaff dispersion in air depends on prevailing atmospheric conditions. After falling from the air, chaff fibers would be expected to float on the sea surface for some period, depending on wave and wind action. The fibers would be dispersed farther by sea currents as they float and slowly sink toward the bottom. Chaff concentrations in benthic habitats following the release of a single cartridge would be lower than the values noted in this section, based on dispersion by currents and the dilution capacity of the ocean.

Several literature reviews and controlled experiments indicate that chaff poses little risk to organisms, except at concentrations substantially higher than those that could reasonably occur from military training (U.S. Air Force 1997; Hullar et al. 1999; Arfsten et al. 2002). Nonetheless, some marine animal species within the Study Area could be exposed to chaff through direct body contact, inhalation, and ingestion. Chemical alteration of water and sediment from decomposing chaff fibers is not expected to occur. Based on the dispersion characteristics of chaff, it is likely that marine animals would occasionally come in direct contact with chaff fibers while either at the water's surface or while submerged, but such contact would be inconsequential. Because of the flexibility and softness of chaff, external contact would not be expected to impact most wildlife (U.S. Air Force 1997) and the fibers would quickly wash off shortly after contact. Given the properties of chaff, skin irritation is not expected to be a problem (U.S. Air Force 1997). The potential exists for marine animals to inhale chaff fibers if they are at the surface while chaff is airborne. Arfsten et al. (2002), Hullar et al. (1999), and U.S. Air Force (1997) reviewed the potential impacts of chaff inhalation on humans, livestock, and other animals and concluded that the fibers are too large to be inhaled into the lungs. The fibers were predicted to be deposited in the nose, mouth, or trachea and either swallowed or expelled.

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

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

The estimated number of events per year that would involve expending chaff and locations where they occur are detailed below in Table 3.0-27.

Table 3.0-27: Annual Number and Location of Events that Involve the Use of Expended Chaff

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Offshore Area	2,900	5,000	5,000	0	0	0

Flares

Flares are pyrotechnic devices used to defend against heat-seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft's engines. Similar to chaff, flares are also dispensed from aircraft and fired from ships. The flare device consists of a cylindrical cartridge approximately 1.4 in. (3.6 cm) in diameter and 5.8 in. (14.7 cm) in length. Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic end cap (approximately 1.4 in. [3.6 cm] in diameter).

An extensive literature review and controlled experiments conducted by the U.S. Air Force revealed that self-protection flare use poses little risk to the environment or animals (U.S. Air Force 1997).

The overall number of flares expended annually is detailed below in Table 3.0-28.

Table 3.0-28: Annual Number and Location of Events that Involve the Use of Expended Flares

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Offshore Area	184	224	224	0	600	660

3.0.5.4 Resource-Specific Impacts Analysis for Individual Stressors

The direct and indirect impacts of each stressor carried forward for further analysis were analyzed for each resource in their respective section. Quantitative and semi-quantitative methods were used to the extent possible, but inherent scientific limitations required the use of qualitative methods for most stressor/resource interactions. Resource-specific methods are described in sections of Chapter 3, where applicable. While specific methods used to analyze the impacts of individual stressors varied by resource, the following generalized approach was used for all stressor/resource interactions:

- The frequency, duration, and spatial extent of exposure to stressors were analyzed for each resource. The frequency of exposure to stressors or frequency of a proposed activity was characterized as intermittent or continuous, and was quantified in terms of number per unit of time when possible. Duration of exposure was expressed as short- or long-term and was quantified in units of time (e.g., seconds, minutes, and hours) when possible. The spatial extent of exposure was generally characterized as widespread or localized, and the stressor footprint or area (e.g., $ft.^2$, square nautical miles [nm^2]) was estimated when possible.
- An analysis was conducted to determine whether and how resources are likely to respond to stressor exposure or be altered by stressor exposure based upon available scientific knowledge. This step included reviewing available scientific literature and empirical data. For many

stressor/resource interactions, a range of likely responses or endpoints was identified. For example, exposure of an organism to sound produced by an underwater explosion could result in no response, a physiological response such as increased heart rate, a behavioral response such as being startled, injury, or mortality.

- The information obtained was used to analyze the likely impacts of individual stressors on a resource and to characterize the type, duration, and intensity (severity) of impacts. The type of impact was generally defined as beneficial or adverse and was further defined as a specific endpoint (e.g., change in behavior, mortality, change in concentration, loss of habitat, loss of fishing time). When possible, the endpoint was quantified. The duration of an impact was generally characterized as short-term (e.g., minutes, days, weeks, months, depending on the resource), long-term (e.g., months, years, decades, depending on the resource), or permanent. The intensity of an impact was then determined. For biological resources, the analysis started with individual organisms and their habitats, and then addressed populations, species, communities, and representative ecosystem characteristics, as appropriate.

3.0.5.5 Resource-Specific Impacts Analysis for Multiple Stressors

The stressors associated with the proposed training and testing activities could affect each resource individually or in combination. The impacts of multiple stressors may be different when considered collectively rather than individually. Therefore, following the stressor-specific impact analysis for specific resources, the combined impacts of all stressors were analyzed for that resource. This step determines the overall impacts of the alternatives on each resource, and it considers the potential for impacts that are additive (where the combined impacts on the resource are equal to the sum of the individual impacts), synergistic (where impacts combine in such a way as to amplify the effect on the resource), and antagonistic (where impacts will cancel each other out or reduce a portion of the effect on the resource). In some ways, this analysis is similar to the cumulative impacts analysis described below, but it only considers the activities in the alternatives and not other past, present, and reasonably foreseeable future actions. This step helps focus the next steps of the approach (cumulative impacts analysis) and make overall impact conclusions for each resource.

Evaluating the combined impacts of multiple stressors can be complex, especially when the impacts associated with a stressor are hard to measure. Therefore, some general assumptions were used to help determine the potential for individual stressors to contribute to combined impacts. For this analysis, combined impacts were considered more likely to occur in the following situations:

- Stressors co-occur in time and space, causing a resource to be simultaneously affected by more than one stressor.
- A resource is repeatedly affected by multiple stressors or is re-exposed before fully recovering from a previous exposure.
- The impacts of individual stressors are permanent or long-term (years or decades) versus short-term (minutes, days, or months).
- The intensity of the impacts from individual stressors is such that mitigation would be necessary to offset adverse impacts.

The resource-specific impacts analysis for multiple stressors included the following steps:

- Information obtained from the analysis of individual stressors was used to develop a conceptual model to predict the combined impacts of all stressors on each resource. This conceptual model incorporated factors such as the co-occurrence of stressors in space and time; the impacts or assessment endpoints of individual stressors (e.g., mortality, injury, changes in animal behavior or physiology, habitat alteration, changes in human use); and the duration and intensity of the impacts of individual stressors.

- To the extent possible, additive impacts on a given resource were considered by summing the impacts of individual stressors. This summation was only possible for stressors with identical and quantifiable assessment endpoints. For example, if one stressor disturbed 0.25 nm^2 of benthic habitat, a second stressor disturbed 0.5 nm^2, and all other stressors did not disturb benthic habitat, then the total benthic habitat disturbed would be 0.75 nm^2.
- For stressors with differing impacts and assessment endpoints, the potential for additive, synergistic, and antagonistic effects were evaluated based on available scientific knowledge, professional judgment, and the general assumptions outlined above. Continuing with the previous example, if these two stressors overlapped, the overlap would lead to an overall area of disturbance that is less than the sum of the individual areas, thereby resulting in a potentially reduced total impact. However, the overlap of some stressors could act synergistically to increase the overall impact to a level greater than the sum of the two stressors.
- For stressors with identical but not quantifiable assessment endpoints, available scientific knowledge, best professional judgment, and the general assumptions outlined above were used to evaluate potential additive impacts.

3.0.5.6 Cumulative Impacts

A cumulative impact is the impact on the environment that results when the incremental impact of an action is added to other past, present, and reasonably foreseeable future actions. The cumulative impacts analysis (Chapter 4, Cumulative Impacts) considers other actions regardless of what agency (federal or nonfederal) or person undertakes the actions. Cumulative impacts result when individual actions combine with similar actions taking place over a period of time to produce conditions that frequently alter the historical baseline (40 C.F.R. § 1508.7). The goal of the analysis is to provide the decision makers with information relevant to reasonably foresee potentially significant impacts. See Chapter 4 (Cumulative Impacts) for the specific approach used for determining cumulative impacts.

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3.1 Sediments and Water Quality

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3.1 SEDIMENTS AND WATER QUALITY

SEDIMENTS AND WATER QUALITY SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following constituents have been analyzed for their effects on sediments and water quality:

- Explosives and explosion byproducts
- Metals
- Chemicals other than explosives (or explosion byproducts)
- Other materials (i.e., chaff and flares)

Preferred Alternative (Alternative 1)

- Impacts of explosion byproducts would be short term and local, while impacts of unconsumed explosives and metals would be long term and local. Chemical or physical changes in sediment or water quality would not exceed applicable standards, regulations, or guidelines.
- Impacts of metals would be long term and local. Corrosion and biological processes would reduce exposure of military expended materials to seawater, decreasing the rate of leaching, and most leached metals would bind to sediments and other organic matter. Elevated levels of metals in sediments would be restricted to a small zone around the metal.
- Impacts of chemicals other than explosives would be both short term and long term as well as local. Chemical or physical changes in sediment or water quality would not be detectable and would be within existing conditions or designated uses.
- Impacts of other materials would be short term and local. Most other constituents of military expended materials would not be harmful to marine organisms and would be consumed during use. Chemical or physical changes in sediment or water quality would not be detectable.

3.1.1 INTRODUCTION AND METHODS

3.1.1.1 Introduction

The following sections provide an overview of the characteristics of sediment and water quality in the Northwest Training and Testing (NWTT) Study Area (hereafter referred to as the Study Area) and describe in general terms the methods used to analyze potential impacts of the Proposed Action on these resources.

3.1.1.1.1 Sediments

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

3.1.1.1.1.1 Characteristics of Sediments

Sediment consists of solid fragments of organic matter derived from biological organisms in the overlying water column and inorganic matter from the weathering of rock that are transported by water, wind, and ice (glaciers) and deposited at the bottom of bodies of water. Sediments range in size from cobble (2.5–10 inches [in.] [64–254 millimeters {mm}]), to pebble (0.15–2.5 in. [4–64 mm]), to granule (0.08–0.15 in. [2.03–3.81 mm]), to sand (0.002–0.08 in. [0.05–2.03 mm]), to silt (0.00008–0.0002 in. [0.002–0.05 mm]), and to clay (less than 0.00008 in. [less than 0.002 mm]). Sediment deposited on the continental shelf is mostly transported by rivers but also by local and regional currents and wind. Most sediments in nearshore areas and on the continental shelf of the Pacific Ocean are land-derived aluminum silicates deposited at rates of more than 10 centimeters (cm) (3.9 in.) per 1,000 years. Sediments may also be produced locally by nonliving particulate organic matter (detritus) that sinks to the bottom. For example, some areas of the deep ocean contain accumulations of the shells of marine microbes composed of silicones and calcium carbonates, termed biogenic ooze (Chester 2003). Many substances in the water column attach to particles that, through the downward movement of organic and inorganic particles in the water column, are incorporated into bottom sediments (Chapman et al. 2003; Kszos et al. 2003).

3.1.1.1.1.2 Factors Affecting Marine Sediment Quality

The quality of sediments is influenced by their physical, chemical, and biological components; by where they are deposited; by the properties of seawater; and by other inputs and sources of contamination. These factors interact to some degree, so the characteristics of sediments tend to be dynamic and are not easily generalized. For this discussion, “contaminant” means biological, chemical, or physical materials, which, when present at concentrations higher than natural conditions, can impact marine processes.

3.1.1.1.1.3 Sediment Physical Characteristics and Processes

At any given site, the texture and composition of sediments are important physical factors that influence the types of substances that are retained in the sediments, as well as subsequent biological and chemical processes. Clay-sized sediments and similarly sized organic particles tend to bind potential sediment contaminants such as metals, hydrocarbons, and persistent organic pollutants. Through this attraction, these particles efficiently scavenge contaminants from the water column and from the water between grains of sediment (pore water), and may bind them so strongly that their movement in the environment is limited (United States [U.S.] Environmental Protection Agency 2008a). Conversely, fine-grained sediments are easily disturbed by currents and bottom-dwelling organisms (Hedges and Oades 1997), dredging (Eggleton and Thomas 2004), storms (Chang et al. 2001), and bottom trawling (Churchill 1989). Disturbance is also possible in deeper areas, where currents are minimal (Carmody et al. 1973), from mass wasting events such as underwater slides and debris flows (Coleman and Prior 1988). If resuspended, fine-grained sediments (and any substances bound to them) can be transported long distances.

3.1.1.1.1.4 Sediment Chemical Characteristics and Processes

The concentration of oxygen in sediments strongly influences sediment quality through its effect on the binding of materials to sediment particles. At the sediment surface, the level of oxygen is usually the same as that of the overlying water. Deeper sediment layers, however, are often low in oxygen (hypoxic) or have no oxygen (anoxic), and have a low oxidation-reduction (redox) potential, which predicts the stability of various compounds that regulate nutrient and metal availability in sediments. Certain substances combine in oxygen-rich environments and become less available for other chemical or biological reactions. If these combined substances settle into the low or no-oxygen sediment zone, the change in oxygen concentration may release them into pore water, making them available for other chemical or biological reactions. Conversely, substances that remain in solution in oxygenated environments may combine with organic or inorganic substances under hypoxic or anoxic conditions and are thus removed from further chemical or biological reactions (Spencer and MacLeod 2002; Wang et al. 2002).

3.1.1.1.1.5 Sediment Biological Characteristics and Processes

Organic matter in sediment provides food for resident microbes. Their metabolism can change the chemical environment in sediments and thereby increase or decrease the mobility of various substances and influence the ability of sediments to retain and transform those substances (Mitsch and Gosselink 2007; U.S. Environmental Protection Agency 2008a). Bottom-dwelling animals often rework sediments in the process of feeding or burrowing (bioturbation). In this way, marine organisms influence the structure, texture, and composition of sediments as well as the horizontal and vertical distribution of substances in the sediment (Boudreau 1998). Moving substances out of or into low- or no-oxygen zones in the sediment may alter the form and availability of various substances. The metabolic processes of bacteria also influence sediment components directly. For example, sediment microbes may convert mercury to methyl mercury, increasing its toxicity (Mitchell and Gilmour 2008).

3.1.1.1.1.6 Location

The quality of coastal and marine sediments is influenced substantially by inputs from adjacent watersheds (Turner and Rabalais 2003). Proximity to watersheds with large cities or intensively farmed lands often increases the amount of both inorganic and organic contaminants that find their way into coastal and marine sediments. Metals enter estuaries through the weathering of natural rocks and mineralized deposits carried by rivers and through man-made inputs that often contribute amounts substantially above natural levels. The metals of greatest concern are cadmium, chromium, mercury, lead, selenium, arsenic, and antimony because they bioaccumulate, are toxic to biota at low concentrations, and have few natural functions in biological systems (Summers et al. 1996). In addition to metals, a wide variety of organic substances, such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs), and pesticides—often referred to collectively as “persistent organic pollutants”—are discharged into coastal waters by urban, agricultural, and industrial point and nonpoint sources in the watershed (U.S. Environmental Protection Agency 2008a).

The natural processes of estuaries retain a wide variety of substances (Li et al. 2008; Mitsch and Gosselink 2007). Examples of these processes include the binding of materials to small particles in the water column and the settling of those particles into sediments in calm areas. Thus, the concentrations of various substances generally decrease with increasing distance from the shore. Once in the ocean, the fates of various substances may also be influenced by alongshore currents that travel parallel to the shore (Duursma and Gross 1971). Location on the ocean floor also influences the distribution and concentration of various elements through local geology and volcanic activity (Demina et al. 2009), as well as through mass wasting events (Coleman and Prior 1988).

3.1.1.1.1.7 Other Contributions to Sediments

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

Hydrocarbons are common in marine sediments. In addition to washing in from land and shipping sources, they are generated by the combustion of fuels (both wood and petroleum), are produced directly by marine and terrestrial biological sources, and arise from processes in sediments, including microbial activity and natural hydrocarbon seeps (Boehm and Gequejo 1986; Geiselbrecht et al. 1998). Means (1995) noted that, because of the large binding capacities of rich, organic, fine-grained sediments found at many coastal and estuarine sites, "hydrocarbons may concentrate to levels far exceeding those observed in the water column of the receiving water body."

3.1.1.1.2 Water Quality

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

3.1.1.1.2.1 Characteristics of Marine Waters

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

pH

The chemical parameter pH is a measure of the hydrogen ion potential, which determines the degree to which a solution is either acidic (pH less than 7.0) or basic (pH greater than 7.0). Seawater has a relatively stable pH between 7.5 and 8.5 because of the presence of dissolved elements, particularly carbon and hydrogen. Most of the carbon in the sea is present as dissolved inorganic carbon generated through the complex interactions of dissolved carbon dioxide (CO_2) in seawater. This CO_2-carbonate equilibrium is the major pH buffering system in seawater. Changes in pH outside of the normal range of seawater can make maintaining the integrity their shells difficult for marine animals that secrete calcium carbonate (e.g., mollusks; Fabry et al. 2008).

Temperature

Temperature influences the speed at which chemical reactions take place in solution: higher temperatures increase reaction rates and vice versa. Seasonal changes in weather influence water temperatures that, in turn, influence the degree to which marine waters mix. The increases in surface water temperatures during summer create three distinct layers in deeper water, a process known as stratification. The warmer surface layer is separated from colder water below by an intervening layer (thermocline) within which the temperature changes rapidly with depth. Stratification can limit the exchange of gases and nutrients, as well as the onset and decline of phytoplankton blooms (Howarth et al. 2002). In fall and winter, lower air temperatures and cool surface waters break down the vertical stratification and promote mixing within the water column.

The Pacific Northwest experiences relatively cool ocean water temperatures because of the southerly flow of the California Current through the region (Burger 2003, Yen et al. 2005). Winter water temperatures range from 46 degrees Fahrenheit (°F) (8° Celsius [°C]) in the northern regions to 50°F (10°C) in the southern regions. Summer water temperatures are similar in the northern and southern regions, ranging up to 63°F (17°C). During the summer, water temperatures vary according to distance from the coast, increasing to 63°F (17°C) offshore compared to 52°F (11°C) along the coast (Greenland 1998). These temperatures have fluctuated considerably over the past 50 years in response to cyclical and long-term climate changes (Douglas et al. 1982, Trenberth 1990, Tanimoto et al. 1993, Airamé et al. 2003).

Water temperatures within Puget Sound vary considerably, ranging from 37°F (3°C) during the winter to 73°F (23°C) during the summer (National Marine Fisheries Service 2008). Deep, well-mixed waters in Puget Sound show less seasonal variation compared to shallow, more stratified waters. Local influences include inputs of fresh water from rivers and streams, which tend to be colder in the winter and warmer in the summer than marine waters (Washington State Department of Ecology 2002).

Oxygen

Surface waters in the ocean are usually saturated or supersaturated with dissolved oxygen by photosynthetic activity and wave mixing (89–106 percent, 4.49–5.82 milliliters per liter [ml/L]). As water depth below the surface increases, the oxygen concentration decreases from more than 60 percent (4.4 ml/L) to a minimum of 27 percent (1.7 ml/L) at intermediate depths between 1,000 and 3,000 feet (ft.) (300 and 900 meters [m]). Thereafter, the oxygen level increases with depth to about 6,500 ft. (2,000 m; 73–88 percent, 5.4–6.7 ml/L) and remains relatively constant at greater depths (Seiwell 1934).

A dissolved oxygen concentration of less than two milligrams per liter (mg/L) is considered to be poor, a condition referred to as hypoxia (Rabalais et al. 2002; U.S. Environmental Protection Agency 2008a). Such low oxygen levels are natural in marine systems under certain conditions, such as oxygen minimum zones at intermediate depths, upwelling areas, deep ocean basins, and fjords (Helly and Levin 2004). Upwelling is the movement of colder, nutrient-rich, and often oxygen-poor waters from deeper areas of the ocean to the surface. However, the occurrence of hypoxia and anoxia in shallow coastal and estuarine areas can adversely affect fish, bottom-dwelling (benthic) creatures, and submerged aquatic vegetation. Hypoxia appears to be increasing, primarily as a result of increases in nutrient inputs (Diaz and Rosenberg 1995), and affects more than half of the estuaries in the United States (Bricker et al. 1999). Hypoxia in the Northwest, however, appears to be driven primarily by natural processes linked to variations in climate (Committee on Environment and Natural Resources 2010). In the summer, upwelling of colder, nutrient-rich, and oxygen-poor waters produce an increase of phytoplankton in coastal waters. The abundant phytoplankton that blooms at the surface ultimately sinks toward the sea floor, where it decomposes. Decomposition consumes oxygen from the water column. The upwelling process can thus lead to oxygen depletion near the sea floor that extends up through two-thirds of the water column. If seasons of strong upwelling are not interrupted with periods of downwelling, low oxygen levels can accumulate, causing a dead zone (Partnership for Interdisciplinary Studies of Coastal Oceans n.d.). Within the Pacific Northwest coastal region, severe hypoxia has become a recurring phenomenon. From 2002 to 2007, the area and extent of the hypoxic zone, or dead zone, has increased (Partnership for Interdisciplinary Studies of Coastal Oceans n.d.). There is uncertainty about the cause of the increasing frequency of hypoxic events in the Northwest. Scientists suspect that there have been fundamental changes in ocean and wind conditions off the Oregon and Washington coasts. These changes may include either oceanic or atmospheric changes or both (Partnership for Interdisciplinary Studies of Coastal Oceans n.d.).

Nutrients

Nutrients are compounds necessary for the growth and metabolism of organisms. In marine systems, basic nutrients include dissolved nitrogen, phosphates, silicates, and metals such as iron and copper. Dissolved inorganic nitrogen occurs in ocean water as nitrates and ammonia (Zehr and Ward 2002). Depending on local conditions, the productivity of marine ecosystems may be limited by the amount of phosphorus available or, more often, by the amount of nitrogen available (Cloern 2001; Anderson et al. 2002). Too much of either nutrient can lead to eutrophication. High concentrations of nutrients can stimulate algal blooms, the rapid expansion of microscopic algae (phytoplankton). Once the excess nutrients are consumed, the algae population dies off and the remains are consumed by bacteria. Bacterial consumption causes dissolved oxygen in the water to decline to the point where organisms can no longer survive (Boesch et al. 1997). Sources of excess nutrients include fertilizers, wastewater, and atmospheric deposition of the combustion products from burning fossil fuels (Turner and Rabalais 2003). Biogeochemical processes in estuaries and on the continental shelf influence the extent to which nitrogen and phosphorus reach the open ocean. Many of these nutrients eventually reside in coastal sediments (Nixon et al. 1996).

Salinity and Ions

The concentrations of major ions in seawater determine its salinity. These ions include sodium, chloride, potassium, calcium, magnesium, and sulfate.

Salinity depends on the ratio of evaporation to precipitation. For example, regions closer to the equator are generally higher in salinity because of their higher evaporation rates. In general, salinity increases southward along the coast, ranging between 32 and 35 practical salinity units (PSU), which is equivalent to parts per thousand (McGowan et al. 1998, Huyer et al. 2002).

The extent of freshwater plumes from surface waters, particularly the Columbia River, can also dramatically affect local salinity. Salinity in Puget Sound ranges from 25 to 30 PSU, while salinity in other estuaries can range from 10 to 25 PSU (Grays Harbor) and 20 to 30 PSU (Willapa Bay) (Washington State Department of Ecology 2002).

Hydrocarbons

Hydrocarbons are common in marine ecosystems. They arise from man-made sources, from natural hydrocarbon seeps, and from microbial activity (Boehm and Requejo 1986; Geiselbrecht et al. 1998). According to Kvenvolden and Cooper (2003), during the 1980s, about 10 percent of crude oil entering the marine environment came from natural sources; 27 percent came from oil production, transportation, and refining; and the remaining 63 percent came from atmospheric emissions, municipal and industrial sources, and urban and river runoff. These sources produce many thousands of chemically different hydrocarbon compounds. When hydrocarbons enter the ocean, the lighter-weight components evaporate, degrade by sunlight (photolysis), or undergo chemical and biological degradation. A wider range of constituents are consumed by microbes (biodegradation). Higher-weight molecular compounds such as asphaltenes are more resistant to degradation and tend to persist after these processes have occurred (Blumer et al. 1973; Mackay and McAuliffe 1988).

Trace Metals

Trace metals commonly present in seawater are listed in Table 3.1-1 (Nozaki 1997). Levels of dissolved metals in seawater are normally quite low because some are extracted by organisms (e.g., iron), many tend to precipitate with various ions already present in the water, and others bind to various metal oxides and small organic and inorganic particles in the water (Turekian 1977). These processes transform the metals from a dissolved state to a solid (particulate) state and substantially decrease concentrations of dissolved metals in seawater (Wallace et al. 1977). Concentrations of heavy metals normally decrease with increasing distance from shore (Wurl and Obbard 2004) and vary with depth (Li et al. 2008). Certain amounts of trace metals are naturally present in marine waters because of the dissolution of geological formations on land by rain and runoff. However, the additional amounts of metals produced by human activity often have adverse consequences for marine ecosystems (Summers et al. 1996), such as the atmospheric deposition of lead into marine systems (Wu and Boyle 1997).

Table 3.1-1: Concentrations of Selected Elements in Seawater

Element	Estimated Mean Oceanic Concentration (µg/kg [ppt])
Magnesium	1,280,000,000
Silicon	2,800,000
Lithium	180,000
Phosphorus	62,000
Molybdenum	10,000
Uranium	3,200
Nickel	480
Zinc	350
Chromium (VI)	210
Copper	150
Cadmium	70
Aluminum	30
Iron	30
Manganese	20
Tungsten	10
Titanium	6.5
Lead	2.7
Chromium (III)	2
Silver	2
Cobalt	1.2
Tin	0.5
Mercury	0.14
Platinum	0.05
Gold	0.02

Notes: kg = kilogram, µg = microgram, ppt = parts per trillion

Persistent Organic Pollutants

Persistent organic pollutants such as herbicides, pesticides, PCBs, organotins, polycyclic aromatic hydrocarbons, and similar synthetic organic compounds are chemical substances that persist in the environment and bioaccumulate through the food web. Persistent organic pollutants have long half-lives in the environment. They resist degradation, do not readily dissolve in water, and tend to adhere to organic solids, lipids (fats) (Jones and deVoogt 1999), and plastics. Although they are present in the open ocean and deep ocean waters (Tanabe and Tatsukawa 1983), they are more common and in higher concentrations in nearshore areas and estuaries (Means 1995; Wurl and Obbard 2004). The surface of the ocean is an important microhabitat for a variety of microbes, larvae, and fish eggs. Because of the tendency of hydrocarbons and persistent organic pollutants to float in this surface microlayer, they can be much more toxic to those organisms than the adjacent subsurface water (Wurl and Obbard 2004). Also, persistent organic pollutants that adhere to particulates may sink to the sea floor. Levels of persistent organic pollutants in bottom-feeding fish were higher than fish that live higher up in the water column on the Palos Verde Shelf off the coast of the Palos Verdes peninsula near Los Angeles (U.S. Environmental Protection Agency 2011). Chemical pollutants are also absorbed into the bodies of marine mammals, accumulating in their blubber and internal organs, or are transferred to the young from mother's milk (Fair et al. 2010). Living closer to the source of pollutants and feeding on higher-level organisms increase the potential for marine mammals to accumulate toxins (Moon et al. 2010). Sauer et al. (1989) noted that concentrations of PCBs and dichlorodiphenyltrichloroethane (DDT) have been declining in the open ocean for several decades.

3.1.1.1.2.2 Influences of Marine Properties and Processes on Seawater Characteristics

Ocean currents and tides mix and redistribute seawater. In doing so, they alter surface water temperatures, transport and deposit sediment, and dilute substances that are dissolved and suspended in the water. These processes operate to varying degrees from nearshore areas to the abyssal plain. Salinity also affects the density of seawater and, therefore, its movement relative to the sea surface (Libes 2009). Upwelling brings cold, nutrient-rich waters from deeper areas, increasing the productivity of local surface waters (Mann and Lazier 1996). Major storms also cause strong mixing of marine waters (Li et al. 2006).

Temperature and pH influence the behavior of trace metals in seawater, such as the extent to which they dissolve in water (solubility) or their tendency to adsorb to organic and inorganic particles. However, the degree of influence differs widely among metals (Byrne et al. 1988). The concentration of a given element may change with its position in the water column. For example, some metals (e.g., cadmium) are present at low concentrations in surface waters and at higher concentrations at depth (Bruland 1992), while others decline quickly with increasing depth below the surface (e.g., zinc and iron; Nozaki 1997, Morel and Price 2003). On the other hand, dissolved aluminum concentrations are highest at the surface, lowest at mid-depths, and increase again at depths below about 3,300 ft. (1,006 m; Li et al. 2008).

Substances like nitrogen, carbon, silicon, and trace metals are extracted from the water by biological processes. Others, like oxygen and CO_2, are produced. Metabolic waste products add organic compounds to the water and may also absorb trace metals, removing those metals from the water column. Those organic compounds may then be consumed by biological organisms, or they may aggregate with other particles and sink (Wallace et al. 1977; Mann and Lazier 1996).

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

3.1.1.1.2.3 Coastal Water Quality

A recent coastal condition report by the U.S. Environmental Protection Agency (USEPA) (2008a) evaluated the condition of U.S. coastal water quality. According to the report, most water quality problems in coastal waters of the United States are from degraded water clarity or increased concentrations of phosphates or chlorophyll *a*. Water quality indicators measured included dissolved inorganic nitrogen, dissolved inorganic phosphorus, water clarity or turbidity, dissolved oxygen, and chlorophyll *a*. Chlorophyll *a* is an indicator of microscopic algae (phytoplankton) abundance used to judge nutrient availability (e.g., phosphates and nitrates). Excess phytoplankton blooms can decrease water clarity and, when phytoplankton die off following blooms, lower concentrations of dissolved oxygen. Most sources of these negative impacts arise from onshore point and nonpoint sources of pollution. Point sources are direct water discharges from a single source, such as industrial or sewage treatment plants, while nonpoint sources are the result of many diffuse sources, such as runoff caused by rainfall.

3.1.1.2 Methods

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

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

The discussion in this section focuses on sediment and water quality within the Offshore Area and the Inland Waters portion of the Study Area. The current and proposed types of activities in Western Behm Canal, Alaska, do not affect sediment or water quality. Therefore, this portion of the Study Area will not be further discussed in this section. The geographic location of these areas is described in Section 2.1.

3.1.1.2.1 State Standards and Guidelines

State jurisdiction over sediment and water quality extends from the mean high tide line out 3 nautical miles (nm) in Alaska, Washington, Oregon, and California (Submerged Lands Act of 1953 [43 U.S. Code {U.S.C.} § 1301, et seq.]). Creating state-level sediment and water quality standards and guidelines begins with each state establishing a use for the water, which is referred to as its “beneficial” or “designated” use. Examples of such uses of marine waters include fishing, shellfish harvest, and swimming. For this section, a water body is considered “impaired” if any one of its designated uses is not met. Once this use is designated, standards or guidelines are established to protect the water at the desired level of quality.

The majority of training activities occur beyond 12 nm from shore, which would be beyond state jurisdiction. Some training activities and most of the testing activities, however, occur within state waters of Alaska and Washington. Therefore, only Alaska and Washington sediment and water quality standards will be discussed in this section. Applicable state standards and guidelines specific to each stressor are detailed in Section 3.1.3 (Environmental Consequences).

3.1.1.2.2 Federal Standards and Guidelines

Chief of Naval Operations Instruction 5090.1 series is the Navy's controlling authority for all at-sea compliance with federal regulations. Federal jurisdiction over ocean waters extends from 3 nm to 12 nm (Submerged Lands Act of 1953 [43 U.S.C. § 1314 et seq. and Executive Order {EO} 5928]). Sediments and water quality standards and guidelines are mainly the responsibility of the USEPA, specifically ocean discharge provisions of the Clean Water Act (33 U.S.C. § 1251, et seq.). Ocean discharge may not result in "unreasonable degradation of the marine environment." Specifically, the disposal may not result in (1) unacceptable negative effects on human health, (2) unacceptable negative effects on the marine ecosystem, (3) unacceptable negative persistent or permanent effects because of the particular volumes or concentrations of the dumped materials, or (4) unacceptable negative effects on the ocean for other uses as a result of direct environmental impact (40 Code of Federal Regulations [C.F.R.] § 125.122). Federal standards and guidelines applicable to each stressor are described in Section 3.1.3 (Environmental Consequences). Where U.S. legal and regulatory authority do not apply (e.g., beyond 12 nm from shore), federal standards including EO 12114 and guidelines may be used as reference points for evaluating effects of proposed training and testing activities on sediment and water quality.

The International Convention for the Prevention of Pollution from Ships (Convention) addresses pollution generated by normal vessel operations. The Convention is incorporated into U.S. law as 33 U.S.C. § 1901–1915. The Convention includes six annexes: Annex I, oil discharge; Annex II, hazardous liquid control; Annex III, hazardous material transport; Annex IV, sewage discharge; Annex V, plastic and garbage disposal; and Annex VI, air pollution. The U.S. Department of the Navy (Navy) is required to comply with the Convention; however, the United States is not a party to Annex IV. The Convention contains handling requirements and specifies where materials can be discharged at sea, but it does not contain standards related to sediment and water quality.

3.1.1.2.3 Intensity and Duration of Impact

Effects on sediment and water quality analyzed in Section 3.1.3 (Environmental Consequences) are categorized in terms of the intensity and duration of impacts identified in this section. The intensity determines the extent of the impact compared to established sediment and water quality standards, while duration identifies how long the impact is expected to affect sediment and water quality. Categories of intensity or severity of impact are defined as follows (increasing order of negative impacts):

- Chemical, physical, or biological changes in sediment or water quality would not be detectable, and total concentrations of contaminants would be below or within existing conditions or designated uses.
- Chemical, physical, or biological changes in sediment or water quality would be measurable, but total concentrations would be below applicable standards, regulations, and guidelines and would be within existing conditions or designated uses.

- Chemical, physical, or biological changes in sediment or water quality would be readily measurable, and some standards, regulations, and guidelines would be periodically approached, equaled, or exceeded by total concentrations. Sediment or water quality would be altered from the historical baseline, desired conditions, or designated uses. Mitigation would be necessary.

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

3.1.1.2.4 Measurement and Prediction

Many of the conditions discussed above often influence each other, so measuring and characterizing various substances in the marine environment is often difficult (Byrne 1996; Ho et al. 2007). For instance, sediment contaminants may also change over time. Valette-Silver (1993) reviewed several studies that demonstrated the gradual increase in a variety of contaminants in coastal sediments that began as early as the 1800s, continued into the 1900s, peaked between the 1940s and 1970s, and declined thereafter (e.g., dioxin, lead, PCBs). After their initial deposition, normal physical, chemical, and biological processes can resuspend, transport, and redeposit sediments and associated substances in areas far removed from the source (Hameedi et al. 2002; U.S. Environmental Protection Agency 2008a). The conditions noted above further complicate predictions of the impact of various substances on the marine environment.

3.1.1.2.5 Sources of Information

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

Because of their importance and proximity to humans, information is readily available on the condition of inshore and nearshore sediments and water quality. However, much less is known about deep ocean sediments and open ocean water quality. Because inshore and nearshore sediments and water quality are negatively affected mostly by various human social and economic activities, two general assumptions are used in this discussion: (1) the greater the distance from shore, the higher the quality of sediments and waters; and (2) deeper waters are generally of higher quality than surface waters.

3.1.1.2.6 Areas of Analysis

The locations where specific military expended materials would be found are discussed under each stressor in Section 3.1.3 (Environmental Consequences). Therefore, as stated previously, this analysis is limited to the Offshore Area and Inland Water portion of the Study Area.

3.1.2 AFFECTED ENVIRONMENT

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

3.1.2.1 Sediments in the Study Area

The following subsections discuss sediments for each region in the Study Area. The discussion that follows is based largely on information regarding sediments in the west coast region and Alaska as provided in the *National Coastal Condition Report IV* (U.S. Environmental Protection Agency 2012). The west coast region includes coastal Washington, Oregon, and California, including 2,551 square miles (mi.^{2}) (6,607 square kilometers [km^2]) of Puget Sound and Strait of Juan de Fuca. Table 3.1-2 provides the sediment quality criteria and index for the U.S. west coast and Alaska.

3.1.2.1.1 Sediments in the Offshore Area

Discussion of the Offshore Area pertains to the two subsets as described in The *National Coastal Condition Report IV* (U.S. Environmental Protection Agency 2012).

- The bays and estuaries in the nearshore environment along the west coast
- The coastal ocean condition along the west coast, including the waters along the western continental shelf

The majority of rivers along the coast of the Pacific Northwest drain small, steep watersheds that produce large amounts of sand-sized sediment. The Columbia River is a major source of sediment along the coast of the Pacific Northwest. The sediment is first deposited near the mouth of the river and then transported by tides and currents northward along the coast (Nittrouer 1978, Baker and Hickey 1986, Hickey and Banas 2003). Currents associated with submarine canyons are major conduits for sediment transport to the deep sea (Thurman 1997). The remainder of the sediment mainly consists of dust blown out to sea from land as well as the remains of small marine plants and animals that sink from the upper layer of the ocean. These transported sediments make their way into bays and harbors along the coast.

Table 3.1-2: United States General Sediment Quality Criteria and Index

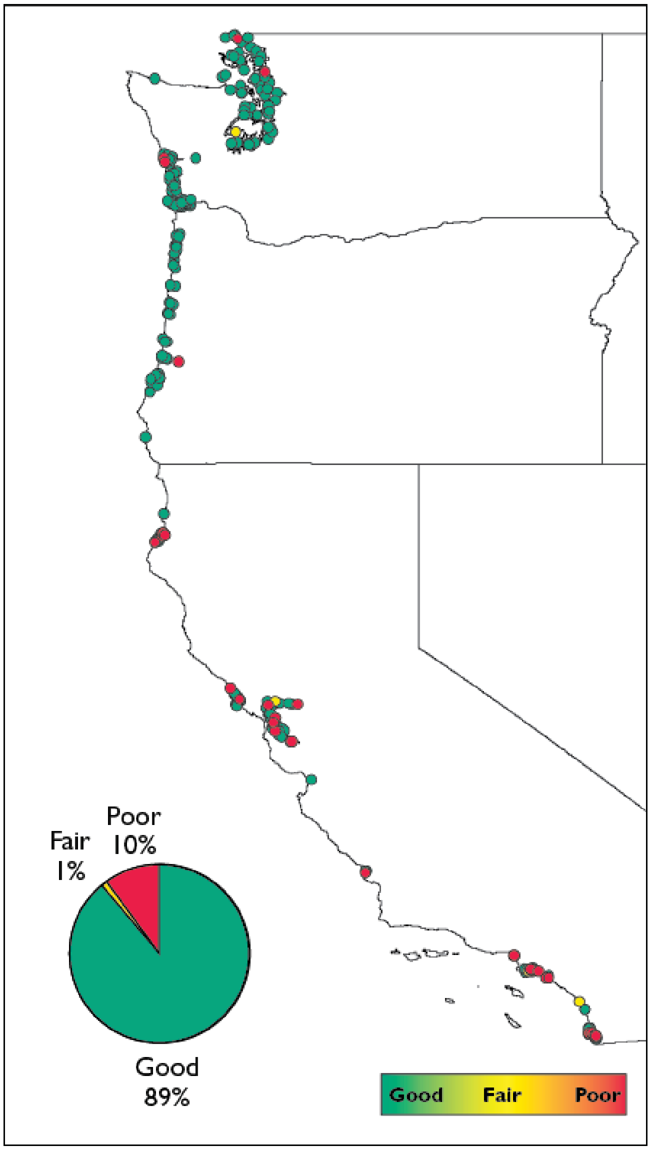
Criterion	Site Criteria			Regional Criteria		
	Good	Fair	Poor	Good	Fair	Poor
Sediment toxicity	Amphipod survival rate ≥ 80%	n/a	Amphipod survival rate < 80%	< 5% of coastal area in poor condition	n/a	≥ 5% of coastal area in poor condition
Sediment contaminants	No ERM concentration exceeded, and < 5 ERL concentrations exceeded	No ERM concentration exceeded, and ≥ 5 ERL concentrations exceeded	An ERM concentration exceeded for one or more contaminants	< 5% of coastal area in poor condition	5–15% of coastal area in poor condition	> 15% of coastal area in poor condition
Excess sediment TOC	TOC concentration < 2%	TOC concentration 2–5%	TOC concentration > 5%	< 20% of coastal area in poor condition	20–30% of coastal area in poor condition	> 30% of coastal area in poor condition
Sediment quality index	No individual criteria rated poor, and sediment contaminants criteria is rated good	No individual criteria rated poor, and sediment contaminants criteria is rated fair	One or more individual criteria rated poor	< 5% of coastal area in poor condition and > 50% in good condition	5–15% of coastal area in poor condition, and > 50% in combined fair and poor condition	> 15% of coastal area in poor condition

Notes: ERL = effects range–low, the level measured in the sediment below which adverse biological effects were measured 10 percent of the time (Long et al. 1995); ERM = effects range–median, the level measured in the sediment below which adverse biological effects were measured 50 percent of the time; n/a = not applicable; TOC = total organic carbon, the amount of carbon contained in organic compounds; < = less than; > = greater than; ≥ = greater than or equal to

Source: U.S. Environmental Protection Agency 2012

In the most recent National Coastal Condition Report (U.S. Environmental Protection Agency 2012), the sediment quality index rating was fair for the nearshore coastal waters of the west coast region, with a rating of poor for 10 percent of the coastal area and a rating of fair for 1 percent of the area. Although the sediment quality index rating for the west coast region was fair, the majority of samples that exceeded sediment toxicity and contaminant standards established by the *National Coastal Condition Report IV* were in harbors along the central and southern California coasts (Figure 3.1-1). The sediment quality index is based on measurements of three indicators: sediment toxicity, sediment contaminants, and sediment total organic carbon.

The coastal ocean assessment for the west coast showed no major evidence of poor water quality, and indications of poor sediment quality only in limited areas along Southern California. According to the report, 97 percent of sediments had total organic carbon levels in the good range, 3 percent was rated fair, and less than 1 percent was rated poor. With regard to sediment contamination, 99 percent of the survey area was rated as good and less than 1 percent was rated fair or poor. The survey area along the Washington coast was rated as good for water quality and sediment quality. Dissolved oxygen along 92 percent of the survey area was rated as fair, and 8 percent of the area was rated as good. The west coast region ocean condition assessment area covers coastal ocean waters along the western U.S. continental shelf, from the Strait of Juan de Fuca in Washington to the U.S.-Mexican border. The sediment quality index is based on measurements of three indicators: sediment toxicity, sediment contaminants, and sediment total organic carbon.



Source: U.S. Environmental Protection Agency 2012

Figure 3.1-1: Sediment Quality Index for Nearshore West Coast Region Waters

3.1.2.1.2 Sediments in the Inland Waters

Sediments in Puget Sound are composed primarily of compact, glacially formed clay layers and relict glacial tills (unsorted, angular gravel, rock, and boulders deposited by glaciers) that are contained within powdery material (Crandell et al. 1965). Major sources of sediment in Puget Sound are shoreline erosion and river discharge. Sand and mud prevail in the eastern regions of Puget Sound, while the shores of Vancouver Island and the complex formation of the Gulf Islands have prominent slopes composed of bedrock and boulders (Palsson et al. 2003).

Sediments collected from a sampling station approximately 500 ft. (152 m) offshore of Naval Undersea Warfare Center (NUWC) Keyport in 1998 consisted of a mix of silt (71 percent), clay (20 percent), and fine to very fine sands (9 percent). Additional sediment samples collected north (Liberty Bay) and east (Bainbridge Island) of the Keyport Range Site contained higher percentages of medium to fine sands and lower percentages of silts and clays (National Oceanic and Atmospheric Administration 2000a. Sediments collected from Hood Canal sites in 1999 consisted of a mix of fine to very fine sands (approximately 70 percent), silt (approximately 20 percent), and clay (approximately 10 percent), while sediments from Dabob Bay contained more silt (47 percent) and clay (44 percent) than sand (9 percent) (National Oceanic and Atmospheric Administration 2002).

Anthropogenic activities in Puget Sound have introduced contaminants through wastes from municipal and industrial activities, dumping operations, spills, and urban and agricultural runoff. Wastes include both inorganic and organic toxic chemicals such as heavy metals, polycyclic aromatic hydrocarbons, PCBs, pesticides, pharmaceuticals, endocrine-disrupting compounds, and flame retardants (Washington State Department of Ecology 2009). Many of these chemicals bind to suspended particles and sink to the bottom of Puget Sound, where they accumulate in sediments. Near urban areas, levels of contamination have been found to be as much as 100 to 300 times the levels in the cleanest rural bays (Washington State Department of Ecology 2009).

Sediment quality in Puget Sound is rated poor (U.S. Environmental Protection Agency 2007). Ratings are based on a composite index of three components: toxicity, contaminant concentrations, and total organic carbon concentration. Although sediments in Puget Sound rated good for contaminant and total organic carbon concentrations, very low scores at two locations in the sediment toxicity component of the index generated the overall poor rating. As of 1999, the Washington State Department of Ecology had compiled sufficient data to characterize more than 15,000 acres (ac.) (6,070 hectares [ha]) of Puget Sound's urban embayments. According to Washington State Department of Ecology records, 38 percent of this area (5,750 ac. [2,330 ha]) was contaminated above the state's sediment quality standards, although contaminants in some areas are declining (Puget Sound Action Team 2000a). Two other estuaries in the Study Area were included in the National Estuary Program analysis of estuary health: Tillamook Bay (good rating) and the Columbia River (fair rating) (U.S. Environmental Protection Agency 2007).

Washington State has established Sediment Management Standards for marine, low salinity, and freshwater surface sediments. The goal of these standards is to eliminate adverse effects on biological resources and significant health threats to humans from surface sediment contamination. The process involves establishing standards for the quality of surface sediments, applying these standards as the basis for management pollutant discharges, and providing a management and decision process for cleaning up contaminated sediments (Washington State Department of Ecology 1995). Sediment that violates Sediment Management Standards is considered for 303(d) listing similar to water-column water quality violations (Washington State Department of Ecology 2004). Sediment Management Standards are used to place water bodies in categories to describe levels of pollution concern, similar to the use of Water Quality Standards to categorize the same water bodies.

The following parameters exceeded the Sediment Management Standards Cleanup Screening Level criteria at three NUWC Keyport identified stations: N-nitrosodiphenylamine; 2-methylphenol; 1, dichlorobenzene; 1,2,4-trichlorobenzene; pentachlorophenol; hexachlorobenzene; 2,4-dimethylphenol; hexachlorobutadiene; benzyl alcohol; 1,4-dichlorobenzene; bis(2-ethylhexyl) phthalate. These data were used to place the Liberty Bay water body in a Category 4B sediment listing (Washington State Department of Ecology 2004).

Other sampling conducted at NUWC Keyport examined the potential human exposure to past spills or waste deposits at the onshore facility (adjacent to the Keyport Range Site). Although the spills occurred onshore and outside of the Keyport Range Site, samples of marine sediments were collected from two nearshore sites (Area 1 and Area 9) to determine the extent of contaminants from past activities. Area 1 (Keyport Landfill), on the western side of the base between Bradley Road and Keys Road, was a former landfill. Area 9 (Liberty Bay) was approximately 5,000 ft. (1,524 m) of shoreline around the NUWC Keyport peninsula, which included nearshore areas around two piers that were removed.

The Keyport Landfill (Area 1) did not have a liner or leachate containment system in place; therefore, there was a potential for contaminants from years of landfill use to migrate into marine sediments and groundwater (U.S. Environmental Protection Agency 1998). Waste contaminants generated and potentially deposited into the landfill included cadmium, chromium, copper, cyanide, lead, nickel, tin, zinc, carbon tetrachloride, methyl ethyl ketone, and trichloroethylene. Results from sampling determined that metals, chlorinated pesticides, and dichlorodiphenyl dichloroethylene exist in marine sediments near Area 1 but at very low concentrations.

Over a 65-year period, metals such as chromium, cadmium, and lead have been discharged into Liberty Bay (Area 9), as well as paint thinners, lead-acid batteries, and sandblasting residue (U.S. Environmental Protection Agency 1994). Benzoic acid, bis(2-ethylhexyl) phthalate, phenol, and arsenic were detected at low concentrations in Area 9 samples (U.S. Environmental Protection Agency 1994). A public health assessment prepared as a result of this sampling determined there was no risk to human health from site-related contaminants (Agency for Toxic Substances and Disease Registry 2001).

The Washington State Department of Ecology surveyed sediment quality in Hood Canal as part of the Puget Sound Assessment and Monitoring Program (Washington State Department of Ecology 2010). The study area included Hood Canal, Port Gamble, Port Ludlow, and Dabob Bay, with sediment collected at 30 locations throughout the 295 km^2 (114 $mi.^2$) study area. None of the sampling locations had chemical concentrations higher than Washington State Sediment Quality Standards or Cleanup Screening Level values. In general, concentrations were highest at the south-central Dabob Bay stations, and concentrations tended to decrease toward the entrance to Hood Canal at Admiralty Inlet. Sediment toxicity was found in 17 percent of samples (5 of 30 samples), with an estimated spatial extent of 52 km^2 (20 $mi.^2$), or about 18 percent of the survey area. The toxicity data showed a pattern similar to that of chemical concentrations, with the highest toxicity in south-central Dabob Bay and generally decreasing with distance from those samples.

The Puget Sound Assessment and Monitoring Program uses three elements to determine the geographic patterns and spatial extent of sediment quality: (1) concentrations of potentially toxic chemicals, (2) degree of response in a laboratory test of toxicity, and (3) health of sediment-dwelling invertebrates (benthos) in each location. The combination of these three elements, commonly referred to as the sediment quality triad, is used to determine sediment quality based on a four-level scale:

- High quality: no chemistry, toxicity, or benthos degradation
- Intermediate/high quality: one triad element degraded
- Intermediate/degraded quality: two triad elements degraded
- Degraded quality: all triad elements degraded

Overall, 65 km^2 (25 $mi.^2$ [22 percent]) of the Hood Canal survey area were classified as high quality, 178 km^2 (69 $mi.^2$ [60 percent]) as intermediate/high quality, 52 km^2 (20 $mi.^2$ [18 percent]) as intermediate/degraded quality, and 0 km^2 (0 percent) as degraded quality (Washington State Department of Ecology 2010). The sediments in south-central Dabob Bay were the most degraded, with high toxicity and impaired benthic communities dominated by species known to tolerate hypoxia and chemical contamination. Sediments in central and southern Hood Canal were moderately degraded, and sediments at shallow sampling locations near the entrance of Hood Canal were the least degraded (Figure 3.1-2).

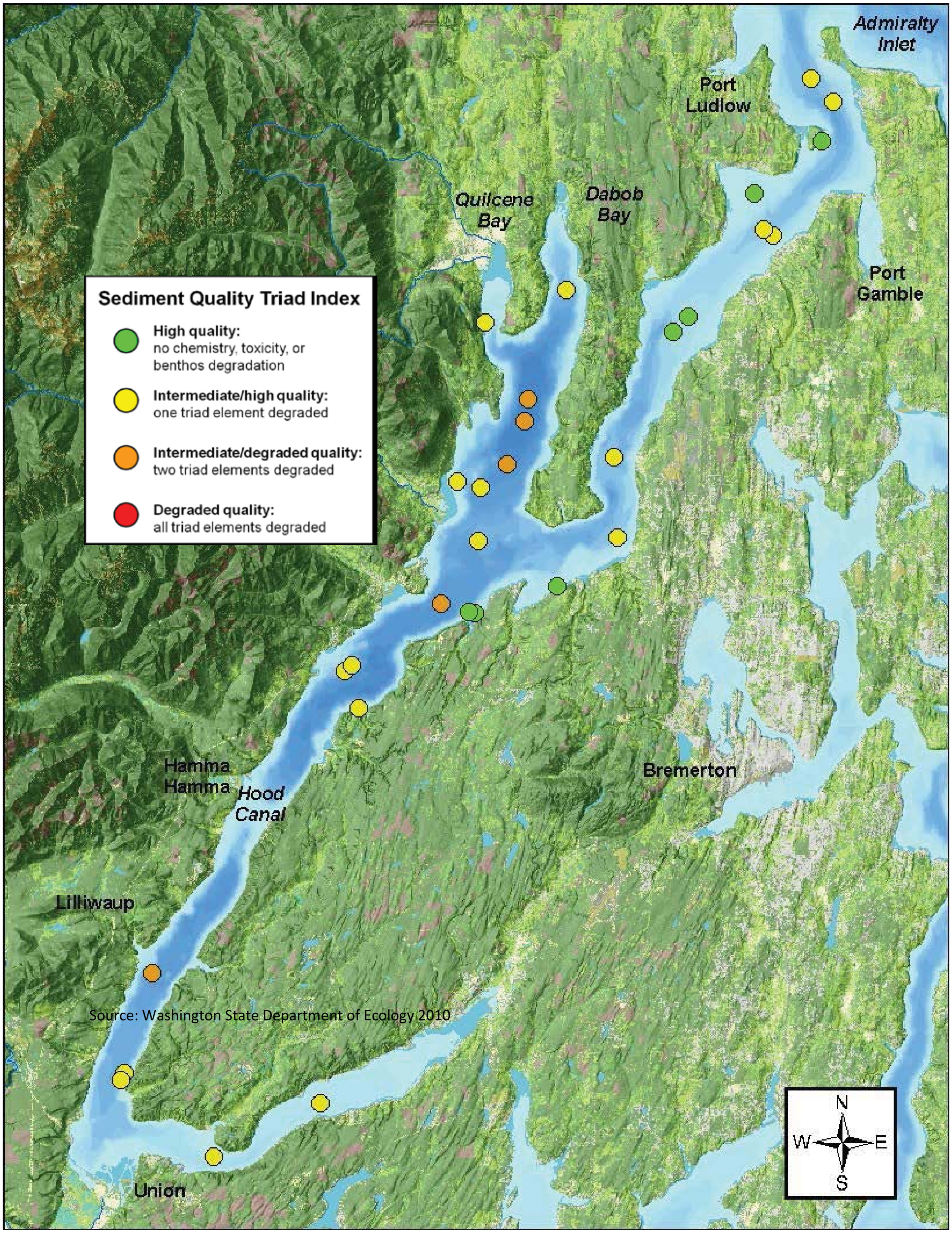
Carr Inlet is within the South Puget Sound sampling region of the Washington State Department of Ecology sediment monitoring program. In 2002, monitoring results indicated no toxicity or chemical contamination at 36 sampling stations, including stations within the Carr Inlets. The sediments were found to be of intermediate/high quality (Washington State Department of Ecology 2002).

In 1999, sediments were collected at five different locations throughout the Dabob Bay Range Complex (DBRC): three in Hood Canal and two in Dabob Bay. To generate a comprehensive picture of sediment quality, the study evaluated sediment parameters that included toxicity testing, chemical analysis, and benthic composition. The study found no toxicity or chemical contamination in samples collected from four of the five locations, indicating high quality sediments. One location with Dabob Bay was categorized as intermediate to high quality sediments. None of the five sediment samples tested exceeded the Sediment Quality Standards. In addition, none of the sites were reported in Washington State Department of Ecology's sediment quality information system database for recent exceedances of Sediment Quality Standards (National Oceanic and Atmospheric Administration 2002).

NUWC Keyport commissioned a field study to document water and sediment quality conditions at DBRC Site in Dabob Bay (Battelle 2001). The purpose of the study was to provide marine chemistry data that would meet the needs of the state and federal agencies that evaluate the potential environmental impacts associated with NUWC Keyport activities at DBRC Site. The study employed methods recognized and approved by state and federal agencies for conducting marine environmental studies in Puget Sound. The results of the study are summarized in Table 3.1-3, and the report can be found in Appendix D of the DBRC Environmental Assessment (U.S. Department of the Navy 2002). Although conducted for the DBRC Site, the results of the study are applicable to Keyport Range Site because the similar nature of activities and the sedimentary, bathymetric, and circulatory conditions are reasonably similar at both locations. Table 3.1-3 compares metal concentrations in Dabob Bay and Puget Sound against Washington State Department of Ecology standards.

The study evaluated surface sediment samples collected at 14 stations on the bottom of Dabob Bay along the main axis of the DBRC. Seawater samples were also collected at four of these stations at 3 ft. (1 m) below the surface and 30 ft. (10 m) above the bottom. The sediment and seawater samples were analyzed for cadmium, copper, lithium, lead, zinc, and zirconium; these elements are identified as present in torpedo exhaust, anchor and dropper weights, and other expendable materials generated by activities at the DBRC.

Laboratory results for the sediment samples indicated that metal concentrations were low and consistent with levels found in other muddy, nonurban bays in Puget Sound. Four metals (cadmium, copper, lead, and zinc) with listed Washington State Sediment Quality Standards criteria were well below these criteria. Sediment quality standards do not exist for the other two metals (lithium and zirconium), but the concentrations were considered typical of naturally occurring sedimentary rock.



Source: Washington State Department of Ecology 2010

Figure 3.1-2: Sediment Quality at Sampling Locations in the Hood Canal

Table 3.1-3: Concentration of Metals in Dabob Bay Water and Sediment Compared to Other Locations

Location	Metal					
	Cu	Cd	Li	Pb	Zn	Zr
Seawater (µg/L)						
Dabob Bay	0.07	0.3	150	0.02	0.50	< 0.2
Puget Sound	-	0.45	-	0.08	0.90	-
WDOE Marine Chronic Standard for Dissolved Metals	9.3	3.1	-	8.1	81	1,000
Sediment (µg/g dry weight)						
Dabob Bay	0.3	40	35	16	95	80
Puget Sound	0.4	50	-	40	115	-
WDOE Sediment Standards	5.1	390	-	450	410	-

Notes: µg = microgram, Cd = cadmium, Cu = copper, g = gram, L = liter, Li = lithium, Pb = lead, WDOE = Washington State Department of Ecology, Zn = zinc, Zr = zirconium
Source: Battelle 2001

Sediment samples were collected to support the construction TRIDENT Support Facilities Explosives Handling Wharf II in Hood Canal on Naval Base Kitsap (U.S. Department of the Navy 2012). The TRIDENT Support Facilities Explosives Handling Wharf II is being constructed in the nearshore water adjacent to an existing explosives handling wharf. Sediment parameters from samples collected at the project site were comparable to background levels for Puget Sound. While sediments contained trace amounts of metals and organic contaminants (e.g., polycyclic aromatic hydrocarbons, chlorinated aromatics, and phenols), concentrations were well below sediment quality standards.

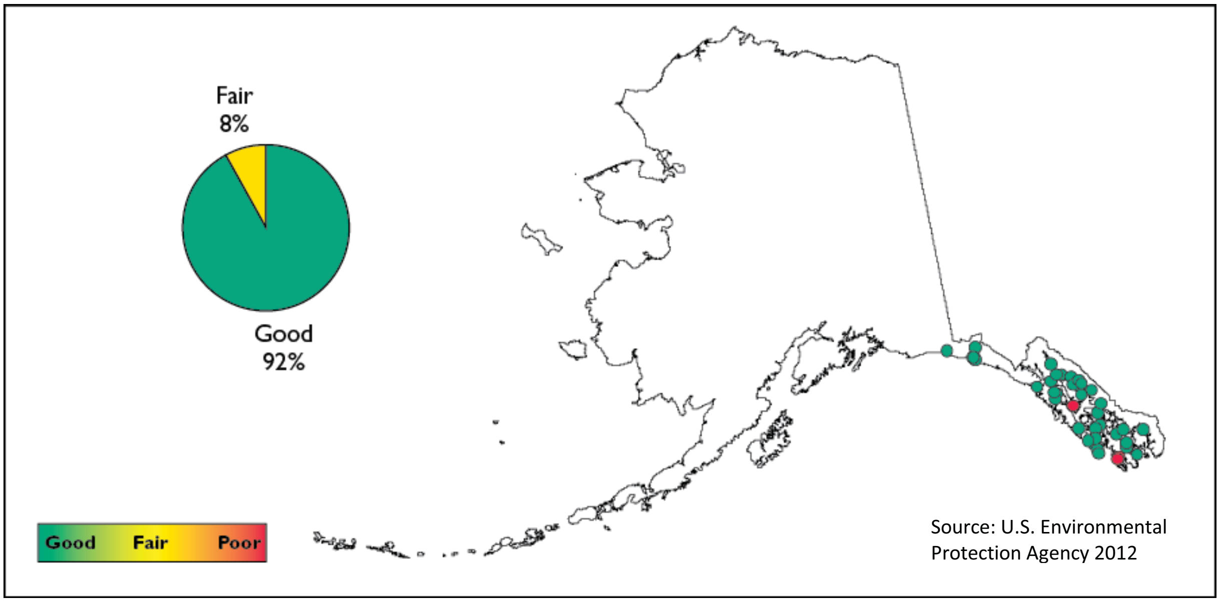
Crescent Harbor is highly influenced by the Skagit River, which enters Puget Sound at Skagit Bay. Sand makes up approximately 66 percent of the sediment in this area. Silt and clay make up the remainder of the sediments. A study conducted in the Whidbey Basin in 2007 found that no sediment quality standards were exceeded within the sediments collected in Crescent Harbor, and sediment quality is considered to be high (Washington State Department of Ecology 2007).

3.1.2.1.3 Sediments in Western Behm Canal

The Southeast Alaska Acoustic Measurement Facility (SEAFAC) is in the western portion of Behm Canal, about 13 miles (mi.) (20.9 kilometers [km]) north-northwest of Ketchikan, Alaska. Behm Canal is a large, deep, protected fjord, with some areas exceeding depths of 2,000 ft. (609.6 m). The western portion is about 60 mi. (96.6 km) long and has a mean width of 3 mi. (4.8 km). The lateral distribution of sediment types is variable across the western Behm Canal sea floor. In general, sediments are either deposited by glaciers as glacial sediments or after the retreat of the glaciers and rise of sea level as post-glacial sediments. Glacial sediments mapped along the sea floor or near subsurface consist of several sizes, ranging from large-grain sizes (e.g., shell, gravel, sand) to mixed sizes (e.g., clayey sand, sandy silt) to finer-grained sizes (e.g., inorganic silt, gray clay) to hard exposed bedrock. Post-glacial sediments are usually soft, unconsolidated, green, organic silt or brown, fluffy mud deposited from streams. Sand is found along the coastal beaches, and gas-charged sea floor sediments have also been reported (Naval Oceanographic Office 2006).

The sediment quality index rating is good for the coastal waters of Southeastern Alaska, with few occurrences of fair or poor ratings at sampling sites (Figure 3.1-3; U.S. Environmental Protection Agency

2012). The fair and poor ratings were primarily associated with sediment total organic carbon concentrations at sampling locations in Angoon and Hydaburg, Alaska.



Source: U.S. Environmental Protection Agency 2012

Figure 3.1-3: Sediment Quality Index for Southeastern Alaska

3.1.2.2 Marine Debris, Military Expended Materials, and Marine Sediments

Keller et al. (2010) surveyed marine debris collected from the sea floor at 1,347 randomly selected stations off the coasts of Washington, Oregon, and California during annual groundfish surveys in 2007 and 2008. The survey locations were within five geographic areas: U.S.-Vancouver, Columbia, Eureka, Monterey, and Conception International North Pacific Fisheries Commission regions. The Study Area overlaps with the U.S.-Vancouver, Columbia, and Eureka regions. Depth of trawling ranged from 180 to 4,200 ft. (55 to 1,280 m), and marine debris was recovered in 469 tows. Categories of marine debris collected included plastic, metal, glass, fabric and fiber, rubber, fishing, and other. Plastic and metallic debris occurred in the greatest number of hauls, followed by fabric and glass. Plastics that were recovered included wrappers, trash bags, bottles, and scrap. Metals recovered were primarily beverage containers. Of the survey locations within the Study Area, plastic debris occurred at greater levels in the U.S.-Vancouver survey area. Fishing-related debris was distributed equally throughout the locations; however, the greatest density occurred in the Columbia survey area. Data about the 103 items categorized military materials as a component of the recovered materials are provided in Table 3.1-4.

Table 3.1-4: Military Materials as Components of All Materials Recovered on the West Coast, United States, 2007–2008

Category	Number of Items	Percent of Total Items Recovered	Weight	Percent of Total Weight
Plastic	29	7.4	62.3 lb. (28.3 kg)	5.8
Metal	37	6.2	926.6 lb. (420.3 kg)	42.7
Fabric, fiber	34	13.2	51.4 lb. (23.3 kg)	6.7
Rubber	3	4.7	32.8 lb. (14.9 kg)	6.8

Notes: kg = kilogram, lb. = pound
Source: Keller et al. 2010

Military materials (103 items) containing metals recovered during surveys included ammunition boxes, helmets, rocket boosters and launchers, and cannon shells (Keller et al. 2010). The authors noted that "virtually all" materials identified as military were collected off the coast of Southern California near Point Conception, California, in an area where naval maneuvers are conducted. The study does not indicate whether military materials were retrieved from survey areas within the Study Area. However, the number of military items recovered during the study may not be reflective of what occurs in the sediments. Bottom trawls would not be an efficient sampling method for military expended materials that were buried deep within the sediments.

Because of their buoyancy, many types of plastic float and may travel thousands of miles in the ocean (U.S. Commission on Ocean Policy 2004). Although plastics resist degradation, they do gradually break down into smaller particles because of exposure to sunlight (photolysis) and mechanical wear (Law et al. 2010). A study in 1998 collected debris from 43 coastal sites in Orange County, California. Approximately 106 million items (weighing 12 metric tons) were collected, with 99 percent of items consisting of preproduction pellets, foamed plastics, and hard plastic fragments (Stevenson 2011). Thompson et al. (2004) found that microscopic particles were common in marine sediments at 18 beaches around the United Kingdom. They noted that such particles were ingested by small filter and deposit feeders, with unknown effects. The fate of plastics that sink beyond the continental shelf is largely unknown. However, analysis of debris in the center of an area near Bermuda with a high concentration of plastic debris on the surface showed no evidence of plastic as a substantial contributor to debris sinking at depths of 1,650 to 10,500 ft. (500 to 3,200 m) (Law et al. 2010). Marine microbes and fungi are known to degrade biologically produced polyesters such as polyhydroxyalkanoates, a bacterial carbon and energy source (Doi et al. 1992). Marine microbes also degrade synthetic polymers, although at slower rates (Shah et al. 2008).

3.1.2.3 Climate Change and Sediments

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

As noted in the beginning of this section, major storms can substantially affect resuspension and distribution of bottom sediments (Wren and Leonard 2005). If storm frequency or intensity increases from climate change, the additional disturbance of marine sediment may adversely impact water quality in nearshore and coastal areas. In the Pacific Northwest, climate change may alter the coastal marine environment by increasing water temperature, increasing vertical stratification in the water column, increasing the number of extreme precipitation events, and changing the intensity and timing of coastal winds and upwelling (U.S. Fish and Wildlife Service 2009). This issue is addressed in more detail in Section 3.1.2.5 (Marine Debris and Marine Water Quality).

3.1.2.4 Water Quality in the Study Area

The current state of water quality in the Study Area is discussed below, from nearshore areas to the open ocean and deep sea bottom. Table 3.1-5 provides the water quality criteria and index for the U.S. west coast region and Alaska as defined in the *National Coastal Condition Report IV* (U.S. Environmental Protection Agency 2012).

Table 3.1-5: Water Quality Criteria and Index, United States West Coast and Alaska

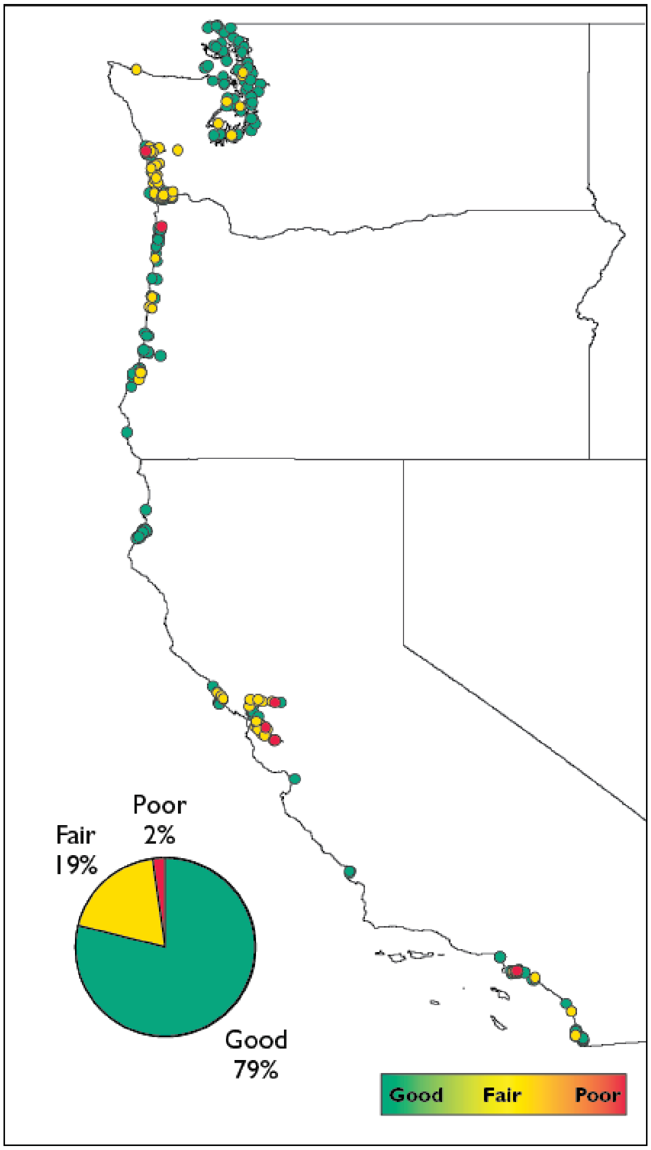
	Site Criteria			Regional Criteria		
Criterion	Good	Fair	Poor	Good	Fair	Poor
Dissolved inorganic nitrogen	< 0.35 mg/L	0.35–1.0 mg/L	> 0.5 mg/L	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10–25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.
Dissolved inorganic phosphorus	< 0.07 mg/L	0.07–0.1 mg/L	> 0.1 mg/L			
Water clarity	Sites with naturally high turbidity: > 10% light at 1 meter. Sites with normal turbidity: > 20% light at 1 meter. Sites that support submerged aquatic vegetation: > 40% light at 1 meter.	Sites with naturally high turbidity: 5–10% light at 1 meter. Sites with normal turbidity: 10–20% light at 1 meter. Sites that support submerged aquatic vegetation: 20–40% light at 1 meter.	Sites with naturally high turbidity: < 5% light at 1 meter. Sites with normal turbidity: < 10% light at 1 meter. Sites that support submerged aquatic vegetation: < 20% light at 1 meter.			
Dissolved oxygen	> 5.0 mg/L	2.0–5.0 mg/L	< 2.0 mg/L	Less than 5% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	5–15% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 15% of the coastal area is in poor condition.
Chlorophyll *a*	< 5 µg/L	5–20 µg/L	> 20 µg/L	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10–20% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 20% of the coastal area is in poor condition.
Water quality index	A maximum of one indicator is rated fair, and no indicators are rated poor.	One of the indicators is rated poor, or two or more indicators are rated fair.	Two or more of the five indicators are rated poor.			

Notes: µg/L = microgram per liter, mg/L = milligram per liter, < = less than, > = greater than
Source: U.S. Environmental Protection Agency 2012

In general, marine water quality in the Study Area is degraded by environmental contaminants that include suspended solids, sediment, nutrients and organic materials, metals, synthetic organic compounds such as pesticides and plastics, and pathogens. Sources of these contaminants include commercial and recreational vessels, oil spills, industrial and municipal discharges (point source pollution), legal and illegal ocean dumping, poorly treated or untreated sewage, and runoff from urban and agricultural areas (nonpoint source pollution). Conduits for contamination include streams, rivers, and air currents that carry materials from inland areas to the sea.

3.1.2.4.1 Water Quality in the Offshore Area

The character of the Pacific Ocean in the northwestern United States is largely controlled by (1) Pacific Ocean-wide circulation of water, especially the California Current; (2) major inputs of fresh water and sediment from the Columbia River; (3) formation of large eddies such as that at the mouth of the Strait of Juan de Fuca; and (4) seasonal prevailing winds (Barth and Smith 1997, Hickey and Banas 2003). In *National Coastal Condition Report IV*, the water quality index for the sampling locations of coastal waters in the west coast region is rated as good, with 19 percent of the coastal area rated fair and 2 percent rated poor (Figure 3.1-4; U.S. Environmental Protection Agency 2012). The water quality index is based on measurements of five component indicators: dissolved inorganic nitrogen, dissolved inorganic phosphorous, chlorophyll *a*, water clarity, and dissolved oxygen.



Source: U.S. Environmental Protection Agency 2012

Figure 3.1-4: Water Quality Index for Sampling Points in the West Coast Region

Most of the Study Area is more than 12 nm offshore from the coasts of Washington, Oregon, and California. There is limited information on offshore water quality because of the lack of consistent water quality monitoring and studies. In general, offshore water quality is better than nearshore water quality because of the reduced number of pollution sources, as well as increased mixing caused by ocean currents. Offshore water quality, however, can be influenced by nearshore water quality. Therefore, for this section, the nearshore water quality of Washington, Oregon, and California will be discussed because of its potential influence and the lack of information on offshore water quality.

The Olympic Coast National Marine Sanctuary lies off the coast of Washington. Water quality has been surveyed in the marine sanctuary, which provides a baseline of the water quality conditions in the offshore environment. Water quality within the Olympic Coast National Marine Sanctuary is similar to natural ocean conditions, with relatively minor influences from human activities at sea and on land (Office of National Marine Sanctuaries 2008). There are few point sources of pollution in the sanctuary, and the sparse population of the region has limited nonpoint source pollutants. Potential water quality contaminants for the sanctuary include petroleum products, pathogens, and other chemicals.

The potential for a large-volume oil spill is considered the greatest threat to the sanctuary's water quality. Washington is one of the nation's major petroleum refining centers, and an estimated 1.5 billion gallons (gal.) (5.7 billion liters [L]) of oil are transported through the area each year (Office of National Marine Sanctuaries 2008). The Strait of Juan de Fuca is a major shipping route for ports in Puget Sound, with daily traffic throughout the year.

In general, marine water quality along the coasts of Oregon and northern California would be similar to marine water quality offshore of Washington because of similar hydrography and bathymetry, being within the California Current Large Marine Ecosystem (U.S. Environmental Protection Agency 2012), and because of similar population densities and commercial industries. Along the coast of Oregon, the fast speeds, multiple directions, high variability, and unpredictability of currents over the continental margin constantly circulate offshore waters. These same processes, however, can make the continental shelf environment vulnerable to adverse effects from pollutants. For example, an oil spill could move up or down the entire Oregon coast in a few weeks and could come ashore from any offshore spill over the continental margin in a few days (Oregon Ocean Resources Management Task Force 1991).

In 1991, six municipal wastewater treatment works and three pulp and paper mills discharged directly into the offshore waters of Oregon, but discharges were relatively small and dispersed. Discharges of dredged material from coastal harbors and rivers were estimated at 7 million–11 million cubic meters per year of sediment to 20 authorized dredged material disposal sites on the continental shelf. The dredged material mostly consisted of clean, uncontaminated mud (Oregon Ocean Resources Management Task Force 1991).

A variety of land uses in northern California, including urban and rural developments, agriculture, timberlands, commercial, and industrial, can impact coastal water quality. These land uses can increase nutrient loading and associated eutrophication, runoff, siltation, and habitat loss (California Department of Fish and Game 2012). Timber harvesting has a substantial impact on water quality from construction of roads, operation of heavy machinery, disruption of sediment, and removal of vegetation. There are numerous impaired waters in the North Coast region, with about 39 impaired water bodies draining to the Pacific Ocean. Major water bodies draining to the Pacific Ocean include Eel River, Redwood Creek, and Klamath River (California Department of Fish and Game 2012).

3.1.2.4.2 Water Quality in the Inland Waters

Water resource issues of concern in the Inland Water portion of the Study Area involve excess nutrients (eutrophication), low levels of dissolved oxygen, and fecal coliform (National Oceanic and Atmospheric Administration 1998, Puget Sound Action Team 2000b, Washington State Department of Ecology 2008). In the Study Area, similar concerns have been noted for Crescent Harbor and Hood Canal (National Marine Fisheries Service 2008, U.S. Environmental Protection Agency 2008b). Locally high levels of urban runoff, treated effluent, and agricultural runoff, coupled with lower levels of mixing and flushing, often cause and exacerbate these conditions. These conditions usually worsen in late summer, when water temperature and salinity are highest, mixing of the water column lessens, and, as a result, stratification increases. Most of the areas with these concerns are in developed areas of southern Puget Sound, several miles from specific activities conducted in the Study Area (Washington State Department of Ecology 2002).

The Washington State Department of Ecology and other agencies initiated the Puget Sound Toxics Loading Analysis in late 2006 to provide scientific information on pollutants and their sources to guide decision-making for prioritizing management strategies for the Puget Sound basin. The primary focus of the Puget Sound Toxics Loading Analysis was to estimate toxic chemical loading to Puget Sound through major pathways. For the majority of constituents of concern, surface runoff contributed the largest loads to Puget Sound, accounting for over half of the estimated combined load from all pathways. Other methods of transport included groundwater discharge, atmospheric deposition, and publicly owned treatment works discharge. The report identified copper, polycyclic aromatic hydrocarbons, bis(2-ethylhexyl) phthalate, and petroleum sources as constituents with the highest priority for early action (Washington State Department of Ecology 2011).

Under Section 303(d) of the Clean Water Act, the Washington State Department of Ecology is required to produce a list of surface waters not expected to meet state water quality standards (designated as impaired water bodies). Washington State has also established Water Quality Standards for surface waters. These standards set limits on pollution in surface waters to protect water quality. Washington State has also applied general water uses and criteria classes to surface waters in the state.

The Washington Department of Ecology monitors water quality within Puget Sound. Water quality monitoring results between 1999 and 2008 indicate that water quality in Whidbey Bay in northern Puget Sound, where Crescent Harbor is located, has declined (Washington State Department of Ecology 2012). Over this 10-year period, monitoring has shown eutrophication is increasing within the basin due largely to increases in nutrients (Washington State Department of Ecology 2012). Concentrations of dissolved oxygen in the waters of the Whidbey Basin are routinely measured by the Washington Department of Ecology in Saratoga Passage, which is directly south of Crescent Harbor. Concentrations of dissolved oxygen tend to be highest in the surface waters (up to 15 mg/L) and lower, around 3.5–4.0 mg/L, at greater depths in fall (National Oceanic and Atmospheric Administration 2000b).

Liberty Bay (approximately 1 mi. [1.6 km] northwest of the Keyport Range Site) is listed by Washington State Department of Ecology as having a moderate level of marine water quality concern with high fecal coliform levels, moderate ammonium concentrations, and seasonal density stratification due to nonpoint sources such as outfalls, marinas, and failing septic systems (Washington State Department of Ecology 2003a). In addition, based on the physical and chemical characteristics of the Bay and surrounding areas, Liberty Bay is listed as being sensitive to eutrophication (Washington State Department of Ecology 2003b).

Hood Canal is classified Class AA as having “water quality that markedly and uniformly exceeds the requirements for all or substantially all uses” (Washington State Department of Ecology 2005). Washington State Department of Ecology operates two ambient water quality stations in Hood Canal—one in the north, near King Spit (#HCB006), and the other in the south near the Hamma Hamma River (#HCB003). North Hood Canal is listed by Washington State Department of Ecology as having a high level of marine water quality concern due to low dissolved oxygen levels (Washington State Department of Ecology 2003a). Similarly, South Hood Canal is listed by Washington State Department of Ecology as having a very high level of marine water quality concern due to very low dissolved oxygen levels, high ammonium concentrations, and persistent density stratification. In addition, due to low dissolved oxygen levels and biological stresses, Hood Canal is listed as being sensitive to eutrophication (Washington State Department of Ecology 2003b).

Dabob and Quilcene Bays are listed on the 1998 Clean Water Act Section 303[d] list of impaired waters for fecal coliform. The main sources of fecal coliform affecting these areas include failing sewage systems and poor pasture management (Washington State Department of Health 2001). Southern Hood Canal (beginning just south of the DBRC) is listed as an impaired water body for fecal coliform and dissolved oxygen (low dissolved oxygen levels) (U.S. Environmental Protection Agency 2003).

NUWC Keyport commissioned a field study to document water and sediment quality conditions at DBRC Site in Dabob Bay (Battelle 2001), as described in Section 3.1.2.1.2 (Sediments in the Inland Waters). The results of the study are summarized in Table 3.1-3. Although conducted for the DBRC Site, the results of the study are applicable to Keyport Range Site because of the similar nature of activities and the similarities of sedimentary, bathymetric, and circulatory conditions at both locations.

Laboratory results for both the surface and bottom seawater samples indicated that metal concentrations were low in Dabob Bay compared to background levels in nonurban portions of Puget Sound. The concentrations of four metals with listed Washington State water quality criteria (cadmium, copper, lead, and zinc) were well below these criteria. Lithium and zirconium do not have Washington State water quality criteria, but lithium concentrations were at the same level as background concentrations. The zirconium concentrations observed were well below levels considered toxic to aquatic organisms.

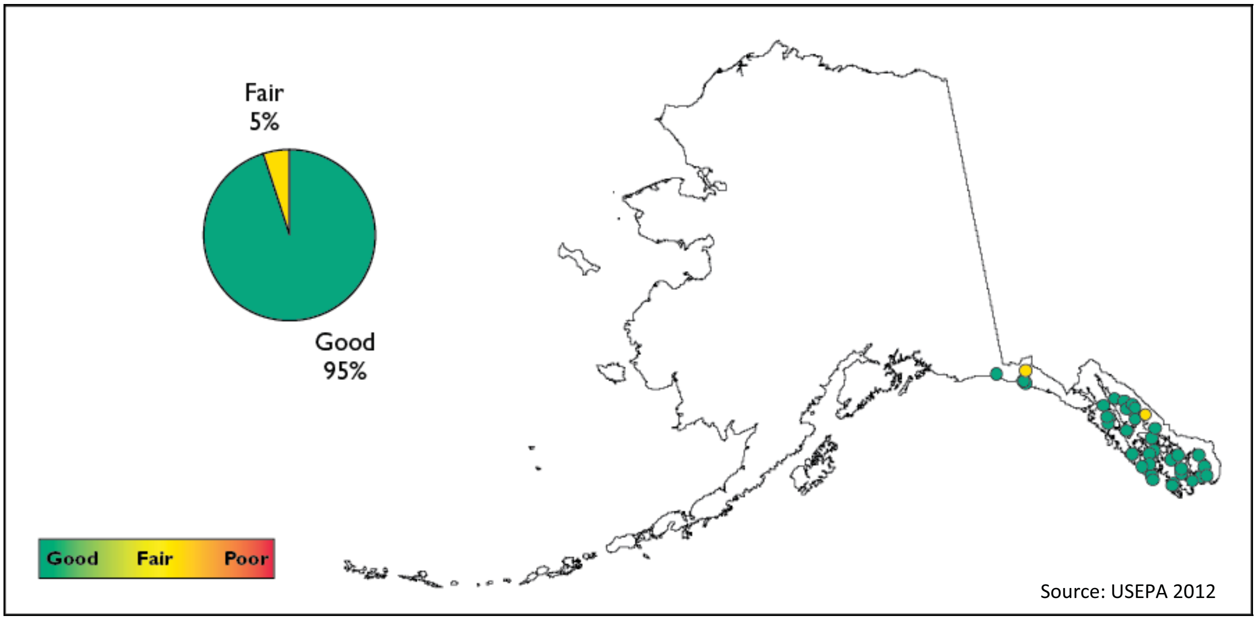
The southern portion of Puget Sound is not flushed as rapidly as northern Puget Sound because of its distance from tidal influence through the Strait of Juan de Fuca. The long residence times, as well as the shallow depths of many of the inlets, harbors, and estuaries, results in less dilution and transport of nutrients out of South Puget Sound. South Puget Sound is more sensitive to nutrient loading, which decreases the dissolved oxygen concentration. Carr Inlet, as well as Base and Budd Inlets, has one of the lowest dissolved oxygen levels within South Puget Sound and may be the inlet most sensitive to increased nutrient loads (Washington State Department of Ecology 2007). Eutrophication, including excessive algal blooms, can affect human health, such as an August 2000 outbreak of paralytic shellfish poisoning in Carr Inlet that afflicted seven people (Washington State Department of Ecology 2007).

South Puget Sound comprises numerous inlets, which increase the amount of shorefront property. Significant population growth has historically occurred within the region, with Thurston County’s population increasing almost 30 percent from 1980 to 1990. Development is expected to continue at a high rate in counties in South Puget Sound (i.e., Thurston, Mason, and Pierce), with the increase in human activities increasing nutrient loading in South Puget Sound (Washington State Department of Ecology 2007).

3.1.2.4.3 Water Quality in Western Behm Canal

The SEAFAC testing facilities are in the western portion of Behm Canal, a fjord where fresh and salt water mix. It has a bathymetric sill that separates the seawater from the fresh inland water. This sill inhibits water mixing, weakens tidal flow at depth, and produces stratification with fresh water (less dense) at the surface and seawater (more dense) entering slowly at depth.

Alaskan coastal resources are generally considered pristine because of the state's low population density and the distance of most of its coastline from major urban and industrial areas (U.S. Environmental Protection Agency 2012). The water quality index rating for the coastal waters of southeastern Alaska is good (Figure 3.1-5). The ratings of fair resulted from low clarity measurements or low dissolved oxygen concentrations; these measurements were probably the result of natural conditions (U.S. Environmental Protection Agency 2012). Low clarity measurements were probably the result of glacial silt input from nearby glaciers or river systems, while low dissolved oxygen levels are typically associated with deeper water of fjords in the southeastern Alaska region. Behm Canal has good water quality because most of the watershed consists of undeveloped lands in Tongass National Forest. The State of Alaska considers none of the waters near SEAFAC to be impaired (Alaska Department of Environmental Conservation 2010).



Source: USEPA 2012

Figure 3.1-5: Water Quality Index for Southeastern Alaska

Domestic wastewater generated at the SEAFAC shore facility on Back Island is treated by a secondary treatment system and is discharged to Behm Canal in accordance with a National Pollutant Discharge Elimination System permit. The permitted maximum daily flow is 3,900 gal. (14,763 L) per day. The permit contains treatment requirements, effluent limitations, and monitoring requirements.

3.1.2.5 Marine Debris and Marine Water Quality

The National Marine Debris Monitoring Program developed three categories of marine debris for its study of the extent of man-made materials in the oceans: land-based, ocean-based, and general (e.g., origin unspecified; Sheavly 2007). Debris from the land may be blown into marine waters by the wind, washed in with stormwater, or arise from recreational use of coastal areas. Ocean sources of marine debris include commercial shipping and fishing, private boating, offshore mining and extraction, and legal and illegal dumping at sea. Ocean currents, weather, and tides as well as proximity to urban centers, industrial and recreational areas, shipping lanes, and fishing grounds influence the types and amounts of debris that are found in marine waters (Sheavly 2010).

Teuten et al. (2007) found that water-borne phenanthrene (a type of polycyclic aromatic hydrocarbon) adhered preferentially to small pieces of plastic that were ingested by a bottom-dwelling marine lugworm and incorporated into its tissue. Plastics also may transport various pollutants, whether through adsorption from seawater or from the constituents of the plastics themselves. Mato et al. (2001) noted that polypropylene resin pellets—precursors to certain manufactured plastics—collected from sites in Japan contained PCBs, dichlorodiphenyl dichloroethylene (a breakdown product of DDT), and nonylphenol, a persistent organic pollutant that is a precursor to certain detergents. PCBs and DDT were adsorbed from seawater. The original source of nonylphenol is less clear; it may have come from the pellets themselves, or may have been adsorbed from the seawater.

3.1.2.6 Climate Change and Marine Water Quality

Marine water quality may be influenced by aspects of climate change, such as decreasing ocean pH, increasing water temperatures, and extreme storms. As described in Section 3.1.1.1.2.1 (Characteristics of Marine Waters), changes in pH outside of the normal range can make it difficult for marine organisms to maintain the integrity of their shells. Many of those creatures, such as phytoplankton, are at the base of the marine food chain, so changes may reverberate through the ecosystem. Rising water temperatures can be detrimental to coastal ecosystems. For example, in waters that are warmer than normal, coral colonies appear to turn white (bleaching) because they expel symbiotic microbes (zooxanthellae) that give them some of their colors. These microbes are important for coral survival because they provide the coral with food and oxygen, while the coral provides shelter, nutrients, and CO_2. Rising seawater temperatures combined with decreasing ocean pH can be especially detrimental to corals (Anthony et al. 2008). Water pollution and natural disturbances (e.g., storms) can inflict additional stress on coral (Hughes and Connell 1999).

3.1.3 ENVIRONMENTAL CONSEQUENCES

This section evaluates how and to what degree the training and testing activities described in Chapter 2 (Description of Proposed Action and Alternatives) may impact sediment and water quality in the Study Area. Tables 2.8-1 through 2.8-3 present the baseline and proposed training and testing activities, as well as the locations of activities and number of ordnance expended, for each alternative. Each water quality stressor is introduced and analyzed by training and testing activities for each alternative. Impacts could result from the following:

- Releasing materials into the water that subsequently disperse, react with seawater, or dissolve over time
- Depositing materials on the ocean bottom that subsequently interact with sediments, or the accumulation of such materials over time
- Depositing materials or substances on the ocean bottom that subsequently interact with the water column
- Depositing materials on the ocean bottom that subsequently disturb those sediments or that resuspend them in the water column

These impacts could result from one or more of the following four stressors: (1) explosives and explosion byproducts, (2) metals, (3) chemicals other than explosives, and (4) a miscellaneous category of other materials. The term “stressor” is used because materials in these four categories may directly impact sediment and water quality by altering their physical and chemical characteristics.

The area of analysis for sediment and water quality includes estuaries, nearshore areas, and the open ocean (including the sea bottom) in the Study Area. Sediments and marine waters within territorial and nonterritorial waters along the coasts of Alaska, Washington, Oregon, and California would react similarly to military expended materials. For instance, sediment size is a major determinant of how metals behave in sediments, and sediment size would be similar at a given distance from shore. Thus, for this analysis, potential impacts on sediment and water quality from military expended materials that are deposited in sediments at any given distance from shore are assumed to be similar.

Table 3.1-6 presents quantitative data (number of components or activities) for the analysis of each stressor applicable to sediments and water quality.

Table 3.1-6: Stressors Applicable to Sediments and Water Quality for Training and Testing Activities

Components	Area	Number of Components or Activities					
		No Action Alternative		Alternative 1		Alternative 2	
		Training	Testing	Training	Testing	Training	Testing
Items containing explosives and explosive byproducts	Offshore Area	7,035	0	7,075	148	7,075	164
	Inland Waters	4	0	42	0	42	0
	W. Behm Canal	0	0	0	0	0	0
Items containing metals	Offshore Area	177,598	214	182,948	1,228	182,948	1,352
	Inland Waters	4	14	42	15	42	17
	W. Behm Canal	0	0	0	0	0	0
Items containing chemicals other than explosives	Offshore Area	188	14	172	96	172	110
	Inland Waters	0	8	0	9	0	11
	W. Behm Canal	0	0	0	0	0	0
Items containing other materials	Offshore Area	3,084	0	5,224	600	5,224	660
	Inland Waters	0	0	0	0	0	0
	W. Behm Canal	0	0	0	0	0	0

3.1.3.1 Explosives and Explosion Byproducts

3.1.3.1.1 Introduction

Explosives are complex chemical mixtures that may affect sediment and water quality through the byproducts of their detonation in water or through the dispersal of unconsumed explosives in water or sediments. Detonating explosives may also disturb sediments and increase turbidity. Underwater explosions resuspend sediments in the water column. However, these impacts are minimal because, depending on site-specific conditions of wind and tidal currents, the sediment plume eventually dissipates as particles settle to the bottom or disperse. Therefore, this issue is not considered further.

The Proposed Action involves three categories of high explosives:

- Nitroaromatics, such as trinitrotoluene (TNT), ammonium picrate, and tetryl (methyl-2,4,6-trinitrophenyl-nitramine)

- Nitramines, such as royal demolition explosive (RDX) (hexahydro-1,3,5-trinitro-1,3,5-triazine) and high melting explosive (HMX) (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)
- Nitrate esters, such as pentaerythritol tetranitrate

The explosives TNT, RDX, and HMX are components of bombs, missile and rocket fuels and warheads, torpedoes, sonobuoys, medium- and large-caliber munitions, and charges used in a variety of training and testing activities, such as mine countermeasure and mine neutralization (Clausen et al. 2007). Pentaerythritol tetranitrate is most commonly used in blasting caps, detonation cord, and other initiators of explosions. Chemical stressors other than explosives are discussed in Section 3.1.3.3.

When they are used, explosives may undergo a high-order detonation or a low-order detonation, or they may fail to detonate. High-order (complete) detonations consume 98–99 percent of the explosive material; the remainder is released into the environment as discrete particles. Low-order (incomplete) detonations consume a lower percentage of the explosive and release larger amounts of explosives into the environment. If ordnance fails to detonate, the energetic materials it contains may be released into the environment over time as its casing corrodes. In this discussion, the term “residual explosives” means unconsumed explosives remaining after low-order detonations and detonation failures. The term “explosion byproducts” is used to refer to the liquids and gases that remain after detonation of explosives.

Explosions that occur above or at the surface are assumed to distribute nearly all of the explosion byproducts into the air, rather than into the water, and are discussed in Section 3.2 (Air Quality). This analysis concerns only those explosions that occur underwater. However, military expended materials that explode in the air or at the water surface may deposit particles of unconsumed explosives in the marine environment. These materials are addressed in the next section on unconsumed explosives.

3.1.3.1.2 Background

Under the Proposed Action, explosions would occur (1) above, at, or just beneath the water surface during training and testing activities that use bombs, medium- and large-caliber projectiles, missiles, and rockets; and (2) underwater during mine countermeasure and mine neutralization training and testing activities and from training and testing activities that use explosive sonobuoys. Mine countermeasure and neutralization activities occur beneath the surface and on or near the bottom, typically in fairly shallow areas. Explosives charges used for mine neutralization training and testing activities in the Study Area can be up to 2.5 pounds (lb.) (1.1 kilograms [kg]) net explosive weight (NEW).

Mine countermeasure and mine neutralization activities frequently use the explosive compound composition 4 (C-4), which is composed of about 95 percent RDX mixed with polyisobutylene, a plastic binding material. When it functions properly (i.e., complete detonation), 99.997 percent of the explosive is converted to inorganic compounds (U.S. Army Corps of Engineers 2003).

Table 3.1-7 lists the byproducts of underwater detonation of RDX. Of the byproducts identified in Table 3.1-7, nitrogen, CO_2, water, carbon monoxide, ammonia, and hydrogen are natural components of seawater and represent 98 percent of all byproducts produced by the detonation of RDX.

Table 3.1-7: Byproducts of Underwater Detonation of Royal Demolition Explosive

Byproduct	Percent of Total, by Weight	Byproduct	Percent of Total, by Weight
Nitrogen	37.0	Propane	0.2
Carbon dioxide	24.9	Methane	0.2
Water	16.4	Hydrogen cyanide	< 0.01
Carbon monoxide	18.4	Methyl alcohol	< 0.01
Ethane	1.6	Formaldehyde	< 0.01
Ammonia	0.9	Other compounds	< 0.01
Hydrogen	0.3		

Note: < = less than
Source: U.S. Department of the Navy 2008a

3.1.3.1.3 Ordnance Failure and Low-Order Detonations

Table 3.1-8 shows rates of failure and low-order detonations for high explosives and other munitions.

Table 3.1-8: Failure and Low-Order Detonation Rates of Military Ordnance

Ordnance	Failure Rate (Percent)	Low-Order Detonation Rate (Percent)
Guns/artillery	4.68	0.16
Hand grenades	1.78	n/a
High-explosive ordnance	3.37	0.09
Rockets	3.84	n/a
Submunitions	8.23	n/a

Note: n/a = not applicable
Source: Rand Corporation 2005; U.S. Army Corps of Engineers 2007

3.1.3.1.4 Approach to Analysis

Most activities involving explosives and explosion byproducts would be conducted more than 12 nm offshore. Explosives are also used in the Inland Waters area during mine countermeasure and mine neutralization training activities. These activities would occur only within 3 nm of shore in Washington. Activities out to 12 nm would be subject to federal sediment and water quality standards and guidelines.

For explosion byproducts, “local” means the water column disturbed by an underwater detonation. For unconsumed explosives, “local” means the area of potential impact from explosives at a distance of about 66 in. (170 cm) from where the ordnance or unconsumed explosive settles on the sea floor.

3.1.3.1.4.1 State Standards and Guidelines

Table 3.1-9 summarizes existing state standards and guidelines for sediment and water quality related to explosives and explosion byproducts. Training activities using explosives and live ordnance would occur only within the state waters of Washington. Therefore, water quality criteria presented in Table 3.1-9 includes only Washington.

Table 3.1-9: State Water Quality Criteria for Explosives and Explosion Byproducts

State	Explosive, Explosion Byproduct	Criteria (µg/L)	Source
Washington	Cyanide	1.0 (1-hour average)	State of Washington 2011

Note: µg/L = microgram per liter

3.1.3.1.4.2 Federal Standards and Guidelines

Table 3.1-10 summarizes the USEPA criteria for explosives and explosion byproducts in saltwater.

Table 3.1-10: Criteria for Explosives and Explosion Byproducts in Saltwater

Explosives, Explosion Byproducts	Criterion Maximum Concentration[1]	Criterion Continuous Concentration[2]	Source
Cyanide	1 µg/L	1 µg/L	U.S. Environmental Protection Agency 2009

[1] "Criterion maximum concentration" is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.

[2] "Criterion continuous concentration" is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

Note: µg/L = microgram per liter

3.1.3.1.5 Fate of Military Munitions in the Marine Environment

3.1.3.1.5.1 Explosives and Explosion Byproducts

Few data are available on the fate and degradation of unconsumed explosives in marine sediments (Zhao et al. 2004). Cruz-Uribe et al. (2007) noted that "contamination of the marine environment by munitions constituents is not well documented," and Montgomery et al. (2008) noted that there is "little published information on TNT degradation in seawater or marine sediments aside from the work of Carr and Nipper (2003)." Still, Zhao et al. (2004) noted that leaching of unconsumed explosives is considered a major source of sediment contamination in seas and waterways, and that contaminants can subsequently move from sediments and accumulate in aquatic organisms. According to Nipper et al. (2002), their studies of Puget Sound sediments demonstrate that the studied ordnance compounds were not a cause for environmental concern at the levels previously measured in marine sediments. The studied compounds included 2,6-dinitrotoluene, tetryl, and picric acid. They remarked that the "levels of ordnance compounds that would be of concern in marine sediments have not yet been identified."

The behavior of explosives and explosion byproducts in marine environments and the extent to which those constituents have adverse impacts are influenced by a number of processes, including the ease with which the explosive dissolves in a liquid such as water (solubility), the degree to which explosives are attracted to other materials (e.g., clay-sized particles and organic matter) in the water (sorption), and the tendency of the explosives to evaporate (volatilization). These characteristics, in turn, influence the extent to which the material is subject to biotic (biological) and abiotic (physical and chemical) transformation and degradation (Pennington and Brannon 2002). The solubility of various explosives is provided in Table 3.1-11. In the table, higher values indicate greater solubility. For example, HMX is virtually insoluble in water. Table salt, which dissolves easily in water, is included in the table for comparison.

Table 3.1-11: Water Solubility of Common Explosives and Explosive Degradation Products

Compound	Water Solubility[1]
Table salt (sodium chloride)	357,000
Ammonium perchlorate (D)	249,000
Picric acid (E)	12,820
Nitrobenzene (D)	1,900
Dinitrobenzene (E)	500
Trinitrobenzene (E)	335
Dinitrotoluene (D)	160–161
TNT (E)	130
Tetryl (E)	51
Pentaerythritol tetranitrate (E)	43
Royal demolition explosive (E)	38
High melting explosive (E)	7

[1] Units are milligrams per liter at 20 degrees Celsius
Notes: D = explosive degradation product, E = explosive
Source: U.S. Department of the Navy 2008a

Solubility rates are not affected by pH, but increase as temperature increases (Lynch et al. 2002). As Table 3.1-11 indicates, explosives associated with the Proposed Action dissolve slowly over time and thus are not very mobile in marine environments (Juhasz and Naidu 2007). Nitroaromatics such as TNT do not bind to metal hydroxides but may bind to clays, depending on the type (more so with potassium or ammonium ions but negligible for clays with sodium, calcium, magnesium, or aluminum ions). Sorption by nitroamines such as RDX is very low (Haderlein et al. 1996).

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

Carr and Nipper (2003) indicated that conversion of TNT to CO_2, methane, and nitrates in coastal sediments (mineralization) occurred at rates that were typical for naturally occurring compounds such as phenanthrene, fluoranthene, toluene, and naphthalene. They noted that transformation of 2,6-dinitrotoluene and picric acid by organisms in sediments is dependent on temperature and type of sediment. Pavlostathis and Jackson (2002) reported the uptake and metabolism of TNT by the marine microalgae *Anabaena* spp. Nipper et al. (2002) noted that enhanced degradation of 2,6-dinitrotoluene, tetryl, and picric acid occurred in fine-grained sediments high in organic carbon. Cruz-Uribe et al. (2007) noted that three species of marine macroalgae metabolize TNT to 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene, and speculate that “the ability of marine macroalgae to metabolize TNT is widespread, if not generic.”

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

According to Singh et al. (2009), typical end products of RDX degradation include nitrite, nitrous oxide, nitrogen, ammonia, formaldehyde, formic acid, and CO_2. Crocker et al. (2006) stated that many of the primary and secondary intermediate compounds from biodegradation of RDX and HMX are unstable in water and spontaneously decompose. Thus, these explosives are degraded by a combination of biotic and abiotic reactions. Formaldehyde is subsequently metabolized to formic acid, methanol, CO_2, or methane by various microorganisms (Crocker et al. 2006).

According to Juhasz and Naidu (2007), TNT, RDX, and HMX also degrade from photolysis (exposure to light) and hydrolysis (exposure to water). The byproducts of TNT photolysis include nitrobenzenes, benzaldehydes, azoxydicarboxylic acids, and nitrophenols. The byproducts of RDX and HMX photolysis include azoxy compounds, ammonia, formaldehyde, nitrate, nitrite, nitrous oxide, and *N*-nitroso-methylenediamine (Juhasz and Naidu 2007). Walker et al. (2006) speculated that degradation of TNT "below the photic [light] zone in coastal waters and sediments may be largely controlled by metabolism by heterotrophic bacteria." According to Monteil-Rivera et al. (2008), at the pH common in marine environments (i.e., pH of 8), there should be a "slow but significant removal" of RDX and HMX through alkaline hydrolysis. Under such conditions, and absent biodegradation, RDX would take over 100 years to hydrolyze, while high melting explosive would require more than 2,100 years (Monteil-Rivera et al. 2008).

3.1.3.1.5.2 Unconsumed Explosives

Most studies of unexploded ordnance in marine environments have not detected explosives or have detected them in the range of parts per billion. As summarized below, several studies examining the impact of ordnance on marine organisms have produced mixed results. The amounts and concentrations of ordnance deposited in those areas studied, however, were far in excess of those that would occur under the Proposed Action.

Several authors have studied the impacts of unexploded ordnance in Halifax Harbor, Nova Scotia, Canada. Rodacy et al. (2000) noted that munitions explosions in 1917 and 1946 scattered ordnance across an area known as the Bedford Basin. Ordnance was both fully exposed on and partially buried in the sea floor. They reported that 34 of 59 water samples (58 percent) "produced detectable signatures" of ordnance, as did 26 of 27 sediment samples (96 percent). They also noted that marine growth was observed on most of the exposed ordnance and that TNT metabolites were present and suspected as the result of biological decomposition. In a prior study (Durrach et al. 1998), sediments collected near unexploded, but broken, ordnance did not indicate the presence of TNT, but samples near ordnance targets that appeared intact showed trace explosives in the range of low parts per billion or high parts per trillion. The sampling distance was 6 to 12 in. (15 to 30 cm) from the munitions. The authors expressed the opinion that, after 50 years, the contents of broken munitions had dissolved, reacted, biodegraded, or photodegraded and that intact munitions appear to be slowly releasing their contents through corrosion pinholes or screw threads. Studies by Zhao et al. (2004) in Halifax Harbor documented the biodegradation of RDX and HMX in cold marine sediments.

Chemical and conventional munitions disposed on the ocean floor approximately 5 mi. (8.05 km) south of Pearl Harbor, Hawaii, were recently studied (Hawaii Undersea Military Munitions Assessment 2010). Documents indicate that sixteen thousand 100 lb. (45 kg) mustard-filled bombs may have been disposed in this area in October and November 1944. The condition of the munitions ranged from "nearly intact to almost completely disintegrated." The authors collected 94 sediment samples and 30 water samples from 27 stations at five locations. These samples were analyzed for chemical agents, explosives, metals (arsenic, copper, lead, and zinc), polycyclic aromatic hydrocarbons, pesticides, PCBs, phenols, and organic tin. No chemical agents or explosives were detected, and comparisons between the disposal site and reference sites showed no statistically significant differences in levels of munitions constituents, chemical agents, or metals. However, the sampling distance for this project was 3–6 ft. (1–2 m). The authors compared their sampling distance to that used by Durrach et al. (1998), that is, 6–12 in. (15–30 cm). They indicated that the project sampling distance may have been too far to detect chemical agents or explosives, and that sampling distance may be a significant factor determining whether munitions constituents can be detected near discarded munitions. Samples with elevated concentrations of metals relative to typical deep-sea sediments were most likely the result of dumping of sediments dredged from Oahu harbors.

Hoffsommer et al. (1972) analyzed seawater and ocean floor sediments and fauna for military ordnance constituents at known ocean dumping sites. The sites were 85 mi. (136 km) west of Cape Flattery, Washington, and 172 mi. (280 km) south-southeast of Charleston, South Carolina. Samples were tested for TNT, RDX, tetryl, and ammonium perchlorate, none of which were detected in the samples. Detection limits were in the parts-per-trillion range. Walker et al. (2006) sampled seawater and sediment at two underwater demolition sites offshore of Oahu, Hawaii, where 10 lb. (4.5 kg) charges of TNT and RDX were used. Seawater concentrations of both explosives were below their detection limits, including samples collected in the detonation plume within 5 minutes of the detonation.

According to Fisheries Research Services (1996), over 1,000,000 tons of chemical and conventional munitions were disposed of at Beaufort's Dyke, a trench in the North Channel between Scotland and Ireland. The trench is more than 30 mi. (48 km) long and 2 mi. (3 km) wide. The average density of munitions is about 2,225 tons per mi.^{2} (5,760 tons per km^2). Seabed sediment samples were obtained from 105 sites. Sampling distance from the munitions was not noted. Sediment sampling results did not find detectable concentrations of the explosives nitroglycerine, TNT, RDX, or tetryl, and analysis of metals indicated that levels within the survey area were within the ranges reported for other Scottish coastal areas.

Nipper et al. (2002) studied the impacts of the explosives 2,6-dinitrotoluene, tetryl, and picric acid on marine sediments in Puget Sound. They noted that the levels measured did not account for the sediment's toxicity. Test subjects and processes included small marine crustaceans (amphipods), marine segmented worms (polychaetes), macro-algae germination and growth, and sea urchin embryo development. The authors suggested that the degradation products of the explosives rather than the explosives themselves may be responsible. They acknowledged that the "persistence of such degradation compounds in marine environments is not known."

An underwater explosion deposits a fraction of the chemical products of the reaction in the water in a roughly circular surface pool that moves with the current (Young and Willey 1977). In a land-based study, Pennington et al. (2006) noted that data demonstrate that explosives in the main charge of howitzer rounds, mortar rounds, and hand grenades are efficiently consumed (on average 99.997 percent or more) during live-fire operations that result in high-order detonations. The explosives not consumed during these detonations are spread over an area that would, on average, contribute 10 µg/kg (parts per billion [ppb]) per detonation or less to the ground surface. However, the applicability of the study by Pennington et al. (2006) to underwater marine systems remains uncertain.

Table 3.1-12 provides (1) the amount of explosive remaining after underwater detonation of 5 and 20 lb. (2.3 and 9.1 kg) charges of C-4, and (2) the volume of water required to meet the marine screening value for the remaining amount of C-4. A 5 lb. (2.3 kg) block of C-4 contains 2.27 lb. (1.03 kg) of RDX; a 20 lb. (9.1 kg) block contains 18.2 lb. (8.25 kg) of RDX (U.S. Department of the Navy 2010). Pennington et al. (2006) assumed that 0.02 percent of RDX residue remained after detonation. The failure rate is zero for C-4 because, during mine countermeasure and mine neutralization activities, personnel do not leave any undetonated C-4 on range at the end of training.

Table 3.1-12: Volume of Water Needed to Meet Marine Screening Value for Royal Demolition Explosive

Screening Value for Ecological Marine Surface Water	Explosive Charge, lb. (kg)			
	5 lb. (2.27 kg)		20 lb. (9.1 kg)	
	Amount of RDX Remaining after Detonation	Attenuation Needed to Meet Screening Value	Amount of RDX Remaining after Detonation	Attenuation Needed to Meet Screening Value
5,000 µg/L	0.01 oz. (0.41 g)	22 gal. (82.6 L)	0.06 oz. (1.65 g)	87 gal. (330 L)

Notes: µg/L = microgram/liter, g = gram, gal. = gallon; kg = kilogram, L = liter; lb. = pound, oz. = ounce, RDX = royal demolition explosive

3.1.3.1.6 Evaluation of Alternatives

Table 3.0-22 summarizes the types and amounts of high-explosive military expended materials proposed to be used annually under the alternatives. In most instances, explosive bombs, projectiles, and missiles detonate above the surface of the water, at the water surface, or just beneath the surface. Underwater detonations may occur during sinking exercises, mine countermeasure and mine neutralization training and testing, and training and testing activities using explosive sonobuoys. No explosions or weapons firing would take place for any training or testing activity under any proposed alternative in the Western Behm Canal portion of the Study Area. Therefore, explosions or weapons firing was not evaluated for this portion of the Study Area.

3.1.3.1.6.1 No Action Alternative

Training Activities

Offshore Area

Under the No Action Alternative, up to 7,035 high-explosive ordnance items would be expended annually during training activities in the Offshore Area, primarily beyond 12 nm.

Numerically, medium- and large-caliber high-explosive projectiles would represent over 97 percent of high-explosive ordnance used during training activities. Charge sizes, in terms of NEW, for medium- and large-caliber projectiles range from 0.5 to 10 lb. (0.2 to 4.5 kg), in comparison to charges in missiles (from 2.5 to 20 lb. [1.1 to 9.1 kg]) and bombs (about 250 lb. [113 kg]).

Comparison of Training Materials by Weight of Explosives

A review of training materials based on the weight of explosives provides another perspective on the relative contribution of various items under the No Action Alternative. Table 3.1-13 depicts those categories of training materials that contribute nearly all (99 percent) of the total weight under the No Action Alternative. The total weight of explosives used during training under the No Action Alternative would be an estimated 16,700 lb. (7,575 kg).

Table 3.1-13: Comparison of Number of High-Explosive Items versus Weight of Explosives – No Action Alternative

Type of Military Expended Material	Percent of Total HE by Number	Percent of Total HE by Weight
Medium- and large-caliber projectiles	97.2	31.8
Bombs	< 1.0	51.7
Missiles	< 1.0	1.2
Torpedoes	< 1.0	7.8
Sonobuoys	< 1.0	7.5

Notes: (1) HE = high-explosive, < = less than. (2) Because the contribution of testing materials to the total amount of high-explosive material is relatively small, by number and by weight, only training materials were used for the comparisons.

Subsurface High-Order Explosions and Explosion Byproducts

Under the No Action Alternative, training-related underwater explosions would be from use of explosive sonobuoys (charges approximately 4.2 lb. [1.9 kg] NEW) and torpedoes (charges approximately 650 lb. [295 kg] NEW). The impacts of explosion byproducts on sediment and water quality would be short term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable and neither state nor federal standards or guidelines would be violated.

Unconsumed Explosives

Under the No Action Alternative, approximately 737 lb. (334 kg) per year of residual explosives would remain from high-explosive ordnance used during training activities because of ordnance failure and low-order detonations. Over 98 percent of residual explosive materials would result from ordnance failures. Ordnance failure rates are listed in Table 3.1-8. The amount of residual explosive materials is based on the rate of failure multiplied by the number of explosive ordnance and weight of explosives of each ordnance item expended during training activities.

In the event of an ordnance failure, the energetic materials it contains would remain intact. These materials would leach from the item slowly because they would have little or no direct exposure to marine waters. Small amounts of explosives may be released into sediment and into the surrounding water column as the ordnance item degrades and decomposes. Ocean currents would quickly disperse leached explosive constituents, and these constituents would not result in water toxicity. Chemical, physical, or biological changes in sediment or water quality would be measurable, but neither state nor federal standards or guidelines would be violated.

Sinking exercises require the highest concentrations of high-explosive ordnance. During each sinking exercise, an estimated 128 high-explosive ordnance items would be expended, 98 percent of which would consist of large-caliber projectiles. Approximately 460 lb. (209 kg) of explosive materials would be released per sinking exercise from low-order detonations and ordnance failures. The sinking exercise training area is approximately 2 square nautical miles (nm^2) in size. Thus, during each exercise, approximately 64 items per nm^2 and 230 lb. (104 kg) of explosive material per nm^2 would sink to the ocean floor.

Inland Waters

Under the No Action Alternative, high explosive materials used in the Inland Waters would consist of two 1.5 lb. (0.68 kg) charges and two 2.5 lb. (1.1 kg) charges each year in Hood Canal and Crescent

Harbor Explosive Ordnance Disposal (EOD) Ranges, respectively, during mine neutralization – EOD training activities. Underwater detonations would likely consume over 99 percent of the explosive material. No explosive material would result from detonation failures because personnel would ensure that charges detonate. Therefore, there would be no effect on sediments and water quality because of the minimal amount of explosive material that would remain.

Testing Activities

Offshore Areas

Under the No Action Alternative, no high-explosive ordnance would be expended during testing activities. Therefore, there would be no impact on sediments or water quality from residual explosive or explosive byproducts.

Inland Waters

No high explosives or live ordnance would be used in the Inland Waters area during testing activities under the No Action Alternative. Therefore, there would be no impact on sediments or water quality from residual explosive or explosive byproducts.

3.1.3.1.6.2 Alternative 1

Training Activities

Offshore Areas

Under Alternative 1, the amount of high-explosive ordnance used for training activities in the Offshore Area would increase slightly from 7,035 to 7,075 items (see Table 3.1-6). Numerically, medium- and large-caliber high-explosive projectiles would represent over 97 percent of high-explosive ordnance used during training activities within the Study Area.

The amount of high-explosive materials expended under Alternative 1, although slightly larger, would be similar to the No Action Alternative and, therefore, impacts would be similar. Short-term impacts would arise from explosion byproducts, while long-term impacts would arise from unconsumed explosives. The majority of high-order explosions would occur at or above the surface of the ocean and would have no impacts on sediments and minimal impacts on water quality.

Comparison of Training Materials by Weight of Explosives

A review of training materials based on the weight of explosives provides another perspective on the relative contribution of various items under Alternative 1.

Table 3.1-14 depicts those categories of training materials that contribute nearly all (99 percent) of the total weight under Alternative 1. Under Alternative 1, the total weight of explosives used during training would decrease from an estimated 16,700 lb. (7,575 kg) to an estimated 10,455 lb. (4,742 kg).

Table 3.1-14: Comparison of Number of High-Explosive Items versus Weight of Explosives – Alternative 1

Type of Military Expended Material	Percent of Total HE by Number	Percent of Total HE by Weight
Medium- and large-caliber projectiles	97.9	43.8
Missiles	< 1.0	25.8
Bombs	< 1.0	18.4
Torpedoes	0	0
Sonobuoys	2.1	12.1

Notes: (1) HE = high-explosive, < = less than. (2) Because the contribution of testing materials to the total amount of high-explosive material is relatively small, by number and by weight, only training materials were used for the comparisons.

Subsurface High-Order Explosions and Explosion Byproducts

Under Alternative 1, nearly all training-related underwater explosions would be from explosive sonobuoys. The impacts of explosion byproducts on sediment and water quality would be short term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable and neither state nor federal standards or guidelines would be violated.

Unconsumed Explosives

Although Alternative 1 would increase the number of training activities, the amount of explosives released during training would decrease compared to the No Action Alternative. The estimated amounts of residual explosives from ordnance failures and low-order detonations during training activities would decrease to approximately 416 lb. (187 kg) per year because of the discontinuation of sinking exercises. Therefore, because the amount of explosives released during training would decrease under Alternative 1, impacts would be less than under the No Action Alternative. Chemical, physical, or biological changes in sediment or water quality would not measurable, but neither state nor federal standards or guidelines would be violated.

Inland Waters

Under Alternative 1, explosive charges would be used only during mine neutralization – EOD training activities. The number of underwater detonations would increase under Alternative 1 compared to the No Action Alternative (42 charges compared to 4 charges). The amount of explosive material would also increase under Alternative 1 as three 2.5 lb. (1.1 kg) charges would be used at both Crescent Harbor and Hood Canal EOD Ranges. The remaining 36 underwater detonations would use Shock Wave Action Generator charges, which are approximately 0.033 lb. (15 grams [g]).

The total amount of explosive materials used in the Inland Waters for training would be approximately 16.2 lb. (7.3 kg). Despite an increase from 8 lb. (3.6 kg) to 16.2 lb. (7.3 kg) in explosive materials, most would be consumed during detonation, and no detonation failures would occur. Therefore, there would be no effect on sediment and water quality.

Testing Activities

Offshore Areas

Under Alternative 1, up to 142 explosive sonobuoys and 6 torpedoes used for testing activities would be expended in the Offshore Area. Explosive sonobuoys contain charges that are approximately 4.2 lb. (1.9 kg) NEW, and torpedoes have an explosive weight of approximately 650 lb. (295 kg) NEW.

Subsurface High-Order Explosions and Explosion Byproducts

Under Alternative 1, underwater explosions associated with testing activities would be from the use of 142 explosive sonobuoys and 6 torpedoes. Despite the increase in number of underwater explosions, the impacts of explosion byproducts on sediment and water quality would be short term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable and neither state nor federal standards or guidelines would be violated.

Unconsumed Explosives

Under Alternative 1, approximately 242 lb. (110 kg) per year of residual explosives would remain from high-explosive ordnance used during testing activities because of ordnance failure and low-order detonations. Over 98 percent of explosive residues would result from ordnance failures. In the event of an ordnance failure, the energetic materials it contains would remain mostly intact. These materials would leach from the item slowly because they would have little or no direct exposure to marine waters. Small amounts of explosives may be released into sediment and into the surrounding water column as the ordnance item degrades and decomposes. Ocean currents would quickly disperse leached explosive constituents, and these constituents would not result in water toxicity. Chemical, physical, or biological changes in sediment or water quality would be detectable, but neither state nor federal standards or guidelines would be violated.

Inland Waters

No explosives or live ordnance would be used in the Inland Waters area during testing activities under Alternative 1. Therefore, there would be no impact on sediments or water quality from residual explosive or explosive byproducts.

3.1.3.1.6.3 Alternative 2

Training Activities

Offshore Areas

Under Alternative 2, the number of training activities and amounts of high-explosive ordnance would be the same as under Alternative 1. Numerically, medium- and large-caliber high-explosive projectiles would represent approximately 97 percent of high-explosive ordnance used during training activities within the Study Area. Therefore, the impacts of underwater explosions and explosives residues would be the same as under Alternative 1.

Inland Waters

Under Alternative 2, the number of high-explosive charges used during training activities and the locations of training activities would be the same as under Alternative 1. Therefore, the effects of residual explosives and explosion byproducts would be the same as under Alternative 1.

Testing Activities

Offshore Areas

Under Alternative 2, high-explosive ordnance used for testing activities would include 156 explosive sonobuoys per year and 8 torpedoes.

Subsurface High-Order Explosions and Explosion Byproducts

Under Alternative 2, underwater explosions associated with testing activities would be from the use of 156 explosive sonobuoys and 8 torpedoes. Despite the increased number of underwater explosions, the impacts of explosion byproducts on sediment and water quality would be short term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

<u>Unconsumed Explosives</u>

Under Alternative 2, approximately 314 lb. (142 kg) per year of residual explosives would remain from high-explosive ordnance used during testing activities because of ordnance failure and low-order detonations. Over 98 percent of explosives residues would result from ordnance failures. In the event of an ordnance failure, the energetic materials it contains would remain mostly intact. These materials would leach from the item slowly because they would have little or no direct exposure to marine waters. Small amounts of explosives may be released into sediment and into the surrounding water column as the ordnance item degrades and decomposes. Ocean currents would quickly disperse leached explosive constituents, and these constituents would not result in water toxicity. Impacts to sediment and water quality would be long-term and negligible. Chemical, physical, or biological changes in sediment or water quality would be measurable, but neither state nor federal standards or guidelines would be violated.

Inland Waters

No explosives or live ordnance would be used in the Inland Waters area during testing activities under Alternative 2. Therefore, there would be no impact on sediments or water quality from residual explosive or explosive byproducts.

3.1.3.1.6.4 Summary and Conclusions for Explosives and Explosion Byproducts

Over 98 percent of residual explosive materials would result from ordnance failures. In the event of an ordnance failure, the energetic materials it contained would remain mostly intact. The explosive materials in failed ordnance items would leach slowly because they would have little or no direct exposure to marine waters. Residual explosive materials deposited in sediments would be limited to small areas surrounding the ordnance item. Ocean currents would quickly disperse leached explosive materials in the water column, and residual explosive materials would not result in water toxicity.

Short-term impacts arise from explosion byproducts; long-term impacts arise from unconsumed explosives. The majority of high-order explosions would occur at or above the surface of the ocean and would have no impacts on sediments and minimal impacts on water quality. Chemical, physical, or biological changes in sediment or water quality would not be detectable. Neither state nor federal standards or guidelines would be violated.

The impacts of unconsumed explosives on water and sediment quality would be long term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would be measurable, but neither state nor federal standards or guidelines would be violated. This conclusion about the level of impact is based on the following: (1) most of the explosives would be consumed during detonation; (2) the frequency of low-order detonations would be low, and therefore the frequency of releases of explosives would be low; (3) the amounts of explosives used would be small relative to the area within which they would be distributed; and (4) the constituents of explosives would be subject to physical, chemical, and biological processes that would render the materials harmless or otherwise disperse them to undetectable levels.

3.1.3.2 Metals

3.1.3.2.1 Introduction

Many metals occur naturally in seawater, and several are necessary for marine organisms and ecosystems to function properly, such as iron, zinc, copper, and manganese. Other metals have adverse impacts on sediment and water quality (e.g., cadmium, chromium, lead, and mercury), but zinc, copper, and manganese may also be harmful to plants and animals at high concentrations.

Metals are introduced into seawater and sediments through military expended materials used during training and testing activities. These materials represent parts or the whole of vessels, manned and unmanned aircraft, ordnance (bombs, projectiles, missiles, and torpedoes), sonobuoys, batteries, electronic components, and anti-corrosion compounds coating the exterior surfaces of some munitions. Because of the physical and chemical reactions that occur with metals in marine systems (e.g., precipitation), metals often concentrate in sediments. Thus, metal contaminants in sediments are a greater issue than metal contaminants in the water column.

Military expended materials such as steel bomb bodies or fins, missile casings, small arms projectiles, and naval gun projectiles may contain small percentages (less than 1 percent by weight) of lead, manganese, phosphorus, sulfur, copper, nickel, tungsten, chromium, molybdenum, vanadium, boron, selenium, columbium, or titanium. Small-caliber projectiles are composed of steel with small amounts of aluminum and copper and brass casings that are 70 percent copper and 30 percent zinc. Medium- and large-caliber projectiles are composed of steel, brass, copper, tungsten, and other metals. The 20 mm cannon shells used in close-in weapons systems are composed mostly of tungsten alloy. Some projectiles have lead cores (U.S. Department of the Navy 2008b). Torpedo guidance wire is composed of copper and cadmium coated with plastic (U.S. Department of the Navy 2008a). Sonobuoy components include metal housing, batteries and battery electrodes, lead solder, copper wire, and lead used for ballast. Thermal batteries in sonobuoys are contained in a hermetically sealed and welded stainless steel case that is 0.03 to 0.1 in. (0.07 to 0.25 cm) thick and resistant to the battery electrolytes (Naval Facilities Engineering Command 1993). Rockets are usually composed of steel and steel alloys, but composite cases made of glass, carbon, or Kevlar fiber are also used (Missile Technology Control Regime 1996).

Non-explosive practice munitions consist of ammunition and components that contain no explosive material; they may include (1) ammunition and components that have had all explosive material removed and replaced with non-explosive material, (2) empty ammunition or components, and (3) ammunition or components that were manufactured with non-explosive material in place of all explosive material. These practice munitions vary in size from 25 lb. to 500 lb. (11 kg to 230 kg) and can be built to simulate different explosive capabilities. Some non-explosive practice munitions may also contain unburned propellant (e.g., missiles), and some may contain spotting charges or signal cartridges for locating the point of impact (e.g., smoke charges for daylight spotting or flash charges for night spotting; U.S. Department of the Navy 2010). Non-explosive bombs—also called “practice” or “bomb dummy units”—are composed mainly of iron and steel casings filled with sand, concrete, or vermiculite. These materials are similar to those used to construct artificial reefs. Non-explosive bombs are configured to have the same weight, size, center of gravity, and ballistics as live bombs (U.S. Department of the Navy 2006). Practice bombs do not contain the energetic materials found in live bombs.

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

(1,830 m) deep (40 C.F.R. 229.2). The USEPA considers the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.).

3.1.3.2.2 Approach to Analysis

Most activities involving military expended materials with metal components would be conducted more than 3 nm offshore in each range complex or test range. Activities occurring within 12 nm of shore would be subject to federal sediment and water quality standards and guidelines. For metals, "local" means the zone of sediment about 0.4 in. (1.0 cm) surrounding the metal where it comes to rest.

3.1.3.2.2.1 State Standards and Guidelines

Table 3.1-15 summarizes the state water quality standards and guidelines for metals in Alaska and Washington. Training and testing activities within the Study Area would occur beyond 12 nm offshore of Oregon and California. Therefore, water quality criteria presented in Table 3.1-15 includes only standards for Alaska and Washington.

Table 3.1-15: Water Quality Criteria for Metals

State	Metal	Water Quality Criteria (µg/L [ppb])	
		Acute[1]	Chronic[2]
Alaska	Cadmium	40	8.8
	Chromium (IV)	1,100	50
	Copper	4.8	3.1
	Lead	210	8.1
	Mercury	1.8	0.94
	Nickel	74	8.2
	Silver	1.9	n/a
	Zinc	90	81
Washington	Cadmium	42.0	9.3
	Chromium	1,100	50.0
	Copper	4.8	3.1
	Lead	210	8.1
	Mercury	1.8	0.025
	Nickel	74	8.2
	Silver	1.9	n/a
	Zinc	90	81

[1] One-hour average period

[2] Four-day average period

Notes: µg/L = microgram per liter, n/a = no value is available, ppb = parts per billion

Sources: Alaska Department of Environmental Conservation 2008; State of Washington 2011

3.1.3.2.2.2 Federal Standards and Guidelines

Table 3.1-16 summarizes the USEPA "threshold values" for metals in marine waters (U.S. Environmental Protection Agency 2012). "Acute toxicity" means an adverse response of test organisms to a substance observed in 96 hours or less (e.g., mortality, disorientation, or immobilization). "Chronic toxicity" means the lowest concentration of a substance that causes an observable effect (e.g., reduced growth, lower reproduction, or mortality) in test organisms. This effect occurs over a relatively long period, such as one-tenth of the life span of the species.

Table 3.1-16: Federal Threshold Values for Exposure to Selected Metals in Saltwater

Metal	Criteria (µg/L [ppb]) Acute (1-hour exposure)	Criteria (µg/L [ppb]) Chronic (4-day mean exposure)
Cadmium	40	8.8
Chromium	1,100	50
Copper	4.8	3.1
Lead	210	8.1
Lithium	6,000	n/a
Mercury	1.8	0.94
Nickel	74	8.2
Silver	1.9[1]	n/a
Zinc	90	81

[1] Instantaneous concentration criteria

Notes: µg/L = microgram per liter, ppb = parts per billion, n/a = no value is available

Source: U.S. Environmental Protection Agency 2012

3.1.3.2.3 Impacts of Metals

The discussion below summarizes studies that investigated the impacts of metals in military expended materials on the marine environment.

In general, one of three things happens to materials that come to rest on the ocean floor: (1) they lodge in sediments below 4 in. (10 cm), where there is little or no oxygen; (2) they remain on the ocean floor and begin to react with seawater; or (3) they remain on the ocean floor and become encrusted by marine organisms. As a result, rates of deterioration depend on the metal or metal alloy and the conditions in the immediate marine and benthic environment. If buried deep in ocean sediments, materials tend to decompose at much lower rates than when exposed to seawater (Ankley 1996). With the exception of torpedo guidance wires and sonobuoy parts, sediment burial appears to be the fate of most ordnance used in marine warfare (Canadian Forces Maritime Experimental and Test Ranges 2005).

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

In one study, the water was sampled for lead, manganese, nickel, vanadium, and zinc at a shallow bombing range in Pamlico Sound (in the state waters of North Carolina) immediately following a training event with non-explosive practice bombs. All water quality parameters tested, except nickel, were within the state limits. The nickel concentration was significantly higher than the state criterion, although the concentration did not differ significantly from the control site located outside the bombing range. The results suggest that bombing activities were not responsible for the elevated nickel concentrations (U.S. Department of the Navy 2010). A recent study conducted by the U.S. Marine Corps sampled sediment and water quality for 26 different constituents related to munitions at several U.S. Marine Corps water-based training ranges. Metals included lead and magnesium. These areas also were used for bombing practice. No munitions constituents were detected above screening values used at the U.S. Marine Corps water ranges (U.S. Department of the Navy 2010).

A study by Pait et al. (2010) of previous Navy training areas at Vieques, Puerto Rico, found generally low concentrations of metals in marine sediments. Areas in which live ammunition and loaded weapons were used (live-fire areas) were included in the analysis. Table 3.1-17 compares the sediment concentrations of several metals from those naval training areas with sediment screening levels established by the National Oceanic and Atmospheric Administration (Buchman 2008).

As shown in Table 3.1-17, average sediment concentrations of the metals evaluated, except for copper, were below both the threshold and probable effects levels. The average copper concentration was above the threshold effect level but below the probable effect level. For other elements, the mean sediment concentration of arsenic at Vieques was 4.37 micrograms per gram (µg/g), and the highest concentration was 15.4 µg/g. Both values were below the sediment quality guidelines examined. In addition, the mean sediment concentration of manganese in sediment was 301 µg/g, and the highest concentration was 967 µg/g (Pait et al. 2010). The National Oceanic and Atmospheric Administration did not report threshold or probable effects levels for manganese.

Table 3.1-17: Concentrations of and Screening Levels for Selected Metals in Marine Sediments, Vieques, Puerto Rico

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

Notes: µg/g = microgram per gram, N/R = not reported
Source: Pait et al. 2010

The impacts of lead and lithium were studied at the Canadian Forces Maritime Experimental and Test Ranges near Nanoose Bay, British Columbia, Canada (Canadian Forces Maritime Experimental and Test Ranges 2005). These materials are common to Expendable Mobile Anti-Submarine Warfare Training Targets, acoustic device countermeasures, sonobuoys, and torpedoes. The study noted that lead is a naturally occurring metal in the environment, and that typical concentrations of lead on the test range were between 0.01 and 0.06 parts per million (ppm) in seawater and between 4 and 16 ppm in sediments. Cores of marine sediments collected from the test range show a steady increase in lead concentration from the bottom of the core to a depth of approximately 8 in. (20.3 cm). This depth corresponds to the late 1970s and early 1980s, and the lead contamination was attributed to atmospheric deposition of lead from gasoline additives. The sediment cores showed a general reduction in lead concentration to the present time, coincident with the phasing out of lead in gasoline by the mid-1980s. The study also noted that the impacts of lead ballasts on other training ranges have been minimal because the ballasts are usually buried deep in marine sediments where the lead is not biologically available. The study concluded that the lead ballasts would not adversely impact marine organisms because of the low probability of mobilization of lead.

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

3.1.3.2.3.1 Lead

Lead is used as ballast in torpedoes, in batteries in torpedoes and sonobuoys, and in various munitions. Lead is nearly insoluble in water, particularly at the near-neutral pH levels of seawater. While some dissolution of lead could occur, such releases into the water column would be small and would be diluted (U.S. Department of the Navy 2006).

Several studies have evaluated the potential impacts of batteries expended in seawater (Naval Facilities Engineering Command 1993; Borener and Maugham 1998; Canadian Forces Maritime Experimental and Test Ranges 2005; U.S. Coast Guard 1994). Sediments sampled adjacent to and near fixed navigation sites where batteries are used were analyzed for all metal constituents of the batteries. Results indicated that metals were either below or consistent with background levels or were below National Oceanic and Atmospheric Administration sediment screening levels (Buchman 2008), “reportable quantities” under the Comprehensive Environmental Response, Compensation, and Liability Act § 103(a), or USEPA toxicity criteria (U.S. Environmental Protection Agency 2008b).

A sonobuoy battery experiment employed lead chloride batteries in a 17 gal. (64 L) seawater bath for 8 hours (Naval Facilities Engineering Command 1993). Under these conditions, the dilution assumptions are conservative relative to normal ocean bottom conditions. The concentration of constituents released from the battery was diluted to 200 µg/L (200 ppb) in 2 seconds, which is less than the acute criterion of 210 µg/L (210 ppb), a criterion applied as a 24-hour mean. Considering each milliliter as a discrete parcel, a current traveling at 2 in. per second (5.1 cm per second) would dilute the lead released from the battery to 200 µg/L (200 ppb) in 2 seconds, which is less than the acute criterion of 210 µg/L (210 ppb), a criterion applied as a 1-hour mean. Assuming the exponential factor of two dilutions, the concentration is less than the chronic limit (8.1 µg/L [8.1 ppb]) in 7 seconds. The calculated rate of leaching will decrease as the concentration of lead in the battery decreases.

Lead (II) chloride tends to dissolve more readily than either silver chloride or copper thiocyanate; this ensures that the potential impacts of batteries employing silver chloride or copper thiocyanate are substantially lower than those of the lead (II) chloride battery. The copper thiocyanate battery also could release cyanide, a material often toxic to the marine environment. However, thiocyanate is tightly bound and can form a salt or bind to bottom sediments. Therefore, the risk from thiocyanate is low (U.S. Department of the Navy 2008a). The peak concentration of copper released by a copper thiocyanate seawater battery was calculated to be 0.015 µg/L (0.015 ppb) (Naval Facilities Engineering Command 1993), which is substantially lower than USEPA acute and chronic toxicity criteria.

3.1.3.2.3.2 Tungsten and Tungsten Alloys

Because of environmental concerns about lead, tungsten has replaced lead in some munitions (Defense Science Board 2003). Tungsten was chosen because it was considered to be nonreactive in the environment under normal circumstances. However, concerns have arisen lately about that assessment. Adverse health consequences arise with inhalation, and movement of tungsten into groundwater is an issue. However, no drinking water standard exists for tungsten, and it is not listed as a carcinogen (U.S. Environmental Protection Agency 2008b). Inhalation and groundwater are not issues related to marine sediment and water quality.

The natural concentration of tungsten reported in seawater is about 0.1 µg/L (Agency for Toxic Substances and Disease Registry 2005). It arises naturally from weathering of tungsten-rich deposits and from underwater hydrothermal vents; elevated levels in marine sediments from natural sources have been reported. Industrial processes also release tungsten into the environment (Koutsospyros et al. 2006). In water, tungsten can exist in several different forms depending on pH, and it has a strong tendency to form complexes with various oxides and with organic matter. The rate at which tungsten dissolves or dissociates increases as the pH decreases below 7.0 (pH of seawater is normally between 7.5 and 8.4). The speed of the process also depends on the metal with which tungsten is alloyed. For instance, iron tends to enhance the dissolution of tungsten, while cobalt slows the process (Agency for Toxic Substances and Disease Registry 2005). Tungsten is a component of metabolic enzymes in various microbes (Kletzin and Adams 1996). Much is known about the physical and chemical properties of tungsten. Less is known about the behavior of the various complexes that tungsten forms, making predictions about its behavior in the environment difficult. For instance, it is not known whether the organic complexes that tungsten forms affect its bioavailability (Koutsospyros et al. 2006).

3.1.3.2.3.3 Lithium

Silver chloride, lithium, or lithium iron disulfide thermal batteries are used to power subsurface units of sonobuoys. Lithium batteries are also used in a variety of unmanned underwater vehicles and other test vehicles, but these systems are not expendable and are recovered to the maximum extent practicable. Therefore, lithium batteries in recovered systems and targets are not discussed in this section.

Lithium-sulfur batteries typically contain lithium sulfur dioxide and lithium bromide but may also contain lithium carbon monofluoroxide, lithium manganese dioxide, sulfur dioxide, or acenitrile (a cyanide compound). During battery operation, the lithium reacts with the sulfur dioxide to form lithium dithionite. Thermal batteries are contained in a hermetically sealed and welded stainless steel case that is 0.03 to 0.1 in. (0.07 to 0.3 cm) thick and resistant to the battery electrolytes.

Lithium always occurs as a stable mineral or salt, such as lithium chloride or lithium bromide (Kszos et al. 2003). Lithium is naturally present in seawater at 180 µg/L, and its incorporation into clay minerals is a major process in its removal from solution (Stoffyn-Egli and Machenzie 1984). Kszos et al. (2003) demonstrated that sodium ions in saltwater mitigate the toxicity of lithium to sensitive aquatic species. Fathead minnows (*Pimephales promelas*) and the water flea (*Ceriodaphnia dubia*) were unaffected by lithium concentrations as high as 6 mg/L (6 ppm) in the presence of tolerated concentrations of sodium. Therefore, in the marine environment, where sodium concentrations are at least an order of magnitude higher than tolerance limits for the tested freshwater species, lithium would be essentially nontoxic.

Canadian Forces Maritime Experimental and Test Ranges (2005) reported that 99 percent of the lithium in a sonobuoy battery would be released into the environment over 55 years. The release will result in a dissolved lithium concentration of 83 mg/L (83 ppm) near the breach in the sonobuoy housing. At a distance of 0.2 in. (0.5 cm) from the breach, the concentration of lithium will be about 15 mg/L (15 ppm), or 10 percent of typical seawater lithium values (150 ppm); thus, it would be difficult to measure the change in the seawater concentration of lithium resulting from lithium leaking out of the battery (Canadian Forces Maritime Experimental and Test Ranges 2005). Cores of marine sediments collected in the Canadian Forces Maritime Experimental and Test Ranges near Nanoose Bay, British Columbia, Canada, showed fairly consistent lithium concentrations with depth, indicating little change in lithium deposition with time. Compared with lithium concentrations measured outside of the range, the report concluded that “it is difficult to demonstrate an environmental impact of lithium caused by (test range activities)” (Canadian Forces Maritime Experimental and Test Ranges 2005).

3.1.3.2.3.4 Metals in Non-Explosive Practice Munitions

On the ocean bottom, non-explosive practice munitions and fragments are exposed to seawater or lodge in sediments. Once settled, metal components slowly corrode in seawater. Over time, natural encrustation of exposed surfaces occurs and reduces the rate of corrosion. Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble, and scavenged by particulates and transported to the bottom sediments (Agency for Toxic Substances and Disease Registry 2008a). Practice bombs are filled with materials similar to those used to construct artificial reefs. The steel and iron, though durable, corrode over time, with no noticeable environmental impacts (U.S. Department of the Navy 2006).

3.1.3.2.3.5 Metals in Vessels Used as Targets

Target vessels are used during sinking exercises. The metal structure of a target vessel can be a suitable substrate for the development of hardbottom marine habitat. Hard reef materials such as rock, concrete, and steel become encrusted with a variety of marine life. Certain bait fish school around sunken ships, and open water (pelagic) species use these structures as sources of prey (Carberry 2008). Properly prepared and strategically sited artificial reefs can enhance fish habitat and provide more access to quality fishing grounds (U.S. Environmental Protection Agency 2006).

3.1.3.2.4 Evaluation of Alternatives

Tables 3.0-21, 3.0-22, and 3.0-23 (Section 3.0, General Approach to Analysis) and Table 3.1-4 summarize the types and amounts of military expended materials with metal components for all alternatives.

No military materials would be expended for any training or testing activity under any proposed alternative in the Western Behm Canal portion of the Study Area. Therefore, metal components of military munitions were not evaluated for this portion of the Study Area.

3.1.3.2.4.1 No Action Alternative

Training Activities

Offshore Area

Under the No Action Alternative, up to 177,958 military items with metal components would be expended within the Offshore Area during training activities annually. Small-caliber projectiles would account for the highest percentages of military expended material by number (over 65 percent). Metal components on the sea floor could be exposed to seawater or, more likely, be buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters.

Comparison of Training Materials by Weight

A review of training materials based on weight compared to the total number expended provides another perspective on the relative contribution of various items under the No Action Alternative. For instance, although small-caliber projectiles compose over 65 percent of the total number of items, small-caliber projectiles represent less than 1 percent of the total weight. Table 3.1-18 depicts those categories of materials that contribute nearly all of the total weight of training items with potentially toxic metals under the No Action Alternative. Under the No Action Alternative, training activities would expend approximately 28,300 lb. (12,836 kg) annually of potentially toxic metals (i.e., cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc).

Table 3.1-18: Comparison of Training Materials with Metal Components – No Action Alternative

Type of Military Expended Material	Percent of Total	
	By Number	By Weight
Sonobuoys	4.7	84.7
Large- and medium-caliber projectiles	29.3	11.0
Bombs	< 1.0	2.3
Missiles	< 1.0	1.1
Small-caliber projectiles	65.7	< 1.0

Note: < = less than

Surface vessels used as targets would also contribute a large amount of metal weight. Under the No Action Alternative, two target vessels per year would be used for sinking exercises during training activities. However, the number and types of vessels used as targets would depend on their availability and, therefore, cannot be specified. A Navy vessel used as a target would weigh between 5,000 and 10,000 tons (4,536,000 and 9,072,000 kg).

Metals with potential toxicity would be incorporated with benign metals (e.g., steel) in military expended materials. Metal components settling on the sea floor would be exposed to seawater or, more likely, would be gradually buried in sea floor sediments. These metals would slowly corrode over years or decades and would release small amounts of metal compounds to adjacent sediments and waters.

Metal concentrations in sediment and water would increase over the long term as a result of Navy training activity. The increase would be very local to each fragment of military material, and there is no evidence to expect that overall water or sediment quality regionally would be affected. Because of slow corrosion rates and prevailing ocean currents, chemical and physical changes in sediment or water quality would not be detectable beyond the vicinity of the corroding metals. This conclusion is based on the following: (1) most of the metals are benign, and those of potential concern are a small percentage of those munitions; (2) metals released through corrosion would be diluted by currents or bound up and sequestered in adjacent sediments; (3) impacts would be limited to a small area around the expended material; (4) the areas within which metal components would be distributed would be large; and (5) most of the metals would be small-caliber projectiles. Neither state nor federal standards or guidelines would be violated.

Inland Waters

Under the No Action Alternative, two mine shapes each would be expended in Crescent Harbor and Hood Canal EOD Ranges during training activities. Mine shapes typically would be bombshells filled with concrete, sand, or some other nonreactive filler. Mine shapes would be expected to contain negligible amounts of metals of potential toxicity. Therefore, metals with potential toxicity from training activities in the Inland Waters Area would not affect sediment or water quality.

Testing Activities

Offshore Area

Approximately 214 military expended materials containing potentially toxic metals would be expended in the Offshore Area during testing activities. Military expended materials would be used within the Quinault Range Site within the Offshore Area. Under the No Action Alternative, testing activities would expend approximately 590 lb. (270 kg) of potentially toxic metals. Because the military expended materials used during testing activities would be similar to those used during training activities, metals with potential toxicity would affect the environment through the same processes analyzed for training activities, but at a much smaller scale overall due to the small total amount of material being deposited. Neither state nor federal standards or guidelines would be violated.

Inland Waters

Under the No Action Alternative, six sonobuoys and eight expendable subsurface targets would be used during testing activities in the Inland Waters. Approximately 67 lb. (30 kg) of metals with potential toxicity would be released annually in the area. The majority of this weight (75 percent) would be from the subsurface targets used during pierside acoustic testing activities.

The effects of testing would be similar to those described for the Offshore Area, although the quantity and weight of the material expended would be much less. Metal components that come to rest on the sea floor would be exposed to seawater or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters. Neither state nor federal standards or guidelines would be violated. Practice torpedoes used at NUWC Division, Keyport during testing activities would be recovered following the activities and therefore would not contribute to impacts on sediment and water quality.

3.1.3.2.4.2 Alternative 1

Training Activities

Offshore Area

The number of military items with metal components expended during training activities would increase from 177,958 under the No Action Alternative to 182,948 under Alternative 1. Numerically, projectiles would represent 94 percent of these materials, with small-caliber projectiles making up 65 percent of all military expended materials with metal components. The increase in military expended materials would result from the increased use of sonobuoys during testing activities.

Comparison of Training Materials by Weight

A review of training materials based on weight compared to the total number expended provides another perspective on the relative contribution of various items under Alternative 1. For instance, although small-caliber projectiles compose 66.3 percent of the total number of items, small-caliber projectiles represents less than 1 percent of the total weight.

Table 3.1-19 depicts those categories of materials that contribute nearly all of the total weight of training items with potentially toxic metals under Alternative 1. Under Alternative 1, the amount of potentially toxic metals expended during training activities would be approximately 28,312 lb. (12,842 kg).

Table 3.1-19: Comparison of Training Materials with Metal Components – Alternative 1

Type of Military Expended Material	Percent of Total	
	By Number	By Weight
Sonobuoys	4.6	88.1
Large- and medium-caliber projectiles	28.9	8.5
Bombs	< 1.0	2.0
Missiles	< 1.0	< 1.0
Small-caliber projectiles	66.3	< 1.0

Note: < = less than

Inland Waters

Under Alternative 1 metal components would come to rest on the sea floor exposed to seawater when resting on the bottom or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters. The amount of expended materials associated with training under Alternative 1 would decrease compared to the No Action Alternative. As a result, the amount of metal with potential toxicity released to the sediment and water over the long term as a result of Navy training activity would be less than the No Action Alternative. Changes in metal concentrations in sediment and water would be very local to each fragment of military material. Water or sediment quality regionally would not be affected and neither state nor federal standards or guidelines would be violated.

Under Alternative 1, 42 mine shapes would be expended in both Crescent Harbor and Hood Canal EOD Ranges during training activities. As described for the No Action Alternative, mine shapes typically would be bombshells filled with concrete, sand, or some other nonreactive filler. Therefore, metals with potential toxicity from training activities in the Inland Waters Area would not affect sediment or water quality.

Under Alternative 1, small boat attack training activities would occur within the Inland Waters portion of the Study Area. During these activities, crews engage pierside surface targets with small-caliber weapons using blank rounds. Casing from approximately 3,000 blank rounds would be deposited on the sea floor.

The amount of expended materials associated with training under Alternative 1 in the Inland Area would increase slightly compared to the No Action Alternative. Metal components would come to rest on the sea floor exposed to seawater or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters. Changes in metal concentrations in sediment and water would be very local to each fragment of military material. Water or sediment quality regionally would not be affected and neither state nor federal standards or guidelines would be violated.

Testing Activities

Offshore Area

During testing activities, approximately 1,228 military items with potentially toxic metals would be expended in the Offshore Area under Alternative 1. The amount of potentially toxic metals expended during testing would increase compared to the No Action Alternative as a result of increased use of sonobuoys as well as an increase in the number of practice torpedoes. The use of non-explosive sonobuoys for Naval Air Systems Command (NAVAIR) anti-submarine warfare testing activities would increase to 1,000 under Alternative 1 compared to 200 under the No Action Alternative. Approximately 3,680 lb. (1,669 kg) of potentially toxic metals would be expended, compared to 590 lb. (270 kg) under the No Action Alternative. Because the military expended materials used during testing activities would be similar to those used during training activities, metals with potential toxicity would have effects similar to those described for training activities. Changes in metal concentrations in sediment and water would be very local to each fragment of military material. Water or sediment quality regionally would not be affected and neither state nor federal standards or guidelines would be violated.

Inland Waters

Under Alternative 1, six sonobuoys and nine expendable subsurface targets would be used during testing activities in the Inland Waters an increase of one subsurface target compared to the No Action Alternative. Approximately 74 lb. (34 kg) of metals with potential toxicity would be released annually in the area. The majority of this weight (62 percent) would be from the subsurface targets used during pierside acoustic testing activities. Because the military expended materials used during testing activities would be similar to those used during training activities, metals with potential toxicity would have effects similar to those described for training activities.

3.1.3.2.4.3 Alternative 2

Training Activities

Offshore Area

Under Alternative 2, the number of military items with metal components expended during training activities would increase from 177,958 to 182,948 compared to the No Action Alternative. The increase in military expended materials would result from the increase of non-explosive sonobuoys for anti-submarine warfare testing activities.

Under Alternative 2, the number of training activities and amounts of military items with metal components expended would be the same as under Alternative 1. Therefore, metals in the military expended materials would have the same environmental impacts under Alternative 2 as they would under Alternative 1.

Inland Waters

Under Alternative 2, the number of training activities and amounts of military items with metal components expended would be the same as under Alternative 1. Therefore, metals in the military expended materials would have the same environmental impacts under Alternative 2 as they would under Alternative 1.

Testing Activities

Offshore

During testing activities, about 1,570 military items with potentially toxic metals would be expended in the Offshore Area under Alternative 2. The amount of potentially toxic metals expended during testing would increase compared to the No Action Alternative, largely due to increased use of sonobuoys. The amount of potentially toxic metals, by weight, would be approximately 4,763 lb. (2,160 kg). Effects of metals with potential toxicity on sediments and water quality under Alternative 2 would be similar to the effects described for Alternative 1. Changes in metal concentrations in sediment and water would be very local to each fragment of military material. Water or sediment quality regionally would not be affected and neither state nor federal standards or guidelines would be violated.

Inland Waters

Under Alternative 2, sonobuoys and expendable subsurface targets would be used during testing activities in the Inland Waters. Approximately 86 lb. (39 kg) of metals with potential toxicity would be released annually in the area. As in Alternative 1, the majority of this weight (67 percent) would be from the subsurface targets used during pierside acoustic testing activities. Effects of metals with potential toxicity on sediments and water quality under Alternative 2 would be similar to the effects described for Alternative 1.

3.1.3.2.4.4 Summary and Conclusions for Metals

Corrosion and biological processes (e.g., colonization by marine organisms) would reduce exposure of military expended materials to seawater, decreasing the rate of leaching. Most leached metals would bind to sediments or other organic matter. Sediments near military expended materials would contain some metals, but metal concentrations would not be at harmful levels because of the bottom substrate composition. Metals in batteries are readily soluble, which would result in faster releases of metals if batteries are exposed to seawater once they are expended. Batteries are sealed, however, and the exterior metal casing can become encrusted by marine organisms or coated by corrosion. Any leached metals would be present in seawater and sediments at low concentrations, and would behave similarly to leached metals from other military expended materials.

3.1.3.3 Chemicals Other than Explosives

3.1.3.3.1 Introduction

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

Hazardous air pollutants from explosives and explosion byproducts are discussed in Section 3.2 (Air Quality). Explosives and explosion byproducts are discussed in Section 3.1.3.1. Fuels onboard manned aircraft and vessels are not reviewed, nor are fuel-loading activities, onboard operations, maintenance activities, or fuel spills reviewed.

3.1.3.3.2 Missile and Rocket Propellant – Solid Fuel

The largest chemical constituent of missiles is solid propellant. Solid propellant contains both the fuel and the oxidizer, a source of oxygen needed for combustion. A Standard Missile-1 typically contains 150 lb. (70 kg) of solid propellant (U.S. Department of the Navy 2008b). Ammonium perchlorate is an oxidizing agent used in most modern solid-propellant formulas. It normally accounts for 50 to 85 percent of the propellant by weight. Ammonium dinitramide may also be used as an oxidizing agent. Aluminum powder as a fuel additive makes up 5 to 21 percent by weight of solid propellant; it is added to increase missile range and payload capacity. The high-explosives HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) may be added, although they usually account for less than 30 percent of the propellant weight (Missile Technology Control Regime 1996).

The most common substance used as binding material for solid propellants is hydroxyl-terminated polybutadiene. Other binding materials include carboxyl-terminated polybutadiene and polybutadiene-acrylic acid-acrylonitrile. These materials also burn as fuels and contribute to missile thrust. Other materials found in solid-fuel propellants include curing agents and catalysts such as triphenyl bismuth, nitrate esters, and nitrated plasticizers—liquid explosives added to increase the engine burn rate—and n-hexyl carborane and carboranylmethyl propionate to increase propellant performance.

Double-base propellant is a solid fuel that is a mixture of fuels and small particulate oxidizers. Like other solid propellants, the most commonly used fuel component of these propellants is ammonium perchlorate. High melting explosive and RDX may be added to improve performance, and the most common binder is hydroxyl-terminated polybutadiene. In addition to the binders listed in the preceding paragraph, polybutadiene-acrylic acid polymer, elastomeric polyesters, polyethers, and nitrocellulose plasticized with nitroglycerine or other nitrate esters may be used. To reduce decomposition of propellant, 2-nitrodiphenylamine and N-methyl-4-nitroaniline may be added (Missile Technology Control Regime 1996).

3.1.3.3.3 Torpedo Propellant – Otto Fuel II and Combustion Byproducts

Torpedoes use Otto Fuel II as a liquid propellant. Otto Fuel II is composed of propylene glycol dinitrate and nitro-diphenylamine (76 percent), dibutyl sebacate (23 percent), and 2-nitrodiphenylamine as a stabilizer (2 percent). Combustion byproducts of Otto Fuel II include nitrous oxides, carbon monoxide, CO_2, hydrogen, nitrogen, methane, ammonia, and hydrogen cyanide. During normal venting of excess pressure or upon failure of the torpedo's buoyancy bag, the following constituents are discharged: CO_2, water, hydrogen, nitrogen, carbon monoxide, methane, ammonia, hydrochloric acid, hydrogen cyanide, formaldehyde, potassium chloride, ferrous oxide, potassium hydroxide, and potassium carbonate (U.S. Department of the Navy 1996a, b).

3.1.3.3.4 Polychlorinated Biphenyls in Target Vessels

Target vessels are used during sinking exercises under the No Action Alternative. Future sinking exercise events will not be conducted in the Northwest and are not included in Alternatives 1 or 2. PCBs are mixtures of up to 209 individual chlorinated compounds that are related chemicals of the same elemental group, also known as congeners. They were used widely as coolants and lubricants in transformers, capacitors, and other electrical equipment. Manufacture of PCBs stopped in the United States in 1977 (Agency for Toxic Substances and Disease Registry 2000). Marine sources include runoff from agricultural and urban areas and atmospheric deposition from industrial areas (Kalmaz and Kalmaz 1979). PCBs do not readily degrade in the environment and tend to persist for many years. They can easily move between air, water, and soil, although in aquatic systems, they tend to adhere to fine-grained sediments, organic matter, and marine debris. PCBs have a variety of effects on aquatic organisms, including disrupting endocrine systems. PCBs persist in the tissues of animals at the bottom of the food chain. Consumers of those species accumulate PCBs to levels that may be many times higher than their concentrations in water. Microbial breakdown of PCBs (dechlorination) has been documented in estuarine and marine sediments (Agency for Toxic Substances and Disease Registry 2000).

PCBs are a concern because they are present in certain solid materials (e.g., insulation, wires, felts, and rubber gaskets) on vessels used as targets for sinking exercises. These vessels are selected from a list of Navy-approved vessels that have been cleaned in accordance with USEPA guidelines (U.S. Environmental Protection Agency 1999). By rule, a sinking exercise must be conducted at least 50 nm offshore and in water at least 6,000 ft. (1,830 m) deep (40 C.F.R. 229.2).

The USEPA estimates that as much as 100 lb. (45 kg) of PCBs remain aboard sunken target vessels. The USEPA considers the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.) (U.S.

Environmental Protection Agency 1999). Based on these considerations, PCBs will not be considered further.

3.1.3.3.5 Other Chemicals Associated with Ordnance

Table 3.1-20 lists ordnance constituents remaining after low-order detonations and in unconsumed explosives. These constituents are in addition to the explosives contained in the ordnance. Lead azide, titanium compounds, perchlorates, barium chromate, and fulminate of mercury are not natural constituents of seawater. Lead oxide is a rare, naturally occurring mineral. It is one of several lead compounds that form films on lead objects in the marine environment (Agency for Toxic Substances and Disease Registry 2007). Metals are discussed in more detail in Section 3.1.3.2.

3.1.3.3.6 Approach to Analysis

Activities involving the chemicals discussed above would be subject to state and federal sediment and water quality standards and guidelines; however, no state or federal sediment or water quality standards or guidelines exist that apply specifically to the chemicals discussed above. These other chemical components could be distributed within each range complex within the Study Area.

Table 3.1-20: Ordnance Constituents in Residues of Low-Order Detonations and in Unconsumed Explosives

Ordnance Component	Constituent
Pyrotechnics, tracers, and spotting charges	Barium chromate, potassium perchlorate, chlorides, phosphorus, titanium compounds
Oxidizers	Lead (II) oxide
Delay elements	Barium chromate, potassium perchlorate, lead chromate
Fuses	Potassium perchlorate
Detonators	Fulminate of mercury, potassium perchlorate
Primers	Lead azide

For properly functioning expended materials, the term “local” means the volume of water that a self-propelled subsurface training or testing device passes through. In these situations, water quality would be impacted by combustion byproducts. For lost or malfunctioning expended training items, the term “local” means a small zone around residual propellant in sediments, perhaps 1 or 2 cm, and a smaller area if directly exposed to seawater.

3.1.3.3.7 Impacts of Chemicals

The following sections discuss the potential impacts on sediment and water quality of solid-fuel propellants from missiles and rockets, Otto Fuel II torpedo propellant, and combustion byproducts.

3.1.3.3.7.1 Solid-Fuel Propellants

Missiles and rockets typically consume 99 to 100 percent of their propellant when they function properly (U.S. Department of the Navy 2008b). The failure rate of rockets is 3.8 percent (Rand Corporation 2005; U.S. Army Corps of Engineers 2007). The remaining solid propellant fragments (i.e., 1 percent or less of the initial propellant weight) sink to the ocean floor and undergo physical and chemical changes in contact with sediments and seawater. Tests show that water penetrates about

0.06 in. (0.15 cm) into the propellant during the first 24 hours of immersion, and that fragments slowly release ammonium and perchlorate ions (Fournier and Brady 2005). These ions would disperse into the surrounding seawater, so local concentrations would be low. For example, a standard missile with 150 lb. (70 kg) of solid propellant would generate less than 1.5 lb. (0.7 kg) of propellant residue after completing its flight. If all the propellant deposited on the ocean floor were in the form of 4 in. (10.2 cm) cubes, about 0.42 percent of the propellant would be wetted during the first 24 hours of immersion. If all of the ammonium perchlorate leached out of the wetted propellant, then approximately 0.01 lb. (0.005 kg) of perchlorate would enter the surrounding seawater (U.S. Department of the Navy 2008b). This leach rate would decrease over time as the concentration of perchlorate in the propellant declined. The aluminum in the binder would be converted to aluminum oxide by seawater.

Perchlorate

Ammonium perchlorate accounts for 50 to 85 percent of solid propellant by weight (Missile Technology Control Regime 1996). Perchlorates are highly soluble and stable in water. According to the Agency for Toxic Substances and Disease Registry (2008b), perchlorate “does not readily bind to soil particles or to organic matter, and does not readily form ionic complexes with other materials in solution.” Because of these characteristics, perchlorate is highly mobile in soils and does not readily leave solution through chemical precipitation. Thus, perchlorate could affect sediment and water quality because of its persistence in the environment.

Natural sources of perchlorate include Chilean caliche ore (U.S. Environmental Protection Agency 2008c) and ozone oxidation of atmospheric chlorine (Petrisor and Wells 2008). Martinelango (2006) stated that perchlorate was present in seawater at levels ranging from less than 0.07 µg/L to 0.34 µg/L (0.07 to 0.34 ppb). Studies indicate that it may accumulate in living organisms such as fish and plants (Agency for Toxic Substances and Disease Registry 2008b). Toxicity in plants and microbes is thought to result from adverse impacts on metabolic enzymes (Van Wijk and Hutchinson 1995). Research by Martinelango (2006) found that perchlorate can concentrate in marine algae from 200 to 5,000 times, depending on the species. Chaudhuri et al. (2002) noted that several species of microbes can metabolize chlorate and perchlorate. The end product is chloride. Logan et al. (2001) used sediment samples from a variety of marine and saline environments to demonstrate that microbial perchlorate reduction can occur in saline solutions greater than 3 percent; seawater salinity is about 3.5 percent. The organism responsible for the perchlorate reduction was not identified in the study. However, Okeke et al. (2002) identified three species of halophilic (salt-loving) bacteria that biodegrade perchlorate. The USEPA has established a drinking water standard for perchlorate, but no standards or guidelines have been established for perchlorate in marine systems.

Polyesters

Regarding other solid-fuel components, marine microbes and fungi are known to degrade biologically produced polyesters such as polyhydroxyalkanoates, a bacterial carbon and energy source (Doi et al. 1992). These organisms also can degrade other synthetic polymers, although at lower rates (Shah et al. 2008). The chemical structure of natural rubber is similar to that of polybutadiene (Tsuchii and Tokiwa 2006). Thus, although no specific studies were found that documented biodegradation of polybutadiene in marine ecosystems, the prospects seem likely based on the findings of researchers such as Tsuchii and Tokiwa (2006).

Nitriles

Nitriles are cyanide-containing organic compounds that are both natural and man-made. Several species of marine bacteria can metabolize acrylonitrile (Brandao and Bull 2003). The productivity of marine ecosystems is often limited by available nitrogen (Vitousek and Howarth 1991), so biodegradation of nitrate esters and nitrated plasticizers in the marine environment seems likely.

3.1.3.3.7.2 Otto Fuel II and Combustion Byproducts

Microbial degradation of the main components of Otto Fuel II (propylene glycol dinitrate and nitro-diphenylamine) has been demonstrated (Sun et al. 1996; Walker and Kaplan 1992). Although these studies did not involve marine microbes, other studies have demonstrated that marine bacteria in anaerobic sediments could degrade 2-nitrodiphenylamine (Drzyzga and Blotevogel 1997; Powell et al. 1998). According to the Agency for Toxic Substances and Disease Registry (1995), 2-nitrodiphenyl-amine tends to bind to sediments. The agency indicated that dibutyl sebacate "is readily degraded by environmental bacteria and fungi" (Agency for Toxic Substances and Disease Registry 1995).

Combustion byproducts of Otto Fuel II would be released into the ocean where they would dissolve, dissociate, or be dispersed and diluted in the water column. Except for hydrogen cyanide, combustion byproducts are not a concern (U.S. Department of the Navy 1996a, b) for the reasons listed below:

- Most Otto Fuel II combustion products, such as CO_2, nitrogen, methane, and ammonia, occur naturally in seawater.
- Several of the combustion products are bioactive. Nitrogen is converted into nitrogen compounds through nitrogen fixation by certain cyanobacteria, providing nitrogen sources and essential micronutrients for marine phytoplankton. Carbon dioxide and methane are integral parts of the carbon cycle in the oceans and are taken up by many marine organisms.
- Carbon monoxide and hydrogen have low solubility in seawater and excess gases bubble to the surface.
- Trace amounts of nitrogen oxides may be present, but they are usually below detectable limits. Nitrogen oxides in low concentrations are not harmful to marine organisms and are a micronutrient source of nitrogen for aquatic plant life.
- Ammonia can be toxic to marine organisms in high concentrations, but releases from the combustion of Otto Fuel II are quickly diluted to negligible concentrations. Ammonia is present in exhaust from Otto Fuel II at estimated concentrations of 10 ppb (U.S. Department of the Navy 2007).

Hydrogen cyanide does not normally occur in seawater. Major releases of cyanide to water are from metal-finishing industries, iron and steel mills, and organic chemical industries (U.S. Environmental Protection Agency 1981). At high concentrations, cyanide can pose a risk to both humans and marine biota. Compared to recommendations of the USEPA of 1.0 µg/L (1.0 ppb) (U.S. Environmental Protection Agency 2010), hydrogen cyanide released from Otto Fuel II combustion would result in ambient concentrations ranging from 140 to 150 ppb (U.S. Department of the Navy 1996b), well above recommended levels. However, because hydrogen cyanide is soluble in seawater, it would be diluted to less than 1 µg/L (1.0 ppb) at a distance of 18 ft. (5.5 m) from the center of the unmanned underwater vehicle's (UUV's) path when first discharged. Additional dilution would occur thereafter.

Approximately 30,000 exercise tests of the MK48 torpedo have been conducted over the last 25 years. Most of these launches have been on U.S. Navy test ranges, where there have been no reports of harmful impacts on water quality from Otto Fuel II or its combustion products. Furthermore, Navy studies conducted at torpedo test ranges that have lower flushing rates than the open ocean did not detect residual Otto Fuel II in the marine environment (U.S. Department of the Navy 1996a, b).

3.1.3.3.7.3 Operational Failure – Torpedoes, Missiles, and Rockets

Some materials are recovered after use, such as torpedoes. However, sometimes these recoverable items are lost or they fail to perform correctly. For instance, the failure rate of rockets is 3.8 percent (Rand Corporation 2005; U.S. Army Corps of Engineers 2007). All practice torpedoes would be recovered after testing activities.

3.1.3.3.8 Evaluation of Alternatives

For all alternatives, Table 3.0-21, Table 3.0-22, and Table 3.1-4 identify the numbers and locations of expended materials (i.e., missiles and torpedoes) from training and testing activities that are being analyzed for chemicals other than explosives. Table 3.0-23 identifies the numbers and locations of subsurface targets expended during training and testing activities. The numbers represent amounts expended annually for each type of material under each alternative.

No military materials would be expended for any training or testing activity under any proposed alternative in the Western Behm Canal portion of the Study Area. Therefore, the other chemical components of military munitions were not evaluated for this portion of the Study Area.

3.1.3.3.8.1 No Action Alternative

Training Activities

Offshore Areas

Under the No Action Alternative, chemicals other than explosives would be used in 188 military devices for training activities. All materials from training activities would consist of subsurface targets, torpedoes, and missiles. Impacts of chemicals from unrecovered military devices on sediment and water quality would be short term, local, and negligible with properly functioning materials and long term, local, and negative with lost or malfunctioning items.

For properly functioning ordnance items, chemical, physical, or biological changes in sediment or water quality would be detectable. However, impacts would be minimal for the following reasons: (1) the size of the area in which materials would be distributed is large; (2) most propellant combustion byproducts are benign, while those of concern would be diluted to below detectable levels within a short time; (3) most propellants are consumed during normal operations; (4) the failure rate is low for such materials; and (5) most of the constituents of concern are biodegradable by various marine organisms or by physical and chemical processes common in marine ecosystems.

Inland Waters

No training items containing chemicals other than explosives would be used in the Inland Waters portion of the Study Area during training activities under the No Action Alternative. Therefore, these activities would not affect sediment or water quality.

Testing Activities

Offshore Areas

Under the No Action Alternative, chemicals would be used in 14 ordnance items during testing activities and released during UUV system tests. The ordnance items are subsurface targets used during anti-submarine warfare testing and countermeasure testing activities in the Quinault Range Site.

Chemicals used during testing activities would be similar to those used during training activities, so impacts would be similar to training activities under No Action Alternative. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long term, local, and negative. In both cases, chemical or physical changes in sediment or water quality would be detectable.

Inland Waters

Under the No Action Alternative, chemicals other than explosives would be contained in eight subsurface targets per year. Releases would also occur as a result of UUV testing activities. Chemicals other than explosives would not be expected to affect sediments or water quality because (1) a low number of items would be used annually, resulting in infrequent releases of small amounts of constituents with large recovery times between events, (2) most propellant combustion byproducts are benign, (3) most propellant would be consumed during normal operations, (4) the failure rate for materials is low, and (5) most of the constituents of concern are biodegradable by various marine organisms or by physical and chemical processes common in marine ecosystems.

3.1.3.3.8.2 Alternative 1

Training Activities

Offshore Area

Under Alternative 1, chemicals other than explosives would be used in 172 ordnance items, a decrease from the 188 used under the No Action Alternative. The decrease would result from the discontinuation of sinking exercises in the Offshore Area. All items with chemicals other than explosives would be expended in the Offshore Area during training activities.

The number of military devices with chemicals other than explosives would decrease compared to the No Action Alternative. The effects under Alternative 1 would be similar to impacts under the No Action Alternative for the reasons enumerated above. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long term, local, and negative. In both cases, chemical or physical changes in sediment or water quality would not be detectable.

Inland Areas

As in the No Action Alternative, no training items containing chemicals other than explosives would be used in the Inland Waters portion of the Study Area during training activities under Alternative 1. Therefore, these activities would not affect sediment or water quality.

Testing Activities

Offshore Area

Under Alternative 1, the number of military devices with chemicals would increase to 96 due to increased use of subsurface targets during testing activities. The impacts would be the same as those described for the No Action Alternative because the chemicals would be the same. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long term, local, and negative. In both cases, chemical or physical changes in sediment or water quality would not be detectable.

Inland Areas

Under Alternative 1, the number of subsurface targets with chemicals would increase to nine during testing activities. The impacts would be the same as those described for the No Action Alternative because the chemicals used would be the same. Chemicals other than explosives would not be expected to affect sediments or water quality because (1) a low number of items would be used annually, resulting in infrequent releases of small amounts of constituents with large recovery times between events, (2) most propellant combustion byproducts are benign, (3) most propellant would be consumed during normal operations, (4) the failure rate for materials is low, and (5) most of the constituents of concern are biodegradable by various marine organisms or by physical and chemical processes common in marine ecosystems.

3.1.3.3.8.3 Alternative 2

Training Activities

Offshore Area

Under Alternative 2, the number of military devices with chemicals used during training activities would be the same as under Alternative 1; therefore, impacts of chemical other than explosives would be as described in Alternative 1.

Inland Waters

As in the No Action Alternative, no training items containing chemicals other than explosives would be used in the Inland Waters portion of the Study Area during training activities under Alternative 2. Therefore, these activities would not affect sediment or water quality.

Testing Activities

Offshore Area

Under Alternative 2, the number of military devices with chemicals would increase from 14 under the No Action Alternative to 110 due to increased use of subsurface targets during testing activities. The impacts would be the same as those described for the No Action Alternative because the chemicals used would be the same. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long term, local, and negative. In both cases, chemical or physical changes in sediment or water quality would not be detectable.

Inland Waters

Under Alternative 2, the number of subsurface targets with chemicals would increase to 11 during testing activities. Given the small increase in sub-surface targets, the release of chemical constituents would increase slightly as a result of Navy testing activities. The impacts would be similar to those described for the No Action Alternative because the chemicals used would be the same. Chemicals other than explosives would not be expected to affect sediments or water quality because (1) a low number of items would be used annually, resulting in infrequent releases of small amounts of constituents with large recovery times between events, (2) most propellant combustion byproducts are benign, (3) most propellant would be consumed during normal operations, (4) the failure rate for materials is low, and (5) most of the constituents of concern are biodegradable by various marine organisms or by physical and chemical processes common in marine ecosystems.

3.1.3.3.8.4 Summary and Conclusions for Chemicals Other than Explosives

Chemicals other than explosives from military devices in the Study Area would be from residual solid propellant and Otto Fuel II. Solid propellants would leach perchlorates. Perchlorates are readily soluble, with a low affinity for sediments. Based on the small amount of residual propellant from training and testing activities, perchlorates would not be expected in concentrations that would be harmful to aquatic organisms in the water column or in marine sediments. Otto Fuel II and its combustion byproducts would be introduced into the water column in small amounts. All torpedoes would be recovered following training and testing activities, and Otto Fuel II would not be expected to come into direct contact with marine sediments. Most combustion byproducts are gases normally found in the atmosphere, and cyanide concentrations would be well below harmful concentrations.

3.1.3.4 Other Materials

3.1.3.4.1 Introduction

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

Steel in ordnance normally contains a variety of metals, with some metals of potential concern. However, these other metals are present at low concentrations (1–5 percent of content), such that steel is not generally considered a potential source of metal contamination. Metals with potential toxicity are discussed in more detail in Section 3.1.3.2. Various chemicals and explosives are present in small amounts in flares and are not considered likely to cause measurable impacts. Chemicals other than explosives are discussed in more detail in Section 3.1.3.3, and explosives and explosion byproducts are discussed in more detail in Section 3.1.3.1.

Towed and stationary targets include floating steel drums, towed aerial targets, the trimaran, and inflatable, floating targets. The trimaran is a three-hulled boat with a 4 ft. (1.2 m) square sail that is towed as a moving target. Large, inflatable, plastic targets can be towed or left stationary. Towed aerial targets are either (1) rectangular pieces of nylon fabric (7.5 ft. by 40 ft. [2.3 m by 12.2 m]) that reflect radar or lasers; or (2) aluminum cylinders with a fiberglass nose cone, aluminum corner reflectors (fins), and a short plastic tail section. This second target is about 10 ft. (30.5 m) long and weighs about 75 lb. (34 kg). All of these targets are recovered after use and will not be considered further.

3.1.3.4.2 Marine Markers and Flares

Marine markers are pyrotechnic devices that are dropped on the water's surface during training exercises to mark a position, to support search and rescue activities, or as a bomb target. Markers release smoke at the water surface for 40–60 minutes. After the pyrotechnics are consumed, the marine marker fills with seawater and sinks. Iron and aluminum constitute 35 percent of the marker weight. To produce the lengthy smoke effect, approximately 40 percent of the marker weight is pyrotechnic materials.

The MK58 marker is a tin tube that weighs about 12 lb. (5 kg). The propellant, explosive, and pyrotechnic constituents of the MK58 include red phosphorus (2.19 lb. [0.99 kg]) and manganese (IV) dioxide (1.40 lb. [0.64 kg]). Other constituents include magnesium powder (0.29 lb. [0.13 kg]), zinc oxide (0.12 lb. [0.05 kg]), nitrocellulose (0.000017 lb. [0.000008 kg]), nitroglycerin (0.000014 lb. [0.000006 kg]), and potassium nitrate (0.2 lb. [0.1 kg]). The failure rate of marine markers is approximately 5 percent (U.S. Department of the Navy 2010).

Flares are used to signal, to illuminate surface areas at night in search and attack operations, and to assist with search and rescue activities. They range in weight from 12 to 30 lb. (5 to 14 kg). The major constituents of flares include magnesium granules and sodium nitrate. Containers are constructed of aluminum, and the entire assembly is usually consumed during flight. Flares may also contain a primer such as TNT, propellant (ammonium perchlorate), and other explosives. These materials are present in small quantities (e.g., 1.0×10^{-4} ounces [oz.] [2.8×10^{-3} g] of ammonium perchlorate and 1.0×10^{-7} oz. [2.8×10^{-6} g] of explosives). Small amounts of metals are used to give flares and other pyrotechnic materials bright and distinctive colors. Combustion products from flares include magnesium oxide, sodium carbonate, CO_2, and water. Illuminating flares and marine markers are usually entirely consumed during use; neither is intended to be recovered. Table 3.1-21 summarizes the components of markers and flares.

Table 3.1-21: Summary of Components of Marine Markers and Flares

Flare or Marker	Constituents
LUU-2 paraflare	Magnesium granules, sodium nitrate, aluminum, iron, TNT, RDX, ammonium perchlorate, potassium nitrate, lead, chromium, magnesium, manganese, nickel
MK45 paraflare	Aluminum, sodium nitrate, magnesium powder, nitrocellulose, TNT, copper, lead, zinc, chromium, manganese, potassium nitrate, pentaerythritol tetranitrate, nickel, potassium perchlorate
MK58 marine marker	Aluminum, chromium, copper, lead, lead dioxide, manganese dioxide, manganese, nitroglycerin, red phosphorus, potassium nitrate, silver, zinc, zinc oxide

Notes: TNT = trinitrotoluene, RDX = royal demolition explosive
Source: U.S. Department of the Navy 2010

3.1.3.4.3 Chaff

Chaff consists of small, thin glass fibers coated in aluminum that are light enough to remain in the air anywhere from 10 minutes to 10 hours. Chaff is an electronic countermeasure designed to confuse enemy radar by deflecting radar waves and thereby obscuring aircraft, ships, and other equipment from radar tracking sources. Chaff is typically packaged in cylinders approximately 6 in. by 1.5 in. (15.2 cm by 3.8 cm), weighing about 5 oz. (140 g), and containing a few million fibers. Chaff may be deployed from an aircraft or may be launched from a surface vessel. The chaff fibers are approximately the thickness of a human hair (generally 25.4 microns in diameter) and range in length from 0.3 to 2 in. (0.8 to 5.1 cm). The major components of the chaff glass fibers and the aluminum coating are listed in Table 3.1-22.

Table 3.1-22: Major Components of Chaff

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

Note: ≤ = less than or equal to
Source: U.S. Air Force 1994

3.1.3.4.4 Additional Examples of Other Materials

Miscellaneous components of other materials include small decelerator/parachutes used with sonobuoys and flares; nylon cord, plastic casing, and antenna float used with sonobuoys; natural and synthetic rubber, carbon or Kevlar fibers used in missiles; and plastic end-cap and piston used in chaff cartridges. These materials are benign in the marine environment and are not likely to cause any physical or chemical changes to marine sediments or water quality. Therefore, these types of materials will not be considered further in this analysis.

3.1.3.4.5 Approach to Analysis

Most activities involving ordnance containing the other materials discussed above would be conducted more than 3 nm offshore in each range complex. Most of the other materials are benign. In the analysis of alternatives, "local" means the area in which the material comes to rest. No state or federal sediment and water quality standards or guidelines specifically apply to major components of the other materials discussed above.

3.1.3.4.6 Impacts of Other Materials

The rate at which materials deteriorate in marine environments depends on the material and conditions in the immediate marine and benthic environment. Usually when buried deep in ocean sediments, materials decompose at lower rates than when exposed to seawater (Ankley 1996). With the exception of plastic parts, sediment burial appears to be the fate of most ordnance used in marine warfare (Canadian Forces Maritime Experimental and Test Ranges 2005). The behavior of these other materials in marine systems is discussed in more detail below.

3.1.3.4.6.1 Flares

Most of the pyrotechnic components of marine markers are consumed and released as smoke in the air. Thereafter, the aluminum and steel canister sinks to the bottom. Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms (California Environmental Protection Agency 2003). The amount of flare residue is negligible. Phosphorus contained in the marker settles to the sea floor, where it reacts with the water to produce phosphoric acid until all phosphorus is consumed by the reaction. Phosphoric acid is a variable, but normal, component of seawater (U.S. Department of the Navy 2006). The aluminum and iron canisters are expected to be covered by sand and sediment over time, to become encrusted by chemical corrosion, or to be covered by marine plants and animals. Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble and adheres to particulates, and transported to the bottom sediments (Agency for Toxic Substances and Disease Registry 2008a).

Red phosphorus, the primary pyrotechnic ingredient, constitutes 18 percent of the marine marker weight. Toxicological studies of red phosphorus revealed an aquatic toxicity in the range of 10–100 mg/L (10–100 ppm) for fish, Daphnia (a small aquatic crustacean), and algae (European Flame Retardants Association 2011). Red phosphorus slowly degrades by chemical reactions to phosphine and phosphorous acids. Phosphine is very reactive and usually undergoes rapid oxidation (California Environmental Protection Agency 2003). The final products, phosphates, are harmless (U.S. Department of the Navy 2010). A study by the U.S. Air Force (1997) found that, in salt water, the degradation products of flares that do not function properly include magnesium and barium.

3.1.3.4.6.2 Chaff

Chaff can remain suspended in air from 10 minutes to 10 hours and can travel considerable distances from its release point (Arfsten et al. 2002; U.S. Air Force 1997). Factors influencing chaff dispersion include the altitude and location where it is released, prevailing winds, and meteorological conditions (Hullar et al. 1999). Doppler radar has tracked chaff plumes containing approximately 31.8 oz. (901.5 g) of chaff drifting 200 mi. (321.9 km) from the point of release, with the plume covering a volume of greater than 400 cubic miles (Arfsten et al. 2002). Based on the dispersion characteristics of chaff, large areas of open water would be exposed to chaff, but the chaff concentrations would be low. For example, Hullar et al. (1999) calculated that an area 4.97 mi. by 7.46 mi. (8 km by 12 km) (37 mi.^{2} [96 km^2] or 28 nm^2) would be affected by deployment of a single cartridge containing 5.3 oz. (150 g) of chaff. The resulting chaff concentration would be about 5.4 g/nm^2. This corresponds to less than 179,000 fibers/nm^2, or less than 0.005 fiber/square foot, assuming that each canister contains 5 million fibers.

Chaff is generally resistant to chemical weathering, and likely remains in the environment for long periods. However, all components of chaff's aluminum coating are present in seawater in trace amounts except magnesium, which is present in seawater at 0.1 percent (Nozaki 1997). Aluminum and silicon are the most common minerals in the earth's crust as aluminum oxide and silicon dioxide, respectively. Aluminum is the most common metal in the Earth's crust, and is a trace element in natural waters. Ocean waters are in constant exposure to crustal materials, so the addition of small amounts of chaff should not affect water or sediment composition (Hullar et al. 1999).

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

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

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

3.1.3.4.6.3 Additional Components of Other Materials

Most components of other materials are plastics. Although plastics are resistant to degradation, they do gradually breakdown into smaller particles as a result of photodegradation and mechanical wear (Law et al. 2010). The fate of plastics that sink beyond the continental shelf is largely unknown, although marine microbes and fungi are known to degrade biologically produced polyesters (Doi et al. 1992) as well as other synthetic polymers, although the latter occurs more slowly (Shah et al. 2008).

3.1.3.4.7 Evaluation of Alternatives

The following sections evaluate each alternative in terms of the information provided in Section 3.1.3.4. Table 3.0-28, Table 3.0-29, and Table 3.1-6 identify the annual number and location of flares and chaff expended under the No Action Alternative and Alternatives 1 and 2.

No military materials would be expended for any training or testing activity under any proposed alternative in the Western Behm Canal portion of the Study Area. Therefore, other materials of military munitions would have no impact to sediments or water quality under any alternative in this portion of the Study Area.

3.1.3.4.7.1 No Action Alternative

<u>Training Activities</u>

Offshore Area

Under the No Action Alternative, up to 3,084 military items composed of other materials would be expended in the Offshore Area and Olympic military operations areas (MOAs), airspaces within the Offshore Area (see Figure 2.1-2), during training activities.

Under the No Action Alternative, flares and chaff cartridges would be expended in the Offshore Area and Olympic MOAs. Flares would account for 94 percent of the expended items, with chaff cartridges accounting for the remaining items. Potential impacts of these other materials on sediment and water quality would be short term and long term, and negative. Chemical or physical changes in sediment or water quality would not be detectable. The composition of chaff is much like clay minerals common in ocean sediments (aluminosilicates), and studies indicate that negative impacts are not anticipated even at concentrations many times the level anticipated during proposed training activities. Most pyrotechnics in marine markers and flares are consumed during use and expended in the air. The failure rate is low (5 percent), and the remaining amounts are small and subject to additional chemical reactions and subsequent dilution in the ocean. Plastics and other floating expended materials would either degrade over time or wash ashore as small particles. Materials would be widely scattered on the sea floor in areas used for training.

Inland Waters

No testing items composed of other materials would be used in Puget Sound during training activities under the No Action Alternative. Therefore, these activities would not affect sediments or water quality.

Testing Activities

Offshore Area

No chaff or flares would be expended during testing activities under the No Action Alternative. Therefore, these activities would not affect sediments or water quality.

Inland Waters

No testing items composed of other materials would be used in Puget Sound during testing activities under the No Action Alternative. Therefore, these activities would not affect sediments or water quality.

3.1.3.4.7.2 Alternative 1

Training Activities

Offshore Area

Under Alternative 1, an estimated 5,224 items composed of other materials would be expended, an 89 percent increase compared to the No Action Alternative. All military expended materials composed of other materials would be used in the Offshore Area and Olympic MOAs.

Under Alternative 1, training items composed of other materials would consist of flares (96 percent) and chaff cartridges (4 percent). The potential impacts of other materials on sediment and water quality would be short term and long term, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable. The increase in other materials used in the Offshore Area during training activities under Alternative 1 would be distributed over a wide area and, coupled with the nature of those materials, would not result in a significant impact.

Inland Waters

No items composed of other materials would be used in Puget Sound during training activities under Alternative 1. Therefore, these activities would not affect sediments or water quality.

Testing Activities

Offshore Area

Under Alternative 1, items composed of other materials would consist of flares. During testing activities, 600 flares would be expended compared to the No Action Alternative where no flares are expended. The impacts of flares on sediments and water quality would be the same as those discussed for training activities but on a smaller scale. The potential impacts of other materials on sediment and water quality would be short term and long term, local, and negative. Chemical or physical changes in sediment or water quality would not be detectable. Most pyrotechnics in flares are consumed during use and expended in the air. The failure rate is low (5 percent), and the remaining amounts are small and subject to additional chemical reactions and subsequent dilution in the ocean. Plastics and other floating expended materials would either degrade over time or wash ashore as small particles. Materials would be widely scattered on the sea floor in areas used for training resulting in insignificant long-term, negative impacts on sediment and water quality.

Inland Waters

No testing items composed of other materials would be used in Puget Sound during testing activities under Alternative 1. Therefore, these activities would not affect sediments or water quality.

3.1.3.4.7.3 Alternative 2

Training Activities

Offshore Area

Under Alternative 2, an estimated 5,224 items composed of other materials would be expended, a 91 percent increase compared to the No Action Alternative. All military expended materials composed of other materials would be used in the Offshore Area and Olympic MOAs.

Under Alternative 2, the number of items composed of other materials that would be expended during training activities would be the same as under Alternative 1. The impacts on sediments and water quality would be the same as Alternative 1. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

Inland Waters

No testing items composed of other materials would be used in Puget Sound during training activities under Alternative 2. Therefore, these activities would not affect sediments or water quality.

Testing Activities

Offshore Area

Under Alternative 2, 660 flares would be expended. The impacts of flares on sediments and water quality would be the same as those discussed for training activities. The potential impacts of other materials on sediment and water quality would be short term and long term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

Inland Waters

No testing items composed of other materials would be used in Puget Sound during testing activities under Alternative 2. Therefore, these activities would not affect sediments or water quality.

3.1.3.4.7.4 Summary and Conclusions for Other Materials

Other military expended materials include plastics, marine markers, flares, and chaff. Some expended plastics from training and testing activities are unavoidable because they are used in ordnance or targets. Chaff fibers are composed of nonreactive metals and glass and would be dispersed by ocean currents as they float and slowly sink toward the bottom. The fine, neutrally buoyant chaff streamers would act like particulates in the water, temporarily increasing the turbidity of the ocean's surface. The chaff fibers would quickly disperse, and turbidity readings would return to normal.

3.1.3.5 Summary of Potential Impacts (Combined Impact of All Stressors) on Sediments and Water Quality

The stressors that may impact sediment and water quality include explosives and explosion byproducts, metals, chemicals other than explosives, and other military expended materials.

3.1.3.5.1 No Action Alternative

Under the No Action Alternative, when considered together, the impact of the four stressors would be additive. Chemical, physical, or biological changes in sediment or water quality would not be detectable and would be below or within existing conditions or designated uses. This conclusion is based on the following reasons:

- Although individual training and testing activities may occur within a fairly small area, overall military expended materials and activities are widely dispersed in space and time.
- Several studies at sites used frequently for training and testing activities in the Puget Sound found traces of metals, but all concentrations were well below background levels for both sediment and water quality. These studies are discussed in Section 3.1.2.1.2 (Sediments in the Inland Waters) and Section 3.1.2.4.2 (Water Quality in the Inland Waters).
- When multiple stressors occur at the same time, it is usually for a brief period.
- Many components of expended materials are relatively nonreactive and corrode slowly.
- Numerically, most of the metals expended are small- and medium-caliber projectiles, metals of concern account for a small portion of the alloys used in expended materials, and metal corrosion is a slow process that allows for dilution.
- Most of the components are subject to a variety of physical, chemical, and biological processes that render them benign.
- Potential areas of negative impacts would be limited to small zones adjacent to the explosive, metals, or chemicals other than explosives. The failure rate is low for explosives and materials with propellant systems, limiting the potential impacts from the chemicals other than explosives involved.

3.1.3.5.2 Alternative 1

Under Alternative 1, the impact of chemicals other than explosives and other materials on sediment and water quality would be short term and long term and negative. Chemical or physical changes in sediment or water quality would be detectable and would be below or within existing conditions or designated uses. The impact of explosives, explosion byproducts, and metals on sediment and water quality would also be short term and long term and local. However, chemical, physical, or biological changes in sediment or water quality from explosives, explosion byproducts, and metals would be measurable but below applicable standards and guidelines, and would be below or within existing conditions or designated uses.

When considered together, the impact of the four stressors would be additive. Chemical, physical, or biological changes in sediment or water quality would be measurable but would still be below applicable standards and guidelines. Although most types of expended materials would increase, some considerably, over the No Action Alternative, this conclusion is based on the reasons provided under the No Action Alternative.

3.1.3.5.3 Alternative 2

Under Alternative 2, when considered separately, the impact of the four stressors on sediment and water quality would be the same as discussed under Alternative 1 because the types and amounts of military expended materials are similar under the two alternatives.

When considered together, the impact of the four stressors would be additive, and changes in sediment or water quality would be measurable but would still be below applicable standards and guidelines. Although most types of expended materials would increase, some considerably, over the No Action Alternative, this conclusion is based on the reasons provided under the No Action Alternative.

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3.2 Air Quality

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3.2 AIR QUALITY

AIR QUALITY SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following constituents have been analyzed for their effects on air quality:

- Criteria Air Pollutants
- Hazardous Air Pollutants

Preferred Alternative (Alternative 1)

- Reasonably foreseeable emissions of criteria air pollutants in attainment areas would not cause federal ambient air quality standards to be exceeded.
- Reasonably foreseeable emissions of criteria air pollutants in maintenance areas would not exceed applicable federal *de minimis* levels.
- The public would not be exposed to substantial concentrations of hazardous air pollutants.

Note: Emissions thresholds for conformity requirements are termed *de minimis* levels.

3.2.1 INTRODUCTION AND METHODS

3.2.1.1 Introduction

Air pollution can threaten public health and damage the environment. Congress passed the Clean Air Act (CAA) and its amendments to regulate air pollutant emissions and ambient air quality and thus help to ensure basic public health and environmental protection from air pollution. Air pollution damages trees, crops, other plants, lakes, and animals. In addition to its effects on public health and the natural environment, air pollution can damage the exteriors of buildings, monuments, and statues. It can create haze or smog that reduces visibility in national parks and cities or that interferes with aviation.

Air quality is defined by atmospheric concentrations of specific air pollutants—pollutants the United States (U.S.) Environmental Protection Agency (USEPA) determined may affect the health or welfare of the public. The six major air pollutants of concern, called “criteria pollutants,” are carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), suspended particulate matter (PM), and lead (Pb). Suspended PM is further categorized as particulates less than or equal to 10 microns in diameter (PM_{10}) and fine PM less than or equal to 2.5 microns in diameter ($PM_{2.5}$). The USEPA established National Ambient Air Quality Standards for these criteria pollutants.

In addition to the six criteria pollutants, the USEPA designated 188 substances as hazardous air pollutants under the CAA. Hazardous air pollutants are air pollutants known to cause or suspected of causing cancer or other serious health effects, or adverse environmental effects (U.S. Environmental Protection Agency 2010b).

National Ambient Air Quality Standards have not been established for hazardous air pollutants. Examples of hazardous air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted by some dry cleaning facilities; and methylene chloride, a solvent and paint stripper used in some industries. Hazardous air pollutants are regulated under the CAA’s National Emission

Standards for Hazardous Air Pollutants, which apply to specific sources of hazardous air pollutants, and under the Urban Air Toxics Strategy, which applies to area sources.[1]

Air pollutants are classified as either primary or secondary pollutants, based on how they are formed. Primary air pollutants are emitted directly into the atmosphere from the source and retain their chemical form. Examples of primary pollutants are the CO produced by a power plant burning fuel and volatile organic compounds emitted by a dry cleaner (U.S. Environmental Protection Agency 2010b). Secondary air pollutants are formed through atmospheric chemical reactions—reactions that usually involve primary air pollutants (or pollutant precursors) and normal constituents of the atmosphere (U.S. Environmental Protection Agency 2010b). Ozone, a major component of photochemical smog, is a secondary air pollutant. Ozone precursors consist of two groups of chemicals: nitrogen oxides (NO_X) and organic compounds. Nitrogen oxides consist of nitric oxide (NO) and NO_2. Organic compound precursors of O_3 are described by various terms, including volatile organic compounds, reactive organic compounds, and reactive organic gases. Finally, some air pollutants are a combination of primary and secondary pollutants. Various mechanical processes (e.g., abrasion, erosion, mixing, or atomization) and combustion processes emit both PM_{10} and $PM_{2.5}$ as primary air pollutants. They are generated as secondary air pollutants through chemical reactions or through the condensation of gaseous pollutants into fine aerosols.

Air pollutant emissions are reported as the rate (by weight or volume) at which specific compounds are emitted into the atmosphere by a source (e.g., tons per year, pounds per hour). Typical emission factors for a source are pounds per thousand gallons of fuel burned, pounds per ton of material processed, and grams (g) per vehicle-mile (mi.) traveled.

Ambient air quality is reported as the atmospheric concentrations of specific air pollutants at a particular time and location. The units of measure are expressed as a mass per unit volume (e.g., micrograms per cubic meter [$\mu g/m^3$] of air) or as a volume fraction (e.g., parts per million [ppm] by volume). The ambient air pollutant concentrations measured at a particular location are determined by the pollutant emissions rate, local meteorology, and atmospheric chemistry. Wind speed and direction, the vertical temperature gradient of the atmosphere, and precipitation patterns affect the dispersal, dilution, and removal of air pollutant emissions from the atmosphere.

3.2.1.2 Methods

Section 176(c)(1) of the CAA, commonly known as the General Conformity Rule, requires federal agencies to ensure that their actions conform to applicable State Implementation Plans for achieving and maintaining the National Ambient Air Quality Standards for criteria pollutants.

3.2.1.2.1 Application of Regulatory Framework

3.2.1.2.1.1 National Ambient Air Quality Standards

National Ambient Air Quality Standards for criteria pollutants are presented in Table 3.2-1. Federally designated Air Quality Control Regions, or portions thereof, that exceed a standard are designated as "nonattainment" for that pollutant, while areas that comply with a standard are in "attainment" for that pollutant. An area may be nonattainment for some pollutants and attainment for others simultaneously.

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[1] An area source is a two-dimensional source of diffuse air pollutant emissions (e.g., the emissions from a forest fire, a landfill, or dust from a large area of disturbed soil).

Table 3.2-1: National Ambient Air Quality Standards

Pollutant	Primary Standards		Secondary Standards	
	Level	Averaging Time	Level	Averaging Time
Carbon monoxide (CO)	9 ppm (10 mg/m^3)	8 hours(1)	None	
	35 ppm (40 mg/m^3)	1 hour(1)	None	
Lead (Pb)	0.15 μg/m^3 (2)	Rolling 3-month average	Same as primary	
Nitrogen dioxide (NO_2)	53 ppb(3)	Annual (arithmetic mean)	Same as primary	
	100 ppb	1 hours(4)	None	
Particulate matter (PM_{10})	150 μg/m^3	24 hours(5)	Same as primary	
Particulate matter ($PM_{2.5}$)	12.0 μg/m^3	Annual(6)	15.0 μg/m^3	Annual(6)
	35 μg/m^3	24 hours(7)	Same as primary	
Ozone (O_3)	0.075 ppm (2008 std)	8 hours(8)	Same as primary	
	0.08 ppm (1997 std)	8 hours(9)	Same as primary	
	0.12 ppm	1 hour(10)	Same as primary	
Sulfur dioxide (SO_2)	0.03 ppm(11) (1971 std)	Annual (arithmetic mean)	0.5 ppm	3 hours(1)
	0.14 ppm(11) (1971 std)	24 hours(1)		
	75 ppb(12)	1 hour	None	

(1) Not to be exceeded more than once per year.
(2) Final rule signed 15 October 2008. The 1978 lead standard (1.5 μg/m^3 as a quarterly average) remains in effect until 1 year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978 standard, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.
(3) The official level of the annual nitrogen dioxide standard is 0.053 parts per million (ppm), equal to 53 parts per billion (ppb), which is shown here for the purpose of a clearer comparison with the 1-hour standard.
(4) To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective 22 January 2010).
(5 Not to be exceeded more than once per year on average over 3 years.
(6) Arithmetic mean. To attain these standards, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 12.0 micrograms per cubic meter (μg/m^3), primary standard, or 15.0 μg/m^3, secondary standard.
(7) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 μg/m^3 (effective 17 December 2006).
(8) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average O_3 concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective 27 May 2008).
(9) (a) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average O_3 concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as the U.S. Environmental Protection Agency (USEPA) undertakes rulemaking to address the transition from the 1997 O_3 standard to the 2008 O_3 standard.
(c) The USEPA is reconsidering these standards (established in March 2008).
(10) (a) The USEPA revoked the 1-hour O_3 standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").
(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤ 1.
(11) The 1971 SO_2 standards remain in effect until 1 year after an area is designated for the 2010 standard, except that in areas designated nonattainment for the 1971 standards, the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved.
(12) Final rule signed 2 June 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

Notes: μg/m^3 = micrograms/cubic meter, mg/m^3 = milligrams/cubic meter, ppb = parts per billion, ppm = parts per million, std = standard

Source: U.S. Environmental Protection Agency 2011b, updated 4 October 2011

States, through their air quality management agencies, are required to prepare and implement State Implementation Plans for nonattainment areas, which demonstrate how the area will meet the National Ambient Air Quality Standards. Areas that have achieved attainment may be designated as "maintenance areas," subject to maintenance plans showing how the area will continue to meet federal air quality standards. Nonattainment areas for some criteria pollutants are further classified, depending upon the severity of their air quality problem, to facilitate their management:

- O_3 – marginal, moderate, serious, severe, and extreme
- CO – moderate and serious
- PM – moderate and serious

The USEPA delegates the regulation of air quality to the state once the state has an approved State Implementation Plan. The CAA also allows states to establish air quality standards more stringent than the National Ambient Air Quality Standards.

The attainment status for most of the Northwest Training and Testing (NWTT) Study Area (hereafter referred to as the Study Area) is unclassified because only areas within state boundaries are classified under the CAA. Marine waters within 3 nautical miles (nm) of the coast are included in the Air Quality Control Region of the adjacent land area. The National Ambient Air Quality Standards attainment status of adjacent onshore areas is considered in determining whether appropriate controls on air pollution sources in the adjacent state marine waters are warranted. The Study Area encompasses three federally designated Air Quality Control Regions in two states (Alaska and Washington). U.S. Department of the Navy (Navy) training and testing activities offshore of Oregon and California occur exclusively more than 12 nm from shore, so Air Quality Control Regions in those states are not affected. The affected Air Quality Control Regions are shown in Figure 3.2-1 and described in Section 3.2.2.4 (Existing Air Quality).

3.2.1.2.1.2 Conformity Analyses in Nonattainment and Maintenance Areas

General Conformity Evaluation

Federal actions are required to conform with the approved State Implementation Plan for those Air Quality Control Regions of the United States that are designated under the CAA as nonattainment or maintenance for any criteria air pollutant (40 Code of Federal Regulations [C.F.R.] §§ 51 and 93). The purpose of the General Conformity Rule is to demonstrate that the Proposed Action would not cause or contribute to a violation of an air quality standard and that the Proposed Action would not adversely affect the attainment and maintenance of federal ambient air quality standards. A federal action would not conform if it increased the frequency or severity of any existing violations of an air quality standard or delayed the attainment of a standard, required interim emissions reductions, or delayed any other air quality milestone. To ensure that federal activities do not impede local efforts to control air pollution, Section 176(c) of the CAA (42 U.S. Code § 7506(c)) prohibits federal agencies from engaging in or approving actions that do not conform to an approved State Implementation Plan. The emissions thresholds that trigger the conformity requirements are called *de minimis* thresholds.

Federal agency compliance with the General Conformity Rule can be demonstrated in several ways. The requirement can be satisfied by a determination that the Proposed Action is not subject to the General Conformity Rule, by a Record of Non-Applicability, or by a Conformity Determination. Compliance is presumed if the net increase in emissions from a federal action would be less than the relevant *de minimis* threshold. If net emissions increases exceed the *de minimis* thresholds, then a formal Conformity Determination must be prepared. *De minimis* thresholds are shown in Table 3.2-2.

Figure 3.2-1: Air Quality Control Regions in the Northwest Training and Testing Study Area

Table 3.2-2: *De Minimis* Thresholds for Conformity Determinations

Pollutant	Nonattainment or Maintenance Area Type	*De Minimis* Threshold (tons per year)
Ozone (VOC or NO_x)	Serious nonattainment	50
	Severe nonattainment	25
	Extreme nonattainment	10
	Other areas outside an ozone transport region	100
Ozone (NO_x)	Marginal and moderate nonattainment inside an ozone transport region	100
	Maintenance	100
Ozone (VOC)	Marginal and moderate nonattainment inside an ozone transport region	50
	Maintenance within an ozone transport region	50
	Maintenance outside an ozone transport region	100
CO, SO_2, and NO_2	All nonattainment and maintenance	100
PM_{10}	Serious nonattainment	70
	Moderate nonattainment and maintenance	100
$PM_{2.5}$	All nonattainment and maintenance	100
Lead (Pb)	All nonattainment and maintenance	25

Notes: (1) Study Area is not in an ozone transport region. (2) CO = carbon monoxide, NO_2 = nitrogen dioxide, NO_x = nitrogen oxides, Pb = lead, $PM_{2.5}$ = particulate matter under 2.5 microns, PM_{10} = particulate matter under 10 microns, SO_2 = sulfur dioxide, VOC = volatile organic compounds

Source: U.S. Environmental Protection Agency 2011a.

Actions not subject to the General Conformity Rule include actions that occur in attainment areas and that do not generate emissions in nonattainment areas. If National Environmental Policy Act (NEPA) documentation is prepared for an agency action, the determination that the proposed action is not subject to the General Conformity Rule is described in that documentation. Otherwise, no documentation is required. This Environmental Impact Statement (EIS)/Overseas EIS (OEIS) includes the determination that actions in attainment areas that do not emit air pollutants in nonattainment areas are not subject to the General Conformity Rule.

3.2.1.2.1.3 Prevention of Significant Deterioration

The CAA defines mandatory Federal Class I areas as national parks greater than 6,000 acres, wilderness areas and national memorial parks greater than 5,000 acres, and international parks that existed in 1977. Prevention of Significant Deterioration provisions (Title 1, Part C of the CAA) were enacted to protect Class I areas from new stationary sources that could cause a Prevention of Significant Deterioration increment (amount of increased air pollution allowed in an area) to be exceeded. The Proposed Action does not include constructing or modifying a stationary source, so Prevention of Significant Deterioration requirements do not apply.

On 13 May 2010, the USEPA issued a final rule that established an approach to addressing greenhouse gas emissions from stationary sources under the CAA permitting programs (U.S. Environmental Protection Agency 2010a). This final rule sets thresholds for greenhouse gas emissions that define when permits under the New Source Review Prevention of Significant Deterioration Program and Title V Operating Permit Program are required for new and existing industrial facilities. The Navy aircraft, vessel, system, and munitions training and testing included in the Proposed Action do not involve any new or existing industrial facilities or stationary sources subject to the greenhouse gas tailoring rule.

3.2.1.2.2 Approach to Analysis

The air quality impact evaluation requires two separate analyses: (1) impacts of air pollutants emitted by Navy training and testing within U.S. territorial seas (i.e., within 12 nm of the coast) are assessed under NEPA, and (2) impacts of air pollutants emitted by Navy training and testing activities outside U.S. territorial seas are evaluated under Executive Order (EO) 12114. State waters are within the jurisdiction of the respective state and, because Alaska and Washington each have a distinct State Implementation Plan, the air quality evaluation separately analyzes those activities that emit air pollutants within those states' jurisdictions. Portions of the Study Area that lie within 3 nm of the coast in Alaska and Washington are within state air quality jurisdictions.

The analysis of health-based air quality impacts under NEPA includes estimates of criteria air pollutants for all training and testing activities where aircraft, ordnance, or targets operate at or below 3,000 feet (ft.) (914 meters [m]) above ground level or which involve vessels in U.S. territorial seas. The analysis of health-based air quality impacts under EO 12114 includes emissions estimates of only those training and testing activities in which aircraft, ordnance, or targets operate at or below 3,000 ft. (914 m) above ground level or that involve vessels outside U.S. territorial seas. Air pollutants emitted more than 3,000 ft. (914 m) above ground level are considered to be above the atmospheric mixing height (also called the atmospheric planetary boundary layer) and, therefore, do not affect ground-level air quality (U.S. Environmental Protection Agency 1992). These emissions thus do not affect the concentrations of air pollutants in the lower atmosphere, measured at ground-level monitoring stations, upon which federal, state, and local regulatory decisions are based. For the analysis of the impacts on global climate change, however, all emissions of greenhouse gases from aircraft and vessels participating in training and testing activities, as well as from targets and ordnance expended, are included regardless of their altitude (Chapter 4, Cumulative Impacts).

Criteria air pollutants are generated by the combustion of fuel by surface vessels and by fixed-wing and rotary-wing aircraft. They also are generated by the combustion of explosives and propellants in various types of munitions. Propellants used in small-, medium-, and large-caliber projectiles generate criteria pollutants when detonated. Non-explosive practice munitions contain spotting charges and propellants that generate criteria air pollutants when they function. Powered targets require fuel, generating criteria air pollutants during their operation, and towed targets generate criteria air pollutants secondarily because another aircraft or vessel is required to provide power. Targets may generate criteria air pollutants if portions of the item burn in a high-order detonation. Chaff cartridges used by ships and aircraft are launched by an explosive charge that generates small quantities of criteria air pollutants. Countermeasure flares, parachute flares, and smoke floats are designed to burn for a prescribed period, emitting criteria pollutants in the process.

The air quality analysis also addresses the hazardous air pollutants emitted by the proposed activities and assesses their potential impacts on air quality. Trace amounts of hazardous air pollutants would be emitted by combustion sources and use of ordnance. Hazardous air pollutants, such as rocket motor exhaust and unspent missile fuel vapors, may be emitted during ordnance and target use. Hazardous air pollutants are generated, in addition to criteria air pollutants, by combustion of fuels, explosives, propellants, and the materials of which targets, munitions, and other training and testing materials are constructed (e.g., plastic, paint, wood). Fugitive volatile and semivolatile petroleum compounds also may be emitted whenever mechanical devices are used. These emissions are typically one or more orders of magnitude smaller than concurrent emissions of criteria air pollutants and only become a concern when large amounts of fuel, explosives, or other materials are consumed during a single activity or in one location.

Emissions of hazardous air pollutants are intermittent and dispersed over a vast ocean area. Because only small quantities of hazardous air pollutants are emitted into the lower atmosphere, which is well mixed over the ocean, the potential for exposure is very low and the risk presented by the emissions is similarly very low. The primary emissions from many munition types are carbon dioxide (CO_2), CO, and PM; hazardous air pollutants are emitted at low levels (U.S. Environmental Protection Agency 2008). A quantitative evaluation of hazardous air pollutant emissions is thus not warranted and was not conducted.

Electronic warfare countermeasures generate emissions of chaff, a form of particulate not regulated under the CAA as a criteria air pollutant (virtually all radio-frequency chaff is 10 to 100 times larger than PM_{10} and $PM_{2.5}$ [Spargo et al. 1999]). The types of training and testing that produce these other emissions may take place throughout the Study Area but occur primarily within Special Use Airspace. The majority of chaff emissions during training and testing occur 3 nm or more from shore and at altitudes over 3,000 ft. (914 m), which is above the atmospheric mixing height. Chaff released over the ocean would disperse in the atmosphere and then settle onto the ocean surface. The air quality impacts of chaff were evaluated by the Air Force in *Environmental Effects of Self-Protection Chaff and Flares* (U.S. Air Force 1997). The study concluded that most chaff fibers maintain their integrity after ejection. Although some fibers are likely to fracture during ejection, tests indicated that the explosive charge in the impulse cartridge results in minimal releases of PM. A later study at Naval Air Station Fallon found that the release of 50,000 cartridges of chaff per year over an area of 10,000 square miles would result in an annual average PM concentration of 0.018 $\mu g/m^3$ (far below the National Ambient Air Quality Standards at the time of 50 $\mu g/m^3$ for PM_{10} and 15 $\mu g/m^3$ for $PM_{2.5}$ [Agency for Toxic Substances and Disease Registry 2003]).[2] Therefore, chaff is not further evaluated as an air quality stressor in this EIS/OEIS.

The NEPA analysis includes a CAA General Conformity Analysis to support a determination pursuant to the General Conformity Rule (40 C.F.R. Part 93B). This analysis focuses on training and testing activities that could impact nonattainment or maintenance areas within the region of influence. To evaluate the conformity of the Proposed Action with the State Implementation Plan elements for each affected Air Quality Control Region or Air Basin, air pollutant emissions within these regions are estimated, based on an assumed distribution of the proposed training and testing activities within the respective portions of the Study Area.

Air pollutant emissions outside U.S. territorial seas are estimated and their potential impacts on air quality are assessed under EO 12114. The General Conformity Rule does not apply to activities outside of state waters because the rule pertains only to federal conformity with State Implementation Plans.

Aircraft, vessel, and ordnance operational parameters for the air quality analysis are based, wherever possible, on information from previous environmental impact reports, from Navy subject matter experts, and from established training requirements. These data and the annual numbers of each activity presented in Tables 2.8-1 to 2.8-3 were used to estimate the numbers and types of aircraft, surface ships and vessels, and munitions (i.e., potential sources of air emissions) that would be involved in each training and testing activity. Navy aircraft carriers and submarines are nuclear powered and have no air pollutant emissions associated with propulsion. Therefore, these vessels are not considered in the analysis below. Emissions sources and the approach used to estimate emissions are presented herein.

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[2] The current standard for PM_{10} is 150 $\mu g/m^3$ over a 24-hour average time (see Table 3.2-1).

3.2.1.2.3 Emissions Estimates

3.2.1.2.3.1 Aircraft Activities

To estimate aircraft emissions, the operating modes (e.g., “cruise” mode), number of hours of operation, and types of engine for each type of aircraft were evaluated. All aircraft are assumed to travel to and from training ranges at or above 3,000 ft. (914 m) above ground level and, therefore, their transits to and from the ranges do not affect surface air quality. Air combat maneuvers and air-to-air missile exercises are primarily conducted at altitudes well in excess of 3,000 ft. (914 m) above ground level and, therefore, are not included in the estimated emissions of criteria air pollutants. Examples of activities typically occurring below 3,000 ft. (914 m) include those involving helicopter platforms, such as mine warfare, anti-surface warfare, and anti-submarine warfare training and testing activities. For each training and testing activity, estimates of the percentage of the activity time spent below 3,000 ft. (914 m) are included in the air quality emissions calculations. Representative emissions calculations are presented in Appendix D.

The types of aircraft used and the numbers of flights flown under the No Action Alternative are derived from previous Navy NEPA and EO 12114 documents and from other historical information and data. The types of aircraft identified include the typical aircraft platforms that conduct a particular training or testing activity (or the closest surrogate when information is not available), including range support aircraft (e.g., non-Navy commercial air services). For Alternatives 1 and 2, estimates of future aircraft flights are based on anticipated evolutionary changes in the Navy’s force structure and mission assignments. Where there are no major changes in types of aircraft, future activity levels are estimated from the distribution of baseline activities. The types of aircraft used in each training or testing activity and numbers of flights flown by such aircraft are included in the air quality emissions calculations. Representative emissions calculations are presented in Appendix D.

Time on range (activity duration) under the No Action Alternative was calculated from average times derived from range records, Navy subject matter experts, and previous EISs. To estimate time on range for each aircraft activity in Alternatives 1 and 2, the average flight duration approximated in the baseline data was used in the calculations. Estimated altitudes of activities for all aircraft were obtained from aircrew members in operational squadrons. Several testing activities are similar to training activities, and therefore similar assumptions were made for such activities in terms of aircraft type, altitude, mode, and flight duration. Where aircraft testing activities were dissimilar to training activities, assumptions for time on range were obtained from Navy subject matter experts.

Air pollutant emissions were estimated based on emission factors in the Navy’s Aircraft Environmental Support Office memorandum reports for individual aircraft categories (Aircraft Emission Estimates: Mission Operations). For aircraft for which Aircraft Environmental Support Office emission factors were not available, emission factors were obtained from other published sources.

The emissions calculations for each alternative conservatively assume that each aircraft activity listed in Tables 2.8-1 to 2.8-3 is separately conducted. In practice, a testing activity may be conducted during a training flight. Two or more training activities also may be conducted during one flight (e.g., chaff or flare exercises may occur during electronic warfare operations, or air-to-surface gunnery and air-to-surface bombing activities may occur during a single flight operation). Using conservative assumptions may produce elevated aircraft emissions estimates but accounts for the possibility (however remote) that each aircraft training and testing activity is separately conducted.

3.2.1.2.3.2 Surface Ship Activities

Marine vessel traffic in the Study Area includes military ship and boat traffic, unmanned surface vessels, and range support vessels providing services for military training and testing activities. Nonmilitary commercial vessels and recreational vessels also are regularly present. These commercial and recreational vessels are not evaluated in the air quality analysis because they are not part of the Proposed Action. The methods of estimating marine vessel emissions involve evaluating the type of activity, the number of hours of operation, the type of propulsion, and the type of onboard generator for each vessel type.

The types of surface ships and numbers of activities for the No Action Alternative are derived from range records and Navy subject matter experts regarding vessel participant data. For Alternatives 1 and 2, estimates of future ship activities are based on anticipated evolutionary changes in the Navy's force structure and mission assignments. Where there are no major changes in types of ships, estimates of future activities are based on the historical distribution of ship use. Minor aboard sources of air pollutants necessary for ship operations and incidental to training or testing activities (e.g., support equipment, generators) were excluded from the emissions inventory.

For surface ships, the durations of activities were estimated by taking an average over the total number of activities for each type of training and testing. Emissions for baseline activities and for future activities were estimated based on discussions with exercise participants. In addition, information provided by subject matter experts was used to develop a breakdown of time spent at each operational mode (i.e., power level) used during activities in which marine vessels participated. Several testing activities are similar to training activities, and therefore similar assumptions were made for such activities in terms of vessel type, power level, and activity duration.

Emission factors for marine vessels were obtained from a database developed for Naval Sea Systems Command (John J. McMullen Associates, Inc. 2001). Emission factors were provided for each marine vessel type and power level. The resulting calculations provided information on the time spent at each power level in each part of the Study Area, emission factors for that power level (in pounds of pollutant per hour), and total emissions for each marine vessel for each operational type and mode.

The pollutants for which calculations are made include exhaust total hydrocarbons, CO, NO_x, PM, CO_2, and SO_2. For nonroad engines, all PM emissions are assumed to be smaller than PM_{10}, and 92 percent of the PM from gasoline and diesel-fueled engines is assumed to be smaller than $PM_{2.5}$ (U.S. Environmental Protection Agency 2002). For gaseous-fueled engines (liquefied petroleum gas/compressed natural gas), 100 percent of the PM emissions are assumed to be smaller than $PM_{2.5}$ (U.S. Environmental Protection Agency 2002).

The emissions calculations for each alternative conservatively assume that each vessel activity listed in Chapter 2, Tables 2.8-1 to 2.8-3, is separately conducted and separately produces vessel emissions. In practice, one or more testing activities may take advantage of an opportunity to travel at sea aboard and test from a vessel conducting a related or unrelated training activity. It is also probable that two or more training activities may be conducted during one training vessel movement (e.g., a ship may conduct large-, medium-, and small-caliber surface-to-surface gunnery exercises during one vessel movement). Furthermore, multiple unit level training activities may be conducted during a larger composite training unit exercise. Using conservative assumptions may produce elevated vessel emissions estimates but accounts for the possibility (however remote) that each training or testing activity is separately conducted.

3.2.1.2.3.3 Naval Gunfire, Missiles, Bombs, Other Munitions, and Military Expended Material

Naval gunfire, missiles, bombs, and other types of munitions used in training and testing activities emit air pollutants. To estimate the amounts of air pollutants emitted by ordnance during their use, the numbers and types of munitions used during training or testing activities are first totaled. Then, generally accepted emissions factors for criteria air pollutants (U.S. Environmental Protection Agency 1995) are applied to the total amounts. Finally, the total amounts of air pollutants emitted by each munition type are summed to produce total amounts of each criteria air pollutant under each alternative.

3.2.1.2.4 Sensitive Receptors

Identifying sensitive receptors is part of describing the existing air quality environment. Sensitive receptors are individuals in residential areas, schools, parks, hospitals, and other sites for whom there is a reasonable expectation of continuous exposure during periods of peak ambient air pollutant concentrations. In the Study Area, commercial and recreational users of the ocean may encounter air pollutants generated by the Proposed Action. Few such individuals are typically present, however, and the durations of their exposures to substantial concentrations of these pollutants are limited because the areas are determined to be clear of nonparticipants before activities commence. These potential receptors within the Study Area are thus not considered sensitive.

3.2.1.3 Climate Change

Greenhouse gases are compounds that contribute to the greenhouse effect—a natural phenomenon in which gases trap heat in the lowest layer of the earth's atmosphere (surface-troposphere system), causing heating (radiative forcing) at the surface of the earth. The primary long-lived greenhouse gases directly emitted by human activities are CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF_6). CO_2, CH_4, and N_2O occur naturally in the atmosphere. However, their concentrations have increased from the preindustrial era (1750) to 2008: CO_2 (38 percent), CH_4 (149 percent), and N_2O (23 percent) (U.S. Environmental Protection Agency 2009b). These gases influence global climate by trapping heat in the atmosphere that would otherwise escape to space. The heating effect of these gases is considered the probable cause of the global warming observed over the last 50 years (U.S. Environmental Protection Agency 2009b). Climate change can affect many aspects of the environment. Not all impacts of greenhouse gases are related to climate. For example, elevated concentrations of CO_2 can lead to ocean acidification and stimulate terrestrial plant growth, and CH_4 emissions can contribute to higher O_3 levels.

The administrator of the USEPA determined that six greenhouse gases taken in combination endanger both the public health and the public welfare of current and future generations. The USEPA specifically identified CO_2, CH_4, N_2O, hydrofluorocarbons, perfluorocarbons, and SF_6 as greenhouse gases (U.S. Environmental Protection Agency 2009d; 74 Federal Register 66496, 15 December 2009).

To estimate the global warming potential, the United States quantifies greenhouse gas emissions using the 100-year timeframe values established in the Intergovernmental Panel on Climate Change Second Assessment Report (Intergovernmental Panel on Climate Change 1995), in accordance with United Nations Framework Convention on Climate Change (United Nations Framework Convention on Climate Change 2004) reporting procedures. All global warming potentials are expressed relative to a reference gas, CO_2, which is assigned a global warming potential equal to 1. The five other greenhouse gases have a greater global warming potential than CO_2, ranging from 21 for CH_4, 310 for N_2O, 140 to 6,300 for hydrofluorocarbons, 6,500 to 9,200 for perfluorocarbons, and up to 23,900 for SF_6. To estimate the CO_2

equivalency of a non-CO_2 greenhouse gas, the appropriate global warming potential of that gas is multiplied by the amount of the gas emitted. All six greenhouse gases are multiplied by their global warming potential and the results are added to calculate the total equivalent (Eq) emissions of CO_2 (CO_2 Eq). The dominant greenhouse gas emitted is CO_2, mostly from fossil fuel combustion (85.4 percent) (U.S. Environmental Protection Agency 2009c). Weighted by global warming potential, CH_4 is the second largest component of emissions, followed by N_2O. Global warming potential-weighted emissions are presented in terms of equivalent emissions of CO_2, using units of teragrams (Tg, equivalent to 1 million metric tons or 1 billion kilograms) of CO_2 equivalents (Tg CO_2 Eq). The Proposed Action is anticipated to release greenhouse gases to the atmosphere. These emissions are quantified for the proposed Navy training and testing in the Study Area, and estimates are presented in Chapter 4.

The potential impacts of proposed greenhouse gas emissions are by nature global; individual sources of greenhouse gas emissions are not large enough to have any noticeable effect on climate change but may have cumulative impacts. Therefore, the impact of proposed greenhouse gas emissions on climate change is discussed in the context of cumulative impacts in Chapter 4.

3.2.1.4 Other Compliance Considerations, Requirements, and Practices

3.2.1.4.1 Executive Order 12088

EO 12088, *Federal Compliance with Pollution Control Standards*, requires each federal agency to comply with applicable pollution control standards, defined as, “the same substantive, procedural, and other requirements that would apply to a private person.” The EO further requires federal agencies to cooperate with USEPA, state, and local environmental regulatory agencies.

3.2.1.4.2 Chief of Naval Operations Instruction 5090.1

The Navy developed Chief of Naval Operations Instruction (OPNAVINST) 5090.1 series, which contains guidance for environmental evaluations. Chapter 7 and Appendix F of this series contain guidance for air quality analysis and General Conformity determinations. The analysis in this EIS/OEIS was performed in compliance with this instruction.

3.2.1.4.3 Current Requirements and Practices

Equipment used by military units in the Study Area, including ships and other marine vessels, aircraft, and other equipment, are properly maintained and fueled in accordance with applicable Navy requirements. Operating equipment meets federal and state emission standards, where applicable. For example, in accordance with the OPNAVINST 5090.1 series, Chapter 7, Navy commands shall comply with Navy and regulatory requirements for composition of fuels used in all motor vehicles, equipment, and vessels. To prevent misfueling, installations shall enforce appropriate controls to ensure that any fuel that does not meet low-sulfur requirements is not dispensed to commercial motor vehicles, equipment, or vessels that are not covered under a national security exemption.

3.2.2 AFFECTED ENVIRONMENT

3.2.2.1 Region of Influence

The region of influence for air quality is a function of the type of pollutant, emission rates of the pollutant source, proximity to other emission sources, and local and regional meteorology. For inert pollutants (all pollutants other than O_3 and its precursors), the region of influence is generally limited to a few miles downwind from the source. For a photochemical pollutant such as O_3, however, the region of influence may extend much farther downwind. Ozone is a secondary pollutant formed in the atmosphere by photochemical reactions of previously emitted pollutants, or precursors (volatile organic compounds and NO_X). The maximum impacts of precursors on O_3 levels tend to occur several hours after the time of emission during periods of high solar load and may occur many miles from the source. Ozone and O_3 precursors transported from other regions can also combine with local emissions to produce high local O_3 concentrations. Therefore, the region of influence for air quality includes the Study Area as well as adjoining land areas several miles inland, which may from time to time be downwind from emission sources associated with the Proposed Action.

3.2.2.2 Climate of the Northwest Training and Testing Study Area

The climate of the coastal Pacific Northwest is generally characterized by cool, dry summers and mild winters with abundant precipitation. This climate pattern is classified as Mediterranean (dry-summer subtropical) to maritime temperate/oceanic. Average annual air temperature gradually decreases and average annual precipitation gradually increases from northern California to southeastern Alaska. Total annual rainfall approximately doubles, from about 70 inches (in.) (178 centimeters [cm]) per year in northern California to over 150 in. (381 cm) per year in Ketchikan, Alaska. Minimum winter temperatures decrease from about 40 degrees Fahrenheit (°F) (4 degrees Celsius [°C]) in northern California to about 30°F (-1°C) in Ketchikan. Maximum winter temperatures decrease from about 55°F (13°C) in northern California to about 45°F (7°C) in Ketchikan. Summer air temperatures are more variable.

Offshore waters and inland areas generally have less rainfall than coastal areas, and portions of the region that lie in the rain shadow of major topographic features—such as the Olympic Range of mountains—have less rainfall. Average annual precipitation on portions of the Olympic Peninsula and coastal Alaska exceeds 200 in. (500 cm) per year. Approximately two-thirds of the region's precipitation occurs between October and March due to cold fronts sweeping down the western coast of North America from the Gulf of Alaska. This climate supports the largest temperate rain forest ecoregion (Nearctic ecozone) in the world. Both temperature and precipitation have increased during the 20th century. Average annual air temperature has increased by about 1.5°F (0.8°C).

The climate of the Study Area influences air quality. Atmospheric stability and mixing height determine the amount of vertical mixing of pollutants. Over water, the atmosphere tends to be neutral to slightly unstable. Over land, atmospheric stability is more variable, being unstable during the day, especially in summer due to rapid surface heating, and stable at night, especially under clear conditions in winter. The mixing height over water typically ranges from 1,640 to 3,281 ft. (500 to 1,000 m) with a slight diurnal (daytime) variation (U.S. Environmental Protection Agency 1972). The air quality analysis presented in this EIS/OEIS assumes that 3,000 ft. (914 m) above ground level is the typical maximum afternoon mixing height, and thus air pollutants emitted above this altitude do not affect ground-level air pollutant concentrations.

3.2.2.3 Regional Air Pollutant Sources and Emissions

Regional air pollutant sources include both marine activities and shore facilities. Unknown quantities of criteria and hazardous air pollutants are emitted by commercial and recreational aircraft and vessels operating in the Study Area. The types of air pollutants emitted from vessels operating in the Study Area can include CO, NO_x, sulfur oxides (SO_x) and PM from diesel fuel combustion (Markle and Brown 1995) and CO, NO_x, SO_x, polycyclic aromatic hydrocarbons, and formaldehyde from Jet Propellant-8 combustion (Ritchie et al. 2001). Other common fuels combusted by commercial and recreational aircraft and vessels include 100-low-lead (resulting in lead emissions in addition to those previously listed) and gasoline. Unknown quantities of criteria and hazardous air pollutants also are emitted by residential, commercial, industrial, and institutional stationary and mobile sources in adjacent land areas. Regional emissions sources associated with existing Navy activities include support craft, special purpose barges, helicopters, and fixed-wing aircraft.

Air pollutant emissions from offshore coastal areas may affect onshore air quality because of prevailing onshore winds during certain seasons and at certain times of day. The influence of transport on a downwind air basin can vary widely depending on the weather. Along the coast of the Pacific Northwest, prevailing winds out of the northwest result in air pollutants dispersing to the south and southeast.

3.2.2.3.1 Washington

The portion of the Study Area that lies within the State of Washington encompasses pristine, rural, and urban areas. Sources and levels of air pollutant emissions accordingly vary widely. Warning Area 237 (W-237) and the Quinault Range Site lie offshore, west of the Olympic Peninsula, in a relatively pristine area where air pollutant emissions consist mostly of particulates from combustion of wood and from marine vessels. However, large portions of the Study Area lie within the transnational Puget Sound-Georgia Basin, where air quality is dominated by the Vancouver and Seattle-Tacoma metropolitan areas.

Air pollutants in the Puget Sound–Georgia Basin are emitted by a variety of point, line, and area sources—including large industrial point sources, major ground transportation corridors, and extensive areas of residential, commercial, and small-scale industrial development. In 2005, criteria air pollutant emissions in the 13 counties within the Study Area totaled approximately 1.67 million tons (State of Washington 2008). The coastal ranges to the west and the Cascades to the east tend to limit the regional dispersal of air pollutants, so air pollutants in Puget Sound are transported north and south, combining with air pollutants from Vancouver to the north and remaining in the atmosphere for long periods. Most of the Navy's training and testing facilities in this region are in rural areas, where they are exposed to a combination of low background concentrations of criteria pollutants from regional sources and substantial concentrations of locally emitted air pollutants such as particulates.

3.2.2.3.2 Oregon

The Study Area starts at 12 nm off the Oregon coast. In general, air pollutant sources along the Oregon coast adjacent to the Study Area consist of area sources of residential, commercial, and small-scale industrial development. Marine vessels are—in the aggregate—a major source of NO_x and PM emissions, and combustion of wood for space heating is a major source of PM. Numerous industrial point sources are located along the Columbia River, and emissions of air pollutants from these sources may increase air pollutant concentrations near the mouth of the Columbia River.

3.2.2.3.3 California

The Study Area starts at 12 nm off the California coast. In general, air pollutant sources along the northern California coast adjacent to the Study Area consist of area sources of residential, commercial, and small-scale industrial development. Marine vessels are—in the aggregate—a major source of NO_x and PM emissions, and combustion of wood for space heating is a major source of PM.

3.2.2.3.4 Alaska

The Ketchikan region of southeastern Alaska has relatively little industrial development and low population densities. Sources of air pollutant emissions in the region include electric power generation facilities, a few industrial facilities, burning of wood for heat, and mobile sources such as vessels, aircraft, and automobiles. A large but seasonal source of air pollutant emissions in Ketchikan is cruise ships, several hundred of which dock in Ketchikan each year between May and September. Fuel combustion by cruise ships and other marine vessels generates the criteria pollutants NO_x, SO_2, CO, and PM.

3.2.2.4 Existing Air Quality

Air quality in offshore ocean areas is generally better than the air quality of adjacent onshore areas because there are few or no large sources of criteria air pollutants offshore. Much of the air pollutants found in offshore areas are transported there from adjacent land areas by low-level offshore winds, so concentrations of criteria air pollutants generally decrease with increasing distance from land. No criteria air pollutant monitoring stations are located in offshore areas, so air quality in the Study Area must be inferred from the air quality in adjacent land areas where air pollutant concentrations are monitored. The air quality in Puget Sound is generally intermediate in quality between that of offshore areas of the Pacific Ocean and adjacent onshore rural and urban areas.

3.2.2.4.1 Washington

Puget Sound Intrastate Air Quality Control Region (see Figure 3.2-1), managed by Puget Sound Clear Air Agency, encompasses Kitsap, King, Pierce, and Snohomish Counties and includes the Seattle-Tacoma metropolitan area. Puget Sound Naval Shipyard, Keyport Range Site, portions of Chinook Military Operations Area, the Explosive Ordnance Disposal Underwater Training Range in Hood Canal, Naval Base Kitsap Bangor, and portions of Dabob Bay Range Complex Site are in Kitsap County. Carr Inlet Operations Area is in Pierce County. Naval Station Everett is in Snohomish County. An urban portion of Pierce County (Wapato Hills–Puyallup River Valley) is in nonattainment of the federal 24-hour $PM_{2.5}$ standard because of smoke from fireplaces and stoves used for space heating. In addition, King, Pierce, and Snohomish Counties are a maintenance area for O_3 and CO. Kitsap County is in attainment of all National Ambient Air Quality Standards (Puget Sound Clear Air Agency 2012, U.S. Environmental Protection Agency 2012) and is not a maintenance area for any criteria air pollutant.

The Olympic Region Air Basin portion of the Olympic-Northwest Washington Air Quality Control Region, managed by Olympic Region Clean Air Agency, includes Clallam, Jefferson, Grays Harbor, Mason, Pacific, and Thurston Counties. Thurston County is an air quality maintenance area for PM_{10}. The Olympic Military Operating Area overlies part of the Olympic peninsula within the Olympic Region Air Basin. Quinault Range Site and portions of Dabob Bay Range Complex Site are in Jefferson County. Jefferson County is in attainment of the National Ambient Air Quality Standards (Olympic Region Clean Air Agency 2012, U.S. Environmental Protection Agency 2012) and is not a maintenance area for any criteria air pollutant.

The Northwest Air Basin portion of the Olympic-Northwest Washington Air Quality Control Region, managed by the Northwest Clean Air Agency, includes Island, Whatcom, and Skagit Counties. Explosives Ordnance Disposal Underwater Training Range Crescent Harbor, Chinook Military Operations Areas A and B, R-6701, and Navy 7 Operating Area (OPAREA) are in Island County, which is in attainment of the National Ambient Air Quality Standards, as well as state and regional air quality standards, for all criteria pollutants.

3.2.2.4.2 Alaska

The Navy's Southeast Alaska Acoustic Measurement Facility is in the Ketchikan Gateway Borough, within the Southeast Alaska Intrastate Air Quality Control Region (see Figure 3.2-1). Air quality in this area is under the management of the Alaska Department of Environmental Conservation. Monitoring by Alaska Department of Environmental Conservation indicated that particulate concentrations increased during the wood smoke season (December and January), but the concentrations did not approach or exceed National Ambient Air Quality Standards. No violations of the federal standards have been observed in this area (Alaska Department of Natural Resources 2006).

3.2.3 ENVIRONMENTAL CONSEQUENCES

This section evaluates how and to what degree the activities described in Chapter 2 could impact air quality within the Study Area. Tables 2.8-1 through 2.8-3 present the baseline and proposed training and testing activity locations for each alternative (including number of activities and ordnance expended). The air quality stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors applicable to air quality in the Study Area analyzed herein include:

- Criteria air pollutants
- Hazardous air pollutants

In this analysis, criteria air pollutant emissions were estimated for vessels, aircraft, and ordnance. For each alternative, emissions were estimated by Air Quality Control Region and by type of activity (training or testing). The emission estimates are provided in Appendix D. Hazardous air pollutants are analyzed qualitatively in relation to the prevalence of the sources emitting hazardous air pollutants during training and testing activities.

3.2.3.1 Criteria Air Pollutants

The potential impacts of criteria air pollutants are evaluated by first estimating the emissions from training and testing activities in the Study Area for each alternative. These estimates are then used to determine the potential impact of the emissions on the attainment status of the affected Air Quality Control Regions. Emissions of criteria air pollutants may affect human health directly by degrading local or regional air quality or indirectly by their impacts on the environment. Air pollutant emissions may also have a regulatory effect separate from their physical effect, if additional air pollutant emissions change the attainment status of an Air Quality Control Region.

The estimates of criteria air pollutant emissions for each alternative are organized by activity (i.e., either training or testing). These emissions are further categorized by region (e.g., Air Quality Control Region) so that differences in background air quality, atmospheric circulation patterns, regulatory requirements, and sensitive receptors can be addressed. Total air pollutant emissions for Navy training and testing activities in the Study Area under each alternative are also estimated.

3.2.3.1.1 No Action Alternative

3.2.3.1.1.1 Training

Table 3.2-3 lists training-related criteria air pollutant and precursor emissions in the Study Area; only those air pollutants emitted below 3,000 ft. above ground level are included in this analysis (see Section 3.2.1.2.3.1, Aircraft Activities). Emissions are totaled for each Air Quality Control Region in the Study Area. Total emissions for each of these regions are then summed to arrive at the total emissions within the Study Area. Totals include aircraft and vessel emissions based on estimated numbers of vessels and aircraft involved in training activities. The air pollutants emitted in the greatest quantity are CO, NO_x, and PM.

Under the No Action Alternative, the annual numbers of Navy training activities in the Study Area would remain at baseline (existing) levels. The criteria pollutant that would be emitted in the greatest quantities by aircraft is NO_x, followed by PM (PM_{10} and $PM_{2.5}$) and CO. These emissions are associated with aircraft involvement in a variety of training activities, including anti-air warfare, electronic warfare, and mine warfare. The air pollutant emitted in the greatest quantities by surface vessels is CO, followed by NO_x and SO_x. These emissions are associated with vessel involvement in a variety of training activities, including anti-submarine warfare, anti-surface warfare, and electronic warfare. The air pollutant emitted in the greatest quantity by munitions is CO, which would be emitted under the No Action Alternative by a variety of munitions, including bombs, rockets, missiles, smokes, flares, and gun rounds.

Table 3.2-3: Annual Criteria Air Pollutant Emissions from Training under the No Action Alternative

Air Quality Control Region	Source Type	Air Pollutant Emissions (tons per year)						
		CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Olympic-Northwest Washington Intrastate (WA)	Aircraft	0.7	0.7	0.1	0.2	0.5	0.5	2.2
	Vessels	0.2	5.5	0.0	0.9	0.1	0.1	6.7
	Ordnance	0.7	0.4	0.0	0.0	0.0	0.0	1.1
	Subtotal	**1.6**	**6.6**	**0.1**	**1.1**	**0.6**	**0.6**	**10.0**
Puget Sound Intrastate (WA)	Aircraft	0.3	0.3	0.0	0.1	0.2	0.2	0.9
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.2	0.0	0.0	0.0	0.0	0.0	0.2
	Subtotal	**0.5**	**0.3**	**0.0**	**0.1**	**0.2**	**0.2**	**1.1**
Federal (3–12 nm)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
International (+12 nm)	Aircraft	5.2	23.0	1.1	5.5	10.7	10.7	45.5
	Vessels	167.8	101.1	15.0	27.5	5.7	5.7	317.1
	Ordnance	1.8	0.4	0.0	0.0	0.1	0.1	2.3
	Subtotal	**174.8**	**124.5**	**16.1**	**33**	**16.5**	**16.5**	**364.9**
Study Area	**Total**	**176.9**	**131.4**	**16.2**	**34.2**	**17.3**	**17.3**	**376.0**

Notes: (1) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, VOC = volatile organic compound. (2) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. Only air pollutants emitted below 3,000 feet above ground level are included in the analysis. $PM_{2.5}$ is included in PM_{10}.

Training activities in international waters generate approximately 97 percent (365 tons/376 tons [332 metric tons/342 metric tons]) of training-related criteria pollutant emissions in the Study Area under the No Action Alternative. The other approximately 3 percent of training-related criteria air pollutants are emitted in state waters (under the No Action Alternative, no training activities take place in federal waters). The spatial distribution of emissions reflects the locations where Navy training most regularly occurs.

Air pollutants emitted in the Study Area may be carried ashore by prevailing winds; 3 percent of training activity would occur within 3 nm of shore in Washington under the No Action Alternative. However, atmospheric mixing would substantially disperse these pollutants before they reached the coast. The contributions of air pollutants generated in the Study Area to the air quality in adjacent Air Basins

(California) or Air Quality Control Regions (Washington, Oregon) are minimal and unlikely to measurably add to existing onshore pollutant concentrations because of the large areas over which they are emitted, the distances these offshore pollutants would be transported, and their substantial dispersion during transport.

3.2.3.1.1.2 Testing

Table 3.2-4 lists testing-related criteria air pollutant and precursor emissions in the Study Area. Emissions are totaled for each Air Quality Control Region in the Study Area. Total emissions for each region are then summed to arrive at the total testing emissions within the Study Area. Totals include aircraft and vessel emissions based on estimated numbers of vessels and aircraft involved in tests. The air pollutants emitted in the greatest quantity are NO_x and CO.

Table 3.2-4: Annual Criteria Air Pollutant Emissions from Testing under the No Action Alternative

Air Quality Control Region	Source Type	Air Pollutant Emissions (tons per year)						
		CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Olympic-Northwest Washington Intrastate (WA)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	6.9	2.7	0.4	0.7	0.1	0.1	10.8
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**6.9**	**2.7**	**0.4**	**0.7**	**0.1**	**0.1**	**10.8**
Puget Sound Intrastate (WA)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	6.9	2.7	0.4	0.7	0.1	0.1	10.8
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**6.9**	**2.7**	**0.4**	**0.7**	**0.1**	**0.1**	**10.8**
Southeastern Alaska	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	4.7	1.6	0.2	0.5	<0.1	<0.1	7.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**4.7**	**1.6**	**0.2**	**0.5**	**<0.1**	**<0.1**	**7.0**
Federal (3–12 nm)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	0.0
International (+12 nm)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Study Area	**Total**	**18.5**	**7.0**	**1.0**	**1.9**	**0.2**	**0.2**	**28.6**

Notes: (1) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, VOC = volatile organic compounds. (2) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. Only air pollutants emitted below 3,000 feet above ground level are included in the analysis. $PM_{2.5}$ is included in PM_{10}.

Under the No Action Alternative, the annual numbers of Navy testing activities in the Study Area would remain at baseline (existing) levels. Criteria pollutants emitted in the Study Area may be transported ashore by periodic changes in prevailing winds but would not affect the air quality in air basins along the coast for the reasons described in Section 3.2.3.1.1.1 (Training). Under the No Action Alternative, no pollutants would be emitted by aircraft or ordnance. The air pollutants that would be emitted in the greatest quantities by surface vessels are CO and NO_x. These emissions are associated with vessel involvement in a variety of testing activities. As shown in Table 3.2-4, testing activities in state waters account for all of the Study Area testing emissions under the No Action Alternative.

The contributions of testing-related air pollutants generated in the Study Area to the air quality in an adjacent Washington Air Quality Control Region would be minimal and unlikely to measurably add to existing onshore pollutant concentrations because of the large areas over which they are emitted, the distances these offshore pollutants would be transported, and their substantial dispersion during transport.

3.2.3.1.1.3 General Conformity Threshold Determination

The No Action Alternative is exempt from the federal General Conformity Rule because conformity is evaluated only for proposed new activities, and the No Action Alternative consists of existing activities. The areas where training and testing activities now occur are in attainment of federal air quality standards.

3.2.3.1.1.4 Summary – No Action Alternative

Criteria air pollutant emissions under the No Action Alternative are summarized in Table 3.2-5. While criteria air pollutants emitted within the territorial waters of the Study Area may be transported ashore, they would not affect the attainment status of coastal Air Quality Control Regions. The amounts of air pollutants emitted in the Study Area and subsequently transported ashore would have no substantial effect on air quality because (1) emissions from Navy training and testing activities are small compared to the amounts of air pollutants emitted by sources ashore, (2) the pollutants are emitted over large areas (i.e., the Study Area is an area source), (3) the distances the air pollutants would be transported are often large, and (4) the pollutants are substantially dispersed during transport. The criteria air pollutants emitted over nonterritorial waters within the Study Area would be dispersed over vast areas of open ocean and thus would not cause significant harm to environmental resources in those areas.

Table 3.2-5: Estimated Annual Criteria Air Pollutant Emissions in Northwest Training and Testing Study Area, No Action Alternative

Source	Emissions by Air Pollutant (tons per year)						
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Training activities	176.9	131.4	16.2	34.2	17.3	17.3	376.0
Testing activities	18.5	7.0	1.0	1.9	0.2	0.2	28.6
Total Study Area	**195.4**	**138.4**	**17.2**	**36.1**	**17.5**	**17.5**	**404.6**

Notes: (1) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, VOC = volatile organic compounds. (2) Table includes criteria pollutant precursors (e.g., VOC). Only air pollutants emitted below 3,000 feet above ground level are included in the analysis. $PM_{2.5}$ is included in PM_{10}.

Estimates of air pollutant emissions under the No Action Alternative are a projection into the future of existing baseline emissions. Under the No Action Alternative, the annual numbers of Navy training and testing activities in the Study Area would remain at baseline levels. Emissions rates would remain constant for those pollutant sources that are not affected by other federal requirements to reduce air emissions. Any impacts of the No Action Alternative on regional air quality are reflected in the current ambient criteria air pollutant concentrations in air quality control regions ashore.

3.2.3.1.2 Alternative 1

3.2.3.1.2.1 Training

Under Alternative 1, the annual number of Navy training activities in the Study Area would increase in comparison to the No Action Alternative (baseline) levels. Emissions of criteria pollutants from training activities less than 3,000 ft. above ground level would increase relative to emissions under the No Action Alternative. Table 3.2-6 lists the estimated training-related criteria air pollutant and precursor emissions in the Study Area by Air Quality Control Region under Alternative 1. Under Alternative 1, about 2 percent of training emissions would be produced in state waters (0–3 nm offshore), about 0 percent would be produced in federal waters (3–12 nm offshore), and about 98 percent of training emissions would be produced in international waters (more than 12 nm offshore).

Table 3.2-6: Annual Criteria Air Pollutant Emissions from Training under Alternative 1

Air Quality Control Region	Source Type	Air Pollutant Emissions (tons per year)						
		CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Olympic-Northwest Washington Intrastate (WA)	Aircraft	1.0	1.0	0.1	0.3	0.7	0.7	3.1
	Vessels	0.0	0.8	0.0	0.1	0.0	0.0	0.9
	Ordnance	0.1	0.0	0.0	0.0	0.1	0.1	0.2
	Subtotal	**1.2**	**1.9**	**0.1**	**0.5**	**0.8**	**0.8**	**4.2**
Puget Sound Intrastate (WA)	Aircraft	0.3	0.3	0.0	0.1	0.2	0.2	0.9
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.1	0.0	0.0	0.0	0.1	0.1	0.2
	Subtotal	**0.5**	**0.4**	**0.0**	**0.1**	**0.4**	**0.4**	**1.1**
Federal (3–12 nm)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
International (+12 nm)	Aircraft	3.3	24.2	0.7	5.3	1.5	1.5	35.0
	Vessels	169.7	102.4	15.1	27.8	5.8	5.8	320.5
	Ordnance	1.3	0.4	0.0	0.0	0.1	0.1	1.9
	Subtotal	**174.3**	**127.0**	**15.8**	**33.1**	**7.4**	**7.4**	**357.6**
Study Area	**Total**	**176.0**	**129.3**	**16.0**	**33.7**	**8.5**	**8.5**	**363.5**

Notes: (1) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, VOC = volatile organic compounds. (2) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. Only air pollutants emitted below 3,000 feet above ground level are included in the analysis. $PM_{2.5}$ is included in PM_{10}.

The air pollutant that would be emitted in the greatest quantity by aircraft under Alternative 1 is NO_x, followed by SO_x and CO. These pollutants are emitted mostly by aircraft involved in anti-submarine warfare training activities. The air pollutant that would be emitted in the greatest quantities by surface vessels is CO, followed by NO_x and SO_x. These pollutants are emitted by vessels involved in a variety of training activities in the offshore OPAREAs, including anti-submarine warfare, anti-surface warfare, and electronic warfare. The air pollutant that would be emitted in the greatest quantity by munitions is CO, which would be emitted under Alternative 1 by bombs, rockets, missiles, smokes, flares, and gun rounds. Under Alternative 1, total training emissions would decrease by about 5 percent in the Study Area compared to the No Action Alternative. This decrease would result mostly from decreased vessel emissions in the Olympic-Northwest Washington Intrastate Air Quality Control Region and a decrease in aircraft emissions in the offshore OPAREAs.

3.2.3.1.2.2 Testing

Under Alternative 1, the annual number of Navy testing activities in the Study Area would increase in comparison to No Action Alternative (baseline) levels. Emissions of all criteria pollutants would increase relative to emissions under the No Action Alternative. Table 3.2-7 lists the estimated testing-related criteria air pollutant and precursor emissions in the Study Area by region under Alternative 1. Under Alternative 1, emissions would increase within the Study Area. Only about 9 percent of testing emissions would be produced 3 nm or more from shore. Over 91 percent of air pollutant emissions would be produced in state waters.

Table 3.2-7: Annual Criteria Air Pollutant Emissions from Testing under Alternative 1

Air Quality Control Region	Source Type	Air Pollutant Emissions (tons per year)						
		CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Olympic-Northwest Washington Intrastate (WA)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	11.4	4.5	0.7	1.1	0.0	0.0	17.7
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**11.4**	**4.5**	**0.7**	**1.1**	**0.0**	**0.0**	**17.7**
Puget Sound Intrastate (WA)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	8.7	3.4	0.6	0.9	0.0	0.0	0.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**8.7**	**3.4**	**0.6**	**0.9**	**0.0**	**0.0**	**13.6**
Southeast Alaska Intrastate (AK)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	5.4	1.9	0.3	0.5	0.0	0.0	8.1
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**5.4**	**1.9**	**0.3**	**0.5**	**0.0**	**0.0**	**8.1**
Federal (3–12 nm)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
International (+12 nm)	Aircraft	0.4	2.9	0.1	0.1	0.2	0.2	3.7
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**0.4**	**2.9**	**0.1**	**0.1**	**0.2**	**0.2**	**3.7**
Study Area	**Total**	**25.9**	**12.7**	**1.7**	**2.6**	**0.2**	**0.2**	**43.1**

Notes: (1) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, VOC = volatile organic compounds. (2) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. Only air pollutants emitted below 3,000 feet above ground level are included in the analysis. $PM_{2.5}$ is included in PM_{10}.

As shown in Table 3.2-7, the air pollutant that would be emitted in the greatest quantity by aircraft under Alternative 1 is NO_x, followed by CO and PM (PM_{10} and $PM_{2.5}$). These emissions are associated mostly with aircraft involvement in anti-submarine warfare. As shown in Table 3.2-7, the air pollutant that would be emitted in the greatest quantities by surface vessels is CO, followed by NO_x and SO_x.

These emissions are associated with vessel involvement in a variety of testing activities. No air pollutants would be emitted by munitions, which would consist of torpedoes and sonobuoys.

3.2.3.1.2.3 General Conformity Threshold Determinations

To address the requirements of the federal General Conformity Rule, the net changes in criteria pollutant emissions associated with the Proposed Action in nonattainment and maintenance areas within the Study Area under Alternative 1 are estimated, relative to their corresponding emissions under the No Action Alternative. No training or testing activities would take place in a nonattainment area.

Under Alternative 1, two training activities could occur in a maintenance area. The Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercise would occur every other year. While the location for this exercise would vary from year to year, it could occur in Puget Sound within Snohomish or King County; these counties are designated as air quality maintenance areas for O_3 and CO. Also, Naval Station Everett is one possible location for the small boat attack exercise. Consisting of several hours each of helicopter, combatant surface vessel, and small boat activity, total air pollutant emissions from these training activities would clearly be well below the *de minimis* thresholds for O_3 precursors and CO. The General Conformity Rule, therefore, is satisfied under Alternative 1. Representative air pollutant emissions calculations and a Record of Non-Applicability are provided in Appendix D.

3.2.3.1.2.4 Summary – Alternative 1

Total criteria air pollutant emissions under Alternative 1 are summarized in Table 3.2-8. Under Alternative 1, the annual numbers of Navy training and testing activities in the Study Area would increase. Total emissions of criteria pollutants would decrease by approximately 0.5 percent; however, emissions of particulates would decrease by about 50 percent. Criteria air pollutants emitted in the Study Area within state waters could be transported ashore but would not affect the attainment status of the relevant air quality control regions. The amounts of air pollutants emitted in the Study Area and subsequently transported ashore would be minor because (1) emissions from Navy training and testing activities would be small compared to the amounts of air pollutants emitted by sources ashore, (2) the pollutants are emitted over large areas (i.e., the Study Area is an area source), (3) the distances the air pollutants would be transported are often large, and (4) the pollutants would be substantially dispersed during transport. The criteria air pollutants emitted over nonterritorial waters within the Study Area would be dispersed over vast areas of open ocean and thus would not cause significant harm to environmental resources in those areas.

Table 3.2-8: Estimated Annual Criteria Air Pollutant Emissions in the Northwest Training and Testing Study Area under Alternative 1

Source	Emissions by Air Pollutant (tons per year)						
	CO	NO$_X$	VOC	SO$_x$	PM$_{10}$	PM$_{2.5}$	Total
Training activities	176.0	129.3	16.0	33.7	8.5	8.5	363.5
Testing activities	25.9	12.7	1.7	2.6	0.2	0.2	43.1
Total Study Area	**201.9**	**142.0**	**17.7**	**36.3**	**8.7**	**8.7**	**406.6**
No Action Alternative	**403.8**	**284.0**	**35.4**	**72.6**	**17.4**	**17.4**	813.2
Net change (tons per year)	6.5	3.6	0.5	0.2	-8.8	-8.8	**-406.6**
Net change (%)	3.3	2.6	2.9	0.6	-50.3	-50.3	-50.0

Notes: (1) CO = carbon monoxide, NO$_X$ = nitrogen oxides, PM$_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM$_{10}$ = particulate matter ≤ 10 microns in diameter, SO$_x$ = sulfur oxides, VOC = volatile organic compounds. (2) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. Only air pollutants emitted below 3,000 feet above ground level are included in the analysis. PM$_{2.5}$ is included in PM$_{10}$.

3.2.3.1.3 Alternative 2

3.2.3.1.3.1 Training

Under Alternative 2, the annual number of Navy training activities in the Study Area would increase in comparison to the No Action Alternative (baseline) levels. Emissions of all criteria pollutants would increase relative to emissions under the No Action Alternative. Table 3.2-9 lists the estimated training-related criteria air pollutant and precursor emissions in the Study Area by region under Alternative 2. Under Alternative 2, about 1 percent of training emissions would be produced in state waters (0–3 nm offshore), less than 1 percent would be produced in federal waters (3–12 nm offshore), and about 99 percent of training emissions would be produced in international waters (more than 12 nm offshore).

The air pollutant that would be emitted in the greatest quantity by aircraft under Alternative 2 is NO$_x$, followed by SO$_x$ and CO. These pollutants are emitted mostly by aircraft involved in anti-submarine warfare training activities. The air pollutant that would be emitted in the greatest quantities by surface vessels is CO, followed by NO$_x$ and SO$_x$. These pollutants are emitted by vessels involved in a variety of training activities, including anti-submarine warfare, anti-surface warfare, and electronic warfare. The air pollutant that would be emitted in the greatest quantity by munitions is CO, which would be emitted under Alternative 2 by bombs, rockets, missiles, smokes, flares, and gun rounds. Under Alternative 2, total training emissions would decrease by about 4 percent in the Study Area compared to the No Action Alternative. This decrease would result mostly from decreased vessel emissions in the Olympic-Northwest Washington Intrastate Air Quality Control Region and a decrease in aircraft emissions in the offshore OPAREAs.

Table 3.2-9: Annual Criteria Air Pollutant Emissions from Training under Alternative 2

Air Quality Control Region	Source Type	Air Pollutant Emissions (tons per year)						
		CO	NO$_x$	VOC	SO$_x$	PM$_{10}$	PM$_{2.5}$	Total
Olympic-Northwest Washington Intrastate (WA)	Aircraft	1.0	1.0	0.1	0.3	0.7	0.7	3.1
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.1	0.0	0.0	0.0	0.1	0.1	0.2
	Subtotal	**1.1**	**1.0**	**0.1**	**0.3**	**0.8**	**0.8**	**3.3**
Puget Sound Intrastate (WA)	Aircraft	0.3	0.3	0.0	0.1	0.2	0.2	0.9
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	1.0
	Ordnance	0.1	0.0	0.0	0.0	0.1	0.1	0.2
	Subtotal	**0.4**	**0.3**	**0.0**	**0.1**	**0.3**	**0.3**	**1.1**
Federal (3–12 nm)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
International (+12 nm)	Aircraft	3.3	24.2	0.7	5.3	1.5	1.5	35.0
	Vessels	169.7	102.4	15.1	27.8	5.8	5.8	320.8
	Ordnance	1.3	0.4	0.0	0.0	0.1	0.1	1.8
	Subtotal	**174.3**	**127.0**	**15.8**	**33.1**	**7.4**	**7.4**	**357.6**
Study Area	**Total**	**175.8**	**128.3**	**15.9**	**33.5**	**8.5**	**8.5**	**362.0**

Notes: (1) CO = carbon monoxide, NO$_X$ = nitrogen oxides, PM$_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM$_{10}$ = particulate matter ≤ 10 microns in diameter, SO$_x$ = sulfur oxides, VOC = volatile organic compounds. (2) Air pollutant emissions estimated to the nearest ton per year. Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. Only air pollutants emitted below 3,000 feet above ground level are included in the analysis. PM$_{2.5}$ is included in PM$_{10}$.

3.2.3.1.3.2 Testing

Under Alternative 2, the annual number of Navy testing activities in the Study Area would increase in comparison to the No Action Alternative (baseline) levels. Emissions of all criteria pollutants would increase relative to emissions under the No Action Alternative. Table 3.2-10 lists the estimated testing-related criteria air pollutant and precursor emissions in the Study Area by air quality control region under Alternative 2. Only about 9 percent of testing-related emissions would be produced more than 3 nm offshore. Over 91 percent of these emissions would be produced within 3 nm of shore.

The air pollutant that would be emitted in the greatest quantity by aircraft under Alternative 2 (Table 3.2-10) is NO_x, followed by CO and PM (PM_{10} and $PM_{2.5}$). These pollutants are emitted mostly by aircraft involved in anti-submarine warfare. The air pollutant that would be emitted in the greatest quantities by surface vessels (Table 3.2-10) is CO, followed by NO_x and SO_x. These pollutants are emitted by vessels involved in a variety of testing activities. No air pollutants would be emitted by munitions, which would consist of torpedoes and sonobuoys.

Table 3.2-10: Annual Criteria Air Pollutant Emissions from Testing under Alternative 2

Air Quality Control Region	Source Type	Air Pollutant Emissions (tons per year)						
		CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Olympic-Northwest Washington Intrastate (WA)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	12.4	5.0	0.7	1.3	0.2	0.2	19.6
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**12.4**	**5.0**	**0.7**	**1.3**	**0.2**	**0.2**	**19.6**
Puget Sound Intrastate (WA)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	9.5	3.7	0.6	1.0	0.2	0.2	15.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**9.5**	**3.7**	**0.6**	**1.0**	**0.2**	**0.2**	**15.0**
Southeastern Alaska Intrastate (AK)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	5.4	1.9	0.3	0.6	0.0	0.0	8.2
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**5.4**	**1.9**	**0.3**	**0.6**	**0.0**	**0.0**	**8.2**
Federal (3–12 nm)	Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
International (+12 nm)	Aircraft	0.4	3.2	0.1	0.1	0.2	0.2	4.0
	Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ordnance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	**0.4**	**3.2**	**0.1**	**0.1**	**0.2**	**0.2**	**4.0**
Study Area	**Total**	**27.7**	**13.8**	**1.7**	**3.0**	**0.6**	**0.6**	**46.8**

Notes: (1) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, VOC = volatile organic compounds. (2) Air pollutant emissions estimated to the nearest ton per year. Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. Only air pollutants emitted below 3,000 feet above ground level are included in the analysis. $PM_{2.5}$ is included in PM_{10}.

3.2.3.1.3.3 General Conformity Threshold Determinations

To address the requirements of the federal General Conformity Rule, the net changes in criteria pollutant emissions associated with the Proposed Action in nonattainment and maintenance areas within the Study Area under Alternative 2 are estimated, relative to their corresponding emissions under the No Action Alternative. No training or testing activities would take place in a nonattainment area.

Under Alternative 2, two activities could occur in a maintenance area. The Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercise would occur once per year. While the location for this exercise would vary from year to year, it could occur in Puget Sound within Snohomish or King County; these counties are designated as air quality maintenance areas for O_3 and CO. Also, Naval Station Everett is one possible location for the small boat attack exercise. Consisting of several hours each of helicopter, combatant surface vessel, and small boat activity, total air pollutant emissions from these training activities would clearly be well below the *de minimis* thresholds for O_3 precursors and CO. The General Conformity Rule, therefore, is satisfied under Alternative 2. Representative air pollutant emissions calculations and a Record of Non-Applicability are provided in Appendix D.

3.2.3.1.3.4 Summary – Alternative 2

Criteria air pollutant emissions under Alternative 2 are summarized in Table 3.2-11. Under Alternative 2, the annual numbers of Navy training and testing activities in the Study Area would increase relative to the No Action Alternative. Total emissions of criteria pollutants would decrease slightly, due to minor changes in the numbers of several training activities. Criteria air pollutants emitted in the Study Area could be transported ashore but would not affect the attainment status of the relevant air quality control regions. The amounts of air pollutants emitted in the Study Area and subsequently transported ashore would be minimal because (1) emissions from Navy training and testing activities would be small compared to the amounts of air pollutants emitted by sources ashore, (2) the air pollutants would be emitted over a large area, (3) the distances the air pollutants would be transported are often large, and (4) the pollutants would be substantially dispersed during transport. The criteria air pollutants emitted over nonterritorial waters within the Study Area would be dispersed over vast areas of open ocean and thus would not cause significant harm to environmental resources in those areas.

Table 3.2-11: Estimated Annual Criteria Air Pollutant Emissions in Northwest Training and Testing Study Area, Alternative 2

Source	Emissions by Air Pollutant (tons per year)						
	CO	**NO_X**	**VOC**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**	**Total**
Training activities	173.0	123.2	15.6	32.4	8.2	8.2	352.4
Testing activities	27.7	13.8	1.7	3.0	0.6	0.6	46.8
Total Study Area	**200.7**	**137.0**	**17.3**	**35.4**	**8.8**	**8.8**	**399.2**
No Action Alternative	**401.4**	**274.0**	**34.6**	**70.8**	**17.6**	**17.6**	**798.4**
Net change (tons per year)	5.3	-1.4	0.1	-0.7	-8.7	-8.7	-399.2
Net change (%)	2.7	-1.0	0.6	-1.9	-50	-50	-50.0

Notes: (1) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, VOC = volatile organic compounds. (2) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. Only air pollutants emitted below 3,000 feet above ground level are included in the analysis. $PM_{2.5}$ is included in PM_{10}.

3.2.3.2 Hazardous Air Pollutants

3.2.3.2.1 No Action Alternative

The USEPA has designated 188 substances as hazardous air pollutants under Title III (Hazardous Air Pollutants), Section 112(g) of the CAA. Hazardous air pollutants are emitted by several processes associated with Navy training and testing activities, including fuel combustion. Trace amounts of hazardous air pollutants are emitted by combustion sources participating in training and testing activities, including aircraft, vessels, targets, and munitions. The amounts of hazardous air pollutants emitted are small compared to the emissions of criteria pollutants; emission factors for most hazardous air pollutants from combustion sources are roughly three or more orders of magnitude lower than emission factors for criteria pollutants (California Air Resources Board 2007). Emissions of hazardous air pollutants from munitions use are smaller still, with emission factors ranging from roughly 10^{-5} to 10^{-15} pounds (lb.) of individual hazardous air pollutants per item for cartridges to 10^{-4} to 10^{-13} lb. of individual hazardous air pollutants per item for mines and smoke cartridges (U.S. Environmental Protection Agency 2009a). As an example, 10^{-4} is equivalent to 0.0001 and 10^{-14} is equivalent to 0.00000000000001. To generate 1 lb. of hazardous air pollutants would require the expenditure of 10,000–10 trillion lb. of munitions.

3.2.3.2.1.1 Training

Human health would not be impacted by training emissions of hazardous air pollutants in the Study Area under the No Action Alternative because (1) hazardous air pollutant emissions from training activities would be released to the environment in a remote area (the ocean) with few existing sources of air pollutants, (2) hazardous air pollutant emissions of training activities would be distributed over the entire Study Area and rapidly dispersed over a large ocean area where few individuals would be exposed to them, and (3) hazardous air pollutant emissions from training activities would be diluted through mixing in the atmosphere to a much lower ambient concentration. Residual hazardous air pollutant impacts when training is not being conducted would not be detectable. Therefore, hazardous air pollutant emissions from training for the Proposed Action will not be quantitatively estimated in this EIS/OEIS.

3.2.3.2.1.2 Testing

Human health would not be impacted by testing emissions of hazardous air pollutants in the Study Area under the No Action Alternative because (1) hazardous air pollutant emissions from testing activities would be released to the environment in a remote area (the ocean) with few existing sources of air pollutants, (2) hazardous air pollutant emissions of testing activities would be distributed over the entire Study Area and rapidly dispersed over a large ocean area where few individuals would be exposed to them, and (3) hazardous air pollutant emissions from testing activities would be diluted through mixing in the atmosphere to a much lower ambient concentration. Residual hazardous air pollutant impacts when testing is not being conducted would not be detectable. Therefore, hazardous air pollutant emissions from testing for the Proposed Action will not be quantitatively estimated in this EIS/OEIS.

3.2.3.2.2 Alternative 1

3.2.3.2.2.1 Training

Trace amounts of hazardous air pollutants would be emitted from sources participating in Alternative 1 training activities, including aircraft, vessels, targets, and munitions. Hazardous air pollutant emissions would increase under Alternative 1 relative to emissions under the No Action Alternative. As noted for the No Action Alternative in Section 3.2.3.2.1 (No Action Alternative), hazardous air pollutant emissions are not quantitatively estimated, but the change in emissions of hazardous air pollutants under Alternative 1 would be roughly proportional to the change in emissions of criteria air pollutants. Therefore, the amounts that would be emitted as a result of Alternative 1 activities would be somewhat greater than those emitted under the No Action Alternative but would remain very small compared to the emissions of criteria air pollutants. The potential health impacts of training-related hazardous air pollutant emissions under Alternative 1 would be the same as those discussed under the No Action Alternative.

3.2.3.2.2.2 Testing

Trace amounts of hazardous air pollutants would be emitted from sources participating in Alternative 1 testing activities, including aircraft, vessels, targets, and munitions. Hazardous air pollutant emissions would increase under Alternative 1 relative to emissions under the No Action Alternative. As noted for the No Action Alternative in Section 3.2.3.2.1 (No Action Alternative), hazardous air pollutant emissions are not quantitatively estimated, but the change in emissions of hazardous air pollutants under Alternative 1 would be roughly proportional to the change in emissions of criteria air pollutants. Therefore, the amounts that would be emitted as a result of Alternative 1 testing activities would be somewhat greater than those emitted under the No Action Alternative but would remain very small compared to the emissions of criteria air pollutants. The potential health impacts of testing-related hazardous air pollutant emissions under Alternative 1 would be the same as those discussed under the No Action Alternative.

3.2.3.2.3 Alternative 2

3.2.3.2.3.1 Training

The amounts and distribution of training-related hazardous air pollutants emitted under Alternative 2 would be similar to those described under Alternative 1. The only difference is that the maritime homeland defense exercise would occur once per year. The potential health impacts of training-related hazardous air pollutants emitted under Alternative 2 would be the same as those discussed under the No Action Alternative.

3.2.3.2.3.2 Testing

The amounts and distribution of testing-related hazardous air pollutants emitted under Alternative 2 would be similar to those described under Alternative 1. The potential health impacts of testing-related hazardous air pollutants emitted under Alternative 2 would be the same as those discussed under the No Action Alternative.

3.2.3.3 Summary of Potential Impacts (Combined Impacts of All Stressors) on Air Quality

3.2.3.3.1 No Action Alternative

As discussed in Sections 3.2.3.1 (Criteria Air Pollutants) and 3.2.3.2 (Hazardous Air Pollutants), emissions associated with Study Area training and testing primarily occur offshore, with 90 percent of emissions occurring 12 nm or more from shore. Fixed-wing aircraft emissions typically occur above the 3,000 ft. (914 m) mixing layer. Even though these stressors can co-occur in time and space, atmospheric dispersion would ensure that the impacts would be short term. Changes in criteria and hazardous air pollutant emissions are not expected to be detectable, so air quality is expected to fully recover before a subsequent activity. For these reasons, impacts on air quality from combinations of these resource stressors are expected to be similar to the impacts on air quality for any stressor taken individually, with no additive, synergistic, or antagonistic interactions.

3.2.3.3.2 Alternative 1

As discussed in Sections 3.2.3.1 (Criteria Air Pollutants) and 3.2.3.2 (Hazardous Air Pollutants), emissions associated with Study Area training and testing under Alternative 1 primarily occur offshore, with 90 percent of emissions occurring at least 12 nm offshore. Fixed-wing aircraft emissions typically occur above the 3,000 ft. (914 m) mixing layer. Even though these stressors can co-occur in time and space, atmospheric dispersion would ensure that the impacts would be short term. Air quality is expected to fully recover before a subsequent activity. For these reasons, the impacts on air quality from combinations of these resource stressors are expected to be similar to the impacts on air quality for any stressor taken individually, with no additive, synergistic, or antagonistic interactions. Emissions of most criteria pollutants and hazardous air pollutants are expected to increase under Alternative 1.

3.2.3.3.3 Alternative 2

As discussed in Sections 3.2.3.1 (Criteria Air Pollutants) and 3.2.3.2 (Hazardous Air Pollutants), emissions associated with Study Area training and testing under Alternative 2 primarily would occur at least 12 nm offshore. Fixed-wing aircraft emissions typically occur above the 3,000 ft. (914 m) mixing layer. Even though these stressors can co-occur in time and space, atmospheric dispersion would ensure that the impacts would be short term. Air quality is expected to fully recover before a subsequent activity. For these reasons, impacts on air quality from combinations of these resource stressors are expected to be similar to the impacts on air quality for any stressor taken individually, with no additive, synergistic, or antagonistic interactions. Emissions of most criteria pollutants and hazardous air pollutants are expected to increase under Alternative 2.

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3.3 Marine Habitats

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3.3 MARINE HABITATS

MARINE HABITATS SYNOPSIS

The United States Department of the Navy considered all potential stressors and the following have been analyzed for marine habitats as a substrate for biological communities:

- Acoustic (impulse sound sources – underwater explosions)
- Physical disturbance (vessel and in-water device strikes, military expended materials, and seafloor devices)

Preferred Alternative (Alternative 1)

- Acoustics: Most of the high-explosive military expended materials would detonate at or near the water surface. Only bottom-laid explosives could affect bottom substrate and, therefore, marine habitats. Habitat utilized for underwater detonations would primarily be soft-bottom sediment. The surface area of bottom substrate affected would be a fraction of the total training area available in the Northwest Training and Testing Study Area (Study Area).
- Physical Disturbance and Strike: Items entering the ocean would not be expected to affect marine habitats because of the nature of high-energy surf in the Offshore Area, and shifting sands in the Offshore Area, Inland Waters, and the Western Behm Canal. Once on the seafloor, larger military expended material would be colonized by benthic organisms because these materials would be anchor points in the shifting bottom substrates. Smaller military expended materials would be incorporated into the bottom substrates. The surface area of bottom substrate affected would be a fraction of the total training and testing area available in the Study Area.
- Pursuant to the Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom, military expended materials, and seafloor devices during training and testing activities may have an adverse effect on Essential Fish Habitat by reducing the quality and quantity of non-living substrates that constitute Essential Fish Habitat and Habitat Areas of Particular Concern. Essential Fish Habitat conclusions for associated marine vegetation and sedentary invertebrates are summarized in corresponding resource sections (e.g., marine vegetation, invertebrates). Impacts to the water column defined as Essential Fish Habitat are summarized in corresponding resource sections (e.g., invertebrates, fish) because they are impacts on the organisms themselves.

3.3.1 INTRODUCTION AND METHODS

This section analyzes potential impacts on marine nonliving (abiotic) habitats found in the Northwest Training and Testing Study Area (Study Area). The Study Area covers a range of marine habitats, each supporting communities of organisms that vary by season and location. The intent of this chapter is to cover abiotic habitat features that were not addressed in the individual biological resource sections (e.g., disturbance of bottom substrate). The water column and bottom substrate provide the necessary habitats for living resources that form biotic habitats (e.g., aquatic beds and attached invertebrates [discussed in Section 3.7, Marine Vegetation], and attached structure forming invertebrates [discussed in Section 3.8, Marine Invertebrates]).

Table 3.3-1 lists the types of habitats that will be discussed in this section in relation to the open-ocean areas, and bays and estuaries in which they occur. Habitat types are derived from the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979). Habitat types and subtypes presented in Table 3.3-1 represent the optimum grouping of habitats, based on similar stressor responses to locations within the aquatic environment (i.e., depth, illumination, waves, and currents) and remote detection signatures for mapping.

Description and distribution information for the water column itself are not provided here because it is unaltered by the physical and acoustic impacts of naval training and testing activities. Impacts to the water column are further analyzed in Section 3.1 (Sediments and Water Quality).

Table 3.3-1: Habitat Types within the Northwest Training and Testing Study Area

Habitat Type	Subtype	Offshore	Inland Waters	Western Behm Canal (Alaska)
Soft Shores[1]	Beach	✓	✓	-
	Tidal Delta/Flat	-	✓	-
Hard Shores[1]	Rocky Intertidal	-	✓	-
	Biotic/Reef	Refer to "Marine Invertebrates" (Section 3.8)		
Vegetated Shores[2]	Salt/Brackish Marsh, Mangrove	Refer to "Marine Vegetation" (Section 3.7)		
Aquatic Beds[2]	Sargassum, Seagrass, Macroalgae			
Soft Bottom[1]	Channel, Flat, Shoal	✓	✓	✓
Hard Bottoms[1]	Seamount	✓	-	✓
	Shelves	✓	-	✓
	Banks	✓	-	✓
	Breaks	✓	-	✓
	Slopes	✓	-	✓
	Canyons	✓	-	✓
	Plains	✓	-	✓
	Hydrothermal vents	✓	-	-
	Rock Reef	✓	✓	✓
	Biotic Reef	Refer to "Marine Invertebrates" (Section 3.8)		
Artificial Structures[1]	Artificial reefs, ship wrecks, oil/gas platforms	✓	✓	✓

[1] See Section 3.8 (Marine Invertebrates) for living habitat component assessment.
[2] See Section 3.7 (Marine Vegetation) for living habitat component assessment.

The rationale for evaluating the impact of stressors on marine habitats differs from the rationale applied to other biological resources. Unlike organisms, habitats are evaluated based on their function, which is largely based on their structural components and ability to support a variety of marine organisms.

Accordingly, the assessment focuses on the ability of substrates to function as habitats. An impact on abiotic marine habitat is anticipated where training or testing could convert one substrate type into another (i.e., bedrock or consolidated limestone converted to unconsolidated soft bottom, or a marked reduction of vertical relief or physical complexity of the habitat). Whereas the impacts on the biotic growth (i.e., vegetation and algae) are covered in their respective resource sections, the impacts on bottom marine habitats itself are considered here.

3.3.2 AFFECTED ENVIRONMENT

Navy activities primarily occur in or over the water column, and most are not designed to interact with marine habitats directly. Relatively little of the Study Area includes intertidal and shallow subtidal areas in state waters, where numerous habitats are exclusively present (i.e., salt/brackish marsh, seagrass beds, kelp forests, rocky reefs). Intertidal abiotic habitats (i.e., beaches, tidal deltas, mudflats, rocky shores) are addressed only where intersections with naval training and testing activities are reasonably likely to occur. The distribution of abiotic marine habitats among the biogeographic units and systems (i.e., estuaries, coastal ocean) is described in their respective sections, and is generalized to system and biogeographic region in Table 3.3-1. All categories (Offshore, Inland Waters, Western Behm Canal [Alaska]) within Table 3.3-1 marked with a (-) will not be further explained in each subsection, since the type of habitat denoted is not present in that portion of the Study Area.

Abiotic marine habitats vary according to geographic location, underlying geology, hydrodynamics, atmospheric conditions, and suspended particles. Flows and sediments from creeks and rivers create channels, tidal deltas, intertidal and subtidal flats, and shoals of unconsolidated material along the shorelines and estuaries. The influence of land-based sediment from point sources increases with proximity to nearshore and inland waters. A patchwork of diverse habitats exists on the open ocean floor, where there is no sunlight, low nutrient levels, and minimal sediment movement (Levinton 2009). Major bottom features in offshore biogeographic units include shelves, banks, breaks, slopes, canyons, plains, and seamounts (see Table 3.3-1). Geologic features such as these affect the hydrodynamics of the ocean water column (i.e., currents, gyres, upwellings) as well as the biological resources present (Roden 1987). Cyclonic circulation, enhanced mixing, and increased productivity are found in submarine canyons and can result in high zooplankton production following a period of upwelling (Kenney and Winn 1987).

Estuarine and ocean environments worldwide are under increasing pressure from human development and expansion, accompanied by increased ship traffic, pollution, invasive species, destructive fishing practices (e.g., overfishing, trawling), vertical shoreline stabilization, offshore energy infrastructure, and global climate change (Boehlert and Gill 2010; Crain et al. 2009; Lotze et al. 2006; Koslow et al. 2000; Pandolfi et al. 2003). The stressors associated with these activities are distributed in concentrated areas across a variety of habitat types and ecosystems (Halpern et al. 2008). Areas where heavy concentrations of human activity co-occur with naval training and testing activities have the greatest potential for cumulative stress on the marine habitat (Chapter 4, Cumulative Impacts). Refer to individual biological resource sections in Chapter 3 for specific stressors and impacts.

3.3.2.1 Soft Shores

Soft shores include all wetland habitats having three characteristics: (1) unconsolidated substrates with less than 75 percent areal coverage of stones, boulders, or bedrock; (2) less than 30 percent areal coverage of vegetation other than pioneering plants; and (3) any of the following water regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded (Cowardin et al. 1979). Soft shores also include beaches, tidal flats and deltas, and stream beds of the tidal riverine and estuarine systems.

Intermittent or intertidal channels of the Riverine System and intertidal channels of the Estuarine System are classified as Streambed (Cowardin et al. 1979). Intertidal flats, also known as tidal flats or mudflats, consist of loose mud, silt, and fine sand with organic-mineral mixtures that are regularly exposed and flooded by the tides (Karleskint et al. 2006). Muddy fine sediment is deposited in sheltered inlets and estuaries where wave energy is low (Holland and Elmore 2008). Mudflats are typically unvegetated, but may be covered with mats of green algae and benthic diatoms (single-celled algae). The muddy intertidal habitat occurs most often as part of a patchwork of intertidal habitats that may include rocky shores, tidal creeks, sandy beaches, and salt marshes.

Beaches form through the interaction of waves, tides, and alongshore currents as particles are sorted by size and deposited along the shoreline (Karleskint et al. 2006). Wide flat beaches with fine-grained sands occur where wave energy is limited. Narrow steep beaches of coarser sand form where energy and tidal ranges are high (Speybroeck et al. 2008). Three zones characterize beach habitats: (1) dry areas above the mean high water, (2) wrack line (line of organic debris left on the beach by the action of tides) at the mean high water mark, and (3) a high-energy intertidal zone. Refer to biological resources sections (3.4, Marine Mammals; 3.6, Birds; 3.7, Marine Vegetation; 3.8, Marine Invertebrates; and 3.9, Fish) for more information on species use of tidal deltas, intertidal flats, or beaches.

3.3.2.1.1 Offshore Area

Much of the Offshore Area is not located near the shoreline and is beyond the Territorial sea. The Study Area does not reach the shoreline in the majority of the offshore portion of the Study Area; furthermore, activities are proposed on the shoreline only along a 1-mile portion of the Quinault Range Site where it extends onto the shore at Pacific Beach (see Figure 2.1-2). This area in the Offshore Area is comprised of sand beaches (Figure 3.3-1).

3.3.2.1.2 Inland Waters

Tidal flats occur on a variety of scales in virtually all estuaries and bays in the Study Area (Figure 3.3-1). Puget Sound is a fjord-like estuary that was formed by tectonic activity, glacial advance and retreat, erosion, and deposition. Soft sediment covers a large portion of the Puget Sound with sand and mud prevailing in the eastern regions (Palsson et al. 2003).

3.3.2.1.3 Western Behm Canal, Alaska

In the Western Behm Canal portion of the Study Area, the seafloor or near subsurface consists of soft sediment such as shells, gravel, sand, clay, silt, and other post-glacial sediment (U.S. Department of the Navy 1988). Sand is also found along the beaches that line the coastline of Alaska. Cobble beaches also exist in very high energy environments in the Western Behm Canal portion of the Study Area.

3.3.2.2 Hard Shores

Rocky Shores include aquatic environments characterized by bedrock, stones, or boulders that, singly or in combination, cover 75 percent or more of the substrate and where vegetation covers less than 30 percent (Cowardin et al. 1979). Water regimes (the prevailing pattern of water flow over a given time) are restricted to irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, and intermittently flooded. Rocky intertidal shores are areas of bedrock that alternate between periods of submergence and exposure to air, depending on whether the tide is high or low. Extensive rocky shorelines can be interspersed with sandy areas, estuaries, or river mouths.

Environmental gradients between hard shorelines and subtidal habitats are determined by wave action, depth and frequency of tidal inundation, and stability of substrate (Cowardin et al. 1979). Where wave energy is extreme, only rock outcrops may persist. In lower energy areas, a mixture of rock sizes will form the intertidal zone (Cowardin et al. 1979). Boulders scattered in the intertidal and subtidal areas provide substrate for attached macroalgae and sessile invertebrates. Refer to biological resources sections (3.4, Marine Mammals; 3.6; Birds; 3.7, Marine Vegetation; 3.8, Marine Invertebrates; and 3.9, Fish) for more information on species inhabiting hard shorelines.

3.3.2.2.1 Inland Waters

The shores of Vancouver Island and the complex formation of the Gulf Islands in the Puget Sound have prominent slopes composed of bedrock and boulders (Palsson et al. 2003). The rest of the Puget Sound is predominantly soft-bottomed (Figure 3.3-1 and Figure 3.3-2).

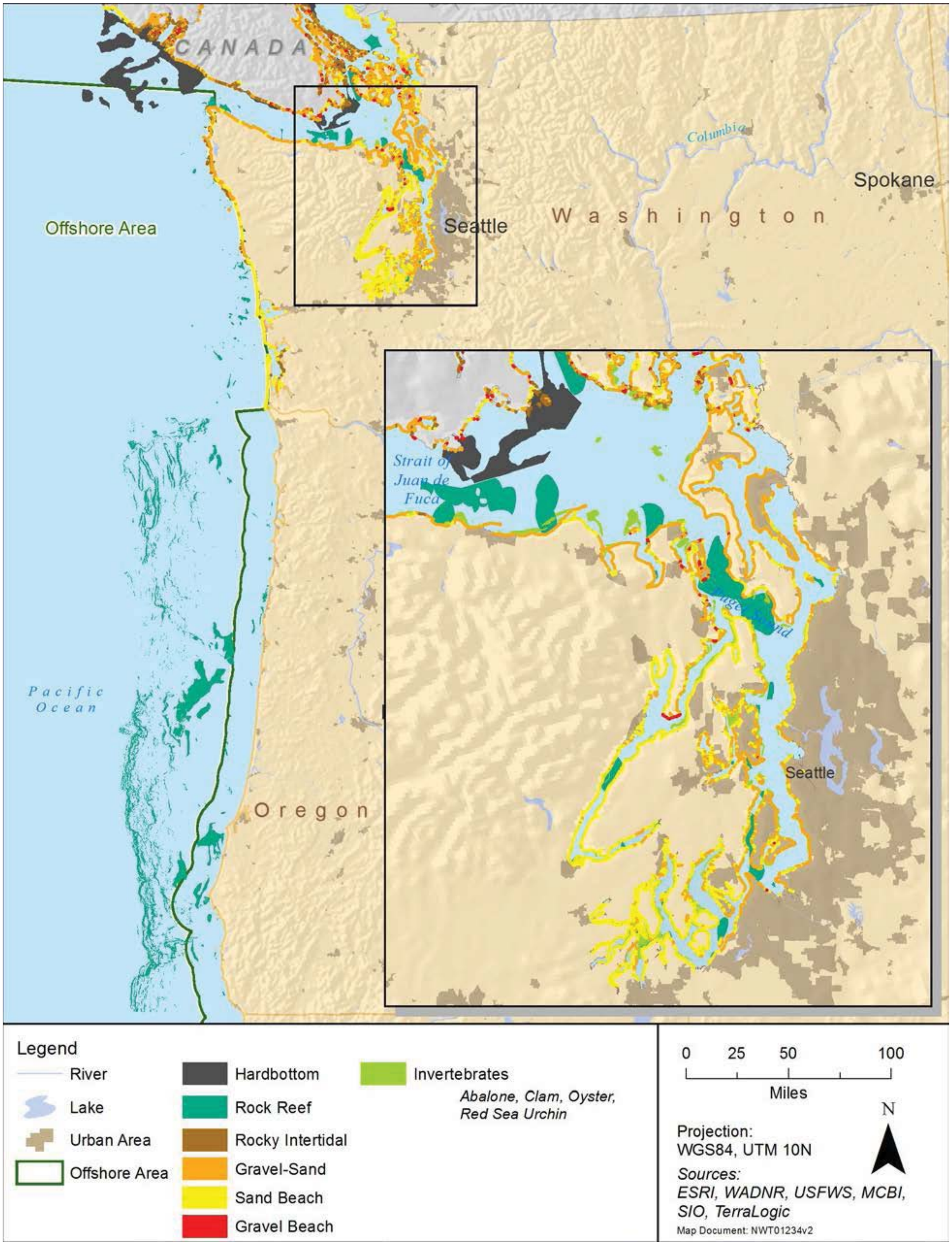

Figure 3.3-1: Marine Habitats in the Inland Waters of the Northwest Training and Testing Study Area

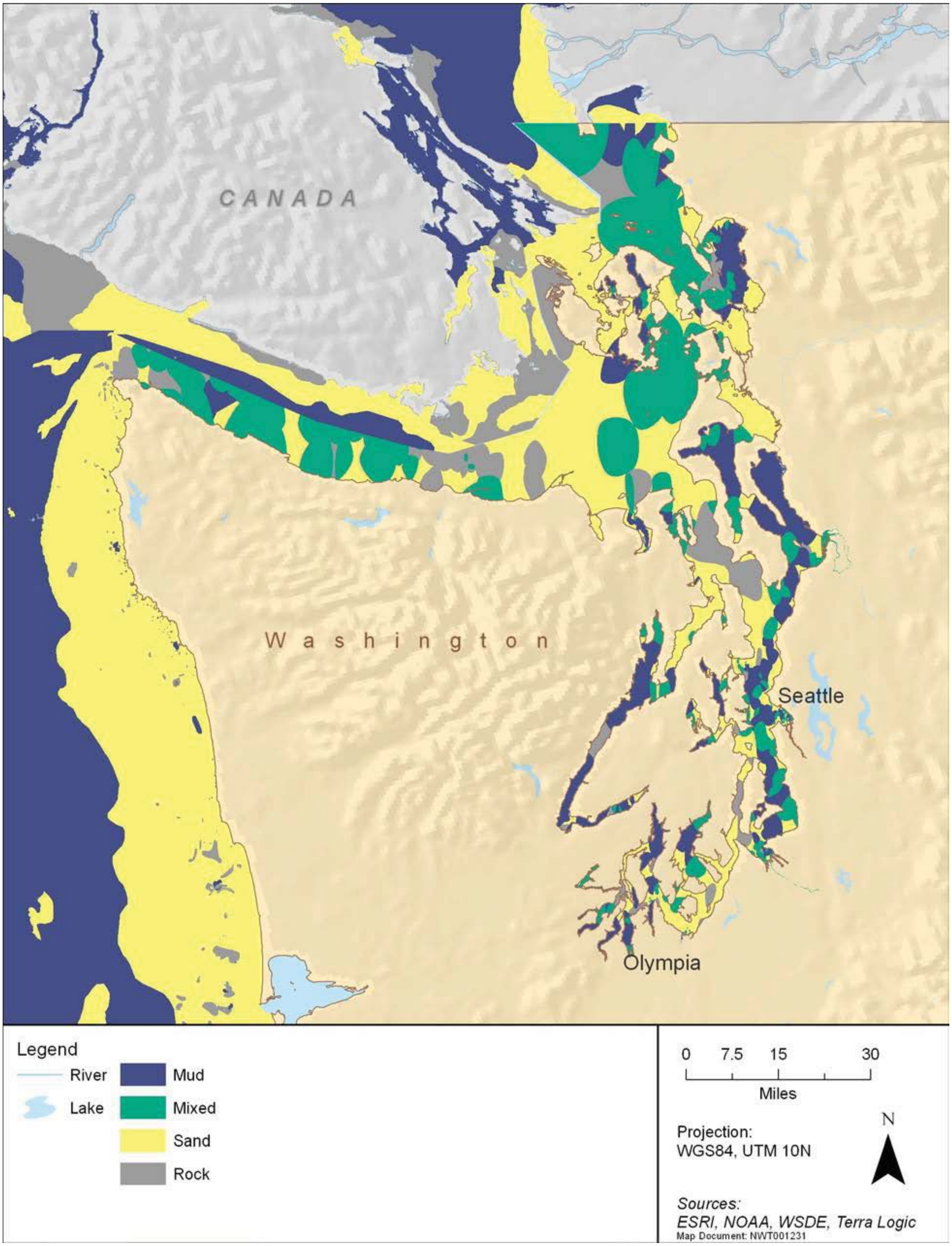

Figure 3.3-2: Bottom Substrates of the Inland Waters of the Northwest Training and Testing Study Area

3.3.2.2.2 Western Behm Canal, Alaska

Although the sediment in the Western Behm Canal is variable across the seafloor, generally sediments range from soft sediments to hard exposed bedrock (U.S. Department of the Navy 1988).

3.3.2.3 Vegetated Shores

Vegetated shorelines are characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens that grow above the water line (Cowardin et al. 1979). This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. All water regimes are included except subtidal and irregularly exposed. Vegetated shorelines in the Study Area are formed by salt marsh plant species. Salt marsh plants are living marine resources and biotic habitat which dominate the intertidal zone, and are therefore not covered in this chapter. Refer to Section 3.7 (Marine Vegetation) for information on salt marsh plant species.

3.3.2.4 Aquatic Beds

Aquatic beds include wetlands and permanently submerged habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years (Cowardin et al. 1979). Water regimes include subtidal, irregularly exposed, regularly flooded, permanently flooded, intermittently exposed, semi-permanently flooded, and seasonally flooded. Seagrasses, attached macroalgae (e.g., kelp), and floating macroalgae (e.g., Sargassum) are living marine resources and biotic habitats which dominate the intertidal or shallow subtidal zone and are therefore not covered in this chapter. Refer to Section 3.7 (Marine Vegetation) for information on seagrass and macroalgae species and to 3.8 (Marine Invertebrates) and 3.9 (Fish) for the species that utilize this biotic habitat.

3.3.2.5 Soft Bottom

Soft bottoms include all wetland and deepwater habitats with at least 25 percent cover of particles smaller than stones, and a vegetative coverage less than 30 percent (Cowardin et al. 1979). Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semi-permanently flooded. Soft bottom forms the substrate of channels, shoals, and subtidal flats. Sandy channels emerge where strong currents connect estuarine and ocean water columns. Shoals form where sand is deposited along converging, sediment-laden currents forming capes. Subtidal flats occur between the soft shores and channels or shoals. Unconsolidated sediments do not remain in place and are frequently shifted through the actions of tides, currents, and storms.

The continental shelf extends seaward of the shoals and inlet channels, and includes an abundance of coarse-grained, soft-bottom habitats. Finer-grained sediments collect off the shelf break, continental slope, and abyssal plain. These areas are inhabited by soft-sediment communities of mobile invertebrates fueled by benthic algae production, chemosynthetic microorganisms, and detritus drifting through the water column. Refer to biological resources sections (3.7, Marine Vegetation; 3.8, Marine Invertebrates; and 3.9, Fish) for more information on species use of soft-bottom habitats.

3.3.2.5.1 Offshore Area

In the Offshore Area, the soft-bottom habitat is located in the Cascadia abyssal plain (Figure 3.3-3). This is a nearly flat area that begins approximately 375 nautical miles (nm) off the west coast that extends to the Juan de Fuca Ridge. Abyssal plains can be described as large and relatively flat regions covered in a thick layer of fine silty sediments with the topography interrupted by occasional mounds and seamounts (Kennett 1982, Thurman 1997).

Figure 3.3-3: Bottom Substrates in the Offshore Area of the Northwest Training and Testing Study Area

The abyssal plain and similar deepwater areas were originally thought to be characterized by depauperate (underdeveloped) biological communities; however, recent research has shown that these areas are host to thousands of species of invertebrates and fish (Beaulieu 2001a, 2001b; O'Dor 2003). Refer to biological resources sections (3.8, Marine Invertebrates; and 3.9, Fish) for more information on species inhabiting the abyssal plain.

3.3.2.5.2 Inland Waters

In the near shore portions of the Study Area in Puget Sound, there are soft bottoms including wetlands, mud flats, and sandy bottoms (see Figure 3.3-2). Most of these habitats are important for birds, marine vegetation, fish, and invertebrate species, which are further discussed in Section 3.6 (Birds), Section 3.7 (Marine Vegetation), and Section 3.8 (Marine Invertebrates).

3.3.2.5.3 Western Behm Canal, Alaska

In the near shore portions of the Study Area in the Western Behm Canal, there are soft bottoms including wetlands, mud flats, and sandy bottoms. Most of these habitats are important for bird species, invertebrate species, and fish species, and are further discussed in Section 3.6 (Birds), Section 3.8 (Marine Invertebrates), and Section 3.9 (Fish).

3.3.2.6 Hard Bottoms

Hard-bottom habitat includes both biogenic reefs and rocky bottoms sometimes covered by a thin veneer of living and dead sedentary invertebrates, as well as algae. Biogenic reefs include ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates (Cowardin et al. 1979). Water regimes are restricted to subtidal, irregularly exposed, regularly flooded, and irregularly flooded. Deep-sea corals form reefs that are living marine resources and biotic habitats, and are covered in Section 3.8 (Marine Invertebrates). “Rock Bottom” includes all wetlands and deepwater habitats with substrates having a surface of stones, boulders, or bedrock (75 percent or greater coverage) and vegetative coverage of less than 30 percent (Cowardin et al. 1979). Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semi-permanently flooded.

Subtidal rocky bottom occurs as extensions of intertidal rocky shores and as isolated offshore outcrops. The shapes and textures of the larger rock assemblages and the fine details of cracks and crevices are determined by the type of rock, the wave energy, and other local variables (Davis 2009). Maintenance of rocky reefs requires wave energy sufficient to sweep sediment away (Lalli 1993) or offshore areas lacking a significant sediment supply; therefore, rocky reefs are rare on deeper water of broad coastal plains near sediment-laden rivers and are more common on high-energy shores and beneath strong bottom currents, where sediments cannot accumulate, as occurs on the outer coast of Washington. The shapes of the rocks determine, in part, the type of community that develops on a rocky bottom (Witman and Dayton 2001). Below a depth of about 65.6 feet (ft.) (20.0 meters [m]) on rocky reefs, light is insufficient to support much plant life (Dawes 1998). Rocky reefs in this zone are encrusted with invertebrates, including sponges, sea cucumbers, soft corals, and sea whips, which provide food and shelter for many smaller invertebrates and fish. Refer to biological resource sections (3.7, Marine Vegetation; 3.8, Marine Invertebrates; and 3.9, Fish) for more information on species inhabiting rock bottoms.

3.3.2.6.1 Offshore Area

Shallow hard-bottom habitat is relatively uncommon and patchy in the Study Area (see Figure 3.3-3). Hard bottoms are most common offshore near rocky headlands, along steep shelf areas, and near the shelf break and submarine canyons (Figures 3.3-3, 3.3-4, and 3.3-5). In waters deeper than 100 ft. (30 m) about 3 percent of the bottom consists of hard substrates, including rocky outcroppings, rubble, talus (a slope formed by the accumulation of rock debris), vertical walls, rocky reefs, and seamounts (U.S. Department of the Navy 2006).

Within the Offshore Area, two types of hard-bottom habitat present are seamounts (Figure 3.3-4) and hydrothermal vents. Generally, seamounts tend to be conical in shape and volcanic in origin, although some seamounts are formed by vertical tectonic activity along converging plate margins (Rogers 1994). Seamounts are a striking contrast to the surrounding flat, sediment covered abyssal plain (Rogers 1994). Seamount topography can affect local ocean circulation, resulting in upwelling, which can supply nutrients to surface waters and support a variety of marine life (Genin et al. 1986, Roden 1987, Rogers 1994). These systems may create high relief biotic habitat that is highly subject to disturbance such as fishing activities (Koslow et al. 2000). Hydrothermal vents are geysers that occur on the seafloor. They continuously release hot mineral-rich water that helps to support a diverse community of organisms. Refer to biological resources sections (3.4, Marine Mammals; 3.6, Birds; 3.7, Marine Vegetation; 3.8, Marine Invertebrates; and 3.9, Fish) for more information on species inhabiting seamounts and hydrothermal vents.

3.3.2.6.2 Inland Waters

Shallow hard-bottom communities are relatively uncommon and patchy in the Inland Waters of the Study Area. Although the primary habitat of the Inland Waters is soft bottom, small portions of hard-bottom habitat are present (see Figure 3.3-1 and Figure 3.3-2).

3.3.2.6.3 Western Behm Canal, Alaska

Shallow hard-bottom substrates are relatively uncommon and patchy in the Western Behm Canal portion of the Study Area. Although the primary habitat in this portion of the Study Area is soft bottom, there are small portions of hard-bottom habitat, such as seamounts.

3.3.2.7 Artificial Structures

Artificial habitats are manmade structures that provide habitat for marine organisms. Artificial habitats occur in the marine environment either by design and intended as habitat (e.g., artificial reefs), by design and intended for a function other than habitat (e.g., oil and gas platforms, fish-aggregating devices, floating objects moored at specific locations in the ocean to attract fishes that live in the open ocean), or unintentionally (e.g., shipwrecks). Artificial structures function as hard-bottom substrate by providing structural attachment points for algae and sessile invertebrates, which in turn support a community of animals that feed, seek shelter, and reproduce there (National Oceanic and Atmospheric Administration 2007).

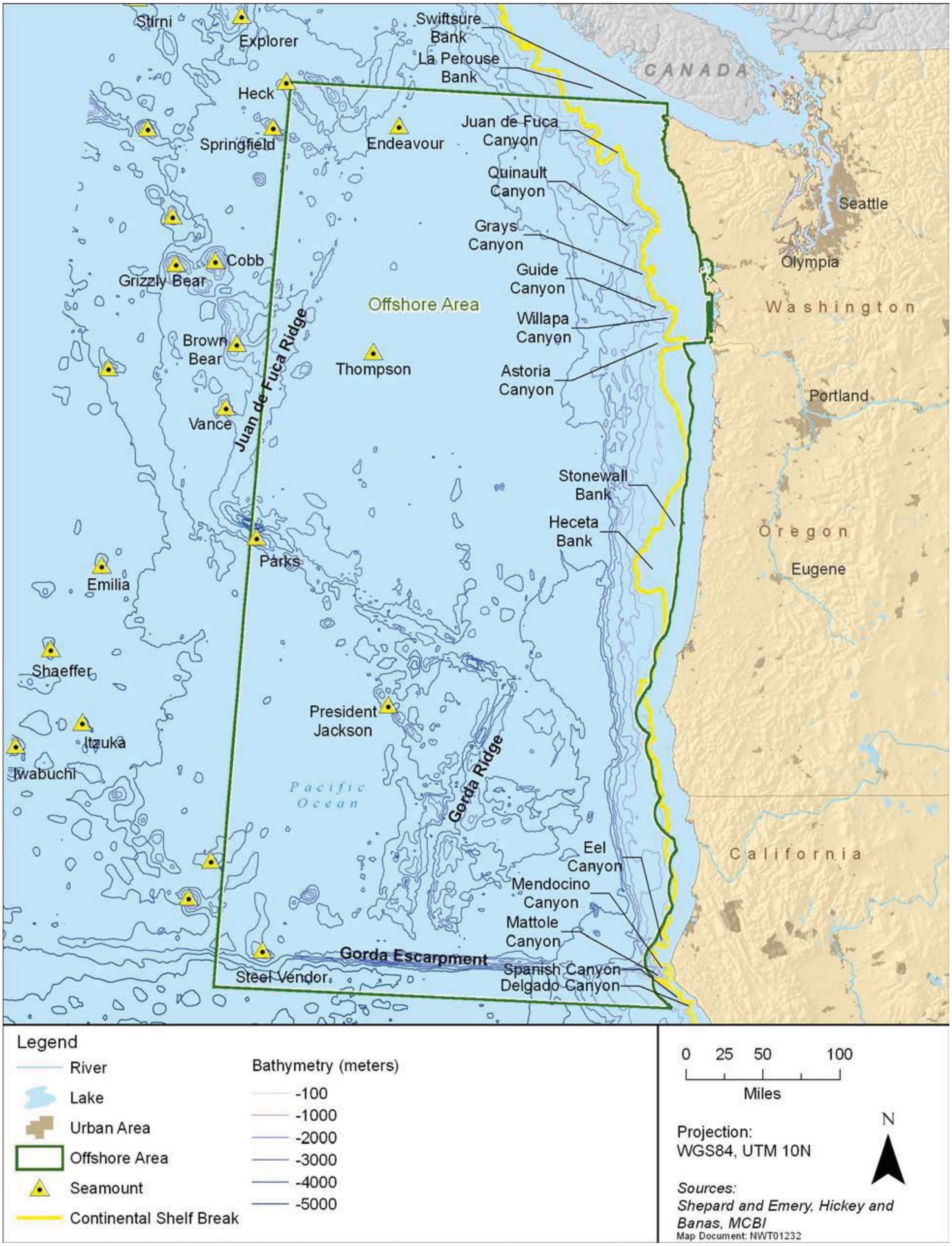

Figure 3.3-4: Topographic Features in the Offshore Area of the Northwest Training and Testing Study Area

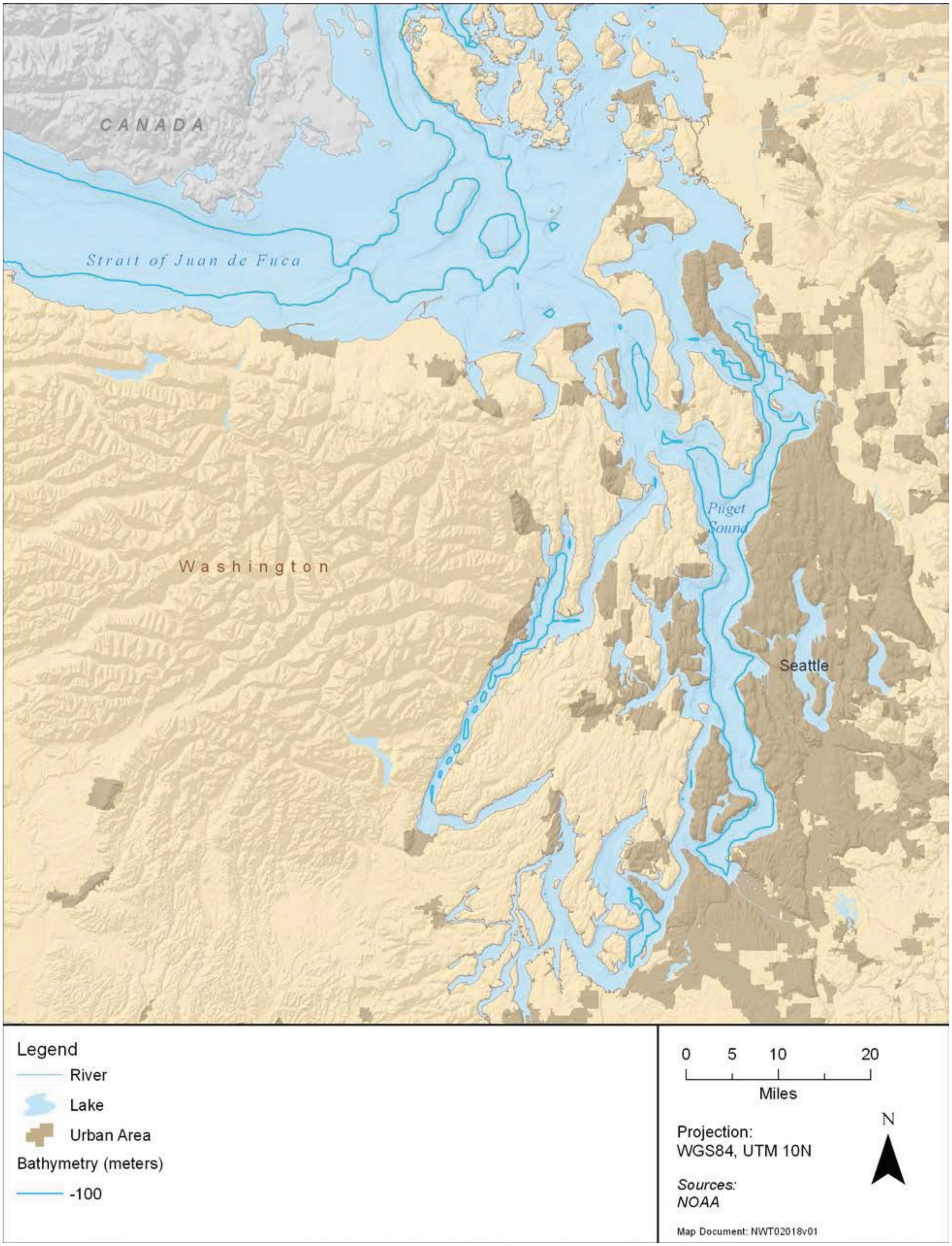

Figure 3.3-5: Topographic Features in the Inland Waters of the Northwest Training and Testing Study Area

3.3.2.7.1 Offshore Area

The stretch of coast between Tillamook Bay in Oregon and Vancouver Island, encompassing the mouth of the Columbia River and the entrance to the Strait of Juan de Fuca has claimed more than 2,000 vessels since 1800 (Wilma 2006). Approximately five shipwrecks have been documented in the vicinity of the Olympic Coast National Marine Sanctuary (Figure 3.3-6); however, due to the destructive forces of wave and current, very few ships remain intact, particularly near the shore. Oregon and Northern California shipwrecks and sinkings are spread out along the coastline sporadically and are not within the Offshore Area.

3.3.2.7.2 Inland Waters

Five artificial reefs are located in the Puget Sound portion of the Study Area, including one in Hood Canal. One of the artificial reefs, located in central Puget Sound approximately 15 miles (24 kilometers) north of Seattle, Washington, is made of tires. The placement of this artificial reef was accomplished between May 1975 and March 1979 as a portion of the Puget Sound Artificial Reef Study and the marine habitat enhancement program of the Washington Department of Fisheries Marine Fish Enhancement Unit (Walton 1982). There are 97 known shipwrecks throughout the Inland Waters (Figure 3.3-7).

3.3.2.7.3 Western Behm Canal, Alaska

In the Western Behm Canal portion of the Study Area there are 61 known shipwrecks (Figure 3.3-8).

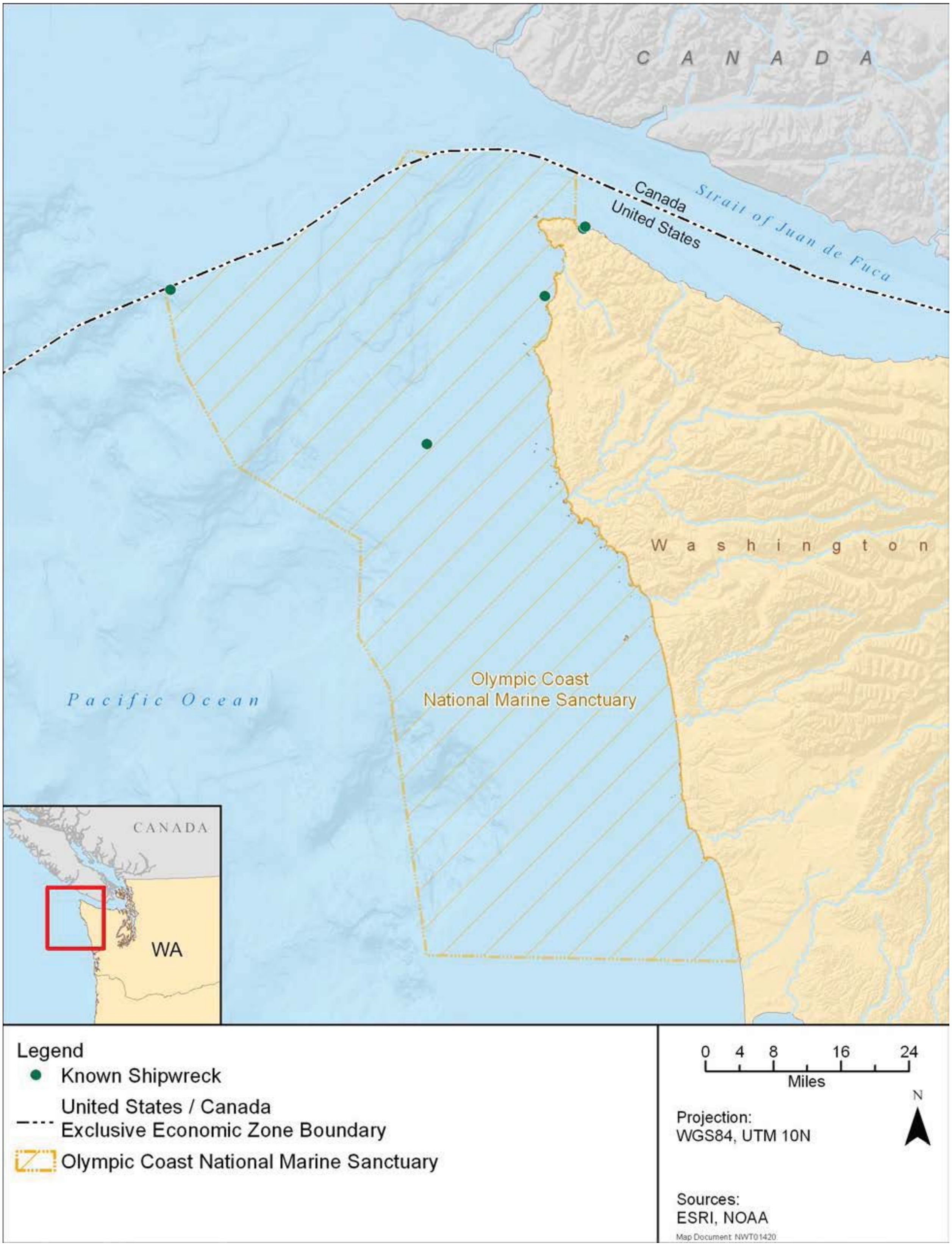

Figure 3.3-6: Shipwrecks in the Washington State Offshore Portion of the Study Area

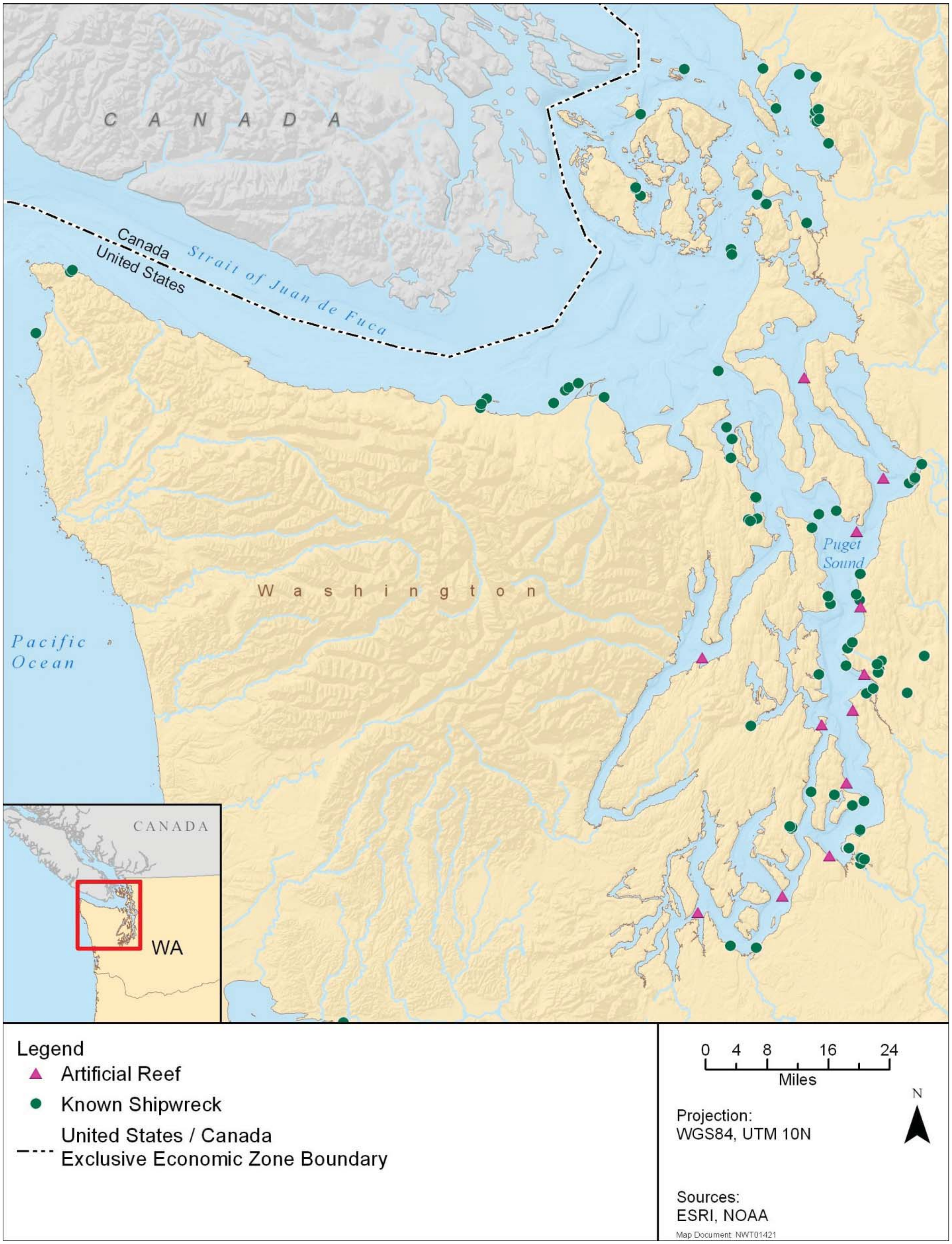

Figure 3.3-7: Shipwrecks and Artificial Reefs in Puget Sound

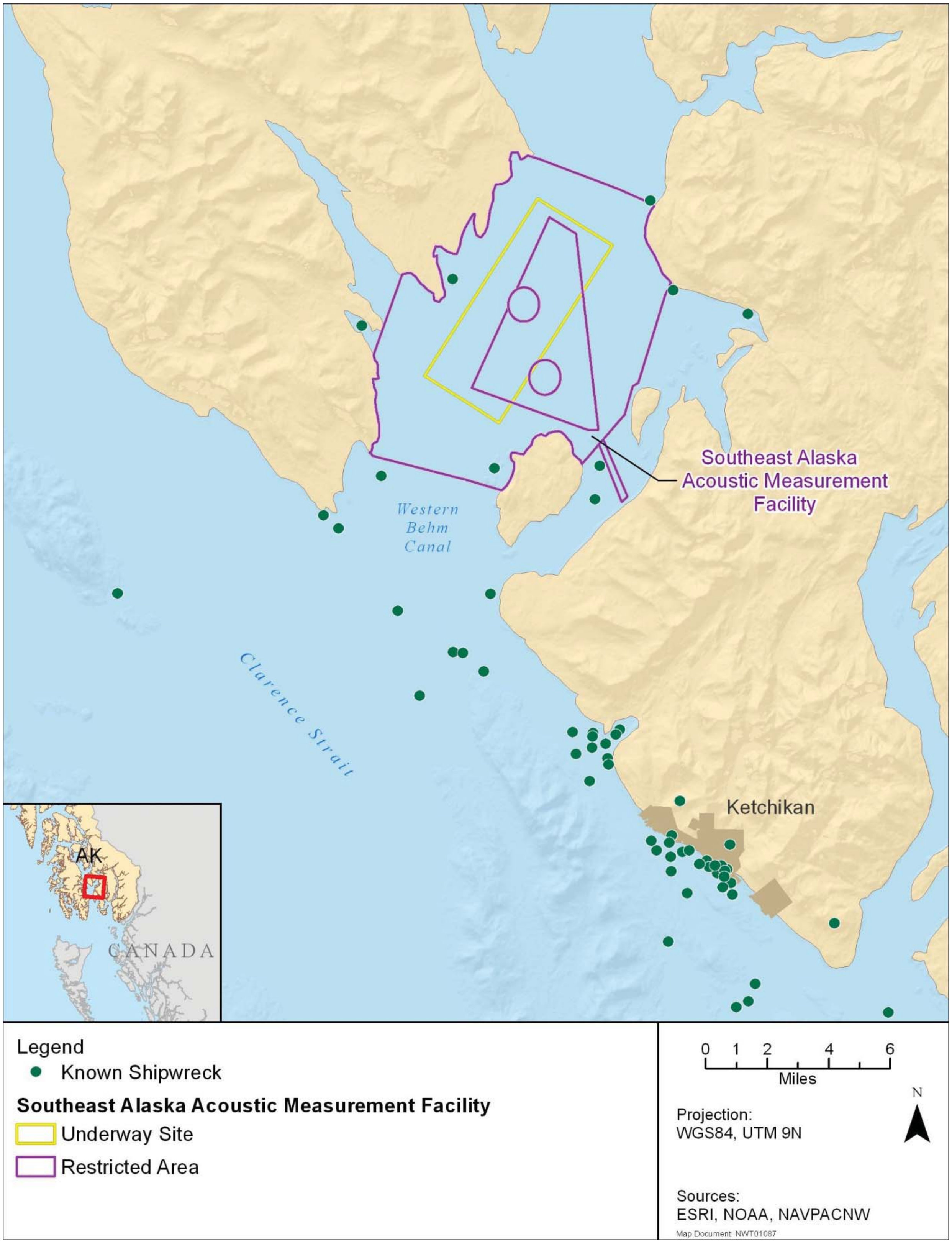

Figure 3.3-8: Shipwrecks in the Western Behm Canal Portion of the Northwest Training and Testing Study Area

3.3.3 ENVIRONMENTAL CONSEQUENCES

This section evaluates how and to what degree training and testing activities described in Chapter 2 (Description of Proposed Action and Alternatives) could impact marine habitats in the Study Area. Tables 2.7-1 through 2.7-6 present the baseline and proposed training and testing activity locations for each alternative (including number of events and ordnance expended). Each marine habitat stressor is introduced, analyzed by alternative, and analyzed for training activities and testing activities. Stressors vary in intensity, frequency, duration, and location within the Study Area (Table 3.3-2). Stressors could alter substrate types or prevent them from providing physical habitat for living resources. The stressors applicable to marine habitats in the Study Area include:

- Acoustic (explosives)
- Physical disturbance and strikes (vessels and in-water devices, military expended materials, and seafloor devices).

Sonar sources do not change the substrate type of the bottom, and energy stressors (electromagnetic devices) do not change the substrate type by their surface orientation and nature. Therefore, sonar sources and energy stressors will not be discussed further in the analysis of impacts on marine 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.

Table 3.3-2: Stressors for Marine Habitats 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							
Underwater 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 vessel movement	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

3.3.3.1 Acoustic Stressors

Of the activities the United States Department of the Navy (Navy) is proposing in which acoustic sources are involved, only those that include the use of underwater explosives have the potential to result in impacts to marine habitats, so only that acoustic stressor will be analyzed.

No training activities with seafloor detonations are proposed in the Offshore Area or Western Behm Canal under any alternative, and no testing activities with seafloor detonations are proposed in any part of the Study Area under any alternative; therefore, only training activities in the Inland Waters portion of the Study Area will be analyzed for impacts from underwater explosives.

3.3.3.1.1 Impacts from Underwater Explosives

This section analyzes the potential impacts of underwater explosions on or near the bottom resulting from training activities within the Study Area. Underwater detonations are primarily used during various mine warfare training activities. The potential impacts of underwater detonations on marine habitats will be assessed according to size of charge (net explosive weight), height above the bottom, substrate types in the area, and equations linking all these factors. The impacts of underwater explosions vary with the bottom substrate type.

Most explosive detonations during training involving the use of high-explosive ordnance, including bombs, missiles, and naval gun shells, would occur in the air or near the water's surface. Explosives associated with torpedoes and explosive sonobuoys would occur in the water column; demolition charges could occur near the surface, in the water column, or the ocean bottom. Most detonations would occur in waters greater than 200 ft. (61 m) in depth, although mine warfare and demolition detonations could occur in shallow water, only in a few specific locations.

3.3.3.1.1.1 No Action Alternative

<u>Training Activities</u>

Inland Waters

Table 3.3-3 lists training activities that include seafloor explosions in the Inland Waters, along with the location of the activity and the associated explosive charges. Primarily soft-bottom habitat would be utilized for underwater detonations. Cobble, rocky reef, and other hard-bottom habitat may be scattered throughout the area, but those areas would be avoided during training to the maximum extent practicable.

Under the No Action Alternative, an estimated four underwater explosions would occur on or near the seafloor within the Inland Waters, as identified in Table 3.3-3. Underwater explosions near the seafloor would occur in the nearshore portions of the Study Area at the underwater training ranges in Crescent Harbor and Hood Canal, which consist mainly of soft-bottom habitats.

Explosions produce high energies that would be partially absorbed and partially reflected by the seafloor. Hard bottoms would mostly reflect the energy (Berglind et al. 2009), whereas a crater would be formed in soft bottom (Gorodilov and Sukhotin 1996). The area and depth of the crater could vary according to depth, bottom composition, and size of the explosive charge. The relationship between crater size and depth of water is non-linear, with relatively small crater sizes in the shallowest water, followed by a spike in size at some intermediate depth, and a decline to an average flat-line at greater depth (Gorodilov and Sukhotin 1996; O'Keeffe and Young 1984).

Table 3.3-3: Training Activities that Include Seafloor Explosions

Activity	Explosive Charge (lb. NEW)	Underwater Detonations by Alternative			Location
		No Action Alternative	Alternative 1	Alternative 2	
Training					
Mine Neutralization (Explosive Ordnance Disposal)	2.5	2	3	3	Crescent Harbor Explosive Ordnance Disposal Training Range
	2.5	0	3	3	Hood Canal Explosive Ordnance Disposal Training Range
	1.5	2	0	0	Hood Canal Explosive Ordnance Disposal Training Range
Shock Wave Action Generator (SWAG)	0.033	0	18	18	Crescent Harbor Explosive Ordnance Disposal Training Range
		0	18	18	Hood Canal Explosive Ordnance Disposal Training Range

Note: lb. = pound(s), NEW = net explosive weight, SWAG = Shock Wave Action Generator

In general, training activities that include seafloor detonations occur in water depths ranging from 6 ft. (2 m) to about 100 ft. (30 m). Based on Gorodilov and Sukhotin (1996), the depth (h) and radius (R) of a crater from an underwater explosion over soft bottom is calculated using the charge radius (r_0)[1] multiplied by a number determined by solving for h or R along a non-linear relationship between [depth of water/r_0] and [h or R/r_0]. For example, a 60-pound (lb.) (27-kilogram) explosive charge (r_0 = 0.16 m) on a sandy bottom would produce a maximum crater size of approximately 31 ft. (9 m) in diameter and 2.6 ft. (0.8 m) deep. The area of the crater on a sandy bottom would be 760 square feet (ft.^{2}) (71 square meters [m^2]). The displaced sand doubles the radius of the crater (O'Keeffe and Young 1984), yielding a crater diameter of 62 ft. (19 m) and an area of 3,060 ft.^{2} (284 m^2) of impacted substrate. The radii of craters are expected to vary little among unconsolidated sediment types. On sediment types with non-adhesive particles (everything except clay), the impacts should be temporary; craters in clay may persist for years (O'Keeffe and Young 1984). The production of craters in soft bottom could uncover subsurface hard-bottom, altering marine substrate types; however, these craters are unlikely to be permanent or cause local community shifts.

Hard substrates reflect more energy from bottom detonations than do soft bottoms (Keevin and Hempen 1997). The amount of consolidated substrate (i.e., bedrock) converted to unconsolidated sediment by surface explosions vary according to material types and degree of consolidation (i.e., rubble, bedrock). Because of a lack of accurate and specific information on hard bottom types, the impacted area is assumed to be equal to the area of soft bottom impacted. Potential exists for fracturing and damage to hard-bottom habitat if underwater detonations occur over that type of habitat.

The total area of disturbed sediment per year in the Inland Waters from detonations from training activities in the Inland Waters would be approximately 313.3 ft.^{2} (29 m^2), or less than 1 percent. Training events that include bottom-laid underwater explosions are infrequent and the percentage of area affected is small. Effects are localized within specific training ranges, so the bottom substrates of disturbed areas would be expected to recover through tidal influences and sediment movement to their previous structure (Gorodilov and Sukhotin 1996), with the exception of hard-bottom areas. However,

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[1] Pounds per cubic inch of TNT (1.64 grams/cubic centimeter) x number of pounds, then solving for radius in the geometry of a spherical volume

soft sediment covers a large portion of the Puget Sound, with sand and mud prevailing in the eastern regions (Palsson et al. 2003).

Therefore, underwater explosions under the No Action Alternative would affect marine habitat structure in the Study Area, but most impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

3.3.3.1.1.2 Alternative 1

Training Activities

Inland Waters

Under Alternative 1, the number of underwater bottom detonations would increase from two 2.5 lb. detonations under the No Action Alternative to three 2.5 lb. detonations at Crescent harbor and from two 1.5 lb. detonations under the No Action Alternative to three 2.5 lb. detonations at Hood Canal. Additionally, 36 shock wave generator underwater detonations would be added for the Inland Waters. Underwater explosions associated with training activities under Alternative 1 would disturb approximately 579.8 ft.^2 (68 m^2) per year of substrate in the Study Area. Under Alternative 1, the total area of substrate affected by underwater detonations on the seafloor would increase by 57 percent compared to the No Action Alternative. Training events that include bottom-laid underwater explosions are infrequent and the percentage of training area affected is small. Effects are localized within specific training ranges, so the soft-bottom substrates of disturbed areas would be expected to recover their previous structure (Gorodilov and Sukhotin 1996), with the exception of hard-bottom areas. However, soft sediment covers a large portion of the Puget Sound with sand and mud prevailing in the eastern regions (Palsson et al. 2003). Therefore, underwater explosions under Alternative 1 would affect marine habitat structure in the Study Area, but most impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

3.3.3.1.1.3 Alternative 2

Training Activities

Inland Waters

Under Alternative 2, the use of underwater detonations would increase from the No Action Alternative as described under Alternative 1 (see Section 3.3.3.1.1.2). The number of underwater detonations would increase from 4 under the No Action Alternative to 42 under Alternative 2, which is the same number of underwater detonations as under Alternative 1. Therefore, impacts from training in the Inland Waters would be similar to those described in Section 3.3.3.1.1.2 (Alternative 1).

3.3.3.1.2 Summary of Acoustic Stressors

The only acoustic stressor from impulse sources that may affect marine habitats is underwater explosions. Most of the explosives would detonate at or near the water surface. Only bottom-laid explosives could affect bottom substrate and, therefore, marine habitats. Habitat utilized for underwater detonations would primarily be soft-bottom sediment, which is expected to recover after a temporary disturbance due to normal sediment transport.

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

Pursuant to the Essential Fish Habitat (EFH) requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom during training activities may have an adverse effect on EFH by reducing the quality and quantity of non-living substrates that constitute EFH and Habitat Areas of Particular Concern. The impacts on soft bottom are determined to be short term and minimal. Mitigation measures should avoid impacts to surveyed hard bottom, as defined in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). Impacts on water column as EFH are summarized in corresponding resource sections (e.g., Section 3.8, Marine Invertebrates; and Section 3.9, Fish) because they are impacts on the organisms themselves.

3.3.3.2 Physical Disturbance Stressors

This section analyzes the potential impacts of various types of physical disturbance stressors resulting from Navy training and testing activities within the Study Area. Bottom substrates could be disturbed by military expended materials and seafloor devices used for Navy training and testing.

Impacts of physical disturbances resulting from Navy training and testing activities on biogenic soft bottom (e.g., seagrass, macroalgae) and hard bottom (e.g., deep sea corals, sponges, tunicates, oysters, mussels) substrates are discussed in Marine Vegetation and Marine Invertebrates, Sections 3.7 and 3.8, respectively. Potential impacts on the underlying substrates (soft, hard, or artificial) are analyzed in this section.

3.3.3.2.1 Impacts from Vessels and In-Water Devices

Vessels used for training and testing activities range in size from small boats (less than 40 ft. [12 m]) to nuclear aircraft carriers (greater than 980 ft. [299 m]). Table 3.0-17 lists representative types of vessels used during training and testing activities. Vessels performing training and testing exercises in the Study Area include large ocean-going ships, range craft, and submarines operating in waters deeper than 328 ft. (100 m), transiting through the Study Area.

Towed mine warfare and unmanned devices are much smaller than Navy vessels, but would also disturb the water column or benthic habitat near the device. Some operations involve vessels towing in-water devices used in mine warfare activities. When towed by a vessel, in-water devices are evaluated as extensions of the vessel because they have the potential to strike marine habitats in similar ways, although striking the bottom is avoided. The towed devices attached to a vessel by cables are smaller than most vessels, and are not towed at high speeds. See Section 2.2.5 (Mine Warfare) and Appendix A (Navy Activities Descriptions) for additional discussion of the vessels, speeds, and systems utilized during these activities.

Vessels and in-water devices (to include towed mine warfare and unmanned devices) could impact any of the habitat types discussed in this section, including soft and hard shores, soft and hard bottoms, and artificial substrates. Soft or unconsolidated sediments along the coast or in the deeper waters of the continental shelf and slope could be disturbed by a vessel or device contacting the substrate. In addition, a vessel or device could disturb the water column enough to stir up bottom sediments, temporarily and locally increasing the turbidity in the area of the event. The shore environment is typically very dynamic because of its exposure to wave action and cycles of erosion and deposition. As a result, disturbed areas would be influenced by waves, tide, current, and storm energy shortly after the disturbance. In deeper waters where tide, current, storm, or normal water action has little influence, sediments suspended into the water column would settle to the seafloor or would be carried along the bottom by currents before settling again. In either case, these disturbances would not be expected to alter the overall nature of the sediments to a degree that would impair their function as habitat.

3.3.3.2.1.1 No Action Alternative

Training Activities

Offshore Area

Under the No Action Alternative, training activities in the Offshore Area would not include activities where in-water devices would contact bottom substrates. Therefore, in-water devices for training activities would have no effect on marine habitats under the No Action Alternative.

Inland Waters

Under the No Action Alternative, training activities in the Study Area would not include activities, such as amphibious landings, where in-water devices would contact bottom substrates (see Table 3.3-2). Therefore, in-water devices for training activities would have no effect on marine habitats under the No Action Alternative.

Testing Activities

Offshore Area

Under the No Action Alternative, testing activities in the Offshore Area would include 40 activities where in-water devices would contact bottom substrates, such as with certain types of unmanned underwater vehicles in the Quinault Range Site. This portion of the Study Area is predominately sandy bottom. These in-water devices used for testing activities could have an effect on marine habitats under the No Action Alternative. These sediments would settle back down within hours of their suspension due to tidal influence, ocean currents, and other natural forces. As this effect would be very short in duration, it would not alter the marine habitat's ability to function, but would create a temporary (not permanent) disturbance on the soft-bottom habitat in the vicinity of the device operation. The effect on marine habitats would be temporary and localized, since sand substrate would be expected to shift back following a disturbance through tidal energy or storm generated waves (Davis 2009, Halpern et al. 2008, Kennett 1982).

Inland Waters

Under the No Action Alternative, testing activities in the Study Area would include 379 activities where in-water devices would contact bottom substrates (see Table 3.3-2). These in-water devices used for testing activities could have an effect on marine habitats under the No Action Alternative, as they would occur primarily over soft-bottom habitats (see Figure 3.3-2). The effect on marine habitats would be temporary and localized; as this effect would be very short in duration, it would not alter the marine habitat's ability to function, but would create a temporary (not permanent) disturbance on the soft bottom habitat in the vicinity of the device operation. Since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm generated waves (Davis 2009, Halpern et al. 2008, Kennett 1982).

Western Behm Canal, Alaska

Under the No Action Alternative, testing activities in the Western Behm Canal portion of the Study Area would not include activities where in-water devices would contact bottom substrates. Therefore, in-water devices for testing activities would have no effect on marine habitats under the No Action Alternative.

3.3.3.2.1.2 Alternative 1

Training Activities

Offshore Area

Under Alternative 1, training activities in the Study Area would not include activities where in-water devices would contact bottom substrates. Therefore, in-water devices for training activities would have no effect on marine habitats under Alternative 1.

Inland Waters

Under Alternative 1, training activities involving in-water devices would increase from zero under the No Action Alternative to one every other year. The training activities, including civilian port defense and anti-surface warfare, in the Study Area would include activities where in-water devices would contact bottom substrates, such as with certain types of unmanned underwater vehicles. These in-water devices used for training activities could have an effect on marine habitats under Alternative 1 as they would occur primarily over soft-bottom habitats (see Figure 3.3-2). The effect on marine habitats would be temporary and localized; as this effect would be very short in duration, it would not alter the marine habitat's ability to function, but would create a temporary disturbance on the soft bottom habitat in the vicinity of the device operation. Since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm generated waves (Davis 2009, Halpern et al. 2008, Kennett 1982).

Testing Activities

Offshore Area

Under Alternative 1, testing activities involving in-water devices would increase from 40 under the No Action Alternative to 154. The testing activities in the Offshore Area would include activities where in-water devices would contact bottom substrates, such as with certain types of unmanned underwater vehicles in the Quinault Range Site. These vehicles would be associated with the Naval Sea Systems Command testing activities (see Table 2.8-2). This portion of the Study Area is predominately sandy bottom. These in-water devices used for testing activities could have an effect on marine habitats under Alternative 1. As this effect would be very short in duration, it would not alter the marine habitat's ability to function, but would create a temporary disturbance on the soft-bottom habitat in the vicinity of the device operation. The effect on marine habitats would be temporary (not permanent) and localized, since sand substrate would be expected to shift back following a disturbance through tidal energy or storm generated waves (Davis 2009; Halpern et al. 2008; Kennett 1982).

Inland Waters

Under Alternative 1, testing activities involving in-water devices and in-water devices would increase from 379 under the No Action Alternative to 648. The testing activities in the Study Area would include activities where in-water devices would contact bottom substrates, such as with certain types of unmanned underwater vehicles. These in-water devices could have an effect on marine habitats as they would occur primarily over soft-bottom habitats (see Figure 3.3-2). The effect on marine habitats would be temporary and localized, since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm generated waves.

Western Behm Canal, Alaska

Under Alternative 1, testing activities in the Western Behm Canal portion of the Study Area would not include activities where in-water devices would contact bottom substrates. Therefore, in-water devices for testing activities would have no effect on marine habitats under Alternative 1.

3.3.3.2.1.3 Alternative 2

Training Activities

Offshore Area

Under Alternative 2, training activities in the Offshore Area would not include activities, where in-water devices would contact bottom substrates. Therefore, in-water devices for training activities would have no effect on marine habitats under Alternative 2.

Inland Waters

Under Alternative 2, civilian port defense would occur every year, instead of every other year, as it would under Alternative 1. All other Alternative 2 training activities would occur at the same level and in the same manner as under Alternative 1. Therefore, training activities under Alternative 2 would have the same impacts on marine habitats as under Alternative 1.

Testing Activities

Offshore Area

Under Alternative 2, testing activities in the Offshore Area would increase to 183 compared to 40 under the No Action Alternative. These activities would include in-water devices that would contact bottom substrates, such as with certain types of unmanned underwater vehicles in the Quinault Range Site. These vehicles would be associated with the Naval Sea Systems Command testing activities (see Table 2.8-2). This portion of the Study Area is predominately sandy bottom. These in-water devices used for testing activities could have an effect on marine habitats under Alternative 2. The effect on marine habitats would be temporary (not permanent) and localized; as this effect would be very short in duration, it would not alter the marine habitat’s ability to function, but would create a temporary disturbance on the soft-bottom habitat in the vicinity of the device operation, since sand substrate would be expected to shift back following a disturbance through tidal energy or storm-generated waves (Davis 2009; Halpern et al. 2008; Kennett 1982).

Inland Waters

Under Alternative 2, testing activities involving in-water devices would increase from 379 under the No Action Alternative to 716. The testing activities in the Study Area would include activities where in-water devices would contact bottom substrates, such as with certain types of unmanned underwater vehicles. These in-water devices used for testing activities could have an effect on marine habitats under Alternative 2 as they would occur primarily over soft-bottom habitats (see Figure 3.3-2). The effect on marine habitats would be temporary and localized, since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm generated waves.

Western Behm Canal, Alaska

Under Alternative 2, testing activities in the Western Behm Canal portion of the Study Area would not include activities where in-water devices would contact bottom substrates. Therefore, in-water devices for testing activities would have no effect on marine habitats under Alternative 2.

3.3.3.2.1.4 Substressor Impact on Marine Habitat 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 may have an impact on EFH by reducing the quality and quantity of non-living substrates that constitute EFH and Habitat Areas of Particular Concern. Any impacts on marine habitats incurred by vessel movements and in-water devices are expected to be minimal and short term.

3.3.3.2.2 Military Expended Materials

Many different types of military expended materials remain on the ocean floor following Navy training and testing activities (described in Chapter 2, Description of Proposed Action and Alternatives) that occur throughout the Study Area. The potential for physical disturbance of marine substrates by military expended materials from Navy training and testing activities exists throughout the Study Area, although the types of military expended materials vary by activity and region, with some areas consisting of greater concentration than others. Section 2.3.6 (Military Expended Materials) describes military expended materials, which include non-explosive practice munitions (projectiles, bombs, and missiles) that are used in Navy training and testing activities. Military expended materials could disturb marine substrates to the extent that they impair the substrate's ability to function as a habitat. These disturbances could result from either the forceful strike displacing material or deposition. Deposition in some cases might replace soft substrate with hard material. Displacing material might allow for soft substrate to re-cover the hard materials, making the impact of those strikes more temporary.

The potential of military expended materials to impact marine substrates as they contact the seafloor depends on several factors, including the size, type, mass, and speed of the material; water depth; and the type of substrate. The two outcomes of military expended materials on marine substrates are damaging strike, or settling on the substrate. Most of the kinetic energy of an expended item is dissipated within the first few yards of the object entering the water, causing it to slow considerably by the time it reaches the substrate. Because the damage caused by a strike is proportional to the force of the strike, slower speeds would result in lesser impacts. Because of the depth of the water in which most training and testing events take place, and Standard Operating Procedures that avoid working over reefs and wrecks, a direct strike on either hard-bottom or artificial structures (e.g., artificial reefs and shipwrecks) with sufficient force to damage the substrate is unlikely. Any damage would be limited to a small portion of the structural habitat. The value of these substrates as habitat for benthic communities to grow on, however, does not depend on the shape of the structure. An alteration in shape or structure caused by military expended materials would not necessarily reduce the habitat value of either hard-bottom or artificial structures; rather it may increase the surface area available for communities to flourish on. In softer substrates (e.g., sand, mud, silt, clay, and composites), the impact of the expended material on the seafloor, if large enough and striking with sufficient momentum, may create a depression and redistribute local sediments as they are temporarily re-suspended in the water column. During Navy training and testing, countermeasures such as flares and chaff are introduced into marine habitats. These types of military expended materials are not expected to impact marine habitats as strike stressors because of their size, distribution of use throughout the Study Area, and low velocity when deployed, compared to projectiles, bombs, and missiles. Chaff and flares should not affect the substrate of Marine Habitats, and therefore were not carried further into the analysis here. They are discussed in respect to Sediment and Water Quality (see Section 3.1).

Other potential effects of military expended materials on marine substrates would be to cover or to alter the type of substrate and, therefore, its function as habitat. The majority of military expended materials that settle on hard-bottom or artificial substrates, while covering the seafloor, would still provide a similar habitat as the substrate it covers by providing a hard surface on which organisms can attach. An exception would be expended materials, such as decelerator/parachutes used to deploy sonobuoys, lightweight torpedoes, expendable mobile anti-submarine warfare training targets, and other devices from aircraft, that would not provide a hard or permanent surface for colonization. In these cases, the hard-bottom or artificial substrate covered by the expended material would not be damaged, but its function as a habitat for colonizing or encrusting organisms would be impaired.

Most military expended materials that settle on soft-bottom habitats, while not damaging the substrate, would eliminate the habitat by covering the substrate with a hard surface. If a crater is created there would be temporary damage to the substrate in addition to changing the composition. This event would alter the substrate from a soft surface to a hard structure and, therefore, would prevent the substrate from supporting a soft-bottom community. Expended materials that settle in the shallower, more dynamic environments of the continental shelf would likely be eventually buried by sediment transport and other coastal processes or encrusted by organisms. In the deeper waters of the continental slope and beyond, where currents do not play as large of a role, large-sized expended materials (e.g., bombs, missiles) may remain exposed on the surface of the substrate with minimal change for extended periods. Softer expended materials, such as decelerator/parachutes, would not damage sediments. Decelerator/parachutes, however, could impair the function of the substrate as habitat because they could act as a temporary barrier to interactions between the water column and the sediment.

One unique type of military expended material, because of its size, is a ship hulk. Sinking exercises use a target (ship hull or stationary artificial target) against which explosive and non-explosive ordnance are fired. These exercises eventually sink the target. The exercise lasts over 1–2 days, normally occurring within 8 hours on the first day, and may use multiple targets. Sinking exercises would only occur in waters more than 9,800 ft. (2,987 m) deep. The potential impacts of sinking exercises depend on the amounts of ordnance and types of weapons used, which are situational and dependent upon training needs (U.S. Department of the Navy 2006). The potential military expended materials from sinking exercises include the ship hull, missiles, torpedoes, and shell fragments. The impact of a ship hull settling on marine substrates would depend on the size of the ship hull and the type of substrate it settles upon. Areas of hard bottom may fragment or break as the ship settles to the seafloor. While the ship would cover a portion of the seafloor, it would support the same type of communities as the hard substrate it covered, and likely would provide more complexity and relief, which are important habitat features for hard-bottom communities. Areas of unconsolidated sediments would experience a temporarily large increase in turbidity as sediment is suspended in the water column. The settling of the ship to the seafloor would displace sediment and create a depression in the substrate. The soft substrates covered by the ship would no longer support a soft-bottom community, having been replaced by a hard structure more suitable for attaching and encrusting organisms.

The analysis to determine the potential level of disturbance of military expended materials on marine substrates assumes that the impact of the expended material on the seafloor is twice the size of its footprint. This assumption would more accurately reflect the potential disturbance to soft-bottom habitats, but overestimates disturbance of hard-bottom habitats. For this analysis, high-explosive munitions were treated in the same manner as non-explosive practice munitions in terms of impacts on the seafloor, to be conservative, even though high-explosive ordnance would normally explode in the upper water column, and only fragments of the ordnance would settle on the seafloor.

No training or testing activities with military expended materials are proposed in the Western Behm Canal portion of the Study Area under the No Action Alternative, Alternative 1, or Alternative 2. Therefore, there would be no impact to marine habitats in the Western Behm Canal portion of the Study Area from military expended materials.

The numbers of military expended materials resulting from training and testing activities under each of the alternatives in the Offshore Area are listed in Table 3.3-4 and Table 3.3-5. The numbers of military expended materials used for testing activities under each of the Alternatives in the Inland Waters portion of the Study Area are listed in Table 3.3-6. The physical impact area is estimated as twice the footprint of each type of military expended material.

3.3.3.2.2.1 No Action Alternative

Training Activities

Offshore Area

Military expended materials from training activities have the potential to impact the marine substrates in training areas. Approximately 189,668 military items would be expended annually in the Offshore Area during training activities, which would result in a total impact area of approximately 1,700,000 $ft.^2$ (158,000 m^2) (Table 3.3-4). The majority of the impact area would be due to ship hulks expended during sinking exercises. With an impact area of 632,000 $ft.^2$ (58,700 m^2) for each vessel and up to two sinking exercises per year, ship hulks would account for about 80 percent (1,265,000 $ft.^2$ [117,500 m^2]) of the annual impact area for training activities under the No Action Alternative. The total impact area of military expended materials from training activities would cover approximately 0.04 square nautical mile (spread out over the entire Offshore portion of the Study Area), which would be a small fraction of the total sea surface area of the Study Area.

Under the No Action Alternative, the majority of military expended materials would be used in open ocean areas, where the substrate is comprised of clays and silts. High-explosive military expended material would typically fragment into small pieces. Ordnance that fails to function as designed and inert munitions would result in larger pieces of military expended material settling to the seafloor. Once on the seafloor, military expended material would be buried by sediments, corroded from exposure to the marine environment, or colonized by benthic organisms (U.S. Department of the Navy 2005); thus, the impacts would be temporary and recoverable.

Table 3.3-4: Number and Impact Footprint of Military Expended Materials Training Activities in the Offshore Area

Military Expended Material	Size (m^2) Single Piece	Impact Footprint (m^2) Single Piece	No Action Alternative		Alternative 1		Alternative 2	
			Number	Approximate Impact (m^2)*	Number	Approximate Impact (m^2)	Number	Approximate Impact (m^2)
Bombs (HE)	0.7544	1.5088	34	51.30	10	15.09	10	15.09
Bombs (NEPM)	0.7544	1.5088	110	165.97	110	165.97	110	165.97
Small caliber	0.0028	0.0056	117,000	655.20	121,200	678.72	121,200	678.72
Medium caliber (HE)	0.0052	0.0104	6,368	66.23	6,498	67.58	6,498	67.58
Medium caliber (NEPM)	0.0052	0.0104	42,392	440.88	43,172	448.99	43,172	448.99
Large caliber (HE)	0.0938	0.1876	470	88.17	390	73.16	390	73.16
Large caliber (NEPM)	0.0938	0.1876	2,800	525.28	2,800	525.28	2,800	525.28
Missiles (HE)	3.4715	6.9430	45	312.44	27	187.46	27	187.46
Missiles (NEPM)	2.8801	5.7602	15	86.40	15	86.40	15	86.40
Chaff (cartridges)	0.0001	0.0002	2,900	.58	5,000	1.00	5,000	1.00
Flares	0.1133	0.2266	184	41.69	224	50.76	224	50.76
Airborne targets	4.3838	8.7676	28	245.49	28	245.49	28	245.49
Surface targets	0.5344	1.0688	210	224.45	210	224.45	210	224.45
Sub-surface targets	0.1134	0.2268	126	28.58	130	29.48	130	29.48
Ship hulk (SINKEX)	29,370	58,740	2	117,480.00	0	0	0	0
Torpedoes (HE)	3.0861	6.1721	2	12.34	0	0	0	0
Marine Markers	0.1134	0.2268	240	54.43	334	75.75	334	75.75
Sonobuoys (NEPM)	0.1134	0.2268	8,208	1,861.57	8,208	1,861.57	8,208	1,861.57
Sonobuoys (HE)	0.1134	0.2268	150	34.02	150	34.02	150	34.02
Decelerator/parachutes	0.8400	1.6800	8,382	14,081.76	8,382	14,081.76	8,382	14,081.76
Fiber Optic Cables	**	**	2	**	0	0	0	0
Total			**189,668**	**136,456.78**	**196,888**	**18,852.94**	**196,888**	**18,852.94**

* The approximate impact area is a measurement of fragments.

** The area of impact for fiber optic cables is included in the footprint for the torpedoes (HE).

Notes: (1) Information to develop this table was obtained from Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0 (General Approach to Analysis). (2) HE = High Explosive, m^2 = square meter(s), NEPM = Non-explosive Practice Munitions, SINKEX = Sinking Exercise.

During sinking exercises, large amounts of military expended material and a vessel hulk would be expended. Sinking exercises in the Study Area, however, would occur over 50 nm from shore where the substrate would be primarily comprised of clays and silts. Impacts of military materials expended over deep-water would be negligible because the Navy would typically avoid hard-bottom sub-surface features (e.g., seamounts). Vessel hulks used during sinking exercises would alter the bottom substrate, converting soft-bottom habitat into an artificial, hard-bottom structure. The amount of area affected by vessel hulks would be a small fraction of the available habitat, and the vessel hulk would provide an anchoring point for sessile organisms in the open ocean where the predominant habitat is soft bottom.

Military material expended near the coastal portions of the Offshore Area, such as W-237, would be limited to small-caliber projectiles, flares, sonobuoys, and target fragments. These materials would be expended in an area of soft-bottom habitat, mainly sand, which is dynamic in nature, as activities are generally performed over soft-bottom areas, avoiding reefs and hard bottom marine habitats. These materials would be small, and would typically be covered by sediment (through wave, tide, current, storm, or normal water movements of sediment or storm generated waves) or colonized by benthic organisms (U.S. Department of the Navy 2005). The small size of military expended materials would not change the habitat structure or composition. Therefore, military expended material from training activities in the Offshore Area would not affect marine habitats.

Inland Waters

Military expended materials from training activities could impact the marine substrates in training areas. Approximately four military items, limited to mine shapes, would be expended annually in the inshore waters of the Study Area during Mine Warfare training activities, which would result in a total impact area of approximately 215 ft.^{2} (20 m^2). The military expended materials would be fragments and remnants of mine shapes.

Under the No Action Alternative, the mine shapes would be used in areas, where the substrate is comprised of clays and silts. Once on the seafloor, military expended material would be buried by sediments, corroded from exposure to the marine environment, or colonized by benthic organisms (U.S. Department of the Navy 2005). The small size, and small total footprint compared to available habitat, of military expended materials would not change the habitat structure. Therefore, military expended material from training activities in the Inland Waters would not affect marine habitats.

Testing Activities

Offshore Area

Military expended materials used for testing activities may impact marine substrates in testing areas. The numbers and sizes of military expended materials in the Study Area were evaluated to determine their level of impact under the No Action Alternative. Annually, approximately 231 items would be expended during testing activities, impacting approximately 830 ft.^{2} (77 m^2) of the Offshore Area (Table 3.3-5).

Military material expended in the Offshore Area for testing activities would be expended in areas of soft-bottom habitat, mainly sand, which is dynamic in nature. These materials would typically be covered by sediment (through wave, tide, current, storm, or normal water movements of sediment or storm generated waves) or colonized by benthic organisms (U.S. Department of the Navy 2005). The low number of military expended materials used during testing activities would not be expected to change the habitat structure. Therefore, military expended material from testing activities in the Offshore Area would not affect marine habitats.

Inland Waters

Military expended materials used for testing activities may impact marine substrates in testing areas. The numbers and sizes of military expended materials in the Inland Waters portion of the Study Area were evaluated to determine their level of impact under the No Action Alternative. Annually, approximately 18 items would be expended during testing activities, impacting approximately 106 ft.^{2} (9.8 m^2) of the Inland Waters portion of the Study Area (Table 3.3-6).

Under the No Action Alternative, the majority of military expended materials would be used in areas where the substrate is comprised of clays and silts. Once on the seafloor, military expended material would be buried by sediments, corroded from exposure to the marine environment, or colonized by benthic organisms (U.S. Department of the Navy 2005). The small size, and small total footprint compared to available habitat, of military expended materials would not change the habitat structure. Therefore, military expended material from testing activities in the inland waters would not affect marine habitats.

3.3.3.2.2.2 Alternative 1

Table 3.3-4 and Table 3.3-5 list the numbers of military items expended in training and testing activities under Alternative 1 in the Offshore Area.

Table 3.3-6 lists the numbers of military items expended in the Inland Waters portion of the Study Area for testing activities under Alternative 1 in the Inland Waters.

Training Activities

Offshore Area

Approximately 196,888 military items would be expended annually in the Study Area during training activities, which would result in a total impact area of approximately 200,000 ft.^{2} (18,600 m^2) (see Table 3.3-4). The number of military expended materials would increase by less than 1 percent compared to the No Action Alternative. However, because of the removal of the sinking exercises in Alternative 1, the impact footprint of military expended materials decreases by 80 percent, compared to the No Action Alternative.

The majority of military training items would be expended in the open ocean, where substrates would primarily be clays and silts. Military expended material expended near the coastal portions of the Offshore Area would be limited to small-caliber projectiles, flares, sonobuoys, and target fragments. These materials would be expended in an area of soft-bottom habitat, mainly sand, which is dynamic in nature. These materials would be small, and would typically be covered by sediment (through wave, tide, current, storm, or normal water movements of sediment or storm generated waves) or colonized by benthic organisms (U.S. Department of the Navy 2005). As described above, the small size of military expended materials, and the placement of them on soft mobile sediments, would not change the habitat structure. Therefore, under Alternative 1, military material expended by training activities in the Study Area would have a temporary and reduced impact on marine habitats than the No Action Alternative.

Inland Waters

Approximately 42 mine shapes would be expended annually in the Inland Waters portion of the Study Area during training activities, which would result in a total impact area of approximately 2,150 ft.^{2} (200 m^2). The number of military expended materials would increase by 95 percent compared to the No Action Alternative, due to an increase in Mine Warfare Training Activities.

The majority of military training items would be expended where substrates are primarily clays and silts. While the number of events would increase, the types of military expended materials under Alternative 1 would be the same as under the No Action Alternative. Therefore, military material expended by training activities in the Inland Waters portion of the Study Area would have a slightly higher impact on marine habitats than the No Action Alternative. The small size, and small total footprint compared to available habitat, of military expended materials would not change the habitat structure. Therefore, military expended material from training activities in the Inland Waters would not affect marine habitats.

Table 3.3-5: Number and Impact Footprint of Military Expended Materials Testing Activities in the Offshore Area

Military Expended Material	Size (m^2)	Impact Footprint (m^2)	No Action Alternative		Alternative 1		Alternative 2	
			Number	Approximate Impact (m^2)*	Number	Approximate Impact (m^2)	Number	Approximate Impact (m^2)
Flares	0.1133	0.2266	0	0	600	135.96	600	135.96
Sub-surface targets	0.1134	0.2268	14	3.18	90	20.41	102	23.13
Torpedoes (HE)	3.0861	6.1721	0	0	6	37.03	6	37.03
Sonobuoys (NEPM)	0.1134	0.2268	200	45.36	1,000	226.80	1,097	248.80
Sonobuoys (HE)	0.1134	0.2268	0	0	142	32.21	156	35.38
Marine Markers	0.1134	0.2268	0	0	190	43.09	210	47.63
Decelerator/parachutes	0.8400	1.6800	17	28.56	1,229	2,064.72	1,351	2,269.68
Total			**231**	**77.10**	**3,257**	**2,560.22**	**3,522**	**2,797.61**

* The approximate impact area is a measurement of fragments.

Notes: (1) Information to develop this table was obtained from Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0 (General Approach to Analysis). The approximate impact area is a measurement of fragments. (2) HE = High Explosive, m^2 = square meter(s), NEPM = Non-explosive Practice Munitions.

Table 3.3-6: Number and Impact Footprint of Military Expended Materials Testing Activities in the Inland Waters

Military Expended Material	Size (m^2)	Impact Footprint (m^2)	No Action Alternative		Alternative 1		Alternative 2	
			Number	Approximate Impact (m^2)*	Number	Approximate Impact (m^2)	Number	Approximate Impact (m^2)
Sub-surface targets	0.1134	0.2268	8	1.81	9	2.04	11	2.49
Sonobuoys (NEPM)	0.1134	0.2268	6	1.36	6	1.36	6	1.36
Decelerator/parachutes	0.8400	1.6800	4	6.72	4	6.72	5	8.40
Total			**18**	**9.90**	**19**	**10.12**	**22**	**12.26**

* The approximate impact area is a measurement of fragments.

Notes: (1) Information to develop this table was obtained from Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0 (General Approach to Analysis). The approximate impact area is a measurement of fragments. (2) m^2 = square meters, NEPM = Non-explosive Practice Munitions.

Testing Activities

Offshore Area

Approximately 3,257 military expended materials would be expended annually in the Study Area during testing activities, which would impact a total area of approximately 27,600 ft.^{2} (2,560 m^2) (see Table 3.3-5). The number of military expended materials would increase substantially compared to the No Action Alternative, and the total area of bottom substrate affected would increase by 88 percent.

The majority of military testing items would be expended in the open ocean, where substrates would primarily be clays and silts. Military expended material expended near the surf zone of the Offshore Area would be limited to small-caliber projectiles, flares, sonobuoys, and target fragments. These materials would be expended in an area of soft-bottom habitat, mainly sand, which is dynamic in nature. These materials would be small, and would typically be covered by sediment (through wave, tide, current, storm, or normal water movements of sediment or storm generated waves) or colonized by benthic organisms (U.S. Department of the Navy 2005).The small size of military expended materials, and the placement of them on soft mobile sediments, would not change the habitat structure. Therefore, military material expended by testing activities, although increasing in the Study Area, would have a temporary impact on marine habitats.

Inland Waters

Approximately 19 military expended materials would be expended annually in the Inland Waters portion of the Study Area during testing activities, which would impact a total area of approximately 110 ft.^{2} (10 m^2). The number of military expended materials and the total area of bottom substrate affected would increase by one military expended material compared to the No Action Alternative; therefore, the impact of military expended materials remain the same as it is in the No Action Alternative.

The majority of military testing items would be expended where substrates are primarily clays and silts. While the number of events would increase by one, the types of military expended materials under Alternative 1 would be the same as under the No Action Alternative. Therefore, military material expended by testing activities in the Inland Waters portion of the Study Area would have a slightly higher impact on marine habitats than the No Action Alternative. The small size, and small total footprint compared to available habitat, of military expended materials would not change the habitat structure. Therefore, military expended material from testing activities in the Inland Waters would not affect marine habitats.

3.3.3.2.2.3 Alternative 2

The numbers of military items that would be expended for training and testing activities under Alternative 2 for the Offshore Area are listed in Table 3.3-4 and Table 3.3-5. The numbers of military items that would be expended for testing activities under Alternative 2 for the Inland Waters are listed in Table 3.3-6.

Training Activities

Offshore Area

Under Alternative 2, the number of military expended materials would be the same as under Alternative 1. Therefore, the impact of military expended materials would be the same as under Alternative 1.

Inland Waters

Under Alternative 2, the number of military expended materials would change from Alternative 1 with one activity every other year, to one activity every year. Because the activity still happens just once a year the impact of military expended materials would be the same as under Alternative 1.

Testing Activities

Offshore Area

Approximately 3,522 military expended materials would be used annually in the Study Area during testing activities, which would impact an area of approximately 30,200 ft.^{2} (2,800 m^2) (see Table 3.3-5). The number of military expended materials would increase substantially compared to the No Action Alternative, and the total area of bottom substrate affected would increase by 91 percent.

The majority of military testing items would be expended in the open ocean, where substrates would primarily be clays and silts. Military expended material expended near the coastal portions of the Offshore Area would be limited to small-caliber projectiles, flares, sonobuoys, and target fragments. These materials would be expended in an area of soft-bottom habitat, mainly sand, which is dynamic in nature. These materials would be small, and would typically be covered by sediment (through wave, tide, current, storm, or normal water movements of sediment or storm generated waves) or colonized by benthic organisms (U.S. Department of the Navy 2005).The small size of military expended materials, and the placement of them on soft mobile sediments, would not change the habitat structure. Therefore, military material expended by testing activities, although increasing in the Study Area, would have a temporary impact on marine habitats.

Inland Waters

Approximately 42 mine shapes would be expended annually in the Inland Waters portion of the Study Area during training activities, which would result in a total impact area of approximately 2,150 ft.^{2} (200 m^2). The number of military expended materials would increase by 95 percent compared to the No Action Alternative, due to an increase in Mine Warfare Training Activities.

The majority of military training items would be expended where substrates are primarily clays and silts. While the number of events would increase, the types of military expended materials under Alternative 1 would be the same as under the No Action Alternative. Therefore, military material expended by training activities in the Inland Waters portion of the Study Area would have a slightly higher impact on marine habitats than the No Action Alternative. The small size, and small total footprint compared to available habitat, of military expended materials would not change the habitat structure. Therefore, military expended material from training activities in the Inland Waters would not affect marine habitats.

3.3.3.2.2.4 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, the use of military expended materials during training and testing activities may have an adverse effect on EFH by reducing the quality and quantity of non-living substrates that constitute EFH and Habitat Areas of Particular Concern. Military expended material impacts to both soft and hard bottom substrates would be minimal with a duration period of long term to permanent within the Study Area.

3.3.3.2.3 Impacts from Seafloor Devices

Seafloor devices are items used during training or testing activities that are deployed onto the seafloor. These items include moored mine shapes, anchors, bottom-placed instruments, and robotic vehicles referred to as "crawlers." Seafloor devices are either stationary or move very slowly along the bottom.

Moored mines deployed by fixed-wing aircraft enter the water and impact the bottom, becoming partially buried in sediments. Upon impact, the mine casing separates and the semi-buoyant mine floats up through the water column until it reaches the end of the mooring line. Bottom mines are typically positioned manually and are allowed to free sink to the bottom to rest. Mine shapes are normally deployed over soft sediments and are recovered within 7–30 days following the completion of the training or testing event.

Precision anchoring testing exercises release anchors in precise locations. The intent of these testing exercises is to practice anchoring the vessel within 100 yards (91 m) of the planned anchorage location. These testing activities typically occur within predetermined shallow water anchorage locations near ports with seafloors consisting of unconsolidated sediments. The level of impact on the soft sediments would depend on the size of the anchor used, which would vary according to vessel type.

3.3.3.2.3.1 No Action Alternative

The numbers of activities including seafloor devices used for training and testing activities under each of the Alternatives in the Offshore Area, Inland Waters, and Western Behm Canal are listed in Table 3.3-2.

Training Activities

Offshore Area

No training activities with seafloor devices are proposed in the Offshore Area under the No Action Alternative. Therefore, seafloor devices for training activities would have no effect on marine habitats under the No Action Alternative.

Inland Waters

Two training activities would use seafloor devices in the Inland Waters under the No Action Alternative. Training events that include seafloor devices are infrequent and the percentage of training area affected is small. The effects are localized within specific training areas, so the soft-bottom substrates of disturbed areas would be expected to recover their previous structure (Gorodilov and Sukhotin 1996). On hard bottom areas the amount of consolidated substrate converted to unconsolidated sediment by disturbance of seafloor devices would vary according to material types and degree of consolidation. Soft sediment covers a large portion within the Inland Waters, with sand and mud prevailing in the eastern regions.

The training activities in the Study Area would include activities where seafloor devices would contact bottom substrates. These in-water devices used for training activities could have a temporary effect on marine habitats under the No Action Alternative as they would occur primarily over soft-bottom habitats (see Figure 3.3-2). The effect on marine habitats would be temporary and localized, since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm-generated waves.

Therefore, seafloor devices under the No Action Alternative have the potential to affect marine habitat structure in the Study Area, but impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

Testing Activities

Offshore Area

There are five testing activities with seafloor devices proposed in the Offshore Area under the No Action Alternative. Seafloor devices could impact any of the habitat types discussed in this section, including soft and hard bottoms and artificial substrates. The substrate of the open ocean area is mostly comprised of clays and silts. Soft or unconsolidated sediments could be disturbed by an anchor or device contacting the substrate. Potential exists for fracturing and damage to hard-bottom habitat if activities occur over that type of habitat. Disturbed areas could be influenced by tide, current, storm, or normal water action that results in sediments being suspended into the water column and settling to the seafloor or being carried along the bottom by currents before settling again. In either case, these disturbances would not be expected to alter the overall nature of the sediments to a degree that would impair their function as habitat.

Therefore, seafloor devices for testing activities under the No Action Alternative have the potential to affect marine habitat structure in the Study Area, but impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

Inland Waters

Approximately 210 testing activities will use seafloor devices in the Inland Waters under the No Action Alternative. The testing activities in the Study Area would include activities where seafloor devices would contact bottom substrates, such as with certain types of unmanned underwater vehicles. These in-water devices used for testing activities could have a temporary effect on marine habitats under the No Action Alternative because they would occur primarily occur over soft-bottom habitats (see Figure 3.3-2). The effect on marine habitats would be temporary and localized, since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm-generated waves. Soft sediment covers a large portion within the Inland Waters, with sand and mud prevailing in the eastern regions.

Therefore, seafloor devices for testing activities under the No Action Alternative have the potential to affect marine habitat structure in the Study Area, but most impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

Western Behm Canal, Alaska

No testing activities with seafloor devices are proposed in the Western Behm Canal under the No Action Alternative. Therefore, seafloor devices for testing activities would have no effect on marine habitats under the No Action Alternative.

3.3.3.2.3.2 Alternative 1

The numbers of activities including seafloor devices used for training and testing activities under each of the Alternatives in the Offshore Area, Inland Waters, and Western Behm Canal are listed in Table 3.3-2.

Training Activities

Offshore Area

No training activities with seafloor devices are proposed in the Offshore Area under Alternative 1. Therefore, seafloor devices for training activities would have no effect on marine habitats under Alternative 1.

Inland Waters

Training activities would increase from two activities that use seafloor devices in the Inland Waters under the No Action Alternative to 16 under Alternative 1. Training events that include seafloor devices are infrequent, the percentage of training area affected is small, and the effects are localized within specific training areas, so the soft-bottom substrates of disturbed areas would be expected to recover their previous structure (Gorodilov and Sukhotin 1996). The effect on marine habitats would be temporary and localized, since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm-generated waves. Soft sediment covers a large portion within the Inland Waters, with sand and mud prevailing in the eastern regions.

Therefore, seafloor devices for testing activities under Alternative 1 have the potential to affect marine habitat structure in the Study Area, but most impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

Testing Activities

Offshore Area

Under Alternative 1, the testing activities with seafloor devices would increase from five under the No Action Alternative to six. The same type of testing activities would occur as under the No Action Alternative. The effects of testing activities would not alter the marine habitat's ability to function, but would create a temporary disturbance on the soft-bottom habitat in the vicinity of the device operation.

Therefore, seafloor devices for testing activities under Alternative 1 have the potential to affect marine habitat structure in the Study Area, but most impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

Inland Waters

Approximately 225 testing activities will use seafloor devices in the Inland Waters under Alternative 1. The testing activities in the Study Area would include activities where seafloor devices would contact bottom substrates, such as with certain types of unmanned underwater vehicles. These in-water devices used for testing activities could have an effect on marine habitats under Alternative 1 as they would occur primarily over soft-bottom habitats (see Figure 3.3-2). The effect on marine habitats would be temporary and localized, since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm generated waves. Soft sediment covers a large portion within the Inland Waters, with sand and mud prevailing in the eastern regions.

Therefore, seafloor devices for testing activities under Alternative 1 have the potential to affect marine habitat structure in the Study Area, but most impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

Western Behm Canal, Alaska

There are five activities that use seafloor devices proposed under Alternative 1 in the Western Behm Canal. Although the sediment in the Western Behm Canal is variable across the seafloor, generally sediments range from soft sediments to hard exposed bedrock (U.S. Department of the Navy 1988).

Soft-bottom sediment is expected to recover after a temporary disturbance due to normal sediment transport. The testing activities in the Study Area would include activities where seafloor devices would contact bottom substrates. These seafloor devices used for testing activities could have an effect on marine habitats under Alternative 1 as they would occur primarily over soft-bottom habitats (see Figure

3.3-2). The effect on marine habitats would be temporary and localized, since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm-generated waves.

Therefore, seafloor devices for testing activities under Alternative 1 have the potential to affect marine habitat structure in the Study Area, but most impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

3.3.3.2.3.3 Alternative 2

The numbers of activities including seafloor devices used for training and testing activities under each of the Alternatives in the Offshore Area, Inland Waters, and Western Behm Canal are listed in Table 3.3-2.

Training Activities

Offshore Area

No training activities with seafloor devices are proposed in the Offshore Area under Alternative 2. Therefore, seafloor devices for training activities would have no effect on marine habitats under Alternative 2.

Inland Waters

Approximately 16 training activities will use seafloor devices in the Inland Waters under Alternative 2. The training activities in the Study Area would include activities where seafloor devices would contact bottom substrates, such as with certain types of unmanned underwater vehicles. These in-water devices used for training activities could have an effect on marine habitats under Alternative 2 as they would occur primarily over soft-bottom habitats (see Figure 3.3-2). The effect on marine habitats would be temporary and localized, since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm-generated waves. Soft sediment covers a large portion within the Inland Waters, with sand and mud prevailing in the eastern regions.

Therefore, seafloor devices for training activities under Alternative 2 have the potential to affect marine habitat structure in the Study Area, but most impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

Testing Activities

Offshore Area

Under Alternative 2, the testing activities with seafloor devices would increase from five under the No Action Alternative to seven. The same type of testing activities would occur as under the No Action Alternative. The effects of testing activities would be very short in duration and would not alter the marine habitat’s ability to function, but would create a temporary disturbance on the soft bottom habitat in the vicinity of the device operation.

Therefore, seafloor devices for testing activities under Alternative 2 have the potential to affect marine habitat structure in the Study Area, but most impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

Inland Waters

Under Alternative 2, the number of seafloor devices would increase from 225 under Alternative 1 to 239 under Alternative 2. Because the increase is not substantial, the impact of seafloor devices would be the same as under Alternative 1.

Western Behm Canal, Alaska

Testing activities under Alternative 2 that use seafloor devices increases from zero under the No Action Alternative to 15. The testing activities in the Study Area would include activities where seafloor devices would contact bottom substrates, such as with certain types of unmanned underwater vehicles. These in-water devices used for testing activities could have an effect on marine habitats under Alternative 2, as they would occur primarily over soft-bottom habitats (see Figure 3.3-2). The effect on marine habitats would be temporary and localized, since soft-bottom substrate would be expected to shift back following a disturbance through tidal energy or storm-generated waves.

Therefore, seafloor devices for testing activities under Alternative 2 have the potential to affect marine habitat structure in the Study Area, but most impacts would be local disturbance to the impact area, would not result in local community shift, and would be temporary.

3.3.3.2.3.4 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 have an adverse effect on soft bottom substrates that constitute EFH. These potential impacts to soft bottom substrates would be minimal in size and temporary (recovery in days to weeks) to short term (recovery in weeks up to 3 years) in duration. Hard bottom substrates and artificial structures should not be adversely affected by the use of seafloor devices.

3.3.3.2.4 Summary of Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors that could affect bottom substrates include vessel and in-water device strikes, military expended materials, and seafloor devices. Items entering the ocean would not be expected to affect marine habitats because of the nature of high-energy surf and currents that would buffer the final impact to the seafloor. Once on the seafloor, military expended material would either be colonized by benthic organisms because military expended materials would be anchor points in the shifting bottom substrates, or buried by sediment transport (U.S. Department of the Navy 2005). Military expended material is a relatively small quantity of inert material distributed over the entire Study Area.

3.3.3.3 Summary of Potential Impacts (Combined Impacts of All Stressors) on Marine Habitats

Most of the high-explosive military expended materials would detonate at or near the water surface. Underwater explosions that could affect bottom substrate, and therefore marine habitats, would be underwater detonations on the seafloor. Habitat utilized for underwater detonations would primarily be soft-bottom sediment. These disturbance events would be spread out over time, allowing natural processes to recover the area. The substrate and water column affected by detonations on the seafloor would be expected to recover from tidal energy or storm generated waves.

Physical stressors that could affect bottom substrates include vessel and in-water device strikes, seafloor devices, and military expended materials. Beach approaches from the ocean would not be expected to affect marine habitats because the biotic community is frequently under disturbance because of the nature of sand movement in surf zones. Once on the seafloor, military expended material could be colonized by benthic organisms because military expended materials provide anchor points in the shifting, soft-bottom substrate, or they could be completely covered by soft-bottom substrate, or they could be buried by sediment transport.

3.3.3.3.1 No Action Alternative

The combined impact area of acoustic stressors, physical disturbances, and strike stressors proposed for training and testing events in the No Action Alternative would not diminish the ability of soft shores, soft bottoms, hard shores, hard bottoms, or artificial substrates to function as habitat. The total area impacted by underwater explosions and military expended is summarized in Table 3.3-7.

Table 3.3-7: Combined Impact of Acoustic Stressors (Underwater Explosions) and Physical Disturbances (Military Expended Materials) on Marine Substrates by Alternative

Training Area	Impact Footprint (m^2)		
	Underwater Explosions	Military Expended Materials	Total
No Action Alternative	29	136,563	136,592
Alternative 1	68	21,624	21,692
Alternative 2	68	21,863	21,931

3.3.3.3.2 Alternative 1

The combined effects of acoustic stressors, physical disturbances, and strike stressors proposed for training and testing events in Alternative 1 would not diminish the ability of soft shores, soft bottoms, hard shores, hard bottoms, or artificial substrates to function as habitat. The total area impacted by underwater explosions and military expended is summarized in Table 3.3-7.

3.3.3.3.3 Alternative 2

The combined effects of acoustic stressors, physical disturbances, and strike stressors proposed for training and testing events in Alternative 2 would not diminish the ability of soft shores, soft bottoms, hard shores, hard bottoms, or artificial substrates to function as habitat. The total area impacted by underwater explosions and military expended is summarized in Table 3.3-7.

3.3.3.3.4 Essential Fish Habitat Determinations

Pursuant to the EFH requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom, vessel movement, military expended materials, and seafloor devices may have an adverse effect on EFH by reducing the quality and quantity of non-living substrates that constitute EFH and Habitat Areas of Particular Concern.

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3.4 Marine Mammals

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3.4 MARINE MAMMALS

MARINE MAMMALS SYNOPSIS

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

- Acoustic (sonar and other active acoustic sources; explosive [impulse] sources; weapons firing, launch, and impact noise; vessel noise; aircraft overflight noise)
- Energy (electromagnetic)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, seafloor devices)
- Entanglement (fiber optic cables and guidance wires, parachutes)
- Ingestion (munitions and military expended materials other than munitions)
- Secondary (sediments and water quality)

Preferred Alternative (Alternative 1)

- Acoustics: Pursuant to the Marine Mammal Protection Act (MMPA), the use of sonar and other active acoustic sources, and explosive (impulse) sources may result in Level A harassment or Level B harassment of certain marine mammals; the use of weapons firing, vessel noise, and aircraft noise are not expected to result in Level A or Level B harassment of any marine mammals. Pursuant to the Endangered Species Act (ESA), sonar and other active acoustic sources and explosive (impulse) sources may affect, and are likely to adversely affect, certain ESA-listed marine mammals; weapons firing, launch, and impact noise; vessel noise, and aircraft overflight noise may affect, but are not likely to adversely affect, certain ESA-listed marine mammals; and all acoustic sources would have no effect on marine mammal critical habitats.
- Energy: Pursuant to the MMPA, the use of electromagnetic devices is not expected to result in Level A or Level B harassment of any marine mammals. Pursuant to the ESA, the use of electromagnetic devices may affect, but is not likely to adversely affect, certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats.
- Physical Disturbance and Strike: Pursuant to the MMPA, the use of vessels may result in mortality or Level A harassment of certain marine mammal species but is not expected to result in Level B harassment. The use of in-water devices, military expended materials, and seafloor devices is not expected to result in Level A or Level B harassment of any marine mammal. Pursuant to the ESA, vessel use may affect, and is likely to adversely affect, certain ESA-listed species. The use of in-water devices and military expended materials may affect, but is not likely to adversely affect, certain marine mammal species. The use of seafloor devices would have no effect on any ESA-listed marine mammal. The use of vessels, in-water devices, military expended materials, and seafloor devices would have no effect on marine mammal critical habitats.
- Entanglement: Pursuant to the MMPA, the use of fiber optic cables, guidance wires, and decelerator/parachutes is not expected to result in mortality or in Level A or Level B harassment of any marine mammal. Pursuant to the ESA, the use of fiber optic cables, guidance wires, and parachutes may affect, but is not likely to adversely affect, certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats.

MARINE MAMMALS SYNOPSIS (continued)

- Ingestion: Pursuant to the MMPA, the potential for ingestion of non-explosive practice munitions, fragments from high-explosive munitions, or military expended materials other than munitions is not expected to result in Level A or Level B harassment of any marine mammal. Pursuant to the ESA, the potential for ingestion of non-explosive practice munitions, fragments from high-explosive munitions, or military expended materials other than munitions may affect, but is not likely to adversely affect, certain ESA-listed species.
- Secondary Stressors: Pursuant to the MMPA, secondary stressors are not expected to result in Level A or Level B harassment of any marine mammal. Pursuant to the ESA, secondary stressors may affect, but are not likely to adversely affect, certain ESA-listed marine mammals and would have no effect on marine mammal critical habitat.

3.4.1 INTRODUCTION

This section provides the analysis of potential impacts to marine mammals that are found in the Northwest Training and Testing (NWTT) Study Area (Study Area). Section 3.4 provides a synopsis of the United States (U.S.) Navy's (Navy's) determination of impacts from the proposed action on marine mammals. Section 3.4.2 (Affected Environment) provides an introduction to the species that occur in the Study Area. The complete analysis and summary of potential impacts of the proposed action on marine mammals are found in Sections 3.4.3 (Environmental Consequences) and 3.4.4 (Summary of Impacts [Combined Impacts of all Stressors] on Marine Mammals), respectively.

Marine mammals are a diverse group of approximately 130 species. Most live predominantly in the marine habitat, although some species spend time in terrestrial habitats (e.g., seals) or in some cases, in freshwater environments, such as certain freshwater dolphins (Rice 1998; Jefferson 2009). The exact number of formally recognized marine mammal species changes periodically with new scientific understanding or findings (Rice 1998). Even the higher-level classification of marine mammals is controversial because the understanding of their origins and relationships continues to evolve (for a list of current species, see the formal list *Marine Mammal Species and Subspecies* maintained by the Society for Marine Mammalogy [Perrin et al. 2009]). This analysis uses the list of species provided by the National Oceanic and Atmospheric Administration (NOAA)/National Marine Fisheries Service (NMFS) 2012 U.S. Pacific Marine Mammal Stock Assessments (Carretta et al. 2013) and the 2012 Alaska Marine Mammal Stock Assessments (Allen and Angliss 2013).

All marine mammals in the United States are protected under the Marine Mammal Protection Act (MMPA), and some species receive additional protection under the Endangered Species Act (ESA). The MMPA defines a marine mammal "stock" as "a group of marine mammals of the same species or smaller taxon in a common spatial arrangement that interbreed when mature." For management purposes under the MMPA, a stock is considered an isolated population or group of individuals within a whole species that is found in the same area. However, generally due to a lack of sufficient information, management stocks defined by NMFS may include groups of multiple species, such as with *Mesoplodon* beaked whales (Carretta et al. 2013). In other cases, a single species may include multiple stocks recognized for management purposes (e.g., harbor porpoise in the Pacific Northwest). Marine mammal species known to occur in the Study Area and their currently recognized stocks are presented in Table 3.4-1. All these species are managed by NMFS or the United States Fish and Wildlife Service (USFWS) in the U.S. Exclusive Economic Zone (EEZ). Relevant information on their status, abundance, and distribution is presented in Section 3.4.2 (Affected Environment).

For summaries of the general biology and ecology of marine mammals beyond the scope of this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), see Rice (1998), Reynolds and Rommel (1999), Twiss and Reeves (1999), Hoelzel (2003), Berta et al. (2006), Jefferson et al. (2008), and Perrin et al. (2008). Additional species profiles and information on the biology, life history, species distribution and conservation of marine mammals can also be found through the following organizations:

- NMFS Office of Protected Resources (includes species distribution maps)
- Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (known as OBIS-SEAMAP) species profiles
- NOAA Cetacean Density and Distribution Mapping Working Group
- International Whaling Commission
- International Union for Conservation of Nature, Cetacean Specialist Group
- The Marine Mammal Commission
- Society for Marine Mammalogy

3.4.1.1 Species Unlikely to be Present in Northwest Training and Testing Study Area

The species carried forward for analysis are those likely to be found in the Study Area based on the most recent data available, and do not include species that may have once inhabited or transited the area but have not been sighted in recent years (e.g., species which were extirpated from factors such as nineteenth and twentieth century commercial exploitation). Several species that may be present in the northeast Pacific Ocean have an extremely low probability of presence in the Study Area. These species are considered extralimital, meaning there may be a small number of sighting or stranding records within the Study Area, but the area of concern is outside the species range of normal occurrence. These species include Bryde’s whale, false killer whale, and long-beaked common dolphin and have been excluded from subsequent analysis for the reasons described below (Sections 3.4.1.1.1, 3.4.1.1.2, and 3.4.1.1.3).

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Northwest Training and Testing Study Area

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region[4]	ESA/MMPA
Order Cetacea						
Suborder Mysticeti (baleen whales)						
Family Balaenidae (right whales)						
North Pacific right whale	*Eubalaena japonica*	Offshore Area	Eastern North Pacific	31 (0.23)	Rare Extralimital in Inland Waters	Endangered/ Depleted
Family Balaenopteridae (rorquals)						
Humpback whale	*Megaptera novaeangliae*	Western Behm Canal, Alaska	Central North Pacific	10,103 (n/a)	Likely spring through fall months but may be sighted year-round	Endangered/ Depleted
		Offshore Area	California, Oregon, & Washington	2,043 (0.10)	Likely with highest numbers in summer and fall but may be present year-round	Endangered/ Depleted
		Inland Waters			Seasonal to rare (varies by water body) with highest likelihood spring to fall	
Blue whale	*Balaenoptera musculus*	Offshore Area	Eastern North Pacific	2,497 (0.24)	Seasonal; highest likelihood in summer and fall and detected acoustically August through February (no acoustic detections between April and July)	Endangered/ Depleted
Fin whale	*Balaenoptera physalus*	Western Behm Canal, Alaska	Northeast Pacific	5,700 (minimum estimate) (n/a)	Rare	Endangered/ Depleted
		Offshore Area	California, Oregon, & Washington	3,044 (0.18)	Seasonal; high numbers in summer and fall and detected acoustically July through April (no acoustic detections May and June)	Endangered/ Depleted
Sei whale	*Balaenoptera borealis*	Offshore Area	Eastern North Pacific	126 (0.53)	Likely	Endangered/ Depleted
Minke whale	*Balaenoptera acutorostrata*	Western Behm Canal, Alaska	Alaska	Not available	Rare	-
		Offshore Area	California, Oregon, & Washington	478 (1.36)	Likely	-
		Inland Waters			Seasonal: More likely spring to fall, Rare in Puget Sound	

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Northwest Training and Testing Study Area (continued)

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region[4]	ESA/MMPA
Order Cetacea						
Suborder Mysticeti (baleen whales)						
Family Eschrichtiidae (gray whale)						
Gray whale	*Eschrichtius robustus*	Offshore Area	Eastern North Pacific	19,126 (0.07)	Likely: Highest numbers during seasonal migrations; small Pacific Coast Feeding Group year-round	-
		Inland Waters			Seasonal to rare (varies by water body). More likely winter to spring	
		Offshore Area	Western North Pacific	155 (n/a)	Rare: Individuals may migrate through offshore portion of study area	Endangered/ Depleted
Suborder Odontoceti (toothed whales)						
Family Physeteridae (sperm whale)						
Sperm whale	*Physeter macrocephalus*	Western Behm Canal, Alaska	North Pacific	Not available	Rare due to pelagic nature and no sightings in study area	Endangered/ Depleted
		Offshore Area	California, Oregon, & Washington	971 (0.31)	Likely; More likely in waters > 1,000 m depth, most often > 2,000 m	Endangered/ Depleted
Family Kogiidae (pygmy and dwarf sperm whale)						
Pygmy sperm whale	*Kogia breviceps*	Offshore Area	California, Oregon, & Washington	579 (1.02)	Likely	-
Dwarf sperm whale	*Kogia sima*	Offshore Area	California, Oregon, & Washington	Not available	Rare	-

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Northwest Training and Testing Study Area (continued)

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region[4]	ESA/MMPA
Order Cetacea						
Family Delphinidae (dolphins)						
Killer whale	*Orcinus orca*	Western Behm Canal, Alaska	Alaskan Resident	2,084 (n/a)	Rare	-
		Western Behm Canal, Alaska	Northern Resident	216 (n/a)	Likely	-
		Western Behm Canal, Alaska & Offshore Area	West Coast Transient	243 (95% CI: 180–339)	Likely	-
		Inland Waters			Likely to Rare in some areas	
		Offshore Area	Eastern North Pacific Offshore	240 (0.49)	Likely	-
		Inland Waters			Extralimital	
		Offshore Area & Inland Waters	Eastern North Pacific Southern Resident	87 (direct count)	Likely to Rare in some areas	Endangered/ Depleted
Short-finned pilot whale	*Globicephala macrorhynchus*	Offshore Area	California, Oregon, & Washington	760 (0.64)	Rare	-
Short-beaked common dolphin	*Delphinus delphis*	Offshore Area	California, Oregon, & Washington	411,211 (0.21)	Likely; more likely off California	-
Bottlenose dolphin	*Tursiops truncatus*	Offshore Area	California, Oregon, & Washington Offshore	1,006 (0.48)	Rare	-
		Inland Waters			Extralimital	-
Striped dolphin	*Stenella coeruleoalba*	Offshore Area	California, Oregon, & Washington	10,908 (0.34)	Rare	-
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	Western Behm Canal, Alaska	North Pacific	Not available	Rare; usually offshore but occasionally ventures into inshore waters	-
		Offshore Area	California, Oregon, & Washington	26,930 (0.28)	Likely	-
		Inland Waters			Rare but more likely summer and fall Extralimital in Puget Sound	

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Northwest Training and Testing Study Area (continued)

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region[4]	ESA/MMPA
Family Delphinidae (dolphins) (continued)						
Northern right whale dolphin	*Lissodelphis borealis*	Offshore Area	California, Oregon, & Washington	8,334 (0.40)	Likely	-
Risso's dolphin	*Grampus griseus*	Offshore Area	California, Oregon, & Washington	6,272 (0.30)	Likely	-
Family Phocoenidae (porpoises)						
Harbor porpoise	*Phocoena phocoena*	Western Behm Canal, Alaska	Southeast Alaska	11,146 (0.24)	Likely; more likely spring through fall, but may occur year-round	-
		Offshore Area	Northern Oregon/WA Coast	15,674 (0.39)	Likely	-
		Offshore Area	Northern CA/Southern OR	39,581 (0.39)	Likely	-
		Inland Waters	WA Inland Waters	10,682 (0.38)	Likely to Rare (varies by water body)	-
Dall's porpoise	*Phocoenoides dalli*	Western Behm Canal, Alaska	Alaska	83,400 (0.097)	Likely; more likely spring through fall, with higher numbers in spring and summer	-
		Offshore Area	California, Oregon, & Washington	42,000 (0.33)	Likely	-
		Inland Waters			Likely to Rare (varies by water body)	
Family Ziphiidae (beaked whales)						
Cuvier's beaked whale	*Ziphius cavirostris*	Western Behm Canal, Alaska	Alaska	Not available	Rare	-
		Offshore Area	California, Oregon, & Washington	2,143 (0.65)	Likely	-
Baird's beaked whale	*Berardius bairdii*	Western Behm Canal, Alaska	Alaska	Not available	Rare	-
		Offshore Area	California, Oregon, & Washington	907 (0.49)	Likely	-

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Northwest Training and Testing Study Area (continued)

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region[4]	ESA/MMPA
Family Ziphiidae (beaked whales) (continued)						
Mesoplodont beaked whales[6]	*Mesoplodon spp.*	Offshore Area	California, Oregon, & Washington	1,024 (0.77)	Likely; distributed throughout deep waters and continental slope regions; difficult to detect given diving behavior; limited sightings; generally seaward of 500–1,000 m depth	-
Suborder Pinnipedia[7]						
Family Otariidae (fur seals and sea lions)						
Steller sea lion	*Eumetopias jubatus*	Western Behm Canal, Alaska	Eastern U.S.	58,334–72,223	Likely	-
		Offshore Area			Likely	
		Inland Waters			Seasonal (unlikely June to September)	
California sea lion	*Zalophus californianus*	Western Behm Canal, Alaska	U.S.	296,750	Rare	-
		Offshore Area			Likely	-
		Inland Waters			Seasonal (unlikely in July)	-
Northern fur seal	*Callorhinus ursinus*	Western Behm Canal, Alaska	Eastern Pacific	653,171	Likely	Depleted
		Offshore Area	California	9,968	Likely	-
		Inland Waters	Eastern Pacific	653,171	Extralimital	Depleted
Guadalupe fur seal[8]	*Arctocephalus townsendi*	Offshore Area	Mexico	14,000–15,000	Seasonal migrants; mainly breeds on Guadalupe Island, Mexico, May–July	Threatened/ Depleted
		Inland Waters			Extralimital	
Family Phocidae (true seals)						
Northern elephant seal	*Mirounga angustirostris*	Western Behm Canal, Alaska	California Breeding	124,000	Extralimital	-
		Offshore Area			Seasonal	-
		Inland Waters			Seasonal to Rare in some areas; Infrequent in Puget Sound	-

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Northwest Training and Testing Study Area (continued)

Common Name	Scientific Name[1]	Region in Study Area	Stock[2]	Stock Abundance[3] (CV)	Occurrence in Region[4]	ESA/MMPA
Family Phocidae (true seals) (continued)						
Harbor seal	*Phoca vitulina*	Western Behm Canal, Alaska	Southeast Alaska (Clarence Strait)	152,602 (23,289)	Likely	-
		Offshore Area	OR/WA Coastal	24,732	Likely	-
		Offshore Area	California	30,196	Likely	-
		Inland Waters	WA Inland Waters	14,612	Likely	-
Order Carnivora						
Family Mustelidae (otters)[9]						
Northern sea otter	*Enhydra lutris kenyoni*	Western Behm Canal, Alaska	Southeast Alaska	25,712	Extralimital	-
		Offshore Area	Washington	1,125	Rare/Likely[10]	-
		Inland Waters			Rare	-

[1] Taxonomy follows Perrin et al. 2009.

[2] Stock abundance estimates and names from Carretta et al. 2013, Allen and Angliss 2013, and U.S. Fish and Wildlife Service 2013 except where noted.

[3] The stated coefficient of variation (CV) is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the population mean. It is expressed as a fraction or sometimes a percentage and can range upward from zero, indicating no uncertainty, to high values. For example, a CV of 0.85 would indicate high uncertainty in the population estimate. When the CV exceeds 1.0, the estimate is very uncertain. The uncertainty associated with movements of animals into or out of an area (due to factors such as availability of prey or changing oceanographic conditions) is much larger than is indicated by the CVs that are given.

[4] Extralimital: There may be a small number of sighting or stranding records, but the area is outside the species range of normal occurrence.

Rare: The distribution of the species is near enough to the area that the species could occur there, or there are a few confirmed sightings.

Infrequent: Confirmed, but irregular sightings.

Likely: Confirmed and regular sightings of the species in the area year-round.

Seasonal: Confirmed and regular sightings of the species in the area on a seasonal basis.

[5] Status of stock given as “unknown” in the 2012 Pacific Stock Assessment Report although not endangered, depleted, or strategic (Carretta et al. 2013).

[6] In waters off the U.S. west coast, the *Mesoplodon* species *M. carlhubbsi, M. ginkgodens, M. perrini, M. peruvianus, M. stejnegeri and M. densirostris* have been grouped by NMFS into a single management unit (*Mesoplodon* spp.) in the 2012 Pacific Stock Assessment report (Carretta et al. 2013).

[7] There are no data regarding the coefficient of variation (CV) for any pinnipeds given that abundance is determined by different methods than those used for cetaceans.

[8] The abundance estimate for Guadalupe fur seal is from Esperon-Rodriguez and Gallo-Reynoso (2012).

[9] There are no data regarding the coefficient of variation (CV) for sea otter given that abundance is determined by different methods than those used for cetaceans.

[10] The northern sea otter would be considered rare in the offshore portions of the Study Area. However, portions of the population overlap with nearshore portions of the NUWC Keyport Range Complex, where their occurrence would be considered likely to the 20 fathom isobath.

Notes: CV = coefficient of variation, n/a = not applicable, ESA = Endangered Species Act, MMPA = Marine Mammal Protection Act, OR = Oregon, WA = Washington, CA = California, U.S. = United States

3.4.1.1.1 Bryde's Whale (*Balaenoptera edeni*)

Bryde's whale is found in tropical and subtropical waters, generally not moving poleward of 40 degrees (°) in either hemisphere (Jefferson et al. 2008). There is some evidence that Bryde's whales migrate, but not as markedly as other large whales. They appear to have a preference for water temperatures between approximately 59° and 68° Fahrenheit (F) [15° and 20° Celsius (C)] (Yoshida and Kato 1999), much warmer than those of the Study Area. Based on sighting data collected by Southwest Fisheries Science Center (SWFSC) during systematic surveys in the northeast Pacific between 1986 and 2005, there were no sightings of Bryde's whales north of about 38° North (N) (Hamilton et al. 2009). An unprecedented stranding of a Bryde's whale occurred in Puget Sound in January 2010 (Cascadia Research 2010a), followed by another in December the same year (Cascadia Research 2010b). Both animals were immature and in poor nutritional condition, suggesting that they were beyond the species' normal range. The occurrence of Bryde's whale within the Study Area is considered extralimital as all regions within the Study Area are outside the normal range of this species' distribution.

3.4.1.1.2 False Killer Whale (*Pseudorca crassidens*)

False killer whales are found in tropical and temperate waters, generally between 50° South (S) and 50°N latitude (Baird 1989; Odell and McClune 1999). Although they can occur as far north as the Study Area, false killer whales are uncommon north of the U.S./Mexico border. Based on sighting data collected by SWFSC during systematic surveys in the northeast Pacific between 1986 and 2005, there were no sightings of false killer whales north of about 30°N (Hamilton et al. 2009). In the 1990s, a pod of nine false killer whales was recorded in Puget Sound south of the Tacoma Narrows for several months and then left. During this same time a lone individual was regularly seen in the Strait of Georgia, with one sighting recorded in Commencement Bay near Tacoma (Jeffries pers. comm. 2013). Norman et al. (2004) observed that most strandings for this species in Washington and Oregon occurred during or within a year of an El Niño event. For the MMPA stock assessment reports, there are five management stocks of false killer whale within the U.S. EEZ around the Pacific islands of Hawaii, Palmyra, and American Samoa (Carretta et al. 2013); there are no management stocks recognized for the U.S. west coast or Alaska waters. The occurrence of false killer whale within the Study Area is considered extralimital as all regions within the Study Area are outside the normal range of this species' distribution.

3.4.1.1.3 Long-beaked Common Dolphin (*Delphinus capensis*)

Waters off the central Californian coast are considered the northern range limit of long-beaked common dolphin, whose population extends south into Mexico (Carretta et al. 2011). However, two individuals were observed during the summer of 2011 in the Puget Sound, and in March 2012, a juvenile female long-beaked common dolphin was found dead in Little Skookum Inlet in southern Puget Sound (Cascadia Research 2012a). The occurrence of long-beaked common dolphin within the Study Area is considered extralimital as all regions within the Study Area are outside the normal range of this species' distribution.

3.4.2 AFFECTED ENVIRONMENT

Four main types of marine mammals are generally recognized: cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees, dugongs, and sea cows), and several species of marine carnivores (marine otters and polar bears) (Rice 1998). Within these types of marine mammals, walruses, sirenians, and polar bears do not occur in the Study Area.

Detailed reviews of the different groups of cetaceans can be found in Perrin et al. (2008). The order Cetacea is divided into two suborders. The toothed whales, (suborder Odontoceti; e.g., sperm whales

[*Physeter macrocephalus*], killer whales [*Orcinus orca*], dolphins, porpoises, beaked whales) range in size from slightly longer than 3 feet (ft.) (1 meter [m]) to more than 60 ft. (18 m) and have teeth, which they use to capture and consume individual prey. The baleen whales (suborder Mysticeti; e.g., minke [*Balaenoptera acutorostrata*], humpback [*Megaptera novaeangliae*], gray [*Eschrichtius robustus*], fin [*B. physalus*], and blue [*B. musculus*] whales) are universally large (more than 15 ft. [4.5 m] as adults). They are called baleen whales because instead of teeth, they have a fibrous structure made of keratin that is suspended from their upper jaws and is called baleen. Keratin is a type of protein similar to that found in human fingernails. The baleen enables the whales to filter and trap food from the water for feeding. They are batch feeders that use baleen instead of teeth to engulf, suck, or skim large numbers of small prey from the water or ocean floor sediments (Heithaus and Dill 2008). The different feeding strategies of mysticetes and odontocetes affect their distribution and occurrence patterns.

Cetaceans inhabit virtually every marine environment in the Study Area, from inland waters to coastal and open ocean environments in the Pacific Ocean. Their distribution is influenced by a number of factors, but primary among these are patterns of major ocean currents, bottom relief, and sea surface temperature, which, in turn, affect prey productivity. The continuous movement of water from the ocean bottom to the surface creates a nutrient-rich, highly productive environment for marine mammal prey (Bakun 1996). For most cetaceans, prey distribution, abundance, and quality largely determine where they occur at any specific time (Heithaus and Dill 2008). Most of the large cetaceans are migratory (e.g., Barlow et al. 2011), but many small cetaceans do not migrate in the strictest sense. Instead, they undergo seasonal dispersal, or shifts in population density induced by seasonal changes in their environment (Forney and Barlow 1998).

Pinnipeds in the Study Area are also divided into two groups: phocids (true seals) and otariids (fur seals and sea lions). Phocids lack ear flaps, their fore flippers are short and have hair, and their hind flippers are oriented towards the back of their bodies and cannot be rotated forward. Otariids have external ear flaps, long hairless or partially haired fore flippers, and hind flippers that can be rotated beneath their bodies. Pinnipeds spend a large portion of their time on land at haul-out sites used for resting and moulting, and at rookeries used for breeding and nursing young, and return to the water to forage. Many pinniped species have well known seasonal cycles, distributions, and established haul-out sites and rookeries which support large colonies of individuals.

The northern sea otter (*Enhydra lutris kenyoni*) is a carnivorous coastal marine mammal species in the family Mustelidae. Sea otters require shallow waters as habitat for reproducing, resting, and foraging. Sea otters rarely come ashore and spend most of their life in the ocean where they regularly swim, feed, and rest.

3.4.2.1 Group Size

Many species of marine mammals, particularly odontocetes, are highly social animals that spend much of their lives living in groups or schools ranging from several to several thousand individuals. Similarly, aggregations of baleen whales may form during particular breeding or foraging seasons. The behavior of aggregating into groups is important for the purposes of mitigation and monitoring in that it can increase the probability of marine mammals being detected. In addition, group size is an important consideration when conducting acoustic exposure analyses. A comprehensive and systematic review of available published and unpublished literature including journals, books, technical reports, cruise reports, raw cruise data, theses, and dissertations was conducted to summarize relevant information on marine mammal group sizes. The results of this review were compiled into a Technical Report that includes tables of group size information by species along with relevant citations (Watwood and Buonantony 2012).

3.4.2.2 Diving

Some species of marine mammals have developed specialized adaptations to allow them to make deep dives lasting over an hour, primarily for the purpose of foraging on deep-water prey such as squid. Other species spend the majority of their lives close to the surface and make relatively shallow dives for shorter durations. The diving behavior of a particular species or individual has implications for the ability to detect them for mitigation and monitoring. In addition, their relative distribution through the water column is an important consideration when conducting acoustic exposure analyses. Information and data on marine mammal diving behavior were compiled and summarized in a Technical Report that provides detailed summaries of time at depth for each species (Watwood and Buonantony 2012).

3.4.2.3 Vocalization and Hearing of Marine Mammals

All marine mammals that have been studied can produce sounds and use sounds to forage, orient and navigate, monitor their environment, detect and respond to predators, and socially interact with others. Measurements of marine mammal sound production and hearing capabilities provide some basis for assessing whether exposure to a particular sound source may affect a marine mammal behaviorally or physiologically. Marine mammal hearing abilities are quantified using live animals either via behavioral audiometry or electrophysiology (see Schusterman 1981; Au 1993; Wartzok and Ketten 1999; Nachtigall et al. 2007). Behavioral audiograms, which are plots of animals' exhibited hearing threshold versus frequency, are obtained from captive, trained live animals using standard testing procedures with appropriate controls, and are considered to be a more accurate representation of a subject's hearing abilities. Behavioral audiograms of marine mammals are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain for experiments in captivity.

Consequently, our understanding of a species' hearing ability may be based on the behavioral audiogram of a single individual or small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that may impact their hearing abilities whether positively or negatively, and may not accurately reflect the hearing abilities of free-swimming animals (Houser et al. 2010). For animals not available in captive or stranded settings (including large whales and rare species), estimates of hearing capabilities are made based on physiological structures, vocal characteristics, and extrapolations from related species.

In comparison, electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans. For both methods of evaluating hearing ability, hearing response in relation to frequency is a generalized U-shaped curve or audiogram showing the frequency range of best sensitivity (lowest hearing threshold) and frequencies above and below with higher threshold values.

Direct measurement of hearing sensitivity exists for approximately 25 of the nearly 130 species of marine mammals (Table 3.4-2). Section 3.4.2.3 (Vocalization and Hearing of Marine Mammals) provides a summary of sound production and hearing capabilities for marine mammal species in the Study Area. For purposes of the analyses in this document, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities (note that these categories are not the same as the sonar source categories described in Chapter 2, Description of Proposed Action and Alternatives): high-frequency cetaceans, mid-frequency cetaceans, low-frequency cetaceans (mysticetes), phocid pinnipeds (true seals), otariid pinnipeds (sea lions and fur seals), and Mustelidae (sea otters).

Table 3.4-2: Hearing and Vocalization Ranges for All Marine Mammal Functional Hearing Groups and Species Potentially Occurring within the Study Area

Functional Hearing Group	Species Which May be Present in the Study Area	Sound Production[1]		Functional Hearing Ability Frequency Range[1]
		Frequency Range	Source Level (dB re 1 μPa at 1 m)	
High-Frequency Cetaceans	Harbor Porpoise, Dall's Porpoise, and *Kogia* Species (Dwarf Sperm Whale and Pygmy Sperm Whale)	100 Hz–200 kHz	120–205	200 Hz–180 kHz
Mid-Frequency Cetaceans	Sperm Whale, Beaked Whales (*Berardius*, *Mesoplodon*, and *Ziphius* species), Bottlenose Dolphin, Short-beaked Common Dolphin, Killer Whale, Northern Right Whale Dolphin, Short-finned Pilot Whale, Risso's Dolphin, Striped Dolphin, Pacific White-sided Dolphin	100 Hz–> 100 kHz	118–236	150 Hz–160 kHz
Low-Frequency Cetaceans	Blue Whale, Gray Whale, Fin Whale, Humpback Whale, Minke Whale, Sei Whale, North Pacific Right Whale	10 Hz–20 kHz	129–195	7 Hz–22 kHz
Phocidae	Northern Elephant Seal, Harbor Seal	100 Hz–12 kHz	103–180	In-water: 75 Hz–75 kHz In-air: 75 Hz–30 kHz
Otariidae	Steller Sea Lion, California Sea Lion, Northern Fur Seal	30 Hz–10 kHz	120–196	In-water: 50 Hz–50 kHz In-air: 50 Hz–75 kHz
Mustelidae	Northern Sea Otter	Primarily (in-air) from 4 kHz to 8 kHz; (energy and harmonics present above 10–60 kHz although behavioral functionality unknown)	In-air: up to 113	In-water: unknown In-air: 125 Hz–35 kHz; peak sensitivity at 16 kHz

[1] Sound production levels and ranges and functional hearing ranges are generalized composites for all members of the functional hearing groups, regardless of their presence in this Study Area.

Sound production data adapted and derived from: Aburto et al. 1997; Ghoul & Reichmuth 2012; Hanggi & Schusterman 1994; Kastelein et al. 2002a, b; Marten 2000; McShane, et al. 1995; Møhl et al. 2003; Philips et al. 2003; Richardson et al. 1995; Schusterman et al. 1972; Villadsgaard et al. 2007; Ghoul & Reichmuth 2012.

Hearing data adapted and derived from: Southall et al. 2007

These frequency ranges and source levels include social sounds for all groups and echolocation sounds for mid- and high-frequency groups. In-air vocalizations were not included for pinniped groups. Vocalization parameters for Mustelidae were measured from in-air vocalizations; no underwater data are available for this group.

Notes: dB re 1 μPa at 1 m = decibels referenced to 1 micropascal at 1 meter, Hz = Hertz, kHz = kilohertz

Note that frequency ranges for high-, mid-, and low-frequency cetacean hearing differ from the frequency range categories defined using similar terms to describe active sonar systems. For discussion of all marine mammal functional hearing groups and their derivation see Finneran and Jenkins (2012).

3.4.2.3.1 High-Frequency Cetaceans

Marine mammals within the high-frequency cetacean functional hearing group are all odontocetes (toothed whales; suborder: Odontoceti) and includes eight species and subspecies of porpoises (family: Phocoenidae); dwarf and pygmy sperm whales (family: Kogiidae); six species and subspecies of river dolphins; the franciscana; and four species of cephalorhynchus. The following members of the high-frequency cetacean group are known to occur or may rarely occur in the Study Area: harbor porpoise (*Phocoena phocoena*), Dall's porpoise (*Phocoenoides dalli*), dwarf sperm whale (*Kogia sima*), and pygmy sperm whale (*Kogia breviceps*). Functional hearing in high-frequency cetaceans occurs between approximately 200 Hertz (Hz) and 180 kilohertz (kHz) (Southall et al. 2007).

Sounds produced by high-frequency cetaceans range from approximately 100 Hz to 200 kHz with source levels of 120–205 decibels (dB) referenced to (re) 1 micropascal (μPa) at 1 m (Richardson et al. 1995; Verboom and Kastelein 2003; Madsen et al. 2005; Villadsgaard et al. 2007). Recordings of sounds produced by dwarf and pygmy sperm whales consist almost entirely of the click/pulse type (Marten 2000). Porpoises, unlike most other odontocetes, either do not produce whistles or do not whistle often (Awbrey et al. 1979; Houck and Jefferson 1999; Thomson and Richardson et al. 1995; Verboom and Kastelein 2003). High-frequency cetaceans also generate specialized clicks used in biosonar (echolocation) at frequencies above 100 kHz that are used to detect, localize, and characterize underwater objects such as prey (Richardson et al. 1995).

An electrophysiological audiometry measurement on a stranded pygmy sperm whale indicated best sensitivity between 90 and 150 kHz (Ridgway and Carder 2001). From a harbor porpoise audiogram using behavioral methods, detection thresholds were estimated from 250 Hz to 180 kHz, with the range of best hearing from 16 to 140 kHz and maximum sensitivity between 100 and 140 kHz (Kastelein et al. 2002a). While no empirical data on hearing ability for Dall's porpoise are available, data on the morphology of the cochlea allows for estimation of the upper hearing threshold at about 170–200 kHz Awbrey et al. (1979).

3.4.2.3.2 Mid-Frequency Cetaceans

Marine mammals within the mid-frequency cetacean functional hearing group are all odontocetes, and include the sperm whale (family: Phystereidae); 32 species and subspecies of dolphins (family: Delphinidae), the beluga (*Delphinapterus leucas*) and narwhal (*Monodon monoceros*) (family: Monodontidae), and 19 species of beaked and bottlenose whales (family: Ziphiidae). The following members of the mid-frequency cetacean group are known to occur or may rarely occur in the Study Area: sperm whale, killer whale, short-finned pilot whale (*Globicephala macrorhynchus*), short-beaked common dolphin (*Delphinus delphis*), common bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), northern right whale dolphin (*Lissodelphis borealis*), Risso's dolphin (*Grampus griseus*), and beaked whales (*Berardius, Mesoplodon*, and *Ziphius* species). Functional hearing in mid-frequency cetaceans is conservatively estimated to be between approximately 150 Hz and 160 kHz (Southall et al. 2007).

Hearing studies on cetaceans have focused primarily on odontocete species (Szymanski et al. 1999; Kastelein et al. 2002a; Nachtigall et al. 2005; Yuen et al. 2005; Houser and Finneran 2006). Hearing sensitivity has been directly measured for a number of mid-frequency cetaceans, including Atlantic white-sided dolphins (*Lagenorhynchus acutus*) (Houser et al. 2010a), common dolphins (*Delphinus* spp.) (Houser, Dankiewicz-Talmadge et al. 2010), Atlantic bottlenose dolphins (*Tursiops truncatus truncatus*) (Johnson 1967), Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) (Houseret al. 2010a), Black Sea bottlenose dolphins (*Tursiops truncatus ponticus*) (Popov et al. 2007), striped dolphins (*Stenella coeruleoalba*) (Kastelein et al. 2003), white-beaked dolphins (*Lagenorhynchus albirostris*) (Nachtigall et al. 2008), Risso's dolphins (Nachtigall et al. 2005), belugas (Finneran et al. 2005; White et al. 1977), long-finned pilot whales (*Globicephala melas*) (Pacini et al. 2010), false killer whales (*Pseudorca crassidens*) (Yuen et al. 2005), killer whales (Szymanski et al. 1999), Gervais' beaked whales (*Mesoplodon europaeus*) (Finneran et al. 2009), and Blainville's beaked whales (*M. densirostris*) (Pacini et al. 2011). All audiograms exhibit the same general U-shaped curve when plotting sound source level against frequency, with a wide nominal hearing range between approximately 150 Hz and 160 kHz (Ketten 2012).

In general, odontocetes produce sounds across the widest band of frequencies. Their social vocalizations range from a few hundreds of Hz to tens of kHz (Southall et al. 2007) with source levels in the range of 118–236 dB re 1 µPa (see Richardson et al. 1995). As mentioned earlier, they also generate specialized clicks used in echolocation at frequencies above 100 kHz that are used to detect, localize and characterize underwater objects such as prey (Au 1993). Echolocation clicks have source levels that can be as high as 229 dB re 1 µPa peak-to-peak (Au et al. 1974).

3.4.2.3.3 Low-Frequency Cetaceans

Marine mammals within the low-frequency functional hearing group are all mysticetes. This group is comprised of 13 species and subspecies of mysticete whales in six genera: *Eubalaena, Balaena, Caperea, Eschrichtius, Megaptera*, and *Balaenoptera*. The following members of the low-frequency cetacean group (mysticetes) are known to occur or may rarely occur in the Study Area: humpback, blue, fin, sei (*Balaenoptera borealis*), minke, gray, and North Pacific right (*Eubalaena japonica*) whales. Functional hearing in low-frequency cetaceans is conservatively estimated to be between approximately 7 Hz and 22 kHz (Southall et al. 2007).

Because of large animal size and general unavailability of live specimens, direct measurements of mysticete whale hearing are not available, although there was one effort to measure hearing thresholds in a stranded gray whale (Ridgway and Carder 2001). Because hearing ability has not been directly measured in these species, it is inferred from vocalizations, ear structure, and field observations. Vocalizations are audible somewhere in the frequency range of production, but the exact range cannot be inferred (Southall et al. 2007).

Mysticete cetaceans produce low-frequency sounds that range in the tens of Hz to several kHz that most likely serve social functions such as reproduction, but may serve an orientation function as well (Green et al. 1994). Humpback whales are the notable exception within the mysticetes, with some calls exceeding 10 kHz. These sounds can generally be categorized as low-frequency moans; bursts or pulses; or more complex songs (Edds-Walton 1997). Source levels of most mysticete cetacean sounds range from 150 to 190 dB re 1 µPa (see Richardson et al. 1995).

3.4.2.3.4 Pinnipeds

Pinnipeds are divided into three functional hearing groups, otariids (sea lions and fur seals), phocid seals (true seals), and odobenids (walrus), with different in-air and in-water hearing ranges. The Study Area contains phocids (true seals) and otariids (fur seals). Species known to occur with varying level of frequency in the Study Area include the harbor seal (*Phoca vitulina*), northern elephant seal (*Mirounga* *angustirostris*), California sea lion (*Zalophus californianus*), northern fur seal (*Callorhinus ursinus*), Guadalupe fur (*Arctocephalus townsendi*), and Steller sea lion (*Eumetopias jubatus*). Measurements of hearing sensitivity have been conducted on species representing all of the families of pinnipeds (Phocidae, Otariidae, Odobenidae) (see Schusterman et al. 1972; Moore and Schusterman 1987; Terhune 1988; Thomas et al. 1990; Turnbull and Terhune 1990; Kastelein et al. 2002b; Wolski et al. 2003; Kastelein et al. 2005a; Kastelein et al. 2012c).

Pinnipeds produce sounds both in air and water that range in frequency from approximately 100 Hz to several tens of kHz and it is believed that these sounds only serve social functions (Miller 1991) such as male-male vocal boundary displays, mother-pup recognition, and reproduction. Source levels for pinniped vocalizations range from approximately 95–190 dB re 1 µPa (see Richardson et al. 1995).

3.4.2.3.5 Phocids

Phocids (true seals) known to occur with varying level of frequency in the Study Area include the harbor seal and northern elephant seal. Hearing in phocids has been tested in the following species: gray seals (Ridgway et al. 1975); harbor seals (Richardson et al. 1995; Terhune and Turnbull 1995; Kastak and Schusterman 1998; Richardson et al. 1995; Wolski et al. 2003; Southall et al. 2007; Kastelein et al. 2012c); harp seals (Terhune and Ronald 1971, 1972); Hawaiian monk seals (Thomas et al. 1990); northern elephant seals (Kastak and Schusterman 1998, 1999); and ringed seals (Terhune and Ronald 1975, 1976).

Phocid hearing limits are estimated to be 75 Hz–30 kHz in air and 75 Hz–75 kHz in water (Terhune and Ronald 1971, 1972; Kastak and Schusterman 1999; Reichmuth 2008; Kastelein et al. 2009).

3.4.2.3.6 Otariids

Otariids (sea lions and fur seals) known to occur with varying level of frequency in the Study Area include California sea lion, northern fur seal, Guadalupe fur seal, and Steller sea lion. Hearing in otariid seals is adapted to low frequency sound and less auditory bandwidth than phocid seals. Hearing in otariid seals has been tested in two species present in the Study Area: California sea lion (Schusterman et al. 1972; Moore and Schusterman 1987; Kastak and Schusterman 1998; Southall et al. 2005) and northern fur seal (Moore and Schusterman 1987; Babushina et al. 1991). The otariids' hearing ranges of 50 Hz–75 kHz in air and 50 Hz–50 kHz in water based on these studies.

3.4.2.3.7 Mustelidae (Sea Otters)

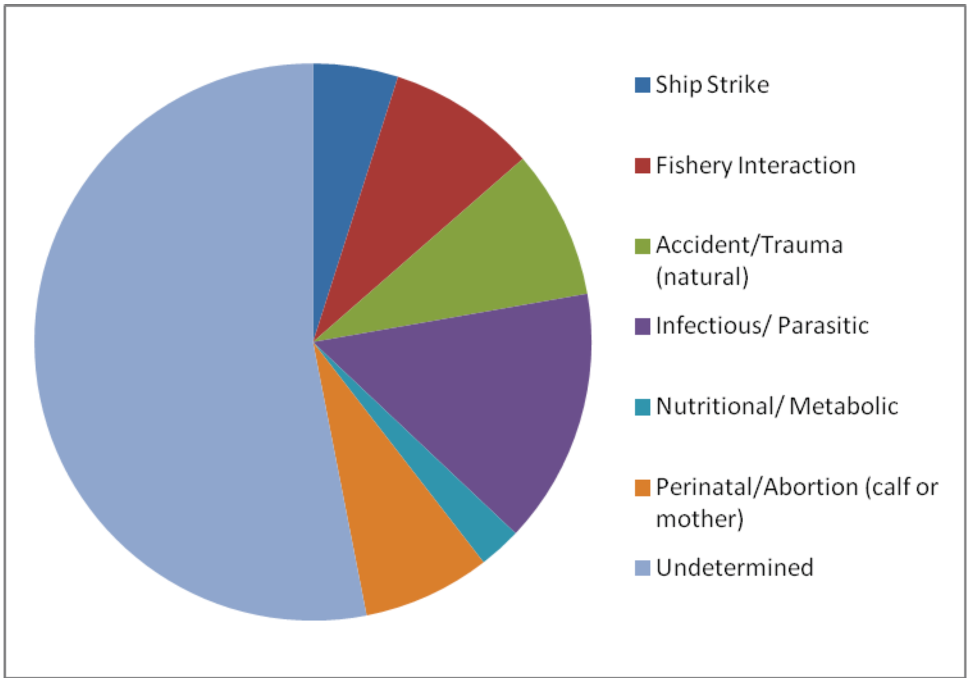
There have been no direct studies of hearing in sea otters although behavioral response to playbacks was undertaken previously (Davis et al. 1988; Ghoul and Reichmuth 2012). Maximum hearing sensitivity for sea otters has been inferred based on the anatomy of the inner ear, which indicates they likely have a maximum hearing sensitivity at 16 kHz (Davis et al. 1988). For purposes of the analysis in this document, it is assumed that northern sea otters in the Study Area have hearing ranges of 125 Hz–35 kHz in air and 50 Hz–50 kHz in water based on their phylogenetic and anatomical similarities to otariids (Finneran and Jenkins 2012).

3.4.2.4 General Threats

Marine mammal populations can be influenced by various factors and human activities. These factors can affect marine mammal populations directly, by activities such as hunting and whale watching, or indirectly, through reduced prey availability or lowered reproductive success of individuals. Twiss and Reeves (1999) provide a general discussion of marine mammal conservation. Norman et al. (2004)

provides an historical overview of strandings occurring in Washington and Oregon between 1930 through 2002. Calambokidis and Huggins (2008) and National Marine Fisheries Service (2012) provide documentation for threats to marine mammals in Washington based on more recent stranding response data.

As detailed in National Oceanic and Atmospheric Administration (2009), investigations of stranded marine mammals are undertaken out of a concern for animal welfare and ocean stewardship and given the understanding that they are sentinels of ecosystem health and may therefore provide valuable links to human health (National Research Council 1991). Investigations into the cause of death for stranded animals can provide indications of the general threats to marine mammals in a given location. Calambokidis and Huggins (2008) provided data on cetacean strandings in Washington from 2004 through 2007 as detailed in Figure 3.4-1 below. While the cause of death could not be determined in approximately half the strandings investigated due to decomposition or a lack of significant pathological or gross findings, human interaction and infectious or parasitic agents were the most common cause of death in those cases where a cause could be determined.



Source: Calambokidis and Huggins (2008)

Figure 3.4-1: Cetacean Cause of Death in Washington from 2004 through 2007

Marine mammals are influenced by natural phenomena, such as storms and other extreme weather patterns. Generally, not much is known about how large storms and other weather patterns affect marine mammals, other than that mass strandings (when two or more marine mammals become beached or stuck in shallow water) sometimes coincide with hurricanes, typhoons, and other tropical storms (Marsh 1989; Rosel and Watts 2008). The global climate is changing and is having impacts on some populations of marine mammals (Simmonds and Eliott 2009; Salvadeo et al. 2010). Climate change can affect marine mammal species directly through habitat loss (especially for species that depend on ice or terrestrial areas) and indirectly via impacts on prey, changing prey distributions and locations, increased ocean acidification, and changes in water temperature. Changes in prey can impact marine mammal foraging success, which in turn affects reproduction success, and survival. Climate change also may influence marine mammals through effects on human behavior, such as increased shipping and oil and gas extraction, resulting from sea ice loss (Alter et al. 2010).

Mass die offs of some marine mammal species have been linked to toxic algal blooms, that is, they consume prey that have consumed toxic plankton, such as die offs of California sea lions and northern fur seals because of poisoning caused by the diatom *Pseudo-nitzschia* spp. (Doucette et al. 2006; Fire et al. 2008; Torres de la Riva et al. 2009; Thomas et al. 2010; Lefebrve et al. 2010). All marine mammals have parasites that, under normal circumstances, probably do little overall harm, but under certain conditions, they can cause serious health problems or even death (Jepson et al. 2005; Bull et al. 2006; Fauquier et al. 2009). Disease affects some individuals (especially older animals), and occasionally disease epidemics can injure or kill a large percentage of the population (Paniz-Mondolfi and Sander-Hoffmann 2009; Keck et al. 2010). Although the cause remains undetermined, there was an Unusual Mortality Event declared for harbor porpoise in the Pacific Northwest in 2006, which continued through 2008 (Calambokidis and Huggins 2008). Recently the first case of morbillivirus in the central Pacific was documented for a stranded juvenile male Longman’s beaked whale at Hamoa beach, Hana, Maui (West et al. 2012).

Human impacts on marine mammals have received much attention in recent decades, and include hunting (both commercial and native practices), fisheries interactions (such as gear entanglement or shootings by fishers), bycatch (accidental or incidental catch), indirect effects of fisheries through takes of prey species, ship strikes, noise pollution, chemical pollution, and general habitat deterioration or destruction. See Williams et al. (2011) regarding impacts from marine debris due to ingestion by and entanglement of marine mammals in Canadian coastal areas to the north of the Study Area.

Direct hunting, as in whaling and sealing operations, provided the original impetus for marine mammal management efforts and has driven much of the early research on cetaceans and pinnipeds (Twiss and Reeves 1999). However, fishery bycatch is likely the most impactful problem presently and may account for the deaths of more marine mammals than any other cause (Hamer et al. 2010; Northridge 2008; Read 2008; Geijer and Read 2013). In 1994, the MMPA was amended to formally address bycatch. The amendment requires the development of a take reduction plan when bycatch exceeds a level considered unsustainable by the marine mammal population. At least in part as a result of the amendment, estimates of bycatch in the Pacific declined by a total of 96 percent from 1994 to 2006 (Geijer and Read 2013). Cetacean bycatch declined by 85 percent from 342 in 1994 to 53 in 2006, and pinniped bycatch declined from 1,332 to 53 over the same time period.

Fishery interactions other than bycatch also include entanglement from nets, fishing line, and the ropes and lines connected to fishing gear (see, for example, Good et al. 2010; Saez et al. 2012; Williams et al. 2011). Derelict or abandoned fishing gear is a recognized conservation concern in the Puget Sound (Good et al. 2010) and can directly impact marine mammals as well as their prey. Calambokidis and Huggins (2008) documented three known marine mammal strandings resulting from entanglement in nets in Washington between 2004 through 2007. Douglas et al. (2008) reported six gray whales in Washington entangled between 1980 and 2006. For the area off the coasts of northern California, Oregon, and Washington, Saez et al. (2013) reported there were 272 large whales entangled in fishing gear between 1982 and 2010 with trap/pot and gillnets being the most common entangling gear.

Ship strikes are an issue of increasing concern for most marine mammals, particularly baleen whale species. In Alaska waters from 1978 to 2006, there were 62 reported vessel collisions with whales (Gabriele et al. 2007). These involved motorized, non-motorized, large and small vessels, engaged in a variety of activities with private small vessel (less than 15 m in length) strikes the most common. Data provided by the NMFS Northwest Regional Stranding Network indicate that there were 21 known ships strikes to large whales and pinnipeds from 1991 to 2010 (National Marine Fisheries Service 2012; see also the earlier publication by Douglas et al. 2008 on ship strikes to large whales in Washington). The majority of strikes in this period involved gray whales (32 percent) followed by fin whales (25 percent), humpback whales (11 percent), and sperm whales (8 percent). There were two strikes to harbor seals and one to a California sea lion. None of these ship strikes involved a Navy vessel. Given that personnel on Navy vessels up to and including aircraft carriers have known when a whale has been struck because of a reported "shudder" in the vessel, even when there has been no visual detection prior to the event, the Navy is confident that, unlike minimally manned commercial vessels, all U.S. Navy vessels have the potential to detect all strikes involving large whales. Any strike by a Navy vessel is reported via the Navy chain of command to NMFS independent of any stranding or stranding data.

Chemical pollution is also of great concern, although for the most part, its effects on marine mammals are just starting to be understood. In a broad scale investigation, the 5.5-year expedition of the *Odyssey* collected 955 biopsy samples from sperm whales around the world to provide a consistent baseline database of ocean contamination and to measure future effects (Ocean Alliance 2010). Chemical pollutants found in pesticides and other substances flow into the marine environment from human use on land and are absorbed into the bodies of marine mammals, accumulating in their blubber, internal organs, or are transferred to the young from mother's milk (Fair et al. 2010). Important factors that determine the levels of pesticides, heavy metals, and industrial pollutants that accumulate in marine mammals are gender (i.e., adult males have no way to transfer pesticides whereas females may pass pollutants to their calves through milk), habitat and diet. Living closer to the source of pollutants and feeding on higher-level organisms increase the potential to accumulate toxins (Moon et al. 2010). The buildup of human-made persistent compounds in marine mammals not only increases their likelihood of contracting diseases or developing tumors but also compromises the function of their reproductive systems (Fair et al. 2010).

In the Pacific Northwest, Krahn et al. (2007) used biopsy samples taken in 2004 and 2006 from southern resident killer whales to measure levels of persistent organic pollutants (obtained via the food chain) and determine if there were changes between the sampling years. While there was no evidence suggesting a shift in the levels between years, differences in the levels between the resident J-pod and L-pod suggested that they may be obtaining prey from separate winter feeding areas and thus leading to the differences in levels noted between the two pods. In another investigation from the Pacific Northwest, Wintle et al. (2011) analyzed samples for total mercury from 105 marine mammals stranded along the Oregon and Washington coasts between 2002 and 2009. Steller sea lions and northern elephant seals exhibited the highest mean concentrations of total mercury followed by harbor seals, harbor porpoises, and California sea lions. Wintle et al. (2011) note that mercury found in those stranded animals can come from multiple sources including run-off from mine tailings, hydrothermal vents, municipal wastes, and gaseous mercury carried by trade winds.

Oil and other chemical spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species (Marine Mammal Commission 2011). Although information on effects of oil spills on marine mammals is limited, new information gained from study of the recent Deep Water Horizon oil spill in the Gulf of Mexico has provided insight on assessment of long-term effects (Marine Mammal Commission 2011) as well as continued study of the 1989 Exxon Valdez in Prince William Sound, Alaska (Matkin et al. 2008; Bodkin et al. 2012). In short, marine mammals can be affected directly by contact or ingestion of the oil, indirectly by activities during the containment and cleanup phases, and through long-term impacts on prey and habitat.

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals, especially those that live in rivers or estuaries, and it may include such factors as depleting a habitat's prey base and the complete loss of habitat (Kemp 1996; Smith et al. 2009; Ayres et al. 2012). In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise is also being increasingly considered as a potential habitat level stressor. Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. Noise may cause marine mammals to leave a habitat, impair their ability to communicate, or to cause stress (Holt et al. 2008; Hildebrand 2009; Tyack et al. 2011; Rolland et al. 2012; Erbe et al. 2012). Noise can cause behavioral disturbances, mask other sounds including their own vocalizations, may result in injury, and, in some cases, result in behaviors that ultimately lead to death (National Research Council of the National Academies 2003, 2005; Nowacek et al. 2007; Tyack 2009; Würsig and Richardson 2008; Southall et al. 2009a). For examples of noise impacts specific to the Study Area, see Erbe (2002, 2012), Griffin and Bain (2006), Holt (2008), and Holt et al. (2008).

Anthropogenic noise is generated from a variety of sources including commercial shipping, oil and gas exploration and production activities, commercial and recreational fishing (including fishing finding sonar, fathometers, and acoustic deterrent and harassment devices), recreational boating and whale watching activities, offshore power generation, research (including noise from airguns, sonar, and telemetry), and military training and testing activities. Vessel noise in particular is a large contributor to noise in the ocean and intensively used inland waters. Commercial shipping's contribution to ambient noise in the ocean has increased by as much as 12 dB over the last few decades (McDonald et al. 2008; Hildebrand 2009). Using a simple sound transmission model and ship track data, Erbe et al. (2012) estimated that for Puget Sound the annual maximum modeled underwater sound exposure level (SEL) from vessel traffic was 215 dB re 1 micropascal squared second (μPa^2-s) near Seattle; this is an estimated exposure integrated over a year. In another study, at Admiralty Inlet in Puget Sound Bassett et al. (2012) measured sound pressure levels (SPL) from commercial shipping and estimated the source level of the Keystone/Port Townsend ferry to be between 175 and 183 dB re 1 µPa at 1 m. Mean total sound pressure levels (in the frequency spectrum between 156 Hz and 30 kHz) over all recordings were 117 dB re 1 µPa and exceeded 135 dB re 1 µPa on some occasions (Bassett et al. 2010).

3.4.2.5 Marine Mammal Density Estimates

A quantitative impact analysis requires an estimate of the number of animals that might be affected. A key element of this estimation is knowledge of the abundance and concentration of the species in specific areas where those activities will occur. The most appropriate unit of metric for this type of analysis is density or the number of animals present per unit area. Marine species density estimation requires a significant amount of effort to both collect and analyze data to produce a reasonable estimate. Unlike surveys for terrestrial wildlife, many marine species spend much of their time submerged, and are not easily observed. In order to collect enough sighting data to make reasonable density estimates, multiple observations are required, often in areas that are not easily accessible (e.g., far offshore). Ideally, marine species sighting data would be collected for the specific area and time period of interest and density estimates derived accordingly. However, in many places poor weather conditions and high sea states prohibit the completion of comprehensive surveys.

For most cetacean species, abundance is estimated using line-transect surveys or mark-recapture studies (e.g., Barlow and Forney 2007; Calambokidis et al. 2008; Barlow 2010). The result provides one single density estimate value, for each species, across broad geographic areas, such as waters within the U.S. EEZ off California, Oregon, and Washington. This is the general approach applied in estimating cetacean abundance in the NMFS stock assessment reports. Though the single value provides a good average estimate of abundance (total number of individuals) for a specified area, it does not provide information on the species distribution or concentrations within that area, and does not estimate density for other timeframes/seasons that were not surveyed. More recently, habitat modeling has been used to estimate cetacean densities (Ferguson et al. 2006a; Redfern et al. 2006; Barlow et al. 2009; Becker et al. 2010, 2012a,b,c; Forney et al. 2012). These models estimate cetacean density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth, etc.) and thus allow predictions of cetacean densities on finer spatial scales than traditional line-transect or mark-recapture analyses. Within the study area that was modeled, densities can be predicted wherever these habitat variables can be measured or estimated.

Uncertainty in published density estimates is typically large because of the low number of sightings available for their derivation. Uncertainty is typically expressed by the coefficient of variation of the estimate, which is derived using standard statistical methods and describes the amount of variation with respect to the population mean. It is expressed as a fraction or sometimes a percentage and can range upward from zero, indicating no uncertainty, to high values. For example, a coefficient of variation of 0.85 would indicate high uncertainty in the population estimate. When the coefficient of variation exceeds 1.0, the estimate is very uncertain. The uncertainty associated with movements of animals into or out of an area (due to factors such as availability of prey or changing oceanographic conditions) is much larger than is indicated by the coefficient of variation.

The methods used to estimate pinniped at-sea densities are typically different than those used for cetaceans. This is discussed in more detail in the Pacific Navy Marine Species Density Database Technical Report (U.S. Department of the Navy 2014a). Pinniped abundance is generally estimated via shore counts of animals at known rookeries and haul-out sites. Translating these numbers to in-water densities is difficult given the variability in foraging ranges, migration, and haul-out behavior between species and within each species, and is driven by factors such as age class, sex class, seasonal variation, etc. Details of the density derivation for each species of pinniped in the Study Area are provided in the Pacific Navy Marine Species Density Database Technical Report (U.S. Department of the Navy 2014a). In summary, the methods used to derive pinniped densities involved a series of species-specific data reviews to compile the most accurate and up-to-date information available. This review was undertaken by a panel of subject matter experts, including marine mammal scientists from the Washington State Department of Fish and Wildlife, Navy, and ManTech International. Once all available information, including known haul-out sites and local abundance, had been reviewed and updated as necessary, the resulting numbers of animals were assigned to inland water areas divided into regions consistent with Jeffries et al. (2003). The total abundance divided by the area of the region was the resultant density for each species in a given location.

There is no single source of density data for every area, species, and season because of the fiscal costs, resources, and effort involved to provide enough survey coverage to sufficiently estimate density. Therefore, to characterize marine mammal density for areas of concern such as the NWTT Study Area, the Navy compiled data from multiple sources. Each data source may use different methods to estimate density, of which, uncertainty in the estimate can be directly related to the method applied.

The Navy thus developed a protocol to select the best available data sources based on species, area, and time (season). The Navy then used this protocol to identify the best available density data from available sources, including habitat-based density models, line-transect analyses, and peer-reviewed published studies. These data were incorporated into a Geographic Information System database that includes seasonal (summer/fall and winter/spring) density values for every marine mammal species present within the Study Area. Detailed information on the Navy's selection protocol, datasets, and specific density values are provided in a Pacific Navy Marine Species Density Database Technical Report (U.S. Department of the Navy 2014a).

The following sections present information on the status and management, abundance, and distribution of species with possible or confirmed presence within the Study Area. Information specific to the three major regions within the Study Area (Offshore, Inland Waters [Puget Sound], and Southeast Alaska [Behm Canal]) is provided if relevant.

3.4.2.6 North Pacific Right Whale (*Eubalaena japonica*)

3.4.2.6.1 Status and Management

North Pacific right whales are listed as depleted under the MMPA and endangered under the ESA. Once abundant, the North Pacific right whale is one of the most endangered whale species in the world (Wade et al. 2011b). This species was listed as endangered under the ESA since 1973 when it was considered the "northern right whale" (including both the North Atlantic [*Eubalaena glacialis*] and North Pacific right whales). In 2008, NMFS listed the right whales as two separate, endangered species. Previously designated critical habitat within the Gulf of Alaska and the Bering Sea was then re-designated as North Pacific right whale critical habitat. In March 2012, NMFS announced a 5-year review of North Pacific right whale under the ESA (National Marine Fisheries Service 2012a) and in April 2012, announced its intent to prepare a recovery plan for this species (National Marine Fisheries Service 2012b). Although there is designated critical habitat for this species in the western Gulf of Alaska and an area in the southeastern Bering Sea, there is no designated critical habitat for this species within the Study Area. NMFS currently recognizes two stocks of North Pacific right whale: (1) an Eastern North Pacific stock and (2) a Western North Pacific stock (Allen and Angliss 2012).

3.4.2.6.2 Abundance

The most recent estimated population for the North Pacific right whale is between 28 and 31 individuals and although this estimate may be reflective of a Bering Sea subpopulation, the total eastern North Pacific population is unlikely to be much larger (Wade et al. 2006, 2011a, 2011b).

3.4.2.6.3 Distribution

Right whales occur in subpolar to temperate waters. They are generally migratory, with at least a portion of the population moving between summer feeding grounds in temperate or high latitudes and winter calving areas in warmer waters (Kraus et al. 1986; Clapham et al. 2004). Historical whaling records provide virtually the only information on North Pacific right whale distribution. This species historically occurred across the Pacific Ocean north of 35°N, with concentrations in the Gulf of Alaska, eastern Aleutian Islands, south-central Bering Sea, Okhotsk Sea, and the Sea of Japan (Omura et al. 1969; Scarff 1986; Clapham et al. 2004). Right whales were probably never common along the west coast of North America (Scarff 1986; Brownell et al. 2001). The rarity of reports for right whales in more southern coastal areas in winter in either historical or recent times suggests that their breeding grounds may have been offshore (Clapham et al. 2004). Presently, sightings are extremely rare, occurring primarily in the Okhotsk Sea and the eastern Bering Sea (Brownell et al. 2001; Shelden et al. 2005;

Shelden and Clapham 2006; Wade et al. 2006). There are far fewer sightings of North Pacific right whales in the Gulf of Alaska than the Bering Sea (Brownell et al. 2001). In addition to sighting data, (see Wade et al. 2011a, b; Matsuoka et al. 2013), passive acoustic data have indicated the presence of North Pacific right whales in the Gulf of Alaska (Mellinger et al. 2004), although recently, no right whales were detected from more than 5,324 hours of passive acoustic data obtained from two High-frequency Acoustic Recording Packages in the north-central Gulf of Alaska (Baumann-Pickering et al. 2012b). Right whales were also not detected from passive acoustic data collected from two bottom deployed monitoring devices in the offshore waters of Washington State from January through November 2011 (Širović et al. 2012b). Based on this information, and considering their current extremely low population numbers, it is highly unlikely for this species to be encountered in any of the regions of the Study Area.

Offshore. Various sightings of North Pacific right whales in the general vicinity of the Study Area have occurred on an irregular basis. Bruce Mate (2013, pers. comm.) reported that he flew over a dead stranded North Pacific right whale in the early 1980s along a remote part of the southern Oregon coast. Two right whales were sighted in 1983 on Swiftsure Bank at the entrance to the Strait of Juan de Fuca (Osborne et al. 1988). In May 1992 there was a sighting of a single of North Pacific right whale over Quinault submarine canyon (Green et al. 1992; Rowlett et al. 1994). Susan Riemer, from the Oregon Department of Fish and Wildlife, reported a sighting of a North Pacific right whale at 3 Arch Rocks, Oregon in 1994 (Susan Riemer 2013, pers. comm.). There were no sightings of North Pacific right whales during six ship surveys conducted in summer and fall off California, Oregon, and Washington from 1991 through 2008 (Barlow 2010). Recently, two sightings of North Pacific right whales have occurred in the vicinity of the Study Area. In June 2013, a single right whale was sighted in waters off Haida Gwaii, British Colombia (located approximately 200 nautical miles (nm) north of the Study Area; Hume 2013). Approximately 4 months later (October 2013) another (different) right whale was sighted in a group of humpback whales off the entrance to the Strait of Juan de Fuca (Pynn 2013); this was just north of the northern border of the Study Area in Canadian Waters. Because of the low population numbers in the North Pacific, few individuals have been observed (Brownell et al. 2001; Wade et al. 2006, 2011b), and both of these sightings are considered extremely rare. As noted above, right whales were not detected during recent passive acoustic monitoring in waters off the state of Washington (Širović et al. 2012b), Based on this information, there is a very low probability of encountering this species anywhere in the coastal and offshore waters in the Study Area and their occurrence is therefore considered rare.

Inland Waters. As noted above, the rarity of coastal records suggests right whales would not be present in more inland areas. The occurrence of a North Pacific right whale within the Inland Waters is considered extralimital.

Western Behm Canal, Alaska. North Pacific right whales were not observed during the Alaska Fisheries Science Center's National Marine Mammal Laboratory 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009). Given their small population size and lack of sightings in southeast Alaska as noted above, North Pacific right whales are considered extralimital within the Behm Canal portion of the Study Area.

3.4.2.7 Humpback Whale (*Megaptera novaeangliae*)

3.4.2.7.1 Status and Management

Humpback whales are listed as depleted under the MMPA and endangered under the ESA, but there is no designated critical habitat for this species in the North Pacific. Based on evidence of population recovery in many areas, the species is being considered by NMFS for removal or down-listing from the U.S. Endangered Species List (National Marine Fisheries Service 2009). In the U.S. North Pacific, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al. 2012). NMFS has designated four stocks: (1) the Central North Pacific stock, consisting of winter and spring populations of the Hawaiian Islands that migrate to feeding areas from southeast Alaska to the Alaska Peninsula; (2) the Western North Pacific stock, consisting of winter and spring populations off Asia that migrate to feeding areas off Russia, the Aleutian Islands, and the Bering Sea; (3) the California, Oregon, and Washington stock, consisting of winter and spring populations in coastal Central America and coastal Mexico that migrate to feed off the west coast of the United States; and (4) the American Samoa stock, with feeding areas largely undocumented but occurring as far south as the Antarctic Peninsula (Carretta et al. 2013). The Central North Pacific stock and the California, Oregon, and Washington stock occur within the Study Area.

3.4.2.7.2 Abundance

A large-scale photo-identification sampling study of humpback whales was conducted from 2004 to 2006 throughout the North Pacific (Calambokidis et al. 2008; Barlow et al. 2011). Known as the SPLASH (Structure of Populations, Levels of Abundance, and Status of Humpbacks) Project, the study was designed to sample all known North Pacific feeding and breeding populations. Overall humpback whale abundance in the North Pacific based on the SPLASH Project was estimated at 21,808 individuals (coefficient of variation = 0.04), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al. 2011). Data indicate that the North Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year, approximately doubling every 10 years (Calambokidis et al. 2008).

The Central North Pacific stock has been estimated at 10,103 individuals based on data from their wintering grounds throughout the main Hawaiian Islands (Allen and Angliss 2012). In summer, the majority of humpback whales from the Central North Pacific stock are found in the Aleutian Islands, Bering Sea, Gulf of Alaska, and southeast Alaska/northern British Columbia, where relatively high densities of whales occur (Allen and Angliss 2012). There is a high rate of interchange between whales found in southeast Alaska and northern British Columbia, and based on data from both inshore and offshore waters in these regions, abundance estimates range from 2,883 to 6,414 animals (Calambokidis et al. 2008).

The current best estimate for the California, Oregon, and Washington stock is 2,043 (coefficient of variation = 0.10) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 260 humpback whales (coefficient of variation = 0.32) occur in waters off Washington and Oregon (Barlow 2010). Abundance estimates derived from finer scale ship survey data collected off the northern Washington coast between 1995 and 2002 yielded line-transect estimates that ranged from 85 to 562 animals (coefficient of variation = 0.21 to 0.33) and capture-recapture estimates that ranged from 89 to 343 animals (coefficient of variation = 0.19 to 0.36) (Calambokidis et al. 2004). Both of the high estimates were for 2002 when sighting rates and corresponding abundance estimates increased dramatically. Without the 2002 data, estimates ranged from 85 to 125 and 80 to 230 animals based on line-transect and capture-recapture methods, respectively.

3.4.2.7.3 Distribution

Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs (Calambokidis et al. 2008; Barlow et al. 2011).

Offshore. The California, Oregon, and Washington stock of humpback whales uses the waters off the west coast of the United States as a summer feeding ground. They are present off the northern California coast mainly between April and December and off the Oregon and Washington coasts mainly from May through November (Dohl et al. 1983; Green et al. 1992; Forney and Barlow 1998; Calambokidis et al. 2004, 2010). Visual surveys and acoustic monitoring studies have detected humpbacks along the Washington coast year-round, with peak occurrence during the summer and fall (Oleson et al. 2009). Consistent with previous recordings from two Navy-funded offshore passive acoustic monitoring devices (Širović et al. 2012a, 2012b), humpback whales were most commonly detected in acoustic recordings between September and December, which is also the peak time for humpback whale singing (Širović et al. 2012b). Lower levels of humpback whale calling were also detected from February through May (Oleson et al. 2009; Širović et al. 2012a, 2012b). Visual and acoustic detections of humpback whales in this area do not fully overlap, as most visual sightings occur during the summer and early fall (Oleson et al. 2009), which is likely the result of the strong seasonal variation in humpback whale singing and other vocal behavior (Širović et al. 2012a,b). Photo-identification studies suggest that whales feeding in this region are part of a small sub-population that primarily feeds from central Washington to southern Vancouver Island (Calambokidis et al. 2004, 2008). Whales appear to range broadly throughout the continental shelf waters, with significant seasonal trends in distribution; however, detailed knowledge of habitat use and individual residency patterns while in this feeding area cannot be determined easily through visual surveys alone (Schorr et al. 2013). In winter and spring (roughly January–March), most whales are south on their breeding grounds and are likely not as abundant in this region of the Study Area during these times.

Off the U.S. west coast, humpback whales are more abundant in shelf and slope waters (< 6,562 ft. [2,000 m] deep), and are often associated with areas of high productivity (Forney et al. 2012; Becker et al. 2010, 2012b). Humpback whales primarily feed along the shelf break and continental slope (Green et al. 1992; Tynan et al. 2005). Off Washington, higher concentrations have been reported between Juan de Fuca Canyon and the outer edge of the shelf break in a region called “the Prairie,” near Barkley and Nitnat Canyons, and near Swiftsure Bank (Calambokidis et al. 2004). Five humpback whales were satellite tagged off Washington between May 2010 and May 2013. Although tag durations were short with a median duration of 7 days, tag tracks showed all five whales using both shelf and slope waters as well as some underwater canyons such as the Juan de Fuca Canyon (one of five whales) (Schorr et al. 2013; U.S. Department of the Navy 2013d).

Inland Waters. Although humpback whales were common in inland Washington waters prior to the whaling period, few sightings had been reported in this area until the last 10 years (Scheffer and Slipp 1948; Calambokidis and Steiger 1990; Pinnell and Sandilands 2004). More recently, with the creation (in 2011) of the Orca Network online forum available to compile whale sighting reports, and increased public interest in reporting whale sightings, the number of humpback whale sightings in inland waters has increased. Inland water opportunistic sightings primarily occur from April through July, but sightings are reported in every month of the year. Most sightings occur in the Strait of Juan de Fuca and in the San Juan Island area, with only occasional sightings in Puget Sound.

In Puget Sound (defined as south of Admiralty Inlet), Calambokidis et al. (2002) recorded only six individuals between 1996 and 2001. However, from January 2003 through July 2012 there were over 60 sightings reported to Orca Network, some of which could be the same individuals (Orca Network 2012). A review of the reported sightings in Puget Sound indicates that humpback whales usually occur as individuals or in pairs (Orca Network 2012).

Sightings of humpback whales in Puget Sound vary by location, but are infrequent. In the Rich Passage to Agate Passage area in the vicinity of Naval Base (NAVBASE) Kitsap Bremerton and Keyport, only one unverified sighting of a humpback whale was reported to Orca Network (2012) from January 2003 through July 2012. In Hood Canal and Dabob Bay (where NAVBASE Kitsap Bangor and the Dabob Bay Range Complex [DBRC] are located, respectively), one humpback whale was observed for several weeks in January and February 2012 (Calambokidis pers. comm. 2012). Prior to this sighting, there were no confirmed reports of humpback whales entering Hood Canal or Dabob Bay (Calambokidis pers. comm. 2012). In the Saratoga Passage area (between Naval Station Everett and Naval Air Station [NAS] Whidbey Island [NASWI], one humpback whale was reported in Penn Cove south of Crescent Harbor in July 2008. This is the only humpback report from January 2003 through September 2012 that was considered a likely positive identification (Orca Network 2012). There have been no verified humpback sightings in the Carr Inlet area between January 2003 and July 2012. Two unverified sightings were reported to Orca Network to the north of Carr Inlet, near Point Defiance, Tacoma, over the same time period. The last verified sighting was in June and July of 1988 when two individually identified juvenile humpback whales were observed traveling throughout the waters of southern Puget Sound for several weeks (Calambokidis and Steiger 1990).

Given their general migration patterns, this species is rare in the inland waters, but is expected to be more likely to occur in the warmer months (May–November), but not be present in all areas, nor remain for long time periods.

Western Behm Canal, Alaska. In summer, relatively high densities of humpback whales occur throughout much of southeast Alaska (Allen and Angliss 2012). Because this species makes extensive use of inland coastal waters, it is the large whale species most likely to be found in the Southeast Alaska area. Humpback whales are commonly sighted in Ernest Sound (north of the Southeast Alaska Acoustic Measurement Facility [SEAFAC]) and near the mouth of Boca de Quadra (south of SEAFAC), but specific data are lacking (U.S. Department of the Navy 1991). Although specific data are lacking, it is likely that humpback whales occasionally use the Behm Canal heading to Gedney Pass (U.S. Department of the Navy 1991). Humpback whales were observed frequently during the 1991–2007 surveys (spring through fall) of the inland waters of southeast Alaska (Dahlheim et al. 2009). Although surveys were not conducted in the winter months in southeast Alaska, observations have been made of humpback whales that have not migrated south, but remained in Alaskan waters to feed (Moran et al. 2009).

3.4.2.8 Blue Whale (*Balaenoptera musculus*)

3.4.2.8.1 Status and Management

The blue whale is listed as depleted under the MMPA and endangered under the ESA, but there is no designated critical habitat for this species. For the MMPA stock assessment reports, the Eastern North Pacific stock of blue whales includes animals found in the eastern North Pacific from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al. 2012).

3.4.2.8.2 Abundance

Widespread whaling over the last century is believed to have decreased the blue whale population to approximately 1 percent of its pre-whaling population size (Sirovic et al. 2004; Branch et al. 2007). The current best available abundance estimate for the Eastern North Pacific stock of blue whales is 2,497 (coefficient of variation = 0.24) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 58 blue whales (coefficient of variation = 0.41) occur in waters off Washington and Oregon (Barlow 2010). There was a documented increase in the blue whale population size between 1979–80 and 1991 (Barlow 1994) and between 1991 and 1996 (Barlow 1997), but there has not been evidence to suggest an increase in the population of the eastern North Pacific stock since then (Barlow and Taylor 2001; Carretta et al. 2012). Based on line-transect surveys conducted off California between 1991 and 2005, the abundance estimates of blue whales declined in these waters over the survey period (Barlow and Forney 2007). However, this apparent decline was likely due to variability in the distribution patterns of blue whales off the coast of North America rather than a true population decline (Calambokidis et al. 2009a). Calambokidis et al. (2009a) suggested that when feeding conditions off California are not optimal, blue whales may move to other regions to feed, including waters further north. A comparison of survey data from the 1990s to 2008 indicates that there has been a northward shift in blue whale distribution within waters off California, Oregon, and Washington (Barlow 2010). Subsequent mark-recapture estimates "indicated a significant upward trend in abundance of blue whales" at a rate of increase just under 3 percent per year for the U.S. west coast blue whale population in the Pacific (Calambokidis et al. 2009b). Consistent with the earlier suggested variability in the distribution patterns, Carretta et al. (2013) report that blue whales from the U.S. west coast have been increasingly found feeding to the north and south of the U.S. west coast during summer and fall.

3.4.2.8.3 Distribution

Blue whales inhabit all oceans and are distributed from the ice edges to the tropics in both hemispheres (Jefferson et al. 1993). Most blue whale sightings are in coastal nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration (Širović et al. 2004). Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al. 2004). Recently it has been suggested that the migration patterns of blue whales in the North Pacific change during different oceanographic conditions (Calambokidis et al. 2009a). Blue whales observed in the spring, summer, and fall off California, Washington, and British Columbia are known to be part of a group that returns to feeding areas off British Columbia and Alaska (Calambokidis and Barlow 2004; Calambokidis et al. 2009a). These animals have shown site fidelity, returning to their mother's feeding grounds on their first migration (Calambokidis and Barlow 2004). Blue whales are known to migrate to waters off Mexico and as far as the Costa Rican Dome (Calambokidis and Barlow 2004; Calambokidis et al. 2009a). Winter migration movements south along the Baja California, Mexico coast to the Costa Rica Dome indicate that the Costa Rica Dome may be a calving and breeding area (Mate et al. 1999).

Offshore. The U.S. west coast is known to be a feeding area for blue whales during summer and fall (Bailey et al. 2010; Calambokidis et al. 2009a), although primary occurrence for this species is south of 44°N (Hamilton et al. 2009; Forney et al. 2012). Blue whales are feeding in the area as late as October, although fewer individuals are seen because the majority of the population migrates south. Acoustic data collected by Sound Surveillance System hydrophones reveal that males are calling at this time of the year in this area (Stafford et al. 2001). More recently, Navy-funded acoustic monitoring studies have detected blue whales along the Washington coast between August and February, with peak calling from October to December, and no detections between April and July (Širović et al. 2012a, b). An individual blue whale was also sighted off Washington in January 2009, in waters approximately 3,281 ft. (1,000 m) deep (Oleson et al. 2012).

Inland Waters. Blue whales are not expected to occur within the Inland Waters region of the Study Area since it is well inland of the areas normally inhabited by blue whales.

Western Behm Canal, Alaska. Blue whales are not expected to occur within the SEAFAC region of the Study Area since it is well inland of the areas normally inhabited by blue whales.

3.4.2.9 Fin Whale (*Balaenoptera physalus*)

3.4.2.9.1 Status and Management

The fin whale is listed as depleted under the MMPA and endangered under the ESA, but there is no designated critical habitat for this species. Fin whale population structure in the Pacific Ocean is not well known. In the North Pacific, NMFS recognizes three fin whale stocks: (1) an Alaska (or Northeast Pacific) stock; (2) a California, Oregon, and Washington stock; and (3) a Hawaii stock (Allen and Angliss 2012; Carretta et al. 2012).

3.4.2.9.2 Abundance

Currently there are no reliable population estimates for the Alaska/Northeast Pacific stock of fin whales. A minimum estimate for the stock is 5,700, based on surveys west of the Kenai Peninsula which covered only a portion of the stock's range (Allen and Angliss 2012).

The current best available abundance estimate of fin whales in California, Oregon, and Washington waters is 3,044 (coefficient of variation = 0.18) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 416 fin whales (coefficient of variation = 0.28) occur in waters off Washington and Oregon (Barlow 2010). A recent study indicates that the abundance of fin whales in waters off the U.S. west coast has increased during the 1991–2008 survey period, most likely from *in situ* population growth combined with distribution shifts (Moore and Barlow 2011).

3.4.2.9.3 Distribution

The fin whale is found in all the world's oceans (Jefferson et al. 2008) but appears to have a preference for temperate and polar waters (Reeves et al. 2002). Locations of breeding and calving grounds for the fin whale are largely unknown, but they typically migrate seasonally to higher latitudes every year to feed and migrate to lower latitudes to breed (Kjeld et al. 2006; MacLeod et al. 2006b). During the summer in the Pacific, fin whales are distributed from the southern Chukchi Sea (69°N) south to 30°N in the California Current (Mizroch et al. 2000). They have been observed during the summer in the central Bering Sea (Moore et al. 2000). During the winter, fin whales are sparsely distributed from 60°N, south to the northern edge of the tropics, near which it is assumed that they mate and calve (Mizroch et al. 2000).

Offshore. This species has been documented from 60°N to 23°N, and they have frequently been recorded in waters offshore Oregon and Washington (Barlow and Forney 2007). Based on predictive habitat models derived from line-transect survey data collected between 1991 and 2008 off the U.S. west coast, relatively high densities of fin whales are predicted off Washington during the summer and fall (Barlow et al. 2009; Becker et al. 2012b; Forney et al. 2012). During visual surveys conducted from August 2004 to September 2008, there was a single sighting of two fin whales off the Washington coast in December 2005, in waters approximately 3,281 ft. (1,000 m) deep (Oleson et al. 2009). Navy-funded offshore passive acoustic monitoring off Washington from 2004 to 2013 has reported fin whales as the most commonly detected baleen whale call type detected with peak calling in winter and spring, and low calling in summer (Kerosky et al. 2013; Širović et al. 2012a, b; U.S. Department of the Navy 2013d). Fin whale calls were detected on more than 90 percent of the days during the months of October, December, January, and February, but were not detected in either May or June (Širović et al. 2012a, b).

Between May 2010 and May 2013, 11 fin whales were tagged with satellite tracking tags off of Washington. Average tag duration was 19 days (range 1–71 days). In general, fin whales were most commonly using waters associated with the outer shelf edge (median distance to shore: 72 kilometers [km]) (Schorr et al. 2013; U.S. Department of the Navy 2013d).

Inland Waters. Prior to commercial whaling off British Columbia, fin whales were occasionally sighted in the Inland Waters (Osborne et al. 1988). However, fin whales are now extremely rare within the Inland Waters (Wade pers. comm. 2005). Strandings reported within Puget Sound have all been individuals struck by ships, and they presumably were carried on the bow into the sound (Norman et al. 2004).

Western Behm Canal, Alaska. Fin whales were observed seven times in the summer during surveys of the inland waters of southeast Alaska from 1991 to 2007 (Dahlheim et al. 2009). Given the limited number of sightings in inland waters and their more pelagic nature, fin whales are considered rare in the SEAFAC region of the Study Area.

3.4.2.10 Sei Whale (*Balaenoptera borealis*)

3.4.2.10.1 Status and Management

The sei whale is listed as depleted under the MMPA and endangered under the ESA, but there is no designated critical habitat for this species. A recovery plan for the sei whale was completed in 2011 and provides a research strategy for obtaining data required to estimate population abundance and trends, and to identify factors that may be limiting the recovery of this species (National Marine Fisheries Service 2011d). Only a single Eastern North Pacific stock is recognized in the U.S. EEZ (Carretta et al. 2012). However, some mark-recapture, catch distribution, and morphological research indicate that multiple stocks exist (Masaki 1976, 1977; Carretta et al. 2012). The Eastern North Pacific population has been protected since 1976, but is likely still impacted by the effects of continued unauthorized takes from whaling (Carretta et al. 2012).

3.4.2.10.2 Abundance

The best current estimate of abundance for the Eastern North Pacific stock of sei whales that occur off California, Oregon, and Washington waters out to 300 nm is 126 animals (coefficient of variation = 0.53) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 52 sei whales (coefficient of variation = 0.62) occur in waters off Washington and Oregon (Barlow 2010). No data are available on current population trends.

3.4.2.10.3 Distribution

Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes (Horwood 1987). Sei whales spend the summer months feeding in the subpolar higher latitudes and return to the lower latitudes to calve in the winter. Whaling data provide some evidence of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood 1987; Perry et al. 1999). In the North Pacific, sei whales are thought to occur mainly south of the Aleutian Islands. In the summer they are present across the temperate Pacific from 35°N to 50°N (Masaki 1977; Horwood 2009; Smultea et al. 2010) and in the winter were recently found south of 20°N near the Mariana Islands (Fulling et al. 2011). Sei whales are most often found in deep, oceanic waters of the cool temperate zone. They appear to prefer regions of steep relief, such as the continental shelf break, canyons, or basins between banks and ledges (Kenney and Winn 1987; Schilling et al. 1992; Gregr and Trites 2001; Best and Lockyer 2002). Characteristics of preferred breeding grounds are unknown, since they have generally not been identified.

Offshore. Sei whales are distributed offshore in waters off the U.S. west coast (Carretta et al. 2012). They are generally found feeding along the California Current (Perry et al. 1999). During six systematic ship surveys conducted between 1991 and 2008 in waters off the U.S. west coast to approximately 300 nm offshore, there were a total of 10 sei whale sightings, four of which were in waters off Oregon and Washington (Barlow 2010). There were no sei whale sightings during more coastal (out to about the 656 ft. [200 m] isobath) ship surveys off the northern Washington coast between 1995 and 2002 (Calambokidis et al. 2004).

Inland Waters. Sei whales are considered rare in the Inland Waters including Puget Sound. A sei whale washed ashore west of Port Angeles in the Strait of Juan de Fuca during September 2003 (Preston 2003), but this is considered an unusual event.

Western Behm Canal, Alaska. Sei whales are not expected to occur within the SEAFAC region of the Study Area since it is well inland of the areas normally inhabited by sei whales.

3.4.2.11 Minke Whale (*Balaenoptera acutorostrata*)

3.4.2.11.1 Status and Management

The minke whale is protected under the MMPA and is not listed under the ESA. Minke whales from two stocks may occur in the Study Area: (1) the Alaska stock and (2) the California/Oregon/Washington stock (Carretta et al. 2012). In the northern part of their range minke whales are believed to be migratory, whereas in the inland waters of Washington and along central California they appear to establish home ranges (Dorsey et al. 1990). Because the "resident" minke whales from California to Washington appear behaviorally distinct from migratory whales further north, minke whales in Alaska are considered a separate stock from minke whales in the coastal waters of California, Oregon, and Washington (including the Inland Waters) (Carretta et al. 2012).

3.4.2.11.2 Abundance

Abundance estimates are not available for the Alaska stock of minke whales because only portions of the stock's range have been surveyed (Allen and Angliss 2012). The abundance estimate for the California, Oregon, and Washington stock of minke whales is 478 individuals (coefficient of variation = 1.36) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 147 minke whales (coefficient of variation = 0.68) occur in waters off Washington and Oregon (Barlow 2010). Two minke whales were seen during 1996 aerial surveys in Washington and British Columbia inland waters (Calambokidis et al. 1997), but no abundance estimates were made.

3.4.2.11.3 Distribution

Minke whales are distributed in polar, temperate, and tropical waters (Jefferson et al. 1993); they are less common in the tropics than in cooler waters. Minke whales generally occupy waters over the continental shelf, including inshore bays, and even occasionally enter estuaries. However, records from whaling catches and research surveys worldwide indicate an open ocean component to the minke whale's habitat. Minke whales are present in the North Pacific from near the equator to the Arctic (Horwood 1990). The summer range extends to the Chukchi Sea (Perrin and Brownell 2002). In the winter, minke whales are found south to within 2° of the equator (Perrin and Brownell 2002). The distribution of minke whale vocalizations (specifically, "boings") suggests that the winter breeding grounds are the offshore tropical waters of the North Pacific Ocean (Rankin and Barlow 2005). Numerous acoustic detections of minke whales were made during a 2007 winter ship survey of the Mariana Islands (Fulling et al. 2011).

The migration paths of the minke whale include travel between breeding and feeding grounds and have been shown to follow patterns of prey availability (Jefferson et al. 2008). In the northern part of their range, minke whales are believed to be migratory, whereas they appear to establish home ranges in the inland waters of Washington State and along central California (Dorsey 1983; Dorsey et al. 1990), and exhibit site fidelity to these areas between years (Dorsey et al. 1990).

Offshore. During six systematic ship surveys conducted by the SWFSC between 1991 and 2008 in waters off the U.S. west coast to approximately 300 nm offshore, there were a total of 18 minke whale sightings, 3 of which were in waters off Oregon and Washington (Barlow 2010). Minke whales tend to be more common in some nearshore areas (Stern 1992), which are not well-sampled during the SWFSC large ship surveys. Plots of all sighting locations from SWFSC ship surveys conducted from 1986 to 2005 show this species has a predominant nearshore distribution along the coast of North America (Hamilton et al. 2009). There were four minke whale sightings during coastal (out to about the 656 ft. [200 m] isobath) ship surveys off the northern Washington coast between 1995 and 2002 (Calambokidis et al. 2004). During surveys along the Washington coast between 2004 and 2008, there was a single minke whale sighting of one individual in November 2004 in waters approximately 125 ft. (38 m) deep (Oleson et al. 2009). Minke whales were not acoustically detected in recordings made by two Navy-funded passive acoustic monitoring devices bottom deployed off Washington from 2008 to 2013 (Kerosky et al. 2013; Širović et al. 2012a, b).

Inland Waters. As noted above, minke whales appear to establish home ranges in the inland waters of Washington (Dorsey 1983; Dorsey et al. 1990). Minke whales are reported in the inland waters year-round, although the majority of the records are from March through November (Calambokidis and Baird 1994). Minke whales are sighted primarily in the San Juan Islands and Strait of Juan de Fuca but are relatively rare in Puget Sound south of Admiralty Inlet (Stern pers. comm. 2005; Orca Network 2012). In the Strait of Juan de Fuca, individuals move within and between specific feeding areas around submarine banks (Stern pers. comm. 2005). Dorsey et al. (1990) noted minke whales feeding in locations of strong tidal currents. Hoelzel et al. (1989) reported that 80 percent of feeding observations in the San Juan Islands were over submarine slopes of moderate incline at a depth of about 66 ft. (20 m) to 328 ft. (100 m). Three feeding grounds have been identified in the Strait of Juan de Fuca and San Juan Islands area (Osborne et al. 1988; Hoelzel et al. 1989; Dorsey et al. 1990; Stern pers. comm. 2005). There is year-to-year variation in the use of these feeding areas, and other feeding areas probably exist (Osborne et al. 1988; Dorsey et al. 1990).

Sightings in Puget Sound south of Admiralty Inlet are infrequent. Approximately 55 minke whale opportunistic sightings were recorded with Orca Network between January 2005 and August 2012 in Puget Sound. The majority of those sightings (41) were in Admiralty Inlet. No sightings were reported in the Rich Passage to Agate Passage area in the vicinity of NAVBASE Kitsap Bremerton and Keyport. Only two sightings were reported for the Saratoga Passage area near NASWI and NAS Everett. Both Saratoga Passage sightings were in 2006, and one was an uncertain identification. There are no known sightings for Hood Canal or Dabob Bay and only one sighting south of Point Defiance in southern Puget Sound near Carr Inlet.

Western Behm Canal, Alaska. Minke whales were observed infrequently during the spring through fall 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009). Although surveys were not conducted in the winter months in southeast Alaska, it is possible that minke whales may be present in the winter.

3.4.2.12 Gray Whale (*Eschrichtius robustus*)

3.4.2.12.1 Status and Management

There are currently two formally recognized North Pacific populations of gray whales: the Western Pacific subpopulation (also known as the Western North Pacific or the Korean-Okhotsk population) that is critically endangered and shows no apparent signs of recovery, and the Eastern Pacific population (also known as the Eastern North Pacific or the California-Chukchi population) that appears to have recovered from exploitation and was removed from listing under the ESA in 1994 (Swartz et al. 2006). All populations of the gray whale are protected under the MMPA; the Western Pacific subpopulation is listed as endangered under the ESA and is depleted under the MMPA, but there is no designated critical habitat for this species.

A group of a few hundred gray whales known as the Pacific Coast Feeding Group feeds along the Pacific coast between southeastern Alaska and southern California throughout the summer and fall (Calambokidis et al. 2002). This group of whales has generated uncertainty regarding the stock structure of the Eastern North Pacific population (Carretta et al. 2013). Photo-identification, telemetry, and genetic studies suggest that the Pacific Coast Feeding Group is demographically distinct (Calambokidis et al. 2010; Mate et al. 2010; Frasier et al. 2011). Currently, the Pacific Coast Feeding Group is not treated as a distinct stock in the NMFS Stock Assessment Reports, but this may change in the future based on new information (Carretta et al. 2013). In 2012–2013, the Navy funded a satellite tracking study of Pacific Coast Feeding Group gray whales (U.S. Department of the Navy 2013d). Tags were attached to 11 gray whales near Crescent City, California in fall 2012. Good track histories were received from 9 of the 11 tags, which confirmed an exclusive near shore (< 15 km) distribution and movement along the California, Oregon, and Washington coast. The whales did not linger near any submarine canyons or other underwater features, remaining entirely on the continental shelf (Mate 2013; U.S. Department of the Navy 2013d).

Gray whales began to receive protection from commercial whaling in the 1930s. However, hunting of the western population continued for many more years. The International Whaling Commission sets a quota allowing catch of gray whales annually from the eastern population for aboriginal subsistence. In 2007 the International Whaling Commission approved a 5-year quota (2008–2012) of 620 whales, with an annual maximum of 140 whales for Russian and U.S. (Makah Indian Tribe) aboriginals. Russia and the United States agreed to a shared annual harvest of 120 and 4 whales, respectively; however, all takes during this time period were from Russia (International Whaling Commission 2013; Norberg and Stone 2013).

3.4.2.12.2 Abundance

Recent abundance estimates for the Eastern North Pacific gray whale population have ranged between 17,000 and 20,000 (Swartz et al. 2006; Rugh et al. 2008; Punt and Wade 2010). For stock assessment purposes, NMFS currently uses an abundance of 19,126 animals (coefficient of variation = 0.071; Carretta et al. 2013). The eastern population appears to be generally increasing, despite the 1999–2000 event in which an unusually large number of gray whales stranded along the coast, from Mexico to Alaska (Gulland et al. 2005).

Based on a defined range for the Pacific Coast Feeding Group of between 41°N to 52°N, the 2008 abundance estimate is 194 (standard error = 17.0) whales (Carretta et al. 2013).

The western subpopulation of gray whale was once considered extinct but now small numbers are known to exist (Weller et al. 2002). The most recent estimate of this population is 155 individuals (95 percent confidence interval = 142 to 165 whales; International Union for Conservation of Nature 2012).

3.4.2.12.3 Distribution

Eastern gray whales are known to migrate along the U.S. west coast on both their northward and southward migration. This species makes the longest annual migration of any mammal: 9,321–12,427 miles (mi.) (15,000–20,000 km) roundtrip (Jefferson et al. 2008; Jones and Swartz 2009). The migration connects summer arctic and north Pacific feeding grounds with winter mating and calving regions in temperate and subtropical coastal waters. Winter grounds extend from central California south along Baja California, the Gulf of California, and the mainland coast of Mexico. The northward migration to the feeding grounds occurs in two phases. The first phase in late January through March consists of newly pregnant females, who go first to maximize feeding time, followed by adult females and males, then juveniles. The second phase, in April through May, consists primarily of mothers and calves that have remained in the breeding area longer, allowing calves to strengthen and rapidly increase in size before the northward migration (Jones and Swartz 2009; Herzing and Mate 1984). Beginning in the fall, whales start the southward migration from the summer feeding areas (spanning the coast from the northern Gulf of Alaska to the Study Area) to winter calving areas and mainly follow the coast to Mexico. The trip averages 2 months. During the southbound migration, peak sightings occur between early December and mid-February off the Oregon coast and in January off the Washington coast (Herzing and Mate 1984; Rugh et al. 2001).

Most of the Eastern North Pacific stock summers in the shallow waters of the northern Bering Sea, Chukchi Sea, and western Beaufort Sea (Rice and Wolman 1981), but a small proportion (approximately 200 individuals) spend the summer and fall feeding along the Pacific coast from southeastern Alaska to central California (Gosho et al. 2011; Carretta et al. 2012; Sumich 1984; Calambokidis et al. 1987, 2002). These whales, collectively known as the “Pacific Coast Feeding Group,” are a trans-boundary population within the United States and Canada and are defined by the International Whaling Commission as a gray whale that is observed between 1 June and 30 November within the region between northern Vancouver Island and northern California and has been photo-identified within this area during 2 or more years (Carretta et al 2014; Punt and Moore 2013). These whales are also referred to as “resident gray whales” by the local population in Oregon and Northern California, even though the whales do migrate and are not present year-round as the name resident suggests (Irvine pers. comm. 2013).

The migration routes of the western subpopulation of gray whales are poorly known (Weller et al. 2002). Previous sighting data suggested that the remaining population of western gray whale had a limited range extent between the Okhotsk Sea off the coast of Sakhalin Island and the South China Sea (Weller et al. 2002). However, recent long-term studies of radio-tracked whales indicate that the coastal waters of eastern Russia, the Korean Peninsula, and Japan are part of the migratory route (Weller et al. 2012). There is also photographic evidence of a match between a whale found off Sakhalin and the Pacific coast of Japan, more than 932 mi. (1,500 km) south of the Sakhalin feeding area (Weller et al. 2008). Further, photo-catalog comparisons of eastern and western North Pacific gray whale populations suggest that there is more exchange between the western and eastern populations than previously thought, since “Sakhalin” whales were sighted off Santa Barbara, California; British Columbia, Canada; and Baja California, Mexico (Weller et al. 2013).

Offshore. During visual surveys off the Washington coast from August 2004 through September 2008, there were a total of 55 gray whale sightings of 116 individuals (Oleson et al. 2009). Clear seasonal differences in gray whale distribution were noted based on three distinct time periods: (1) winter (December–January), corresponding to the timing of their southbound migration; (2) spring (February–April), corresponding to the timing of their northbound migration; and (3) summer/fall (May–October), a time when any gray whales present are primarily members of the Pacific Coast Feeding Group. Oleson et al. (2009) found significant differences in the sighting distributions between these three time periods, based on an analysis of distance from shore, distance from the shelf break, and water depth. During the winter southbound migration, gray whales were sighted mainly offshore, with an average distance of 18 mi. (29 km) from the coast. This compared to the spring northbound migration when the average distance was 6.2 mi. (10 km) from shore. During summer and fall, gray whale sightings were clustered in two areas, in and around the entrance to Grays Harbor and in an offshore area approximately 12.4 to 15.5 mi. (20 to 25 km) from shore (Oleson et al. 2009). These offshore sightings were unusual given that in the Pacific Northwest the Pacific Coast Feeding Group is typically close to shore (Calambokidis et al. 2002).

The occurrence of Eastern North Pacific gray whales and members of the Pacific Coast Feeding Group is considered seasonally likely in the offshore portion of the Study Area. Given their small population size and limited number of sightings off the U.S. west coast, the occurrence of Western North Pacific gray whales in the offshore portion of the Study Area is considered rare.

Inland Waters. As the majority of gray whales migrate past the Strait of Juan de Fuca en route to or from their feeding or breeding grounds, a few of them enter the inland waters to feed. Gray whales are observed in Washington inland waters in all months of the year (Calambokidis et al. 2010; Washington State Department of Fish and Wildlife 2012), with peak numbers from March through June (Calambokidis et al. 2010). Typically fewer than 20 gray whales have been documented annually in the inland waters of Washington and British Columbia based on a review of Orca Network (Washington Department of Fish and Wildlife 2012). Calambokidis et al. (2009) reported that Puget Sound (mudflats near the Whidbey Island and Camano Island area) is used as a springtime feeding area for a small, regularly occurring group of gray whales. Observed feeding areas are located in Saratoga Passage between Whidbey and Camano Islands including Crescent Harbor, and in Port Susan Bay located between Camano Island and the mainland in Possession Sound. These areas are between NASWI (Crescent Harbor) and Naval Station Everett.

In the Rich Passage to Agate Passage area in the vicinity of NAVBASE Kitsap Bremerton and Keyport, 11 opportunistic sightings of gray whales were reported to Orca Network between January 2003 and July 2012. One stranding occurred at NAVBASE Kitsap Bremerton in January 2013. There are typically anywhere from 2 to 10 stranded gray whales per year in Washington (Cascadia Research 2012b). Gray whales have been sighted in Hood Canal south of the Hood Canal Bridge on six occasions since 1999, including a stranded whale at Belfair State Park (Calambokidis pers. comm. 2013). The most recent report in Hood Canal was of characteristic “blows” (air exhaled through the whale’s blowhole) in the waters near Lilliwaup in November 2010 (Calambokidis pers. comm. 2013).

Western Behm Canal, Alaska. Gray whales were not observed during 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009), and they are considered extralimital in this region of the Study Area.

3.4.2.13 Sperm Whale (*Physeter macrocephalus*)

3.4.2.13.1 Status and Management

The sperm whale is listed as depleted under the MMPA and has been listed as endangered since 1970 under the precursor to the ESA (National Marine Fisheries Service 2009), but there is no designated critical habitat for this species in the North Pacific. Sperm whales are divided into three stocks in the Pacific: (1) the Alaska/North Pacific stock; (2) the California, Oregon, and Washington stock; and (3) the Hawaii stock.

3.4.2.13.2 Abundance

Currently there is no reliable abundance estimate for the Alaska/North Pacific stock of sperm whales (Allen and Angliss 2013). The number of sperm whales within the eastern temperate North Pacific (between 20°N and 45°N) was estimated at 26,300 (coefficient of variation = 0.81) from visual surveys and 32,100 (coefficient of variation = 0.36) from acoustic detections (Barlow and Taylor 2005). The current best available estimate of abundance for the California, Oregon, and Washington stock is 971 (coefficient of variation = 0.31) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 329 sperm whales (coefficient of variation = 0.45) occur in waters off Washington and Oregon (Barlow 2010). The Barlow (2010) sperm whale density estimate for waters off Washington and Oregon (1.0 animals per 386 square miles [mi.^{2}] [1,000 square kilometers {km^2}]) is similar to the worldwide global average for this species (1.4 animals per 386 mi.^{2} [1,000 km^2]; Whitehead 2002).

3.4.2.13.3 Distribution

Male sperm whales are found from tropical to polar waters in all oceans of the world, between approximately 70°N and 70°S (Rice 1998). The female distribution is more limited and corresponds approximately to the 40° parallels but extends to 50° in the North Pacific (Whitehead 2003). Sperm whales are somewhat migratory. General shifts occur during summer months for feeding and breeding, while in some tropical areas, sperm whales appear to be largely resident (Rice 1989; Whitehead 2003; Whitehead et al. 2008). Pods of females with calves remain on breeding grounds throughout the year, between 40°N and 45°N (Rice 1989; Whitehead 2003), while males migrate between low-latitude breeding areas and higher-latitude feeding grounds (Pierce et al. 2007). In the northern hemisphere, "bachelor" groups (males typically 15–21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al. 2007). Sperm whales show a strong preference for deep waters (Rice 1989; Whitehead 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters.

Offshore. Sperm whales were seen in every season except winter (December–February) during systematic surveys off Washington and Oregon from 1989 to 1990 (Green et al. 1992). More recently, sperm whales were detected acoustically year-round at offshore sites monitored from 2004 to 2008 off the Washington coast, with a peak occurrence from April to August, and at an inshore recording station they were detected from April to November (Oleson et al. 2009). Acoustic detections of sperm whale were also reported at the inshore monitoring site every month from June through January in 2009; there was an absence of detections between February and May 2009 (Širović et al. 2012a).

Two noteworthy sperm whale stranding events occurred in this region of the Study Area. During November 1970, there was an incident that was well-publicized by the media of attempts to dispose of a decomposed sperm whale carcass on an Oregon beach by using explosives. A mass stranding of 47 sperm whales occurred in Oregon during June 1979 (Rice et al. 1986; Norman et al. 2004).

Inland Waters. Given their documented preference for deep offshore waters, sperm whales are unlikely to occur within the Inland Waters region of the Study Area and would be considered extralimital.

Western Behm Canal, Alaska. Given their documented preference for deep offshore waters, sperm whales are unlikely to occur within the SEAFAC region of the Study Area since it is characterized by coastal waters removed from the continental shelf break.

3.4.2.14 Pygmy Sperm Whale (*Kogia breviceps*) and Dwarf Sperm Whale (*Kogia sima*)

There are two species of *Kogia*: the pygmy sperm whale and the dwarf sperm whale. Before 1966 they were considered to be the same species until morphological distinction was shown (Handley 1966). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al. 2008), hence their combined discussion here.

3.4.2.14.1 Status and Management

Both the pygmy sperm whale and the dwarf sperm whale are protected under the MMPA but not listed under the ESA. Pygmy sperm whales are divided into two discrete stocks: (1) the California, Oregon, and Washington stock; and (2) the Hawaii stock (Carretta et al. 2012). Dwarf sperm whales are also divided into two discrete stocks: (1) the California, Oregon, and Washington stock; and (2) the Hawaii stock (Carretta et al. 2012).

3.4.2.14.2 Abundance

Few abundance estimates have been made for the two *Kogia* species, and too little information is available to obtain reliable population estimates in west coast waters (Carretta et al. 2012). The current abundance estimate for pygmy sperm whales found along the U.S. west coast is based on the mean of two ship surveys conducted in California, Oregon, and Washington waters in 2005 and 2008. The resulting abundance estimate of 579 (coefficient of variation = 1.02) individuals is considered the best estimate for the California, Oregon, and Washington stock of pygmy sperm whales (Carretta et al. 2012). An abundance estimate for the California, Oregon, and Washington stock of dwarf sperm whales is not available (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 229 *Kogia* spp. (both pygmy and dwarf sperm whales) (coefficient of variation = 1.11) occur in waters off Washington and Oregon (Barlow 2010). This estimate includes sightings categorized as the genus *Kogia*; however, it is likely that these sightings were of pygmy sperm whales given previous sighting data and historical stranding data (Carretta et al. 2012).

3.4.2.14.3 Distribution

Both species of *Kogia* apparently have a worldwide distribution in tropical and temperate waters (Jefferson et al. 1993), and tend to occur along the continental shelf break and over the continental slope (McAlpine 2009; Bloodworth and Odell 2008). *Kogia* is known to occur in eastern North Pacific waters around Washington (Scheffer and Slipp 1948; Hubbs 1951; Roest 1970; Everitt et al. 1979) and, possibly, British Columbia (Baird et al. 1996). Little is known about possible migrations of this species. No specific information regarding routes, seasons, or resighting rates in specific areas is available. Based on sighting data collected by SWFSC during systematic surveys in the Northeast Pacific between 1986 and 2005, the pygmy sperm whale frequents more temperate habitats than the dwarf sperm whale, which is more of a tropical species (Hamilton et al. 2009).

Offshore. Although deep oceanic waters may be the primary habitat for pygmy and dwarf sperm whales, very few oceanic sightings offshore have been recorded within this region of the Study Area (Hamilton et al. 2009; Barlow 2010). However, this may be because of the difficulty of detecting and identifying these animals at sea (Caldwell and Caldwell 1989). Their range generally includes tropical and temperate warm water zones and is not likely to extend north into subarctic waters (Bloodworth and Odell 2008; Jefferson et al. 2008). There are eight confirmed stranding records of *Kogia* from Oregon and Washington and all are of the pygmy sperm whale (Norman et al. 2004). There is one stranding record of the dwarf sperm whale from British Columbia (Nagorsen and Stewart 1983; Willis and Baird 1998a), but this was considered an extralimital stray.

Inland Waters. Pygmy sperm whales are not expected to occur within the Inland Waters region of the Study Area.

Western Behm Canal, Alaska. Pygmy sperm whales are not expected to occur within the SEAFAC region of the Study Area.

3.4.2.15 Killer Whale (*Orcinus orca*)

A single species of killer whale is currently recognized, but strong and increasing evidence indicates the possibility of several different species of killer whales worldwide, many of which are called "ecotypes" (Ford 2008; Morin et al. 2010). The different geographic forms of killer whale are distinguished by distinct social and foraging behaviors and other ecological traits. In the North Pacific, these recognizable geographic forms are variously known as ''residents,'' ''transients," and "offshore" ecotypes (Hoelzel et al. 2007).

3.4.2.15.1 Status and Management

The killer whale is protected under the MMPA, and the overall species is not listed on the ESA. The Eastern North Pacific Southern Resident population is listed as depleted under the MMPA and endangered under the ESA. The AT1 Transient stock of killer whales is also designated as depleted under the MMPA; this stock's current abundance estimate is seven animals (Allen and Angliss 2013). Eight killer whale stocks are recognized within the Pacific U.S. EEZ, including (1) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock (Prince William Sound through the Aleutian Islands and Bering Sea); (2) the AT1 Transient stock (Alaska from Prince William Sound through the Kenai Fjords); (3) the Alaska resident stock (southeastern Alaska to the Aleutian Islands and Bering Sea); (4) the Northern Resident stock (Washington State through part of southeastern Alaska); (5) the West Coast Transient stock (Alaska through California); (6) the Offshore stock (southeast Alaska through California); (7) the Southern Resident stock (mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from southeast Alaska through California); and (8) the Hawaii stock (Allen and Angliss 2014; Carretta et al. 2013). As shown in Table 3.4-1, out of these eight stocks there are five (Alaska resident, Northern Resident, West Coast Transient, Offshore, and Southern Resident stocks) that may be present in the Study Area.

In November 2006, NMFS designated critical habitat for Southern Resident killer whales within 2,560 mi.^2 (6,630 km^2) of marine habitat that includes Haro Strait and the waters around the San Juan Islands, Puget Sound, and the Strait of Juan de Fuca. Eighteen sites owned or controlled by the

Department of Defense are excluded from this critical habitat designation, including Navy installations within Puget Sound. The primary constituent elements essential for conservation of the Southern Resident killer whale critical habitat have been identified as (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging (National Marine Fisheries Service 2006).

3.4.2.15.2 Abundance

The current best available abundance estimates for the five killer whale stocks expected to occur in the Study Area are as follows: Alaska Resident stock = 2,084 animals; Northern Resident stock = 216 animals; West Coast Transient stock = 243 animals; Offshore stock = 240 animals; and Southern Resident stock = 87 individuals (Allen and Angliss 2012; Carretta et al. 2013). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 536 (coefficient of variation = 0.46) killer whales occur in waters off Washington and Oregon (Barlow 2010). In these offshore waters, there is currently no way to reliably distinguish the different stocks of killer whales from sightings at sea (Carretta et al. 2012); therefore this estimate includes animals from both the Offshore and West Coast Transient stocks.

3.4.2.15.3 Distribution

Killer whales are found in all marine habitats from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning 1999; Forney and Wade 2006). Offshore killer whales are known to inhabit both the western and eastern temperate Pacific and likely have a continuous distribution across the North Pacific (Steiger et al. 2008). In most areas of their range, killer whales do not show movement patterns that would be classified as traditional migrations. However, there are often seasonal shifts in density, both onshore/offshore and north/south.

Based on sightings, strandings, and acoustic detections along the west coast of North America, all three killer whale ecotypes (residents, transients and offshore) are known to occur, including along the entire Alaskan coast, in British Columbia and Washington inland waterways, and along the outer coasts of Washington, Oregon, and California (Forney et al. 1995; Baird and Dill 1996; Ford and Ellis 1999; Calambokidis and Barlow 2004; Dahlheim et al. 2008).

Offshore. Along the west coast of the United States, three stocks of killer whale may occur: the West Coast Transient stock, the Offshore stock, and the Southern Resident stock (Carretta et al. 2012), although Northern Resident killer whales may be found infrequently in waters off Washington (Allen and Angliss 2012). Killer whales tend to show up along the Oregon coast during late April and May and may target gray whale females and calves migrating north. Based on food type, these probably are transients. As noted above, when observed offshore it is difficult to determine if a particular whale is a transient, offshore, or a resident ecotype.

Offshore killer whales usually occur 9 mi. (15 km) or more offshore, but also visit coastal waters and occasionally enter protected inshore waters (Wiles 2004). Offshore killer whales have been documented off the west coast of Vancouver Island (National Marine Fisheries Service 2005), and groups of offshore killer whales have been encountered as far south as Los Angeles, mostly during winter (Ford et al. 1994).

Southern Resident killer whales regularly visit coastal sites off Washington State and Vancouver Island (Ford et al. 1994) and in the winter are known to travel as far south as Monterey off central California (Black 2011).

Inland Waters. Among the genetically distinct assemblages of killer whales in the northeastern Pacific, the West Coast Transient stock and the Southern Resident stocks are the two that occur in the Inland Waters region of the Study Area, although individuals of the Northern Resident stock occasionally venture into the area. Transient killer whales in the Pacific Northwest spend most of their time along the outer coast of British Columbia and Washington, but visit inland waters in search of harbor seals, sea lions, and other prey. Transients may occur in inland waters in any month (Orca Network 2010) but several studies have shown peaks in occurrences: Morton (1990) found bimodal peaks in spring (March) and fall (September–November) for transients on the northeastern coast of British Columbia. Baird and Dill (1995) found some transient groups frequenting the vicinity of harbor seal haul-out sites around southern Vancouver Island during August and September, which is the peak period for pupping through post-weaning of harbor seal pups. However, not all transient groups were seasonal in these studies, and their movements appear to be unpredictable. The number of West Coast Transient killer whales in Washington inland waters at any one time is probably fewer than 20 individuals (Wiles 2004). Transient killer whale occurrences inside marine waters have increased between 1987 and 2010, possibly because the abundance of some prey species (e.g., seals, sea lions, and porpoises) has increased (Houghton et al., in preparation).

The Eastern North Pacific Southern Resident stock is a trans-boundary stock including killer whales in inland Washington and southern British Columbia waters. Photo-identification of individual whales through the years has resulted in a substantial understanding of this stock's structure, behaviors, and movements in inland waters. In 1993, the three pods comprising this stock totaled 96 killer whales (Ford et al. 1994). The population increased to 99 whales in 1995, then declined to 79 whales in 2001. The current abundance estimate for this stock is 86 whales (Carretta et al. 2012). In spring and summer months, the Southern Resident stock is most frequently seen in the San Juan Islands region with intermittent sightings in Puget Sound (Whale Museum 2012). In the fall and early winter months, the Southern Residents are seen more frequently in Puget Sound, where returning chum and Chinook salmon are concentrated (Osborne et al. 1988). By winter, they spend progressively less time in the inland marine waters and more time off the coast of Washington, Oregon, and California (Black 2011).

While both Southern Resident killer whales and transient killer whales are frequently sighted in the main basin of Puget Sound, their presence near Navy installations varies from not present at all to infrequent sightings, depending on the season (Orca Network 2012; Whale Museum 2012). Southern Resident killer whales have not been reported in Hood Canal or Dabob Bay since 1995 (National Marine Fisheries Service 2008). Southern resident killer whales (J pod) were historically documented in Hood Canal by sound recordings in 1958 (Ford 1991), a photograph from 1973, sound recordings in 1995 (Unger 1997), and also anecdotal accounts of historical use, but these latter sightings may be transient whales (National Marine Fisheries Service 2008). Transient killer whales were last observed in Hood Canal in 2005 and prior to that in 2003, but they have not been observed since. Prior to these occurrences, transients were rarely seen. Near NAVBASE Kitsap Bremerton and Keyport, the Southern Resident killer whale is also rare, with the last confirmed sighting in Dyes Inlet in 1997. There was a more recent confirmed Southern Resident occurrence along the Washington State Ferries route between Bremerton and Seattle in December 2007, but the exact location of the sighting is not known (Orca Network 2012). Transient killer whales have been seen infrequently near NAVBASE Kitsap Bremerton (e.g., a sighting in 2013 at Dyes Inlet; Orca Network 2013). Both Southern resident killer whales and transients have been observed in Saratoga Passage and Possession Sound near NASWI and Naval Station Everett respectively. Transients and Southern Resident killer whales have also been observed in southern Puget Sound in the Carr Inlet area.

Western Behm Canal, Alaska. The Alaska Resident, Northern Resident, and West Coast Transient stocks of killer whale occur in waters of southeast Alaska; however, transients are considered rare in the SEAFAC region of the Study Area (Dahlheim et al. 2009). Northern Resident killer whales have been documented in southeast Alaska, although in the summer they are found primarily in central and northern British Columbia (Allen and Angliss 2012). Therefore, individuals belonging to the Alaska Resident stock are the killer whales most likely to occur in the SEAFAC region of the Study Area, and are more likely from spring through fall (Dahlheim et al. 2009). Southern resident killer whales (L pod, 30 individuals) were photographically identified in Chatham Strait, Southeast Alaska (northwest of Behm Canal), in June 2007. Southern Residents were previously thought to range as far north as the Queen Charlotte Islands, B. C.; however, this sighting extends their known range about 200 mi. to the north (Barre 2012).

3.4.2.16 Short-Finned Pilot Whale (*Globicephala macrorhynchus*)

3.4.2.16.1 Status and Management

Short-finned pilot whales are protected under the MMPA and are not listed under the ESA. For MMPA stock assessment reports, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete areas: (1) the California, Oregon and Washington stock; and (2) the Hawaii stock (Carretta et al. 2012).

3.4.2.16.2 Abundance

The current abundance estimate for short-finned pilot whales found along the U.S. west coast is based on the mean of two ship surveys conducted in California, Oregon, and Washington waters in 2005 and 2008. The resulting abundance estimate of 760 (coefficient of variation = 0.64) individuals is considered the best estimate for the California, Oregon, and Washington stock (Carretta et al. 2012).

3.4.2.16.3 Distribution

The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world. A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Hui 1985; Payne and Heinemann 1993; Bernard and Reilly 1999). Short-finned pilot whale distribution off Southern California changed dramatically after El Niño in 1982–1983, when squid did not spawn as usual in the area, and pilot whales virtually disappeared from the area for 9 years (Shane 1995). Pilot whales appear to have returned to California waters as evidenced by an increase in sighting records, as well as incidental fishery bycatch data (Carretta et al. 2004; Barlow 2010); however, current and historic sightings of this species in waters off Oregon and Washington are rare (Hamilton et al. 2009; Barlow 2010).

Offshore. Along the U.S. west coast, short-finned pilot whales are most abundant south of Point Conception, California (Reilly and Shane 1986; Carretta et al. 2012). Stranding records for this species from Oregon and Washington waters are considered to be beyond the normal range of this species rather than an extension of its range (Norman et al. 2004). The occurrence of a short-finned pilot whale within offshore waters of the Study Area is considered rare.

Inland Waters. Short-finned pilot whales are not expected to occur within the Inland Waters region of the Study Area.

Western Behm Canal, Alaska. Short-finned pilot whales are not expected to occur within the SEAFAC region of the Study Area.

3.4.2.17 Short-Beaked Common Dolphin (*Delphinus delphis*)

3.4.2.17.1 Status and Management

The short-beaked common dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. EEZ of California, Oregon and Washington (Carretta et al. 2012).

3.4.2.17.2 Abundance

The California, Oregon, and Washington stock of short-beaked common dolphin has a current population estimate of 411,211 individuals (coefficient of variation = 0.21) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 3,312 short-beaked common dolphins (coefficient of variation = 0.53) occur in waters off Washington and Oregon (Barlow 2010).

3.4.2.17.3 Distribution

Historically along the U.S. west coast, short-beaked common dolphins were sighted primarily south of Point Conception (Dohl et al. 1983), but now they are commonly encountered as far north as 42°N (Hamilton et al. 2009), and occasionally as far north as 48°N (Forney 2007). Although they are not truly migratory, the abundance of short-beaked common dolphins off the U.S. west coast varies, with seasonal and year-to-year changes in oceanographic conditions; movements may be north-south or inshore-offshore (Forney and Barlow 1998; Barlow et al. 2009; Forney et al. 2012; Becker et al. 2012b). Short-beaked common dolphin abundance off California has increased dramatically since the late 1970s, along with a smaller decrease in abundance in the eastern tropical Pacific, suggesting a large-scale northward shift in the distribution of this species in the eastern North Pacific (Forney et al. 1995; Forney and Barlow 1998). In general, the northward extent of short-beaked common dolphin distribution appears to vary from year to year and with changing ocean conditions (Forney and Barlow 1998; Becker et al. 2012b).

Offshore. Short-beaked common dolphins are found off the U.S. west coast throughout the year, distributed between the coast and at least 345 mi. (556 km) from shore (Barlow et al. 2009; Carretta et al. 2012). The short-beaked common dolphin is the most abundant cetacean species off California (Forney et al. 1995; Carretta et al. 2012); however, their abudance decreases dramatically north of about 40°N (Barlow et al. 2009; Forney et al. 2012; Becker et al. 2012b). During summer and fall, the primary occurrence of the short-beaked common dolphin in the offshore region of the Study Area is along the outer coast in waters deeper than 656 ft. (200 m), south of 42°N. However, short-beaked common dolphins are occasionally sighted in waters off Oregon and Washington, and one group of approximately 40 short-beaked common dolphins was sighted off northern Washington in 2005 at about 48°N (Forney 2007).

Inland Waters. Short-beaked common dolphins are not expected to occur within the Inland Waters region of the Study Area.

Western Behm Canal, Alaska. Short-beaked common dolphins are not expected to occur within the SEAFAC region of the Study Area.

3.4.2.18 Common Bottlenose Dolphin (*Tursiops truncatus*)

3.4.2.18.1 Status and Management

The common bottlenose dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, bottlenose dolphins within the Pacific U.S. EEZ are divided into seven stocks: (1) the California coastal stock; (2) the California, Oregon and Washington offshore stock; (3) the Kauai and Niihau stock; (4) the Oahu stock; (5) the 4-Islands region stock; (6) the Hawaii Island stock; and (7) the Hawaii pelagic stock (Carretta et al. 2012). The stock of California coastal bottlenose dolphins are found within about 0.62 mi. (1 km) of shore, generally from as far south as San Quintin, Mexico, north to Point Conception, California (Carretta et al. 1998; Defran and Weller 1999). During El Niño events, when water temperatures increase, coastal bottlenose dolphins have been consistently sighted off central California and as far north as San Francisco, but are considered extralimital in all regions of the Study Area. The following discussion is therefore specific to the California, Oregon and Washington offshore stock.

3.4.2.18.2 Abundance

The California, Oregon, and Washington stock of common offshore bottlenose dolphin has a current population estimate of 1,006 (coefficient of variation = 0.48) (Carretta et al. 2012).

3.4.2.18.3 Distribution

Bottlenose dolphins are found most commonly in coastal and continental shelf waters of tropical and temperate regions of the world. Off the U.S. west coast, individuals have been documented in offshore waters as far north as about 41°N; they may range into Oregon and Washington waters during warm-water periods (Carretta et al. 2012).

Offshore. During surveys off the U.S. west coast, offshore bottlenose dolphins were generally found at distances greater than 1.86 mi. (3 km) from the coast and were most abundant off southern California (Barlow 2010). Based on sighting data collected by SWFSC during systematic surveys in the Northeast Pacific between 1986 and 2005, there were few sightings of offshore bottlenose dolphins north of about 40°N (Hamilton et al. 2009). The occurrence of offshore bottlenose dolphins within offshore waters of the Study Area is considered rare.

Inland Waters. Bottlenose dolphins are considered extralimital in Washington inland waters; only three sightings and one stranding of bottlenose dolphins have been documented in Puget Sound since 2004 (Cascadia Research 2011).

Western Behm Canal, Alaska. Common bottlenose dolphins are not expected to occur within the SEAFAC region of the Study Area.

3.4.2.19 Striped Dolphin (*Stenella coeruleoalba*)

3.4.2.19.1 Status and Management

The striped dolphin is protected under the MMPA and is not listed under the ESA. NMFS divides striped dolphin management stocks within the U.S. EEZ into two discrete areas: (1) the California, Oregon and Washington stock; and (2) the Hawaii stock (Carretta et al. 2012).

3.4.2.19.2 Abundance

The current best abundance estimate of the California, Oregon, and Washington stock is 10,908 (coefficient of variation = 0.34) striped dolphins (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 12 striped dolphins (coefficient of variation = 1.05) occur in waters off Washington and Oregon (Barlow 2010).

3.4.2.19.3 Distribution

Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus *Stenella*. Striped dolphins also are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman 1985; Reilly 1990).

Offshore. During ship surveys conducted off the U.S. west coast in the summer and fall from 1991 to 2005, striped dolphins were sighted primarily from 100 to 300 nm offshore of the California coast (Barlow and Forney 2007). Striped dolphin encounters increase in deep, relatively warmer waters off the U.S. west coast (Becker et al. 2012b), and their abudance decreases north of about 42°N (Barlow et al. 2009; Becker et al. 2012b; Forney et al. 2012). Although striped dolphins typically do not occur north of California, there are a few sighting records off Oregon and Washington (Von Saunder and Barlow 1999; Barlow 2003; Barlow 2010). Strandings are documented along the coasts of Oregon, Washington, and British Columbia (Kellogg and Scheffer 1947; Kenyon and Scheffer 1949; Cowan and Guiguet 1952; Scheffer 1960). Occurrences north of California may be related to incidents of warm water moving northward (Baird et al. 1993; Norman et al. 2004). The occurrence of striped dolphins within the northwest offshore waters of the Study Area is considered rare.

Inland Waters. Striped dolphins are not expected to occur within the Inland Waters region of the Study Area.

Western Behm Canal, Alaska. Striped dolphins are not expected to occur within the SEAFAC region of the Study Area.

3.4.2.20 Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*)

3.4.2.20.1 Status and Management

This species is protected under the MMPA and not listed under the ESA. NMFS divides Pacific white-sided dolphin management stocks within the U.S. Pacific EEZ into two discrete areas: (1) the Alaska/North Pacific stock; and (2) the California, Oregon, and Washington stock (Allen and Angliss 2012; Carretta et al. 2012). Morphological studies and genetic analysis suggests existence of several populations of Pacific white-sided dolphins throughout their range (Lux et al. 1997; Hayano et al. 2004). Four populations have been suggested: in the offshore waters of Baja California, in the offshore waters of California to Oregon, offshore of British Columbia and Alaska, and in the offshore waters west of 160° West (W) (Hayano et al. 2004). However, the population boundaries are dynamic, and there is no reliable way to distinguish animals reliably in the field. Thus, populations occurring in the U.S. Pacific EEZ are managed by NMFS as the two stocks noted above (Allen and Angliss 2012; Carretta et al. 2012).

3.4.2.20.2 Abundance

There is currently no reliable population estimate for the Alaska/North Pacific stock of Pacific white-sided dolphins (Allen and Angliss 2012). The current abundance estimate for the California, Oregon, and

Washington stock is 26,930 individuals (coefficient of variation = 0.28) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 11,250 Pacific white-sided dolphins (coefficient of variation = 0.36) occur in waters off Washington and Oregon (Barlow 2010).

3.4.2.20.3 Distribution

The Pacific white-sided dolphin is found in cold temperate waters across the northern rim of the Pacific Ocean (Reeves et al. 2002; Jefferson et al. 2008). It is typically found in deep waters along the continental margins and outer shelf and slope waters. It is also known to inhabit inshore regions of southeast Alaska, British Columbia, and Washington, and occurs seasonally off Southern California (Forney and Barlow 1998; Brownell et al. 1999).

Offshore. Forney and Barlow (1998) found significant north/south shifts in the seasonal distribution of Pacific white-sided dolphin off California, with the animals moving north into Oregon and Washington waters during the summer, and showing increased abundance in the Southern California Bight in the winter. In late spring (May), Pacific white-sided dolphins can be found in shelf waters off the coast of Oregon and Washington (Tsutsui et al. 2001; Reeves et al. 2002). During ship surveys conducted off the U.S. west coast in the summer and fall from 1991 to 2005, the number of Pacific white-sided dolphin sightings showed no clear pattern with respect to geographic region, although they were consistently found in larger groups off central California (Barlow and Forney 2007). Acoustic detections of Pacific white-sided dolphin have been made consistently from June through March in waters off Washington, with a notable absence of detections in April and May (Oleson et al. 2009).

Based on habitat models developed with survey data collected during summer and fall from 1991 to 2008, Becker et al. (2012b) found that encounters of Pacific white-sided dolphin increased in shelf and slope waters and in relatively cooler waters in the study area. These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al. 2009; Forney et al. 2012). Line-transect analyses of the 1991–2008 data revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow 2010). Pacific white-sided dolphins are thus likely to occur year-round in the offshore region of the Study Area, with increased abundance in the summer/fall.

Inland Waters. Pacific white-sided dolphins are known to enter the inshore passes of British Columbia and Washington, and have been encountered in the Strait of Juan de Fuca and the Strait of Georgia (Stacey and Baird 1991; Norman et al. 2004). Small groups have also been seen in Haro Strait off San Juan Island. Pacific white-sided dolphins are extremely rare in Puget Sound, with only one stranding in southern Puget Sound recorded in the 1980s (Osborne et al. 1988). Two incidental sightings were reported to Orca Network: one in April 2010 near Everett reported by a naturalist and one in March 2011 near Seattle that was unverified (Orca Network 2012). Pacific white-sided dolphin occurrence in the Inland Waters is considered rare with the exception of southern Puget Sound, where occurrence is considered extralimital.

Western Behm Canal, Alaska. Pacific white-sided dolphins are known to enter the inshore passes of Alaska, British Columbia, and Washington (Osborne et al. 1988; Ferrero and Walker 1996). During surveys conducted in the inland waters of southeast Alaska between 1991 and 2007, Pacific white-sided dolphins were only seen during the spring and summer surveys (Dahlheim et al. 2009). Because most sightings occur in water deeper than 656 ft. (200 m), and the SEAFAC area is at least this deep in many areas, the species may occasionally visit the SEAFAC area.

3.4.2.21 Northern Right Whale Dolphin (*Lissodelphis borealis*)

3.4.2.21.1 Status and Management

This species is protected under the MMPA and is not listed under the ESA. Dizon et al. (1994) examined a small sample of northern right whale dolphin specimens to determine whether there were different populations along the west coast of North America and in the open sea waters of the central North Pacific. Although no evidence of separate populations was found, separate stocks are assumed to exist. Currently, the management stock in U.S. Pacific EEZ waters consists of a single California, Oregon, and Washington stock (Carretta et al. 2012).

3.4.2.21.2 Abundance

The current abundance estimate for the California, Oregon, and Washington stock of northern right whale dolphin is 8,334 individuals (coefficient of variation = 0.40) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 4,152 northern right whale dolphins (coefficient of variation = 0.38) occur in waters off Washington and Oregon (Barlow 2010).

3.4.2.21.3 Distribution

The northern right whale dolphin occurs in cool-temperate to subarctic waters of the North Pacific Ocean, from the west coast of North America to Japan and Russia. This oceanic species is distributed from approximately 30°N to 50°N, 145°W to 118° East and generally not as far north as the Bering Sea (Jefferson et al. 2008). Occasional movements south of 30°N are associated with unusually cold water temperatures (Leatherwood and Walker 1979; Jefferson and Lynn 1994). This species tends to occur along the outer continental shelf and slope, normally in waters colder than 68°F (20°C) (Leatherwood and Walker 1979; Jefferson and Lynn 1994). Northern right whale dolphins generally move nearshore only in areas where the continental shelf is narrow or where productivity on the shelf is especially high (Smith et al. 1986). The species does not migrate, although seasonal shifts do occur.

Offshore. Survey data suggest that, at least in the eastern North Pacific, seasonal inshore-offshore and north-south movements are related to prey availability, with peak abundance in the Southern California Bight during winter and distribution shifting northward into Oregon and Washington as water temperatures increase during late spring and summer (Leatherwood and Walker 1979; Barlow 1995; Forney et al. 1995; Forney and Barlow 1998). Based on habitat models developed with survey data collected during summer and fall from 1991 to 2008, Becker et al. (2012b) found that encounters of northern right whale dolphin increased in shelf and slope waters in the study area, and encounters decreased substantially in waters warmer than approximately 64°F (18°C). These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al. 2009; Forney et al. 2012). Line-transect analyses of the 1991–2008 data revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow 2010). Northern right whale dolphins are thus likely to occur year-round in the offshore region of the Study Area, with increased abundance in the summer/fall.

Inland Waters. Northern right whale dolphins are relatively common off the Washington coast, but based on a lack of sighting records, this species is not expected to occur within the Inland Waters region of the Study Area.

Western Behm Canal, Alaska. Northern right whale dolphins are not expected to occur within the SEAFAC region of the Study Area.

3.4.2.22 Risso's Dolphin (*Grampus griseus*)

3.4.2.22.1 Status and Management

Risso's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, Risso's dolphins within the Pacific U.S. EEZ are divided into two discrete areas: (1) a California, Oregon and Washington stock; and (2) a Hawaii stock (Carretta et al. 2012).

3.4.2.22.2 Abundance

Risso's dolphin is a widely distributed species that occurs in all major oceans, and although no global population estimates exist, it is generally considered to be one of the most abundant of the large dolphins. The abundance for the California, Oregon, and Washington stock, based on surveys between 2005 and 2008, is 6,272 individuals (coefficient of variation = 0.30) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 3,607 Risso's dolphins (coefficient of variation = 0.36) occur in waters off Washington and Oregon (Barlow 2010).

3.4.2.22.3 Distribution

Risso's dolphins are distributed worldwide in tropical to warm-temperate waters, roughly between 60°N and 60°S, where surface water temperature is usually greater than 50°F (10°C; Kruse et al. 1999). In the eastern North Pacific, Risso's dolphins extend north into Canadian waters (Reimchen 1980; Baird and Stacey 1991). They are most often found along the continental slope (Green et al. 1992; Kruse et al. 1999) and Baumgartner (1997) hypothesized that this distribution strongly correlates with cephalopod distribution. Water temperature appears to affect the distribution of Risso's dolphins in the Pacific (Leatherwood et al. 1980; Kruse et al. 1999). Risso's dolphin does not migrate, although schools may range over very large distances, and seasonal shifts in centers of abundance are known for some regions.

Offshore. Risso's dolphin exhibits apparent seasonal shifts in distribution off the U.S. west coast, with movements from California waters north into Oregon and Washington waters in spring and summer (Green et al. 1992; Forney and Barlow 1998; Soldevilla et al. 2008). They were the most commonly sighted odontocete in the northwest offshore waters of the Study Area during aerial surveys in the late 1980s (Green et al. 1992), and were sighted frequently off the Washington coast in summer and fall during ship surveys in 1996, 2001, and 2005 (Barlow and Forney 2007). However, they have been sighted infrequently during recent surveys (Oleson et al. 2009). Based on systematic survey data and acoustic studies conducted in offshore waters of the Study Area during the last 10 years, there appears to be high interannual variability in the occurrence of this species (Oleson et al. 2009; Barlow 2010). Acoustic detections of Risso's dolphins have been made year-round in the Study Area (Oleson et al. 2009).

Inland Waters. This species is not expected to occur within the Inland Waters region of the Study Area. Inland water stranding records for this species include a March 1975 report for Discovery Bay in the eastern Strait of Juan de Fuca (Everitt et al. 1979) and another near Port Angeles in October 1987 (Osborne et al. 1988). Two reported sightings of juvenile Risso's dolphins took place in late 2011 (Cascadia Research 2011), and a pair of Risso's dolphins was sighted in Puget Sound during aerial surveys in 2013 (Smultea and Bacon 2013); however, these sightings are considered very unusual as the species is considered extralimital to the Study Area and occurrence is highly unlikely.

Western Behm Canal, Alaska. Risso's dolphins are not expected to occur within the SEAFAC region of the Study Area.

3.4.2.23 Harbor Porpoise (*Phocoena phocoena*)

3.4.2.23.1 Status and Management

The harbor porpoise is protected under the MMPA and is not listed under the ESA. Based on genetic differences and discontinuities identified from aerial surveys for populations off California, Oregon, and Washington, and based on somewhat arbitrary boundaries for Alaska populations, nine separate stocks are recognized within U.S. Pacific EEZ waters: (1) a Bering Sea stock, (2) a Gulf of Alaska stock, (3) a Southeast Alaska stock, (4) a Washington Inland Waters stock,(5) a Northern Oregon/Washington Coast stock, (6) a Northern California/Southern Oregon stock, (7) a San Francisco-Russian River stock; (8) a Monterey Bay stock; and (9) a Morro Bay stock (Carretta et al. 2012). As shown in Table 3.4-1, harbor porpoise from four of these stocks may occur in the Study Area, including the Southeast Alaska, Washington Inland Waters, Northern Oregon/Washington Coast, and Northern California/Southern Oregon stocks.

3.4.2.23.2 Abundance

Abundance estimates for harbor porpoise stocks that may occur in the Study Area are as follows: Southeast Alaska stock = 11, 146 individuals (coefficient of variation = 0.24); Northern Oregon/Washington Coast stock = there are no recent data but 2002 estimates were 15,674 individuals (coefficient of variation = 0.39); Northern California/Southern Oregon stock = 39,581 individuals (coefficient of variation = 0.39); Washington Inland Waters stock = there are no recent data but 2002/03 estimates were 10,682 individuals (coefficient of variation = 0.38) (Allen and Angliss 2012; Carretta et al. 2012).

3.4.2.23.3 Distribution

Harbor porpoise are generally found in cool temperate to subarctic waters over the continental shelf in both the North Atlantic and North Pacific (Read 1999). In the eastern North Pacific, harbor porpoise are found in nearshore coastal (generally within a mile or two of shore) from Alaska south to Point Conception, California, which is considered the southern extent of this species normal range (Dohl et al. 1983; Carretta et al. 2009; Hamilton et al. 2009).

Offshore. The harbor porpoise is a common species in the nearshore coastal waters of the Study Area year-round (Barlow 1988; Green et al. 1992; Osmek et al. 1996, 1998; Forney and Barlow 1998; Carretta et al. 2009). Harbor porpoise was the most frequently sighted marine mammal (114 sightings) during 42 small boat surveys in waters off Washington from August 2004 through September 2008 (Oleson et al. 2009). The range of harbor porpoise habitat extends from the shore out to roughly the 656 ft. (200 m) isobath (Carretta et al. 2009). Based on aerial survey data collected off the coasts of California and southern Oregon in summer and fall from 2002 to 2007, higher densities of harbor porpoise were found between the coast and the 295 ft. (90 m) isobath as compared to densities in the region between the 295 ft. (90 m) and 656 ft. (200 m) isobaths (Carretta et al. 2009). Data from earlier studies suggest that peak abundance is in the fall off northern California (Dohl et al. 1983) and in fall and winter off Oregon and Washington (Green et al. 1992). Seasonal shifts in distribution have been documented, and it has been suggested that harbor porpoise may move to relatively deeper waters during late winter (Dohl et al. 1983; Barlow 1988), but such seasonal movement patterns are not well understood. Based on data collected during surveys in waters off Washington from August 2004 through September 2008, Oleson et al. (2009) found a significant seasonal difference in harbor porpoise sighting locations; in fall, sightings were closest to the shore, furthest from the shelf edge, and in shallow water, while in summer they were farthest from the shore, closest to the shelf edge, and in deeper water.

Inland Waters. Harbor porpoise are known to occur in the Strait of Juan de Fuca and the San Juan Island area year-round (Calambokidis and Baird 1994; Osmek et al. 1995; Carretta et al. 2012).

Harbor porpoises were historically one of the most commonly observed marine mammals in Puget Sound (Scheffer and Slipp 1948); however, there was a significant decline in sightings beginning in the 1940s (Everitt et al. 1979; Calambokidis et al. 1992), but recent increased sightings may indicate a return to the area. Only a few sightings were reported between the 1970s and 1990s (Calambokidis et al. 1992; Osmek et al. 1995; Raum-Suryan and Harvey 1998). Incidental sightings of marine mammals during aerial bird surveys conducted as part of the Puget Sound Ambient Monitoring Program (PSAMP) detected few harbor porpoises in Puget Sound between 1992 and 1999 (Nysewander et al. 2005). However these sightings may be negatively biased due to the low elevation of the plane which may have caused avoidance behavior. The apparent decline in harbor porpoises observed since the 1940s may be due to by-catch from gill net fisheries coupled with the sharp decline of the herring fishery. Since 1999, PSAMP data and stranding data documented increasing numbers of harbor porpoise in Puget Sound, indicating that the species may be returning to the area (Nysewander et al. 2005; Jeffries pers. comm. 2013). Sightings in northern Hood Canal (north of the Hood Canal Bridge) have increased in recent years. In 2011, harbor porpoise were documented in small numbers in Hood Canal near NAVBASE Kitsap Bangor and in the DBRC Site (U.S. Department of the Navy 2012e). From 1999 to 2008 there were harbor porpoise seen in southern Puget Sound in and near Carr Inlet, but no sightings between Rich Passage and Agate Passage in the vicinity of NAVBASE Kitsap Bremerton and Keyport (Washington Department of Fish and Wildlife 2008a). There were no sightings in Saratoga Passage near NASWI, but there was one sighting in Port Susan north of Naval Station Everett.

Western Behm Canal, Alaska. In Alaskan waters, harbor porpoises inhabit nearshore areas and are common in bays, estuaries, and tidal channels. Harbor porpoises are often found in coastal waters in southeast Alaska, and occur most frequently in waters less than 328 ft. (100 m) deep (Hobbs and Waite 2010). Harbor porpoise was the second-most frequently observed species during surveys conducted in the inland waters of southeast Alaska between 1991 and 2007 (Dahlheim et al. 2009). Although surveys were not conducted in the winter months in southeast Alaska, it is possible that harbor porpoises may be present in the winter.

3.4.2.24 Dall's Porpoise (*Phocoenoides dalli*)

3.4.2.24.1 Status and Management

This species is protected under the MMPA and is not listed under the ESA. Dall's porpoise is managed by NMFS within U.S. Pacific EEZ waters as two stocks: (1) an Alaska stock; and (2) a California, Oregon, and Washington stock (Allen and Angliss 2012; Carretta et al. 2012).

3.4.2.24.2 Abundance

Dall's porpoises are very abundant, probably one of the most abundant small cetacean in the cooler waters of the North Pacific Ocean. However, population structure within North American waters has not been well studied. The current estimate for the Alaska stock of Dall's porpoise is 83,400 animals (coefficient of variation = 0.97), corrected for vessel attraction behavior although the survey data is over 21 years old and therefore provides no reliable abundance data for the Alaska stock (Allen and Angliss 2014). The abundance for the California, Oregon, and Washington stock is 42,000 individuals (coefficient of variation = 0.33) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 27,010 Dall's porpoise (coefficient of variation = 0.29) occur in waters off Washington and Oregon (Barlow 2010).

3.4.2.24.3 Distribution

Dall's porpoise is one of the most common odontocete species in North Pacific waters (Jefferson 1991; Ferrero and Walker 1999; Calambokidis and Barlow 2004; Zagzebski et al. 2006; Williams and Thomas 2007). Dall's porpoise is found from northern Baja California, Mexico, north to the northern Bering Sea and south to southern Japan (Jefferson et al. 1993). However, the species is only common between 32°N and 62°N in the eastern North Pacific (Morejohn 1979; Houck and Jefferson 1999). Dall's porpoise are found in outer continental shelf, slope, and oceanic waters, typically in temperatures less than 63°F (17°C) (Houck and Jefferson 1999; Reeves et al. 2002; Jefferson et al. 2008).

Offshore. Dall's porpoise distribution off the U.S. west coast is highly variable between years, most likely due to changes in oceanographic conditions (Forney and Barlow 1998; Barlow et al. 2009; Becker et al. 2010, 2012b; Forney et al. 2012). North-south movements in California, Oregon, and Washington have been observed, with Dall's porpoise shifting their distribution southward during cooler-water periods on both interannual and seasonal time scales (Forney and Barlow 1998). Seasonal movements have also been noted off Oregon and Washington, where higher densities of Dall's porpoises were sighted offshore in winter and spring and inshore in summer and fall (Green et al. 1992). Based on habitat models developed using 1991–2008 survey data collected during summer and fall, Becker et al. (2012b) found that encounters of Dall's porpoise increased in shelf and slope waters in the Study Area, and encounters decreased substantially in waters warmer than approximately 63°F (17°C). These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Forney 2000; Barlow et al. 2009; Forney et al. 2012). Line-transect analyses of these data revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow 2010). Dall's porpoise was one of the most frequently sighted marine mammal (44 sightings of 206 animals) during 42 small boat surveys in waters off Washington from August 2004 through September 2008 (Oleson et al. 2009).

Inland Waters. Dall's porpoise occur in the inland waters year-round, but abundance and distribution varies between summer and winter (Calambokidis pers. comm. 2006). Dall's porpoise are most frequently observed in the Strait of Juan de Fuca and Haro Strait between San Juan Island and Vancouver Island (Nysewander et al. 2005). Tagging studies suggest that Dall's porpoise seasonally move between Haro Strait and the Strait of Juan de Fuca or farther west (Hanson et al. 1998).

The most recent Dall's porpoise sightings in Puget Sound are from aerial surveys during winter (1993–2008) and summer (1992–1999) as part of the Puget Sound Ambient Monitoring Program (PSAMP) (Nysewander et al. 2005; Washington Department of Fish and Wildlife 2008a). During these surveys, Dall's porpoise were sighted in Puget Sound as far south as Henderson Bay in Carr Inlet (Nysewander et al. 2005; Washington Department of Fish and Wildlife 2008a). Dall's porpoise may also occasionally occur in Hood Canal (Jeffries pers. comm. 2006); the last one was observed in deeper water near Naval Base Kitsap Bangor in the summer of 2008 (Tannenbaum et al. 2009). In recent years several vessel line-transect surveys and other monitoring efforts have been completed in Hood Canal (including Dabob Bay), and Dall's porpoise were not seen (U.S. Department of the Navy 2011, 2012, 2013). Dall's porpoise have not been documented in the Rich Passage to Agate Passage area in the vicinity of NAVBASE Kitsap Bremerton or Keyport in either the summer or winter surveys (Washington Department of Fish and Wildlife 2008a; Nysewander et al. 2005). Dall's porpoise have been documented in Possession Sound near Naval Station Everett and in Saratoga Passage near NASWI, with all but one sighting occurring in the winter (Washington Department of Fish and Wildlife 2008a; Nysewander et al. 2005).

Western Behm Canal, Alaska. When inshore, Dall's porpoise are found most often in deep channels with strong currents (Dahlheim et al. 2009). Dall's porpoise was the most frequently observed species during surveys conducted in the inland waters of southeast Alaska between 1991 and 2007 (Dahlheim et al. 2009). Although surveys were not conducted in the winter months in southeast Alaska, it is possible that Dall's porpoises may be present in the winter.

3.4.2.25 Cuvier's Beaked Whale (*Ziphius cavirostris*)

3.4.2.25.1 Status and Management

Cuvier's beaked whale is protected under the MMPA and is not listed under the ESA. Cuvier's beaked whale is managed by NMFS within U.S. Pacific EEZ waters as three stocks: (1) an Alaska stock; (2) a California, Oregon, and Washington stock; and (3) a Hawaii stock (Allen and Angliss 2012; Carretta et al. 2012).

3.4.2.25.2 Abundance

There is currently no reliable abundance estimate for the Alaska stock of Cuvier's beaked whale (Allen and Angliss 2012). The current best available abundance estimate for the California, Oregon, and Washington stock is 2,143 individuals (coefficient of variation = 0.65) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 137 Cuvier's beaked whales (coefficient of variation = 1.12) occur in waters off Washington and Oregon (Barlow 2010). A recent study using the 1991 to 2008 survey data provides evidence that the abundance of Cuvier's beaked whales has declined off California, Oregon, and Washington since the early 1990s, although reasons for these apparent declines are unknown (Moore and Barlow 2013).

3.4.2.25.3 Distribution

Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres (Barlow and Gisner 2006; Ferguson et al. 2006b; Jefferson et al. 2008; Pitman et al. 1988). Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters. Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 656 ft. (200 m) and are frequently recorded in waters with bottom depths greater than 3,281 ft. (1,000 m) (Jefferson et al. 2008). A single population likely exists in offshore waters of the eastern North Pacific, ranging from Alaska south to Mexico (Carretta et al. 2012). Little is known about potential migration.

Offshore. Cuvier's beaked whale is the most commonly encountered beaked whale off the U.S. west coast (Hamilton et al. 2009; Carretta et al. 2012). This species is found from Alaska to Baja California, Mexico, and there are no apparent seasonal changes in distribution (Pitman et al. 1988; Mead 1989; Carretta et al. 2012). Repeated sightings of the same individuals have been reported off San Clemente Island in Southern California, which indicates some level of site fidelity. Line-transect analyses of data collected during summer and fall of 1991–2008 revealed that abundance estimates were lower off Oregon and Washington as compared to areas off central and southern California (Barlow 2010). One sighting of three Cuvier's beaked whales was recorded in June 2006 during surveys conducted from August 2004 through September 2008 off the Washington coast (Oleson et al. 2009). Acoustic analyses of data collected from a Navy-funded monitoring device in Washington offshore waters detected Cuvier's beaked whale pulses between January and November 2011 (Širović et al. 2012b).

Inland Waters. Cuvier's beaked whales are not expected to occur within the Inland Waters region of the Study Area.

Western Behm Canal, Alaska. In the North Pacific, Cuvier's beaked whales range from Canadian waters north to the northern Gulf of Alaska, the Aleutian Islands, and the Commander Islands off Russia (Rice

1998). Cuvier's beaked whales were not observed during the 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009). Due to their preference for shelf and pelagic waters, the occurrence of Cuvier's beaked whale in the SEAFAC region of the Study Area is considered rare.

3.4.2.26 Baird's Beaked Whale (*Berardius bairdii*)

3.4.2.26.1 Status and Management

Baird's beaked whale is protected under the MMPA and is not listed under the ESA. Baird's beaked whale is managed by NMFS within Pacific U.S. EEZ waters as two stocks: (1) an Alaska stock; and (2) a California, Oregon, and Washington stock (Allen and Angliss 2012; Carretta et al. 2012).

3.4.2.26.2 Abundance

There is currently no reliable abundance estimate for the Alaska stock of Baird's beaked whale (Allen and Angliss 2012). The population estimate for the California, Oregon, and Washington stock of Baird's beaked whale is 907 (coefficient of variation = 0.49) (Carretta et al. 2012). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 380 Baird's beaked whales (coefficient of variation = 0.48) occur in waters off Washington and Oregon (Barlow 2010).

3.4.2.26.3 Distribution

Baird's beaked whale occurs mainly in deep waters over the continental slope, near oceanic seamounts, and areas with submarine escarpments, although they may be seen close to shore where deep water approaches the coast (Jefferson et al. 2008; Kasuya 2009). This species is generally found through the colder waters of the North Pacific, ranging from off Baja California, Mexico, to the Aleutian Islands of Alaska (MacLeod and D'Amico 2006; Jefferson et al. 2008).

Offshore. Baird's beaked whale is found mainly north of 28°N in the eastern Pacific (Kasuya et al. 1997; Reeves et al. 2002). Along the U.S. west coast, Baird's beaked whales are seen primarily along the continental slope, from late spring to early fall (Balcomb 1989; Green et al. 1992; Carretta et al. 2012). Baird's beaked whales are sighted less frequently and are presumed to be farther offshore during the colder water months of November through April (Carretta et al. 2012). Off Washington and British Columbia, Baird's beaked whales have been sighted in offshore waters with a bottom depth of 2,297 ft. (700 m) to 5,495 ft. (1,675 m) (Wahl 1977; Willis and Baird 1998b). Based on habitat models developed using 1991–2008 survey data collected during summer and fall, Becker et al. (2012b) found that encounters of Baird's beaked whale increased in waters near the 6,562 ft. (2,000 m) isobath. These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al. 2009; Forney et al. 2012). Line-transect analyses of these data revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow 2010). Acoustic analyses of data collected from a Navy-funded monitoring device in Washington offshore waters detected Baird's beaked whale pulses between January and November 2011, with a peak in detections in February and July (Širović et al. 2012b).

Inland Waters. Baird's beaked whales are not expected to occur within the Inland Waters region of the Study Area.

Western Behm Canal, Alaska. In the North Pacific Ocean and along the U.S. west coast, Baird's beaked whales are seen primarily along the continental slope in deep waters (Balcomb 1989; Reeves and Mitchell 1993). Baird's beaked whales were not observed during the 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009). Due to their preference for shelf and pelagic waters, the occurrence of Baird's beaked whale in the SEAFAC region of the Study Area is considered rare.

3.4.2.27 Mesoplodont Beaked Whales (*Mesoplodon* spp.)

3.4.2.27.1 Status and Management

All of the beaked whales in the genus *Mesoplodon* are protected under the MMPA but none are listed under the ESA. Due to the difficulty in distinguishing different *Mesoplodon* species from one another, NMFS includes six species in a single California, Oregon, and Washington management stock (Carretta et al. 2012). The six species known to occur in this region are Blainville's beaked whale (*M. densirostris*), Hubbs' beaked whale (*M. carlhubbsi*), Perrin's beaked whale (*M. perrini*), pygmy beaked whale (*M. peruvianus*), Stejneger's beaked whale (*M. stejnegeri*), and gingko-toothed beaked whale (*M. gingkodens*). In addition to the California, Oregon, and Washington stock of *Mesoplodon* species, Stejneger's beaked whale is also recognized separately as an Alaska stock and Blainville's beaked whale separately as a Hawaii stock (Allen and Angliss 2012; Carretta et al. 2012).

3.4.2.27.2 Abundance

The combined estimate of abundance for all species of *Mesoplodon* beaked whales in the California, Oregon, and Washington stock is 1,024 (coefficient of variation = 0.77) (Carretta et al. 2012). This estimate was derived from surveys in 2005 and 2008 and does not include sightings of unidentified beaked whales (which may have included species in the genus *Mesoplodon*). Based on ship surveys conducted in the summer and fall from 1991 to 2008, it is estimated that 565 *Mesoplodon* beaked whales (coefficient of variation = 0.72) occur in waters off Washington and Oregon (Barlow 2010). A recent study using the 1991 to 2008 survey data provides evidence that the abundance of *Mesoplodon* beaked whales have declined off California, Oregon, and Washington since the early 1990s, although reasons for these apparent declines are unknown (Moore and Barlow 2013).

3.4.2.27.3 Distribution

Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters (greater than 656 ft. [200 m]) (Waring et al. 2001; Canadas et al. 2002; Ferguson et al. 2006b; MacLeod and Mitchell 2006; Pitman 2008). They are occasionally reported in waters over the continental shelf (Pitman 2008). At least six species in this genus have been recorded off the U.S. west coast, but due to the rarity of records and the difficulty in identifying these animals in the field, very little species-specific information is available. In addition, the technology for identifying beaked whale species from acoustic detections is still rather new (Baumann-Pickering et al. 2013), and some species may not yet have been recorded. It is likely that new beaked whale species may be discovered in the future (Pitman 2008). As available, relevant species-specific distribution information is summarized below.

Blainville's beaked whale is one of the most widely distributed species within the *Mesoplodon* genus (MacLeod et al. 2006a; Jefferson et al. 2008). They are found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific (Mead 1989; Leslie et al. 2005; MacLeod and Mitchell 2006). There are a handful of known records of Blainville's beaked whale from the U.S. west coast and Baja California, Mexico, but the species does not appear to be common in this region (Pitman et al. 1988; Mead 1989; Hamilton et al. 2009). Acoustic analyses of data collected between January and November 2011 from a Navy-funded monitoring device in Washington offshore waters detected Blainville's beaked whale pulses once, in March (Širović et al. 2012b).

Hubbs' beaked whale distribution is generally associated with the deep subarctic current system along the Pacific coast of North America (Mead et al. 1982; Mead 1989). MacLeod et al. (2006a) speculated that the distribution might be continuous across the North Pacific between about 30°N and 45°N, but this remains to be confirmed.

Perrin's beaked whale distribution generally includes deep waters off the Pacific coast of North America (MacLeod et al. 2006a). Perrin's beaked whale is known only from five stranded specimens along the California coastline (Dalebout et al. 2002; MacLeod et al. 2006a). Stranded animals previously identified as Hector's beaked whale from the eastern North Pacific, specifically the California coast, have been reclassified as Perrin's beaked whale (Mead 1981; Mead and Baker 1987; Mead 1989; Dalebout et al. 2002). While this stranding pattern suggests an eastern North Pacific Ocean distribution, too few records exist for this to be conclusive (Dalebout et al. 2002). The five stranding records are from 1975 to 1997 and include two at U.S. Marine Corps Base Camp Pendleton (33°15' N, 117°26' W), and one each at Carlsbad, (33°07'N, 117°20'W), Torrey Pines State Reserve (32°55'N, 117°15'W), and Monterey (36°37'N, 121°55'W) (Mead 1981; Dalebout et al. 2002), all of which are in California.

Pygmy beaked whale distribution is based on stranding data from the Pacific coast of Mexico; this species' range is thought to include deep waters off the Pacific coast of North America (Urban-Ramirez and Aurioles-Gamboa 1992; Aurioles and Urban-Ramirez 1993; Jefferson et al. 2008). This species was first described in 1991 from stranded specimens from Peru and since then, strandings have been recorded along the coasts of both North and South America at Mexico, Peru, and Chile (Reyes et al. 1991; Pitman and Lynn 2001; Sanino et al. 2007). MacLeod et al. (2006a) suggested that the pygmy beaked whale occurs in the eastern Pacific from about 30°N to about 30°S. There were no confirmed sightings of pygmy beaked whale north of 30°N during SWFSC systematic ship surveys of the eastern North Pacific between 1986 and 2005 (Hamilton et al. 2009).

Stejneger's beaked whale appears to prefer cold temperate and subpolar waters (Loughlin and Perez 1985; MacLeod et al. 2006a). This species has been observed in waters ranging in depth from 2,395 to 5,120 ft. (730 to 1,560 m) on the steep slope of the continental shelf (Loughlin and Perez 1985). The farthest south this species has been recorded in the eastern Pacific is Cardiff, California (33°N), but this is considered an extralimital occurrence (Loughlin and Perez 1985; Mead 1989; MacLeod et al. 2006a). Acoustic analyses of data collected from a Navy-funded monitoring device in Washington offshore waters detected Stejneger's beaked whale calls between January and June 2011, with an absence of calls from mid-July through November 2011 (Širović et al. 2012b).

Ginkgo-toothed beaked whale distribution likely includes deep waters off the Pacific coast of North America. The handful of known records of the ginkgo-toothed beaked whale is from strandings, one of which occurred in California (MacLeod and D'Amico 2006; Jefferson et al. 2008).

Offshore. There were a total of 12 sightings of species identified to the genus *Mesoplodon* during ship surveys conducted in the summer and fall from 1991 to 2008 off California, Oregon, and Washington (Barlow 2010). Line-transect analyses of these data revealed that abundance estimates were highest off Oregon and Washington as compared to areas off California (Barlow 2010). Based on habitat models developed using 1991–2008 survey data collected during summer and fall, Becker et al. (2012b) found that encounters of small beaked whales (including both *Mesoplodon* spp. and Cuvier's beaked whale) increased in deeper waters with greatest slopes within the study area. These patterns are consistent with previous habitat modeling efforts using a subset of the same data (Barlow et al. 2009; Forney et al. 2012).

Inland Waters. Mesoplodont beaked whales are not expected to occur within the Inland Waters region of the Study Area. Strandings from the east coast of Vancouver Island have been documented (Osborne et al. 1988) but they are considered extralimital in this region.

Western Behm Canal, Alaska. Mesoplodont beaked whales were not observed during the 1991–2007 surveys of the inland waters of southeast Alaska (Dahlheim et al. 2009). Due to their preference for shelf and pelagic waters, the occurrence of any of the *Mesoplodon* beaked whale species in the SEAFAC region of the Study Area is considered rare.

3.4.2.28 Steller Sea Lion (*Eumetopias jubatus*)

3.4.2.28.1 Status and Management

In the North Pacific, NMFS has designated two Steller sea lion stocks: (1) the Western U.S. stock, consisting of populations at and west of Cape Suckling, Alaska (144°W longitude); and (2) the Eastern U.S. stock, consisting of populations east of Cape Suckling, Alaska. The western U.S. stock of Steller sea lions is listed as depleted under the MMPA and endangered under the ESA. Although there is evidence of mixing between the two stocks (Jemison et al. 2013), animals from the western U.S. stock are not present in the Study Area; Steller sea lions in the Study Area are from the eastern U.S. stock. The eastern U.S. stock of Steller sea lions is listed as depleted under the MMPA. Due to their recovery, the eastern distinct population segment (the eastern U.S. stock) of Steller sea lion was recently removed from the List of Endangered and Threatened Wildlife (National Oceanic and Atmospheric Administration 2013).

Critical habitat has been defined for the western stock of Steller sea lions in the Aleutian Islands and Western Alaska, which are outside of the Study Area. Critical habitat has been defined for the eastern stock of Steller sea lions in southeast Alaska, Oregon, and California. At this time, there has been no change in the designation of critical habitat despite the recent delisting (National Oceanic and Atmospheric Administration 2013). In southeast Alaska, there is no designated habitat near the Western Behm Canal (SEAFAC) portion of the Study Area. In Oregon and California, critical habitat includes six listed aquatic zones that extend 3,000 ft. (0.9 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery, and an air zone that extends 3,000 ft. (0.9 km) above the aquatic zones; however, these areas are inshore of the Study Area's southeastern boundary by approximately 25 km (16 mi.). There is thus no designated Steller sea lion critical habitat in the Study Area including the SEAFAC site in Southeast Alaska. Steller sea lion haul-out sites in Washington, Oregon and California have not been identified as critical habitat and there are no rookeries for the species in Washington State Waters (National Marine Fisheries Service 1993b), although up to 25 Steller sea lion pups have been born at Washington haul-out sites in recent years (Jeffries pers. comm. 2013).

3.4.2.28.2 Abundance

The eastern stock of Steller sea lions breeds on rookeries located in southeast Alaska, British Columbia, Oregon, and California; there are no rookeries located in Washington. The most recent pup counts available by region were 7,462 in 2009 for southeast Alaska, 4,118 in 2006 for British Columbia, 1,418 in 2009 for Oregon, and 891 in 2009 for California (Allen and Angliss 2012). Using pup multipliers (sea lion population can be estimated by multiplying pup counts by a factor based on the birth rate, sex and age structure, and growth rate of the population) of either 4.2 or 5.2, the population is estimated to be within the range of 58,334 and 72,223. Counts in Oregon have shown a gradual increase since 1976, as the adult and juvenile state-wide count for that year was 1,486 compared to 4,169 in 2002. Unlike the observed decline in the western U.S. stock of Steller sea lion, there has been an overall increase in the eastern U.S. stock. The eastern U.S. stock is increasing throughout the northern portion of its range (southeast Alaska and British Columbia), and is stable or increasing slowly in the central portion (Oregon through central California) (Pitcher et al. 2007; Edgell and Demarchi 2012; National Oceanic and Atmospheric Administration 2013).

3.4.2.28.3 Distribution

Steller sea lions range along the North Pacific Rim from northern Japan to California, with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands. The species is not known to migrate, but individuals disperse widely outside of the breeding season.

Offshore. The Steller sea lion uses haul-out sites primarily along the outer coast from the Columbia River to Cape Flattery, as well as along the Vancouver Island side of the Strait of Juan de Fuca. Steller sea lion numbers vary seasonally with peak counts of 1,000 animals present during the fall and winter months (Jeffries et al. 2000). Haul-out sites are found on jetties, offshore rocks and coastal islands. During the breeding season, the majority of animals will be located at these rookeries, as well as at haul-out sites off the northern Washington coast where up to 25 pups are born annually (Jeffries pers. comm. 2013).

Outside of breeding season, Steller sea lions may be present throughout the northwest Offshore Area, following aggregations of prey. The occurrence of Steller sea lions in the northwest Offshore Area of the Study Area is considered likely.

Inland Waters. While Steller sea lions are occasionally observed in the Strait of Juan de Fuca, they are seasonally present in Puget Sound. Jeffries (pers. comm. 2012) identified five winter haul-out sites used by Steller sea lions, ranging from immediately south of Port Townsend (near Admiralty Inlet) to Olympia in southern Puget Sound. Numbers of animals observed at these sites ranged from a few animals to less than 100. Steller sea lions opportunistically haul out on various navigational buoys between Admiralty Inlet and southern Puget Sound near Olympia (Jeffries pers. comm. 2012). One or two animals occur on these buoys. Up to six individuals have been observed in Hood Canal hauled out on submarines at Naval Base Kitsap Bangor (U.S. Department of the Navy 2012b). Steller sea lions would be expected to forage within the area, following local prey availability. Steller sea lions have been seasonally documented at Naval Base Kitsap Bangor in Hood Canal since 2008 during daily haulout surveys. Similar opportunistic surveys at Naval Base Kitsap Bremerton have not identified any Steller sea lions, although one was apparently sighted on the Navy security fence during a vessel survey in November 2012 (Lance pers. comm. 2012) and during aerial surveys conducted by the Washington Department of Fish and Wildlife in spring 2013 (Jeffries pers. comm. 2013). There is a large sea lion haulout (used by California and Steller sea lions) near Manchester, approximately 8 mi. from Naval Base Kitsap Bremerton. There are no known occurrences of Steller sea lions at Keyport, Everett, or Crescent Harbor. Steller sea lions are seasonally present in large numbers in southern Puget Sound near Carr Inlet and off the mouth of the Nisqually River (Jeffries pers. comm. 2013).

Adjacent to the Study Area in Canadian waters, Race Rocks, British Columbia, Canada (Canadian side of the Strait of Juan de Fuca) has also been identified as a major winter haul-out site for Steller sea lions (Edgell and Demarchi 2012). During summer months and associated breeding periods, the inland waters would not be considered a high-use area by Steller sea lions. Specifically, Steller sea lions are not expected June through September. The occurrence of Steller sea lions in the Inland Waters of the Study Area is considered seasonal.

Western Behm Canal, Alaska. The most recent counts of pups and non-pups of Steller sea lions were 24,447 sea lions (7,462 pups) at rookery and haul-out sites in southeast Alaska in 2009 (Allen and Angliss

2012). Womble et al. (2008) presented annual observation data which indicates that Steller sea lions are present year-round in the SEAFAC area, but their areas of concentration fluctuate through the year. During the winter, haul-out locations were situated close to known over-wintering herring locations. In the spring, Steller sea lions hauled out near locations of spawning forage fish. During the summer and autumn months, haul-out locations were located close to migrating salmon locations. The seasonal use of haul-outs by sea lions and ultimately haul-out-specific foraging patterns of Steller sea lions depend in part upon seasonally available prey species in each region. The occurrence of Steller sea lions in the SEAFAC portion of the Study Area is considered likely.

3.4.2.29 California Sea Lion (*Zalophus californianus*)

3.4.2.29.1 Status and Management

The California sea lion is protected under the MMPA and is not listed under the ESA.

NMFS has defined one stock for the California sea lion (U.S. stock), with five genetically distinct geographic populations; (1) Pacific Temperate, (2) Pacific Subtropical, (3) Southern Gulf of California, (4) Central Gulf of California, and (5) Northern Gulf of California. The Pacific Temperate population includes rookeries within U.S. waters and the Coronados Islands just south of the U.S./Mexico border. Animals from the Pacific Temperate population range north into Canadian waters, and movement of animals between U.S. waters and Baja California waters has been documented (Carretta et al. 2012). Animals from the Pacific Temperate and the Pacific Subtropical stocks are expected to be within the NWTT Study Area (National Marine Fisheries Service 1997).

3.4.2.29.2 Abundance

The current population estimate of California sea lions in the U.S. stock is 296,750 (Carretta et al. 2012). The entire population cannot be counted because all age and sex classes are not ashore at the same time during field surveys. In lieu of counting all sea lions, pups are counted during the breeding season (because this is the only age class that is ashore in its entirety), and the number of births is estimated from the pup count. The size of the population is then estimated from the number of births and the proportion of pups in the population (Carretta et al. 2012).

3.4.2.29.3 Distribution

During the summer, California sea lions breed on islands from the Gulf of California to the Channel Islands and seldom travel more than about 31 mi. (50 km) from the islands. The primary rookeries are located on the California Channel Islands of San Miguel, San Nicolas, Santa Barbara, and San Clemente. Their distribution shifts to the northwest in fall and to the southeast during winter and spring, probably in response to changes in prey availability (Edgell and Demarchi 2012). In the non-breeding season, adult and subadult males migrate northward along the coast to central and northern California, Oregon, Washington, and Vancouver Island, are occasionally sighted hundreds of miles offshore, and return south the following spring. Primarily male California sea lions migrate into northwest waters, with most adult females with pups remaining in waters near their breeding rookeries off the coast of California and Mexico. Females and juveniles tend to stay closer to the rookeries. They also enter bays, harbors, and river mouths and often haul-out on man-made structures such as piers, jetties, offshore buoys, and oil platforms.

Offshore. The California sea lion is the most frequently sighted otariid found in Washington waters and uses numerous haul-out sites along the coast. Sea lions are present along the coast of Oregon from October to April (National Marine Fisheries Service 1997). Main haul-out sites include the Columbia

River (South Jetty), Cascade Head, Cape Arago, and Orford and Rogue Reefs. Sea lions also use the northern coast of California mainly during May and June, and September and October (Bonnell et al. 1983). Main haul-out sites include St. George Reef, Castle Rock, and Farallon and Año Nuevo Islands. California sea lions feed on a wide variety of prey, including many species of fish and squid, and typically feed over the continental shelf. The occurrence of California sea lions in the northwest offshore portion of the Study Area is considered likely.

Inland Waters. Jeffries et al. (2000) identified numerous haul-out sites used by California sea lions throughout the Puget Sound region. California sea lions are present between August and June in the inland waters, with peak numbers between October and May (National Marine Fisheries Service 1997; Jeffries et al. 2000). Haul-out sites occur at Naval Base Kitsap Bangor, Naval Base Kitsap Bremerton, and Naval Station Everett, as well as in Rich Passage near Manchester, Seattle (Shilshole Bay), south Puget Sound (Commencement Bay, Budd Inlet), and numerous navigation buoys south of Whidbey Island to Olympia (Jeffries et al. 2000; Jeffries pers. comm. 2012). Adjacent to the Study Area in Canadian waters, Race Rocks, British Columbia, Canada (Canadian side of the Strait of Juan de Fuca) has been identified as a major winter haul-out for California sea lions (Edgell and Demarchi 2012). Numbers of animals observed at these sites ranged between 10 and 100 animals. California sea lions would be expected to forage within the area, following local prey availability. During summer months and associated breeding periods, the inland waters would not be considered a high-use area by California sea lions, as they would be returning to rookeries in California waters. However, information from sightings of opportunistic animals hauled out at Bangor indicates that a few California sea lions are present in Hood Canal almost year-round with the exception of July. The occurrence of California sea lions in the Inland Waters of the Study Area is considered seasonal.

Western Behm Canal, Alaska. A total of 52 (25 male, 5 female, and 22 undetermined) California sea lions have been reported in Alaskan waters between 1974 and 2004, with an increasing presence in recent years (Maniscalco et al. 2004). California sea lions in Alaska most often were seen alone and only occasionally in small groups of two or more, although hundreds have been found to haul-out together along the Washington coast and in southern British Columbia. The relatively few California sea lions found in Alaska usually have been associated with Steller sea lions at their haul-outs and rookeries. The occurrence of California sea lions in the SEAFAC portion of the Study Area is considered rare.

3.4.2.30 Northern Fur Seal (*Callorhinus ursinus*)

3.4.2.30.1 Status and Management

NMFS has identified two stocks of northern fur seals based on high natal site fidelity, as well as substantial differences in population dynamics between Pribilof Islands (located in the Bering Sea) and the California populations. Animals from the Pribilof Islands are recognized as the Eastern Pacific stock, and those from San Miguel Island and the Farallon Islands are the California stock (Allen and Angliss 2013). Both stocks may be present in the Study Area. The Eastern Pacific stock of northern fur seals is listed as depleted under the MMPA and not listed under the ESA. The California stock of northern fur seals is not listed as depleted under the MMPA and not listed under the ESA.

3.4.2.30.2 Abundance

The population estimate for the Eastern Pacific stock of northern fur seals is calculated as the estimated number of pups counted at rookeries in the eastern Bering Sea multiplied by a series of different expansion factors determined from a life table analysis to estimate the number of yearlings, 2-year-olds, 3-year-olds, and animals 4 or more years old. The most recent estimate for the number of fur seals in the Eastern Pacific stock, based on pup counts from 2008 on Sea Lion Rock, St. Paul and St. George Islands, and from 2007 on Bogoslof Island, is 653,171 (Allen and Angliss 2012).

The smaller California population estimate is calculated in a similar manner as for the Eastern Pacific stock. Based on the 2007 count and the expansion factor, the most recent population estimate of the California stock is 9,968 northern fur seals (Carretta et al. 2012).

Estimated stock size for all northern fur seals in the United States in 2010 was approximately 671,000 (Testa 2012).

3.4.2.30.3 Distribution

The northern fur seal is endemic to the North Pacific Ocean, and it occurs from southern California to the Bering Sea, the Okhotsk Sea, and Honshu Island, Japan. Most northern fur seals are highly migratory and annually move from the high latitude breeding areas in the Bering Sea and Sea of Okhotsk they occupy in the warm season to more southern at-sea feeding areas in cold season (Olesiuk 2012). During the breeding season (June–September), most of the world's population of northern fur seals occurs on the Pribilof and Bogoslof islands. Males are present in the Pribilof Island rookeries from around mid-May until August; females are present in the rookeries from mid-June to late October. Nearly all fur seals from the Pribilof Island rookeries are foraging at sea from fall through late spring. In November, females and pups leave the Pribilof Islands and migrate through the Gulf of Alaska to feeding areas primarily off the coasts of British Columbia, Washington, Oregon, and California before migrating north again to the rookeries in spring (Ream et al. 2005). Immature seals can remain in southern foraging areas year-round until they are old enough to mate (National Marine Fisheries Service 2012). Adult males migrate only as far south as the Gulf of Alaska.

The northern fur seal is a highly oceanic species, spending all but 35–45 days per year at sea. They are usually sighted 44–81 mi. (70–130 km) from land along the continental shelf and slope, seamounts, submarine canyons, and sea valleys, where upwelling of nutrient-rich water occurs (Kajimura 1984). The subpolar continental shelf and shelf break from the Bering Sea to California provides suitable feeding habitat (National Marine Fisheries Service 1993a). Although rookeries are typically composed of a rocky substrate, northern fur seals use sandy beaches for breeding on San Miguel Island (Bonnell et al. 1983; Baird and Hanson 1997). Both the Eastern Pacific and the California stocks occur within the Study Area.

Offshore. Northern fur seals are present in the northwest offshore region year-round (Bonnell et al. 1992), but are most abundant between January and May. Sightings are more common off the northern Washington and Vancouver Island coasts in winter, and off central and southern Oregon in spring (Bonnell et al. 1992). Adult females and juveniles from the California stock are found in offshore waters of northern California, Oregon, and Washington from October through May or early June. They return to the rookery islands to pup and breed in June and July (National Marine Fisheries Service 2007d). These fur seals are commonly found in deep waters (> 6,562 ft. [2,000 m]) offshore Oregon and Washington (Bonnell et al. 1992), and they rarely haul-out on land during migrations (Bonnell et al. 1983). The occurrence of northern fur seals in the northwest offshore portion of the Study Area is considered likely.

Inland Waters. As mentioned earlier, the northern fur seal is a highly oceanic species. Some individuals, mostly juveniles, make their way into the Strait of Juan de Fuca and Puget Sound each year (Everitt et al. 1979), albeit not in large numbers or with any regularity. Inland waters of the Puget Sound are an area of rare occurrence for this species.

Western Behm Canal, Alaska. The Eastern Pacific stock spends May–November in northern waters and at northern breeding colonies (north of the Gulf of Alaska). Peak abundance near SEAFAC should occur between March and June during the annual migration north to the Pribilof Islands breeding grounds (Fiscus et al. 1976). However, tagging data presented by Ream et al. (2005) indicate the main foraging areas and the main migration route through the Gulf of Alaska are located far to the west of SEAFAC. There are no rookeries or haul-out sites in the vicinity of SEAFAC. Some northern fur seals, particularly juvenile males and nonpregnant females, remain in the region throughout the summer and have been documented in the nearshore waters of southeastern Alaska and Prince William Sound (Fiscus et al. 1976). The occurrence of northern fur seals in the SEAFAC portion of the Study Area is considered likely.

3.4.2.31 Guadalupe Fur (*Arctocephalus townsendi*)

3.4.2.31.1 Status and Management

The Guadalupe fur seal is listed as depleted under the MMPA and threatened under the ESA. The primary breeding rookery of Guadalupe fur seals is at Isla de Guadalupe, Mexico, and a second breeding population has been established at Islas San Benito, Baja California, Mexico (Maravilla-Chavez and Lowry 1999; Esperon-Rodriguez and Gallo-Reynoso 2012), and are considered a single stock (Carretta et al. 2013).

3.4.2.31.2 Abundance

The population estimate for the entire stock of Guadalupe fur seals is 14,000–15,000 animals and was based on surveys conducted in 2008 (Hernandez-Montoya 2009; Esperon-Rodriguez and Gallo-Reynoso 2012).

3.4.2.31.3 Distribution

Before intensive hunting decreased their numbers, Guadalupe fur seals ranged from Monterey Bay, California, to the Revillagigedo Islands, Mexico (Aurioles-Gamboa and Camacho-Ríos 2007), but have occasionally been identified from strandings (Northwest Region Stranding Database; Wilkinson 2013) or in archaeological contexts as far north as northern California, Oregon, and Washington (Etiner 2002; Rick et al. 2009). Between 1989 and 2011, a total of 118 dead stranded animals were found along the Washington and Oregon coastline (Northwest Region Stranding Database; Wilkinson 2013). Between 20 June and 1 November 2007, 19 Guadalupe fur seals stranded on the Washington and Oregon outer coasts, prompting NOAA to declare an Unusual Mortality Event on 19 October 2007 (Lambourn et al. 2012). The Unusual Mortality Event was officially closed on 11 December 2009. In 2012, approximately 58 Guadalupe fur seals stranded on the outer coasts of Washington and Oregon (Lambourn 2013 pers. comm.). This is three times the number of strandings that prompted the Unusual Mortality Event in 2007. Of all the strandings reported off Washington and Oregon (1989–2012), most occurred from mid-May through August with occasional reports between October and December (Lambourn et al. 2012; Northwest Region Stranding Database).Sightings of live animals off Washington and Oregon are more limited, although there is photo documentation of apparently healthy Guadalupe fur seals in offshore waters of Washington and British Columbia in recent years during summer and early autumn (Lambourn et al. 2012). Given the increased number of strandings in the Pacific Northwest, coupled with their increasing population, it is possible that Guadalupe fur seals are returning to their historic pelagic migration range suggested by the archaeological findings (Eitner 2002; Rick et al. 2009; Lambourn et al. 2012).

Offshore. Based on their rookeries occurring in Baja California, Mexico, the species predominantly distribute off Mexico, but with annual strandings in Oregon and Washington, Guadalupe fur seals are considered "seasonal" migrants within the offshore portion of the Study Area.

Inland Waters. Guadalupe fur seals are not expected to occur within the Inland Waters region of the Study Area. Strandings from the offshore portion of the study area have been documented as noted above, but they are considered extralimital in the inland waters.

Western Behm Canal, Alaska. Guadalupe fur seals are not expected to occur in the SEAFAC portion of the Study Area.

3.4.2.32 Northern Elephant Seal (*Mirounga angustirostris*)

3.4.2.32.1 Status and Management

The northern elephant seal is protected under the MMPA and is not listed under the ESA. NMFS has defined one stock for the northern elephant seal, the California Breeding stock, which is geographically distinct from a population in Baja California.

3.4.2.32.2 Abundance

A complete population count of elephant seals is not possible because all age classes are not ashore at the same time. Instead, pups are counted during the breeding season (because this is the only age class that is ashore in its entirety), and the number of births is estimated from the pup count. The size of the population is then estimated from the number of births and the proportion of pups in the population. Based on the estimated 35,549 pups born in California in 2005, the California stock was approximately 124,000 in 2005 (Carretta et al. 2012). Based on trends in pup counts, northern elephant seal colonies were continuing to grow in California through 2005.

3.4.2.32.3 Distribution

The northern elephant seal occurs almost exclusively in the eastern and central North Pacific. Rookeries are located from central Baja California, Mexico, to northern California (Stewart and Huber 1993). In California, they include the Channel Islands, Piedras Blancas, Cape San Martin, Año Nuevo Island and Peninsula, the Farallon Islands, and Point Reyes (Stewart et al. 1994; Carretta et al. 2012).

Adult elephant seals engage in two long northward migrations per year, one following the breeding season, and another following the annual molt (Stewart and DeLong 1995; Robinson et al. 2012). Between the two foraging periods, they return to land to molt, with females returning earlier than males (March–April vs. July–August). After the molt, adults then return to their northern feeding areas until the next winter breeding seasons. Breeding occurs from December to March (Stewart and Huber 1993). Juvenile elephant seals typically leave the rookeries in April or May and head north, traveling an average of 559–621 mi. (900–1,000 km). Most elephant seals return to their natal rookeries when they start breeding (Huber et al. 1991). The foraging range extends thousands of miles offshore into the central North Pacific. Adults tend to stay offshore, but juveniles and subadults are often seen along the coasts of Oregon, Washington, and British Columbia (Condit and Le Boeuf 1984; Stewart and Huber 1993).

Offshore. Adult male elephant seals migrate north via the California current to the Gulf of Alaska during foraging trips, and could potentially be passing through the area off Washington in May and August (migrating to and from molting periods) and November and February (migrating to and from breeding periods) (Stewart and DeLong 1995), but their presence there is transient and short-lived. Bonnell et al.

(1992) reported that northern elephant seals were distributed equally in shelf, slope, and offshore waters during surveys conducted off Oregon and Washington, as far as 93 mi. (150 km) from shore, in waters > 6,562 ft. (2,000 m) deep. Most elephant seal sightings at sea were during June, July, and September off Washington; sightings recorded from November through May were off southern Oregon (Bonnell et al. 1992). The occurrence of elephant seals in the northwest offshore portion of the Study Area would be considered seasonal.

Inland Waters. There are regular haul-out sites at Smith and Minor Islands, Dungeness Spit, and Protection Island in the Strait of Juan de Fuca that are thought to be used year-round (Jeffries et al. 2000; Jeffries pers. comm. 2012). Pupping has also occurred at these sites, as well as Race Rocks on the British Columbia side of the Strait of Juan de Fuca (Jeffries pers. comm. 2012). Typically these sites have small numbers of 2–10 individuals present.

No haulout sites occur in Puget Sound, with the exception of individual elephant seals occasionally hauling out for 2–4 weeks to molt, usually during the spring and summer and typically on sandy beaches (Calambokidis and Baird 1994; Norberg pers. comm. 2012). These animals are usually yearlings or subadults, and their haul-out locations are unpredictable (Norberg pers. comm. 2012). The National Stranding Network database reported one male subadult elephant seal hauled out to molt at Manchester Fuel Depot in February 2004.

The Whale Museum (www.thewhalemuseum.com) occasionally reports incidental observations of northern elephant seal individuals throughout Puget Sound. Rat Island across the bay from the Port Townsend ferry terminal is occasionally used by juvenile elephant seals. Given that the reported haul-out sites are in the Strait of Juan de Fuca, the occurrence of elephant seals in the Puget Sound region would occur infrequently and be associated with the molting season.

Western Behm Canal, Alaska. Elephant seals prefer Offshore Areas but occasionally visit southeast Alaska. The species breeds off the California coast, but the nonbreeding distribution extends to the Gulf of Alaska. From April through June the species can be found in Alaska waters. Elephant seals feed in deep water, an average of 590 ft. (180 m), on fish and squid. While occasional sightings have occurred near Ketchikan, the species favors Offshore Areas and is not expected to be found near SEAFAC (U.S. Department of the Navy 1991). The occurrence of elephant seals in the SEAFAC portion of the Study Area is considered to be extralimital.

3.4.2.33 Harbor Seal (*Phoca vitulina*)

3.4.2.33.1 Status and Management

For management purposes, differences in mean pupping date, movement patterns, pollutant loads, and fishery interactions have led NOAA to recognize 15 stocks within U.S. waters from California to Alaska (Carretta et al. 2014; Allen and Angliss 2014). As shown in Table 3.4-1, out of these 15 stocks there are 4 present in the Study Area. Those within the Study Area include the Southeast Alaska stock (in the Western Behm Canal portion of the Study Area), the Washington Inland Waters stock, the Oregon/Washington Coastal stock, and the California stock (Carretta et al. 2014). All four of these harbor seal stocks are protected under the MMPA and are not listed under the ESA.

3.4.2.33.2 Abundance

The current statewide abundance estimate for Alaskan harbor seals is 152,602, based on aerial survey data collected during 1998–2007 (Allen and Angliss 2014). For the Clarence Strait stock that is present at SEAFAC in the Western Behm Canal, the latest stock abundance for harbor seals is 23,289 animals.

Aerial surveys were conducted in Oregon and Washington during the 1999 pupping season. After applying a correction factor to account for animals in the water during the time of the survey, the most recent abundance calculation for the Oregon/Washington stock is 24,732 (Carretta et al. 2012).

Based on the most recent harbor seal counts (19,608 in May–July 2009) and a correction factor to compensate for the number of animals in the water during the time of the survey, the harbor seal population in California is estimated to number 30,196 seals (coefficient of variation = 0.157) (Carretta et al. 2014).

Aerial surveys of harbor seals in Washington were conducted during the pupping season in 1999, during which time the total numbers of hauled-out seals (including pups) were counted. In 1999, the mean count of harbor seals occurring in Washington’s inland waters was 9,550 (coefficient of variation = 0.14) animals. Using a correction factor to account for animals in the water which are missed during the aerial surveys (Huber et al. 2001) results in a population estimate of 14,612 (coefficient of variation = 0.15) for the Washington Inland Waters stock of harbor seals (Carretta et al. 2012). However, because the most recent abundance estimate is greater than 8 years old, there is no current estimate of abundance. Jeffries et al. (2003) reported that the annual rate of increase in the population in Washington up until 1999 had slowed indicating that the population was nearing carrying capacity.

3.4.2.33.3 Distribution

Harbor seals are a coastal species, rarely found more than 12 mi. (20 km) from shore, and frequently occupy bays, estuaries, and inlets (Baird 2001). Individual seals have been observed several miles upstream in coastal rivers (Baird 2001). Ideal harbor seal habitat includes haul-out sites, shelter during the breeding periods, and sufficient food (Bjørge 2002). Haul-out areas can include intertidal and subtidal rock outcrops, sandbars, sandy beaches, peat banks in salt marshes, and manmade structures such as log booms, docks, and recreational floats (Wilson 1978; Prescott 1982; Schneider and Payne 1983, Gilbert and Guldager 1998; Jeffries et al. 2000; Lambourn et al. 2010). Harbor seals do not make extensive pelagic migrations, though some long distance movement of tagged animals in Alaska (108 mi. [174 km]) and along the U.S. west coast (up to 342 mi. [550 km]) have been recorded (Brown and Mate 1983; Womble and Gende 2013). Harbor seals have also displayed strong fidelity to haul-out sites.

Offshore. Harbor seals haul-out on rocks, reefs, beaches, and offshore islands along the U.S. west coast (Carretta et al. 2012). Jeffries et al. (2000) documented several harbor seal rookeries and haul-outs along the Washington coastline. This is the only pinniped species that breeds in Washington State. Pupping in Oregon and Washington occurs from April to July (Brown 1988). Bonnell et al. (1992) noted that most harbor seals sighted off Oregon and Washington were 12.4 mi. (20 km) from shore, with the farthest sighting 57 mi. (92 km) from the coast. During surveys off the Oregon and Washington coasts, 88 percent of at-sea harbor seals occurred over shelf waters < 656 ft. (200 m) deep, with a few sightings near the 6,562 ft. (2,000 m) contour, and only one sighting over deeper water (Bonnell et al. 1992). The occurrence of harbor seals in the northwest offshore portion of the Study Area is considered likely.

Inland Waters. The harbor seal is the most common, widely distributed pinniped found in Washington waters, and is frequently observed by recreational boaters, ferry passengers and other users of the marine environment. Harbor seals are the most abundant marine mammal in Hood Canal, where they can occur anywhere in Hood Canal waters year-round (U.S. Department of the Navy 2012b). London et al. (2012) identified five locations in Hood Canal (including Dabob Bay) the authors termed “major haul-out sites” and noted these were locations having documented human (non-Navy) disturbance. London et al. (2012) report that disturbance occurs on a regular basis and described that disturbance for four of the five sites as follows: Quilcene Bay—operational salmon net-pen floats and oyster rafts; Dosewallips—state park and marina with motorized boats, kayakers, and canoers; Hamma Hamma—working oyster farm; and Skokomish—a kayak rental facility and a tribal and commercial fisheries site.

In southern Puget Sound, harbor seals haul-out on a variety of substrate materials including intertidal beaches, reefs, sandbars, log booms and floats. There are five main harbor seal haul-out areas including: mouth of the Nisqually River, Cutts Island, Gertrude Island, Eagle Island, and Woodard Bay (Lambourn et al. 2010). Based on periodic aerial and boat surveys, each of these sites regularly supports a population of over 100 seals (Lambourn et al. 2010). The harbor seal is the only pinniped species which is found year-round and breeds in Washington waters. Pupping seasons vary by geographic region, with pups born in coastal estuaries (Columbia River, Willapa Bay and Gray Harbor) from mid-April through June; Olympic Peninsula coast from May through July; San Juan Islands and eastern bays of Puget Sound from June through August; southern Puget Sound from mid-July through September; and Hood Canal from August through January (Jeffries et al. 2000). The occurrence of harbor seals in the Inland Waters of the Study Area is considered likely.

Western Behm Canal, Alaska. Surveys from 1983 through 1999 revealed a stable and increasing population of harbor seals in the Ketchikan, Sitka, and Kodiak areas. Between 1983 and 1999, the population near Ketchikan rose from approximately 1,059 animals to 3,149 animals (Small et al. 2001). The latest stock abundance estimate for harbor seals in the SEAFAC region (Clarence Strait) is 23,289 animals (Allen and Angliss 2012).The occurrence of harbor seals in the SEAFAC region is considered likely.

3.4.2.34 Northern Sea Otter (*Enhydra lutris kenyoni*)

3.4.2.34.1 Status and Management

The USFWS recognizes five northern sea otter stocks in U.S. waters under MMPA guidelines. These include three stocks in Alaska that are designated southeast, southcentral, and southwest; a single stock in Washington (the northern sea otter [*Enhydra lutris kenyoni*]); and a single stock in California (the southern sea otter [*Enhydra lutris nereis*]). The southeast Alaska stock is not likely to be present in the western Behm Canal portion of the Study Area. Only the Washington stock of sea otter occurs in the Study Area.

Sea otters that occur along the coast of Washington are the result of reintroduction efforts of the northern sea otter (from Amchitka Island, Alaska) in 1969 and 1970 (Lance et al. 2004). The Washington stock is not classified as strategic because the population is growing and is not listed as depleted under the MMPA or threatened or endangered under the ESA. A federal species recovery plan for the northern sea otter population has not been developed; however, the State of Washington developed a recovery plan to address the northern sea otter population in its waters (Lance et al. 2004).

3.4.2.34.2 Abundance

Based on a 2011 survey (actual count), the minimum population estimate of the Washington sea otter population is 1,154 individuals (Jameson and Jeffries 2011). No correction factor for missed animals has been applied to count data to determine a total population estimate from survey counts for Washington.

3.4.2.34.3 Distribution

Sea otters occupy nearly all coastal marine habitats, from bays and estuaries to rocky shores exposed to oceanic swells (Riedman and Estes 1990; U.S. Fish and Wildlife Service 2003, 2008; Washington Department of Fish and Wildlife 2004, 2008b). Although sea otters prefer rocky shoreline and relatively shallow water (< 131 ft. [40 m] deep) with kelp beds, this is not an essential habitat requirement, and some individuals use soft-sediment areas where kelp is absent (Riedman and Estes 1990; Washington Department of Fish and Wildlife 2004). Sea otters seldom range more than 1.2 mi. (2 km) from shore, although some individuals, particularly juvenile males, travel farther offshore (Riedman and Estes 1990; Ralls et al. 1995, 1996; Lance et al. 2004; Washington Department of Fish and Wildlife 2004). Sea otters move seasonally to areas where there is food or where sheltered water offers protection from storms and rough seas (Kenyon 1975; Riedman and Estes 1990). Individual sea otters in Washington show such shifts (Lance et al. 2004), but the population as a whole does not migrate, and otters range along the Washington coast from Pt. Grenville to Neah Bay year-round.

Offshore. The 2011 Washington sea otter survey was conducted in July 2011 and included the inshore area from the South Jetty at the mouth of the Columbia River on the outer Washington coast to Pillar Point in the Strait of Juan de Fuca. Survey results for 2011 indicate growth of the Washington sea otter population continues to remain positive, with a total of 1,154 sea otters observed (Jameson and Jeffries 2011). As sea otters seldom range more than 1.2 mi. (2 km) from shore and are not known to migrate, it is not anticipated that they would be present in the offshore portion of the Study Area, where their occurrence is considered rare. However, their occurrence in the nearshore waters of Washington would overlap with portions of the Naval Undersea Warfare Center, Keyport Range Complex where their occurrence is considered likely.

Inland Waters. Although the sea otter is not usually seen in the Inland Waters, there are confirmed sightings and movements of tagged individuals in the eastern Strait of Juan de Fuca, around the San Juan Islands, and within the Puget Sound near Olympia (Calambokidis et al. 1987; Lance et al. 2004; Jameson and Jeffries 2013). Prior to recent sightings, the Strait of Juan de Fuca had not been occupied by sea otters for over 100 years (Jeffries et al. 2005). One sea otter was sighted about 6 mi. (9 km) inland up McAllister Creek in south Puget Sound (Jeffries and Allen 2001). Recent sea otter surveys have not covered the Inland Waters east of Tongue Point; however, there have been confirmed sightings of scattered individuals in the San Juan Islands and Puget Sound (Jameson and Jeffries 2013). Most of these sightings have been of one or two animals, with no sightings of multiple animals reported (Jameson and Jeffries 2013). Based on the low numbers of sightings in the Inland Waters portion of the Study Area, the occurrence of sea otters is considered rare.

Western Behm Canal, Alaska. Based on surveys conducted in 2003, there are common sightings in southeast Alaska along the western portions of Prince of Wales Islands and throughout the Chatham and Summer Strait. The closest sea otter populations, as determined by these surveys, are 37–50 mi. (60–80 km) east of the SEAFAC area (Esslinger and Bodkin 2009). As sea otters seldom range more than 1.2 mi. (2 km) from shore and are not known to migrate, it is not anticipated that they would be present in the SEAFAC area. The presence of sea otters in the SEAFAC portion of the Study Area is considered extralimital.

3.4.3 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 mammals known to occur within the Study Area. Tables 2.8-1 through 2.8-3 present the baseline and proposed typical training and testing activity locations for each alternative (including number of events and ordnance expended). The stressors (see Section 3.0) vary in intensity, frequency, duration, and location within the Study Area. The stressors applicable to marine mammals in the Study Area that are analyzed below include the following:

- Acoustic (sonar and other active acoustic sources, explosives; weapons firing, launch, and impact noise; vessel noise; aircraft overflight noise)
- Energy (electromagnetic devices)
- Physical disturbance and strike (vessels; in-water devices; military expended materials; seafloor devices)
- Entanglement (fiber optic cables and guidance wires; decelerator/parachutes)
- Ingestion (non-explosive practice munitions; fragments from high explosive munitions; military expended materials other than munitions)
- Secondary stressors

Each of these stressors is analyzed for its potential impacts to marine mammals. The specific analyses of the training and testing activities consider these stressors within the context of the geographic range of the species.

Table 3.4-3 presents the stressor categories and components of those stressors that are applicable to marine mammals and are used in the analysis of training and testing activities. Due to the anticipated level of impact, some of the analysis in the following sections will be qualitative and has been noted as such. In addition to the analysis here, the details of all training and testing activities, stressors, components that cause the stressor, and geographic occurrence within the Study Area are included in Section 3.0.5.3 (Identification of Stressors for Analysis).

In this analysis, marine mammal species are grouped together based on similar biology (such as hearing) or behaviors (such as feeding or expected reaction to stressors) when most appropriate for the discussion. In addition, for some stressors, species are grouped based on their taxonomic relationship and discussed as follows: mysticetes (baleen whales), odontocetes (toothed whales), pinnipeds (seals and sea lions), and mustelids (sea otters).

When impacts are expected to be similar to all species or when it is determined there is no impact to any species, the discussion will be general and not species-specific. However, when impacts are not the same to certain species or groups of species, the discussion will be as specific as the best available data allow. In addition, if activities only occur in or will be concentrated in certain areas, the discussion will be geographically specific. Based on acoustic thresholds and criteria developed with NMFS, impacts from sound sources as stressors will be quantified at the species or stock level as is required pursuant to authorization of the proposed actions under the MMPA.

In cases where potential impacts rise to the level that warrants mitigation, mitigation measures designed to minimize the potential impacts are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). In addition to the measures presented, additional mitigations, different mitigations, or both may subsequently be implemented in coordination with NMFS resulting from the MMPA authorization and ESA consultation processes.

Table 3.4-3: Stressors Applicable to Marine Mammals for Training and Testing Activities

Components	Area	Number of Components or Activities					
		No Action Alternative		Alternative 1		Alternative 2	
		Training	Testing	Training	Testing	Training	Testing
Acoustic Stressors							
Sonar and other active sources (hours)	Offshore Area	362	24	551	977	551	1,073
	Inland Waters	0	2,354	407	5,448	407	5,939
	W. Behm Canal	0	0	0	2,762	0	3,838
Sonar and other active sources (items)	Offshore Area	880	364	916	943	916	1,024
	Inland Waters	0	308	0	1,308	0	1,410
	W. Behm Canal	0	0	0	0	0	0
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
Weapons firing, launch, and impact noise	Offshore Area	QUALITATIVE					
	Inland Waters						
	W. Behm Canal						
Activities including vessel noise	Offshore Area	996	37	1,088	138	1,088	162
	Inland Waters	4	337	31	582	31	640
	W. Behm Canal	0	28	0	60	0	83
Activities including aircraft noise	Offshore Area	3,826	2	6,471	74	6,471	84
	Inland Waters	124	2	127	20	127	25
	W. Behm Canal	0	0	0	0	0	0
Energy Stressors							
Activities including electromagnetic devices	Offshore Area	0	0	0	0	0	0
	Inland Waters	0	0	1	0	1	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

Table 3.4-3: Stressors Applicable to Marine Mammals for Training and Testing Activities (continued)

Components	Area	Number of Components or Activities					
		No Action Alternative		Alternative 1		Alternative 2	
		Training	Testing	Training	Testing	Training	Testing
Entanglement Stressors							
Fiber optic cables and guidance wires	Offshore Area	2	16	0	20	0	24
	Inland Waters	0	105	1	122	1	133
	W. Behm Canal	0	0	0	0	0	0
Decelerator/Parachutes	Offshore Area	8,382	17	8,382	1,229	8,382	1,351
	Inland Waters	0	4	0	4	0	5
	W. Behm Canal	0	0	0	0	0	0
Ingestions Stressors							
Military expended materials from munitions	Offshore Area	177,778	200	182,804	1,946	182,804	2,139
	Inland Waters	4	6	42	6	42	6
	W. Behm Canal	0	0	0	0	0	0
Military expended materials other than munitions	Offshore Area	11,890	421	9,084	555	9,084	625
	Inland Waters	4	440	43	511	43	562
	W. Behm Canal	0	0	0	0	0	0
Secondary Stressors							
Habitat (sediments and water quality; air quality)	Offshore Area	QUALITATIVE					
	Inland Waters						
	W. Behm Canal						
Prey	Offshore Area	QUALITATIVE					
	Inland Waters						
	W. Behm Canal						

3.4.3.1 Acoustic Stressors

3.4.3.1.1 Non-Impulse and Impulse Sound Sources

Long recognized by the scientific community (Payne and Webb 1971), and summarized by the National Academies of Science, human-generated sound could possibly harm marine mammals or significantly interfere with their normal activities (National Research Council of the National Academies 2005). Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals. For an overview and discussion of acoustic measures and terminology and the two basic sound types (non-impulse and impulse), see Southall et al. (2007). Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council of the National Academies 2003, 2005), there are many unknowns in assessing impacts such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007, 2009a). Furthermore, many other factors besides just the received level of sound may affect an animal's reaction such as the animal’s physical condition, prior experience with the sound, and proximity to the source of the sound (Ellison et al. 2012).

The methods used to predict acoustic effects to marine mammals build on the *Conceptual Framework for Assessing Effects from Sound Producing Activities* (Appendix H, Section H.1). Additional research specific to marine mammals is presented where available.

3.4.3.1.2 Analysis Background and Framework

3.4.3.1.2.1 Direct Injury

The potential for direct injury in marine mammals has been inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973; Ketten et al. 1993). Additionally, non-injurious effects on marine mammals (e.g., Temporary Threshold Shift [TTS]) are extrapolated to injurious effects (e.g., Permanent Threshold Shift [PTS]) based on data from terrestrial mammals to derive the criteria serving as the potential for injury (Southall et al. 2007). Actual effects on marine mammals may differ from terrestrial animals due to anatomical and physiological adaptations to the marine environment, e.g., some characteristics such as a reinforced trachea and flexible thoracic cavity (Ridgway and Dailey 1972) may or may not decrease the risk of lung injury.

Potential non-auditory direct injury from non-impulse sound sources, such as sonar, is unlikely due to relatively lower peak pressures and slower rise times than potentially injurious impulse sources such as explosives. Non-impulse sources also lack the strong shock wave such as that associated with an explosion. Therefore, primary blast injury and barotrauma (i.e., injuries caused by large pressure changes; discussed below) would not occur due to exposure to non-impulse sources such as sonar. Even for the most sensitive auditory tissues and although there have been strandings associated with use of sonar (see Department of the Navy 2013), as Ketten (2012) has recently summarized, "to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result [of] anthropogenic noise exposures, including sonar." The theories of sonar induced acoustic resonance and sonar induced bubble formation are discussed below. These phenomena, if they were to occur, would require the co-occurrence of a precise set of circumstances that in the natural environment under real-world conditions are unlikely to occur.

3.4.3.1.2.2 Primary Blast Injury and Barotrauma

The greatest potential for direct, non-auditory tissue effects is primary blast injury and barotrauma after exposure to high amplitude impulse sources, such as explosions. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to a blast wave. Primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the auditory system (Office of the Surgeon General 1991; Craig and Hearn 1998; Craig Jr. 2001). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of pulmonary contusions, pneumothorax, pneumomediastinum, traumatic lung cysts, or interstitial or subcutaneous emphysema (Office of the Surgeon General 1991). These injuries may be fatal depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air emboli that can cause a cerebral infarct or heart attack by restricting oxygen delivery to these organs. Though often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer contusions and lacerations from blast exposure, particularly in air-containing regions of the tract. Potential traumas include hematoma, bowel perforation, mesenteric tears, and ruptures of the hollow abdominal viscera. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered.

The only known occurrence of mortality or injury to a marine mammal due to a U.S. Navy training or testing event involving impulse sources occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area has been used for underwater demolitions training for at least three decades without incident. On this occasion, however, a group of long-beaked common dolphins entered the mitigation zone surrounding an area where a time-delayed firing device had been initiated on an explosive with a net explosive weight of 8.76 pounds (lb.) (3.97 kilograms [kg]) placed at a depth of 48 ft. (14.6 m). Approximately 1 minute after detonation, three animals were observed dead at the surface; a fourth animal was discovered 3 days later stranded dead 42 nm to the north of the detonation. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Leger 2011). See Section 3.4.3.1.8 (Stranding) and U.S. Department of the Navy (2013) for more information on the topic of stranding.

3.4.3.1.2.3 Auditory Trauma

Relatively little is known about auditory system trauma in marine mammals resulting from a known sound exposure. A single study spatially and temporally correlated the occurrence of auditory system trauma in humpback whales with the detonation of a 5,000 kg (11,023 lb.) explosive (Ketten et al. 1993). The exact magnitude of the exposure in this study cannot be determined, but it is likely the trauma was caused by the shock wave produced by the explosion. There are no known occurrences of direct auditory trauma in marine mammals exposed to tactical sonar or other non-impulse sound sources (Ketten 2012). The potential for auditory trauma in marine mammals exposed to impulse sources (e.g., explosions) is inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973; Ketten et al. 1993).

3.4.3.1.2.4 Acoustic Resonance

Acoustic resonance has been proposed as a hypothesis suggesting that acoustically-induced vibrations (sound) from sonar or sources with similar operating characteristics could be damaging tissues of marine mammals. In 2002, NMFS convened a panel of government and private scientists to investigate the issue (National Oceanic and Atmospheric Administration 2002). They modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding (U.S. Department of the Navy 2013d). The conclusions of that group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding (National Oceanic and Atmospheric Administration 2002). The frequencies at which resonance was predicted to occur were below the frequencies utilized by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations, even at resonant frequencies, were not considered to be of sufficient amplitude to cause tissue damage, even under the worst-case scenario in which air volumes would be undamped by surrounding tissues and the amplitude of the resonant response would be maximal. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance is not likely under realistic conditions during training and testing activities and this type of impact is not considered further in this analysis.

3.4.3.1.2.5 Bubble Formation (Acoustically Induced)

A suggested cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a bubble by exposing it to a sound field (see Section 3.4.3.1.8, Stranding, regarding strandings that gave rise to the debate about bubble formation). The process is dependent upon a number of factors including the sound pressure level and duration. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs, (2) bubbles develop to the extent that a complement immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based upon what is known about the specific process involved. Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard 1979). The dive patterns of some marine mammals (e.g., beaked whales) are theoretically predicted to induce greater supersaturation (Houser et al. 2001b, 2010a). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness.

It is unlikely that the short duration of sonar or explosion sounds would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of the tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough period of time for bubbles to become a problematic size. Recent research with *ex vivo* supersaturated bovine tissues suggested that for a 37 kHz signal, a sound exposure of approximately 215 dB re 1 µPa would be required before microbubbles became destabilized and grew (Crum et al. 2005). Assuming spherical spreading loss and a nominal sonar source level of 235 dB re 1 µPa at 1 m, a whale would need to be within 10 m (33 ft.) of the sonar dome to be exposed to such sound levels. Furthermore, tissues in the study were supersaturated by exposing them to pressures of 400–700 kilopascals for periods of hours and then releasing them to ambient pressures. Assuming the equilibration of gases with the tissues occurred when the tissues were exposed to the high pressures, levels of supersaturation in the tissues could have been as high as 400–700 percent. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al. 2001b; Saunders et al. 2008). It is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings. Both the degree of supersaturation and exposure levels observed to cause microbubble destabilization are unlikely to occur, either alone or in concert.

There is considerable disagreement among scientists as to the likelihood of this phenomenon (Piantadosi and Thalmann 2004; Evans and Miller 2003). Although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernandez et al. 2005; Jepson et al. 2003), nitrogen bubble formation as the cause of the traumas has not been verified. The presence of bubbles postmortem, particularly after decompression, is not necessarily indicative of bubble pathology (Moore et al. 2009; Dennison et al. 2011; Bernaldo de Quiros et al. 2012). Prior experimental work has also demonstrated the post-mortem presence of bubbles following decompression in laboratory animals can occur as a result of invasive investigative procedures (Stock et al. 1980).

3.4.3.1.2.6 Nitrogen Decompression

Although not a direct injury, variations in marine mammal diving behavior or avoidance responses could possibly result in nitrogen tissue supersaturation and nitrogen off-gassing, possibly to the point of deleterious vascular and tissue bubble formation (Jepson et al. 2003; Saunders et al. 2008; Hooker et al. 2012); nitrogen off-gassing occurring in human divers is called decompression sickness. The mechanism for bubble formation from saturated tissues would be indirect and also different from rectified diffusion, but the effects would be similar. Although hypothetical, the potential process is under debate in the scientific community (Saunders et al. 2008; Hooker et al. 2012). The hypothesis speculates that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Jepson et al. 2003; Fernández 2005; Hooker et al. 2012). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation.

Previous modeling suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer and Tyack 2007). Tyack et al. (2006) suggested that emboli observed in animals exposed to mid-frequency active (MFA) sonar (Jepson et al. 2003; Fernández 2005) could stem instead from a behavioral response that involves repeated dives, shallower than the depth of lung collapse. A bottlenose dolphin was trained to repetitively dive to specific depths to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser et al. 2010a).

More recently, modeling has suggested that the long, deep dives performed regularly by beaked whales over a lifetime could result in the saturation of long-halftime tissues (e.g., fat, bone lipid) to the point that they are supersaturated when the animals are at the surface (Saunders et al. 2008; Hooker et al. 2009). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009), while the condition of supersaturation required for bubble formation has been demonstrated in by-catch animals drowned at depth and brought to the surface (Moore et al. 2009). Since bubble formation is facilitated by compromised blood flow, it has been suggested that rapid stranding may lead to bubble formation in animals with supersaturated, long-halftime tissues because of the stress of stranding and the cardiovascular collapse that can accompany it (Houser et al. 2010a).

A fat embolic syndrome was identified by Fernández et al. (2005) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals, and was thought to possibly arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream. Recently, Dennison et al. (2011) reported on investigations of dolphins stranded in 2009–2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of 22 live-stranded dolphins and in the liver of two of 22. The authors postulated that stranded animals are unable to recompress by diving, and thus may retain bubbles that are otherwise re-absorbed in animals that can continue to dive. The researchers concluded that the minor bubble formation observed can be tolerated since the majority of stranded dolphins released did not re-strand (Dennison et al. 2011). Recent modeling by Kvadsheim et al. (2012) determined that while behavioral and physiological responses to sonar have the potential to result in bubble formation, the actually observed behavioral responses of cetaceans to sonar did not imply any significantly increased risk of over what may otherwise occur normally in individual marine mammals. As a result, no marine mammals addressed in this analysis are given differential treatment due to the possibility for acoustically mediated bubble growth.

3.4.3.1.3 Hearing Loss

The most familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. The meaning of the term “hearing loss” does not equate to “deafness.” This phenomenon is called a noise-induced threshold shift, or simply a threshold shift (Miller 1994). If high-intensity sound over stimulates tissues in the ear, causing a threshold shift, the impacted area of the ear (associated with and limited by the sound's frequency band) no longer provides the same auditory impulses to the brain as before the exposure (Ketten 2012). The distinction between PTS and TTS is based on whether there is a complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (the threshold returns to the pre-exposure value), the threshold shift is a TTS.

For TTS, full recovery of the hearing loss (to the pre-exposure threshold) has been determined from studies of marine mammals, and this recovery occurs within minutes to hours for the small amounts of TTS that have been experimentally induced (Finneran et al. 2005, 2010a; Nachtigall 2004). The recovery time is related to the exposure duration, sound exposure level, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005, 2010a; Mooney 2009a, b). In some cases, threshold shifts as large as 50 dB (loss in sensitivity) have been temporary, although recovery sometimes required as much as 30 days (Ketten 2012). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Again for clarity, PTS, as discussed in this document, is not the loss of hearing, but instead is the loss of hearing sensitivity over a particular range of frequency. Figure 3.4-2 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. The actual amount of threshold shift depends on the amplitude, duration, frequency, temporal pattern of the sound exposure, and on the susceptibility of the individual animal.

Both auditory trauma and auditory fatigue may result in hearing loss. Many are familiar with hearing protection devices (i.e., ear plugs) required in many occupational settings where pervasive noise could otherwise cause auditory fatigue and possibly result in hearing loss. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic fatigue and exhaustion of the hair cells and cochlear tissues. Note that the term "auditory fatigue" is often used to mean "temporary threshold shift"; however, in this EIS/OEIS a more general meaning is used to differentiate fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) from trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure). The actual amount of threshold shift depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure.

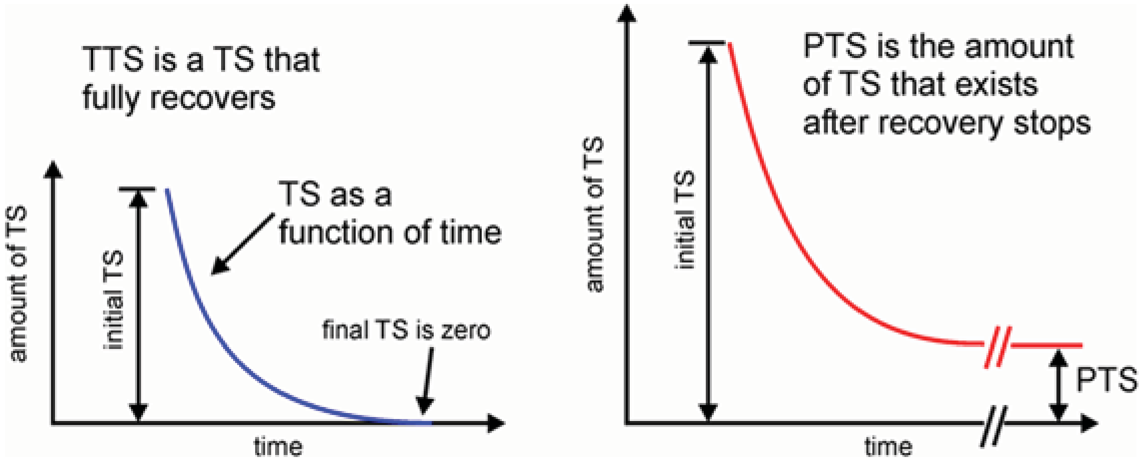


Figure 3.4-2: Two Hypothetical Threshold Shifts, Temporary and Permanent

Hearing loss, or auditory fatigue, in marine mammals has been studied by a number of investigators (Schlundt et al. 2000; Finneran et al. 2000, 2002; Finneran et al. 2005, 2007; Nachtigall et al. 2003, 2004; Mooney 2009a, b; Lucke 2009). The studies of marine mammal auditory fatigue were all designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency. In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicated the amount of TTS. Species studied include the bottlenose dolphin (total of 9 individuals), beluga (2), harbor porpoise (1), finless porpoise (2), California sea lion (3), harbor seal (1), and Northern elephant seal (1). Some of the more important data obtained from these studies are onset-TTS levels—exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (Schlundt et al. 2000). These criteria for onset-TTS are very conservative, and it is not clear that this level of threshold shift would have a functional effect on the hearing of a marine mammal in the ocean.

The primary findings of the marine mammal TTS studies are:

- The growth and recovery of TTS shift are analogous to those in terrestrial mammals. This means that, as in terrestrial mammals, threshold shifts primarily depend on the amplitude, duration, frequency content, and temporal pattern of the sound exposure.
- The amount of TTS increases with exposure sound pressure level and the exposure duration.
- For continuous sounds, exposures of equal energy lead to approximately equal effects (Ward 1997). For intermittent sounds, less hearing loss occurs than from a continuous exposure with the same energy (some recovery will occur during the quiet `period between exposures) (Kryter et al. 1965; Ward 1997).
- Sound exposure level is correlated with the amount of TTS and is a good predictor for onset-TTS from single, continuous exposures with similar durations. This agrees with human TTS data presented by Ward et al. (1958; 1959a, b). However, for longer duration sounds—beyond 16–32 seconds, the relationship between TTS and sound exposure level breaks down and duration becomes a more important contributor to TTS (Finneran et al. 2010a).
- The maximum TTS after tonal exposures occurs one-half to one octave above the exposure frequency (Schlundt et al. 2000; Finneran et al. 2007). TTS from tonal exposures can thus extend over a large (greater than one octave) frequency range.
- For bottlenose dolphins, sounds with frequencies above 10 kHz are more hazardous than those at lower frequencies (i.e., lower sound exposure levels required to affect hearing) (Finneran 2010a).
- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic. The amount of time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., 40 dB) require several days for recovery.
- TTS can accumulate across multiple intermittent exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same sound exposure level. This means that predictions based on total, cumulative sound exposure level will overestimate the amount of TTS from intermittent exposures.

Although there have been no marine mammal studies designed to measure PTS, the potential for PTS in marine mammals can be estimated based on known similarities between the inner ears of marine and terrestrial mammals. Experiments with marine mammals have revealed their similarities with terrestrial mammals with respect to features such as TTS, age-related hearing loss (called Presbycusis), ototoxic drug-induced hearing loss, masking, and frequency selectivity. Therefore, in the absence of marine mammal PTS data, onset-PTS shift exposure levels may be estimated by assuming some upper limit of TTS that equates the onset of PTS, then using TTS growth relationships from marine and terrestrial mammals to determine the exposure levels capable of producing this amount of TTS.

Hearing loss resulting from auditory fatigue could effectively reduce the distance over which animals can communicate, detect biologically relevant sounds such as predators, and echolocate (for odontocetes). The costs to marine mammals with TTS, or even some degree of PTS have not been studied; however, it is likely that a relationship between the duration, magnitude, and frequency range of hearing loss could have consequences to biologically important activities (e.g., intraspecific communication, foraging, and predator detection) that affect survivability and reproduction.

3.4.3.1.4 Auditory Masking

Auditory masking occurs when a sound, or noise in general, limits the perception of another sound. As with hearing loss, auditory masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone.

Critical ratios have been determined for pinnipeds (Southall et al. 2000; Southall et al. 2003) and bottlenose dolphins (Johnson 1967) and detections of signals under varying masking conditions have been determined for active echolocation and passive listening tasks in odontocetes (Johnson 1971; Au and Pawloski 1989; Erbe 2000). These studies provide baseline information from which the probability of masking can be estimated.

Clark et al. (2009) developed a methodology for estimating masking effects on communication signals for low frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that in Stellwagen Bank National Marine Sanctuary, when two commercial vessels pass through a North Atlantic right whale's optimal communication space (estimated as a sphere of water with a diameter of 20 km), that space is decreased by 84 percent. This methodology relies on empirical data on source levels of calls (which is unknown for many species), and requires many assumptions about ancient ambient noise conditions and simplifications of animal behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Subsequent research for the same species and location estimated that an average of 63–67 percent of North Atlantic right whale's communication space has been reduced by an increase in ambient noise levels, and that noise associated with transiting vessels is a major contributor to the increase in ambient noise (Hatch et al. 2012).

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Changes to vocal behavior and call structure may result from a need to compensate for an increase in background noise. In cetaceans, vocalization changes have been reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying.

In the presence of low frequency active sonar, humpback whales have been observed to increase the length of their 'songs' (Miller et al. 2000; Fristrup et al. 2003), possibly due to the overlap in frequencies between the whale song and the low frequency active sonar. North Atlantic right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007) as well as increasing the amplitude (intensity) of their calls (Parks 2009). In contrast, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test (Bowles et al. 1994), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Differential vocal responding in marine mammals has been documented in the presence of seismic survey noise. An overall decrease in vocalization during active surveying has been noted in large marine mammal groups (Potter et al. 2007), while blue whale feeding/social calls increased when seismic exploration was underway (Di Iorio and Clark 2010), indicative of a potentially compensatory response to the increased noise level. Melcón et al. (2012) recently documented that blue whales decreased the proportion of time spent producing certain types of calls when simulated mid-frequency sonar was present. Castellote et al. (2012) found that vocalizing fin whales in the Mediterranean left the area where a seismic survey was being conducted and that their displacement persisted beyond the completion of the survey. At present it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors. Controlled exposure experiments (CEEs) in 2007 and 2008 in the Bahamas recorded responses of false killer whales, short-finned pilot whales, and melon-headed whales to simulated MFA sonar (DeRuiter et al. 2013b). The responses to exposures between species were variable. After hearing each MFA signal, false killer whales were found to “increase their whistle production rate and made more-MFA-like whistles” (DeRuiter et al. 2013b). In contrast, melon-headed whales had “minor transient silencing” after each MFA signal, while pilot whales had no apparent response. Consistent with the findings of other previous research (see, for example, Southall et al. 2007), DeRuiter et al. (2013b) found the responses were variable by species and with the context of the sound exposure.

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for attending to and responding to all killer whale calls. The occurrence of masking or hearing impairment provides a means by which marine mammals may be prevented from responding to the acoustic cues produced by their predators. Whether or not this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

3.4.3.1.5 Physiological Stress

Marine mammals may exhibit a behavioral response or combinations of behavioral responses upon exposure to anthropogenic sounds. If a sound is detected by a marine mammal, a stress response (e.g., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, and interactions with predators all contribute to the stress a marine mammal experiences. In some cases, naturally occurring stressors can have profound impacts on marine mammals; for example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), has been demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006).

Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. Various efforts have been undertaken to investigate the impact from vessels (both whale-watching and general vessel traffic noise) and demonstrated impacts do occur (Bain 2002; Erbe 2002; Williams et al. 2006, 2009; Noren et al. 2009). For example, in an analysis of energy costs to killer whales, Williams et al. (2009) suggested that whale-watching in the Johnstone Strait resulted in lost feeding opportunities due to vessel disturbance, which could carry higher costs than other measures of behavioral change might suggest. Ayres et al. (2012) recently reported on research in the Salish Sea involving the measurement of southern resident killer whale fecal hormones to assess two potential of threats to the species recovery: lack of prey (salmon) and impacts to behavior from vessel traffic. Ayres et al. (2012) suggested that the lack of prey overshadowed any population-level physiological impacts on southern resident killer whales from vessel traffic.

Although preliminary because of the small numbers of samples collected, different types of sounds have been shown to produce variable stress responses in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al. 1990) but showed an increase in catecholamines following exposure to impulse sounds produced from a seismic water gun (Romano et al. 2004). A bottlenose dolphin exposed to the same seismic water gun signals did not demonstrate a catecholamine response, but did demonstrate an elevation in aldosterone, a hormone that has been suggested as being a significant indicator of stress in odontocetes (St. Aubin and Geraci 1989; St. Aubin and Dierauf 2001). Increases in heart rate were observed in bottlenose dolphins to which conspecific calls were played, although no increase in heart rate was observed when tank noise was played back (Miksis et al. 2001). Collectively, these results suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal.

Other types of stressors include the presence of vessels, fishery interactions, acts of pursuit and capture, the act of stranding, and pollution. In contrast to the limited amount of work performed on stress responses resulting from sound exposure, a considerably larger body of work exists on stress responses associated with pursuit, capture, handling and stranding. Many cetaceans exhibit an apparent vulnerability in the face of these particular situations when taken to the extreme. A recent study compared pathological changes in organs/tissues of odontocetes stranded on beaches or captured in nets over a 40-year period (Cowan and Curry 2008). The type of changes observed indicate multisystemic harm caused in part by an overload of catecholamines into the system, as well as a restriction in blood supply capable of causing tissue damage or tissue death. This extreme response to a major stressor/s is thought be mediated by the over activation of the animal’s normal physiological adaptations to diving or escape. Pursuit, capture and short-term holding of belugas have been observed to result in a decrease in thyroid hormones (St. Aubin and Geraci 1988) and increases in epinephrine (St. Aubin and Dierauf 2001). In dolphins, the trend is more complicated with the duration of the handling time potentially contributing to the magnitude of the stress response (St. Aubin et al. 1996; Ortiz and Worthy 2000; St. Aubin 2002). Male grey seals subjected to capture and short-term restraint showed an increase in cortisol levels accompanied by an increase in testosterone (Lidgard et al. 2008). This result may be indicative of a compensatory response that enables the seal to maintain reproduction capability in spite of stress. Elephant seals demonstrate an acute cortisol response to handling, but do not demonstrate a chronic response; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al. 2002). Similarly, no correlation between cortisol levels and heart/respiration rate changes were seen in harbor porpoises during handling for satellite tagging (Eskesen et al. 2009). Taken together, these studies illustrate the wide variations in the level of response that can occur when faced with these stressors.

Factors to consider when trying to predict a stress or cueing response include the mammal's life history stage and whether they are naïve or experienced with the sound. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation (St. Aubin and Dierauf 2001).

The sound characteristics that correlate with specific stress responses in marine mammals are poorly understood. Therefore, in practice, a stress response is assumed if a physiological reaction such as a hearing loss or trauma is predicted; or if a significant behavioral response is predicted.

3.4.3.1.6 Behavioral Reactions

The response of a marine mammal to an anthropogenic sound will depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). The distance from the sound source and whether it is perceived as approaching or moving away can affect the way an animal responds to a sound (Wartzok et al. 2003). For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson and others (Richardson et al. 1995). More recent reviews (Nowacek et al. 2007; Southall 2007, 2009a; Ellison et al. 2012) address studies conducted since 1995 and focus on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated.

Except for some vocalization changes that may be compensating for auditory masking, all behavioral reactions are assumed to occur due to a preceding stress or cueing response, however stress responses cannot be predicted directly due to a lack of scientific data (see preceding section). Responses can overlap; for example, an increased respiration rate is likely to be coupled to a flight response. Differential responses between and within species are expected since hearing ranges vary across species and the behavioral ecology of individual species is unlikely to completely overlap.

Southall et al. (2007) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response. Nonetheless, in some conditions consistent avoidance reactions were noted at higher sound levels dependent on the marine mammal species or group allowing conclusions to be drawn. Most low-frequency cetaceans (mysticetes) observed in studies usually avoided sound sources at levels of less than or equal to 160 dB re 1 µPa. Published studies of mid-frequency cetaceans analyzed include sperm whales, belugas, bottlenose dolphins, and river dolphins. These groups showed no clear tendency, but for non-impulse sounds, captive animals tolerated levels in excess of 170 dB re 1 µPa before showing behavioral reactions, such as avoidance, erratic swimming, and attacking the test apparatus. High-frequency cetaceans (observed from studies with harbor porpoises) exhibited changes in respiration and avoidance behavior at levels between 90 and 140 dB re 1 µPa, with profound avoidance behavior noted for levels exceeding this. Phocid seals showed avoidance reactions at or below 190 dB re 1 µPa, thus seals may actually receive levels adequate to produce TTS before avoiding the source. Recent studies with beaked whales have shown them to be particularly sensitive to noise, with animals during 3 playbacks of sound breaking off foraging dives at levels below 142 dB re 1 µPa, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at levels up to 157 dB re 1 µPa (Tyack et al. 2011).

3.4.3.1.6.1 Behavioral Reactions to Impulse Sound Sources

Mysticetes

Baleen whales have shown a variety of responses to impulse sound sources, including avoidance, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Richardson et al. 1995; Gordon et al. 2003; Southall 2007). While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson et al. 1995), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 µPa root mean square. Additionally, Malme et al. (1988) observed clear changes in diving and respiration patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 µPa.

Gray whales migrating along the U.S. west coast showed avoidance responses to seismic vessels by 10 percent of animals at 164 dB re 1 µPa, and by 90 percent of animals at 190 dB re 1 µPa, with similar results for whales in the Bering Sea (Malme 1986, 1988). In contrast, noise from seismic surveys was not found to impact feeding behavior or exhalation rates while resting or diving in western gray whales off the coast of Russia (Yazvenko et al. 2007; Gailey et al. 2007).

Humpback whales showed avoidance behavior at ranges of 5–8 km from a seismic array during observational studies and CEEs in western Australia (McCauley 1998; Todd et al. 1996) found no clear short-term behavioral responses by foraging humpbacks to explosions associated with construction operations in Newfoundland, but did see a trend of increased rates of net entanglement and a shift to a higher incidence of net entanglement closer to the noise source.

Seismic pulses at average received levels of 131 dB re 1 µPa^2-s caused blue whales to increase call production (Di Iorio 2010). In contrast, McDonald et al. (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 10 km from the seismic vessel (estimated received level 143 dB re 1 µPa peak-to-peak). Castellote et al. (2012) found that vocalizing fin whales in the Mediterranean left the area where a seismic survey was being conducted and that their displacement persisted beyond the completion of the survey. These studies demonstrate that even low levels of noise received far from the noise source can induce behavioral responses.

Odontocetes

Madsen et al. (2006) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys. Sound sources were from approximately 2–7 nm away from the whales and based on multipath propagation received levels were as high as 162 dB SPL re 1 µPa with energy content greatest between 0.3 to 3.0 kHz (Madsen 2006). The whales showed no horizontal avoidance, although the whale that was approached most closely had an extended resting period and did not resume foraging until the airguns had ceased firing (Miller et al. 2009). The remaining whales continued to execute foraging dives throughout exposure, however swimming movements during foraging dives were 6 percent lower during exposure than control periods, suggesting subtle effects of noise on foraging behavior (Miller et al. 2009).

Captive bottlenose dolphins sometimes vocalized after an exposure to impulse sound from a seismic watergun (Finneran et al. 2010a).

Pinnipeds

A review of behavioral reactions by pinnipeds to impulse noise can be found in Richardson et al. (1995) and Southall et al. (2007). Blackwell et al. (2004) observed that ringed seals exhibited little or no reaction to pipe-driving noise with mean underwater levels of 157 dB re 1 µPa root mean square and in air levels of 112 dB re 20 µPa, suggesting that the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an impulse source at levels of 165–170 dB re 1 µPa (Finneran et al. 2003).

Experimentally, Götz and Janik (2011) tested, underwater, startle responses to a startling sound (sound with a rapid rise time and a 93 dB sensation level [the level above the animal's threshold at that frequency]) and a non-startling sound (sound with the same level, but with a slower rise time) in wild-captured gray seals. The animals exposed to the startling treatment avoided a known food source, whereas animals exposed to the non-startling treatment did not react or habituated during the exposure period. The results of this study highlight the importance of the characteristics of the acoustic signal in an animal's response of habituation.

3.4.3.1.6.2 Behavioral Reactions to Sonar and Other Active Acoustic Sources

Mysticetes

Specific to U.S. Navy systems using low frequency sound, studies were undertaken in 1997–98 pursuant to the Navy's Low Frequency Sound Scientific Research Program. These studies found only short-term responses to low frequency sound by mysticetes (fin, blue, and humpback) including changes in vocal activity and avoidance of the source vessel (Clark 2001; Miller et al. 2000; Croll et al. 2001; Fristrup et al. 2003; Nowacek et al. 2007). Recent work by Risch et al. (2012) found that humpback whale vocalizations ("song") were reduced concurrent with pulses from the low frequency Ocean Acoustic Waveguide Remote Sensing source located approximately 200 km away. Baleen whales exposed to moderate low-frequency signals demonstrated no variation in foraging activity (Croll et al. 2001). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives, although the alarm signal was long in duration, lasting several minutes, and purposely designed to elicit a reaction from the animals as a prospective means to protect them from ship strikes (Nowacek et al. 2004). Although the animal's received sound pressure level was similar in the latter two studies (133–150 dB re 1 µPa), the frequency, duration, and temporal pattern of signal presentation were different. Additionally, the right whales did not respond to playbacks of either right whale social sounds or vessel noise, highlighting the importance of the sound characteristics, species differences, and individual sensitivity in producing a behavioral reaction.

Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source were not found to affect dive times of humpback whales in Hawaiian waters (Frankel and Clark 2000) or to overtly affect elephant seal dives off California (Costa et al. 2003). However, they did produce subtle effects that varied in direction and degree among the individual seals, again illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low frequency calls usually associated with feeding behavior (Melcón et al. 2012). It is not known whether the lower rates of calling actually indicated a reduction in feeding behavior or social contact since the study used data from remotely deployed, passive acoustic monitoring buoys. In contrast, blue whales increased their likelihood of calling when ship noise was present, and decreased their likelihood of calling in the presence of explosive noise, although this result was not statistically significant (Melcón et al. 2012). Additionally, the likelihood of an animal calling decreased with the increased received level of mid-frequency sonar, beginning at a sound pressure level of approximately 110–120 dB re 1 µPa (Melcón et al. 2012). Preliminary results from the 2010–2011 field season of an ongoing behavioral response study in Southern California waters indicated that in some cases and at low received levels, tagged blue whales responded to mid-frequency sonar but that those responses were mild and there was a quick return to their baseline activity (Southall et al. 2011). Blue whales responded to a mid-frequency sound source, with a source level between 160 and 210 dB re 1 µPa at 1 m and a received sound level up to 160 dB re 1 µPa, by exhibiting generalized avoidance responses and changes to dive behavior during CEEs (Goldbogen et al. 2013). However, reactions were not consistent across individuals based on received sound levels alone, and likely were the result of a complex interaction between sound exposure factors such as proximity to sound source and sound type (mid-frequency sonar simulation vs. pseudo-random noise), environmental conditions, and behavioral state. Surface feeding whales did not show a change in behavior during CEEs, but deep feeding and non-feeding whales showed temporary reactions that quickly abated after sound exposure. Whales were sometimes less than a mile from the sound source during CEEs. These preliminary findings from Melcón et al. (2012) and Goldbogen et al. 2013 are consistent with the Navy’s criteria and thresholds for predicting behavioral effects to mysticetes (including blue whales) from sonar and other active acoustic sources used in the quantitative acoustic effects analysis (Section 3.4.3.1.12, Behavioral Responses). The behavioral response function predicts a probability of a substantive behavioral reaction for individuals exposed to a received sound pressure level of 120 dB re 1 µPa or greater, with an increasing probability of reaction with increased received level as demonstrated in Melcón et al. (2012).

Odontocetes

From 2007 to 2011, behavioral response studies were conducted through the collaboration of various research organizations in the Bahamas, Southern California, Mediterranean, Cape Hatteras, and Norwegian waters. These studies attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to better understand their potential impacts. Results from the 2007–2008 study conducted near the Bahamas showed a change in diving behavior of an adult Blainville's beaked whale to playback of mid-frequency source and predator sounds (Boyd et al. 2008; Southall et al. 2009b; Tyack et al. 2011). Reaction to mid-frequency sounds included premature cessation of clicking and termination of a foraging dive, and a slower ascent rate to the surface. Preliminary results from a similar behavioral response study in Southern California waters have been presented for the 2010–2011 field season (Southall 2011). DeRuiter et al. (2013a) presented results from two Cuvier’s beaked whales that were tagged and exposed to simulated MFA sonar during the 2010 and 2011 field seasons of the southern California behavioral response study. The 2011 whale was also incidentally exposed to MFA sonar from a distant naval exercise. Received levels from the MFA sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa root mean square, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Cuvier's beaked whale responses suggested particular sensitivity to sound exposure as consistent with results for Blainville’s beaked whale. Similarly, beaked whales exposed to sonar during British training exercises stopped foraging (Defence Science and Technology Laboratory 2007) and preliminary results of controlled playback of sonar may indicate feeding/foraging disruption of killer whales and sperm whales (Miller et al. 2011).

In the 2007–2008 Bahamas study, playback sounds of a potential predator— a killer whale—resulted in a similar but more pronounced reaction, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area. The authors noted, however, that the magnified reaction to the predator sounds could represent a cumulative effect of exposure to the two sound types since killer whale playback began approximately 2 hours after mid-frequency source playback. Pilot whales and killer whales off Norway also exhibited horizontal avoidance of a transducer with outputs in the mid-frequency range (signals in the 1–2 kHz and 6–7 kHz ranges) (Miller et al. 2011). Additionally, separation of a calf from its group during exposure to mid-frequency sonar playback was observed on one occasion (Miller et al. 2011). In contrast, preliminary analyses suggest that none of the pilot whales or false killer whales in the Bahamas showed an avoidance response to controlled exposure playbacks (Southall et al. 2009).

Through analysis of the behavioral response studies, a preliminary overarching effect of greater sensitivity to all anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al. 2009). Therefore, recent studies have focused specifically on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Defence Science and Technology Laboratory 2007; Claridge and Durban 2009; Moretti et al. 2009; McCarthy et al. 2011; Tyack et al. 2011). In the Bahamas, Blainville’s beaked whales located on the range will move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge and Durban 2009; Moretti et al. 2009; McCarthy et al. 2011; Tyack et al. 2011).

As presented in more detail in Section 3.4.3.1.8 (Stranding), in May 2003, killer whales in Haro Strait, Washington were observed exhibiting what were believed by some observers to be aberrant behaviors while the USS SHOUP was in the vicinity and using MFA sonar. Sound fields modeled for the USS SHOUP sonar transmissions (National Marine Fisheries Service 2011b; U.S. Department of the Navy 2004; Fromm 2004a) estimated a mean received sound pressure level of approximately 169.3 dB re 1 µPa at the location of the killer whales during the closest point of approach between the animals and the vessel (estimated sound pressure levels ranged from 150 to 180 dB re 1 µPa).

In the Caribbean, research on sperm whales near the Grenadines in 1983 coincided with the U.S. intervention in Grenanda where sperm whales were observed to interrupt their activities by stopping echolocation and leaving the area in the presence of underwater sounds surmised to have originated from submarine sonar signals since the source was not visible (Watkins and Schevill 1975; Watkins et al. 1985). The authors did not provide any sound levels associated with these observations although they did note getting a similar reaction from banging on their boat hull. It was unclear if the sperm whales were reacting to the “sonar” signal itself or to a potentially new unknown sound in general as had been demonstrated previously on another occasion in which sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins et al. 1975).

Researchers at the Navy's Marine Mammal Program facility in San Diego, California have conducted a series of controlled experiments on bottlenose dolphins and beluga whales to study TTS (Schlundt et al. 2000; Finneran et al. 2001; Finneran et al. 2003; Finneran and Schlundt 2004; Finneran et al. 2010b). Ancillary to the TTS studies, scientists evaluated whether the marine mammals performed their trained tasks when prompted, during and after exposure to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Schlundt et al. 2000; Finneran et al. 2002).

Bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa root mean square, and beluga whales did so at received levels of 180–196 dB re 1 μPa and above. In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000). While these studies were generally not designed to test avoidance behavior and animals were commonly reinforced with food, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to noise sources.

Studies with captive harbor porpoises showed increased respiration rates upon introduction of acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al. 2001, 2006) and emissions for underwater data transmission (Kastelein et al. 2005b). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006), again highlighting the importance in understanding species differences in the tolerance of underwater noise (Southall et al. 2007).

Pinnipeds

Different responses displayed by captive and wild phocid seals to sound judged to be ‘unpleasant’ have been reported; where captive seals habituated (did not avoid the sound), and wild seals showed avoidance behavior (Götz and Janik 2011). Captive seals received food (reinforcement) during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an animal habituates to novel or unpleasant sounds. Another study found that captive hooded seals reacted to 1–7 kHz sonar signals, in part with displacement to the areas of least sound pressure level, at levels between 160 and 170 dB re 1 µPa (Kvadsheim et al. 2010).

Captive studies with other pinnipeds have shown a reduction in dive times when presented with qualitatively ‘unpleasant’ sounds. These studies indicated that the subjective interpretation of the pleasantness of a sound, minus the more commonly studied factors of received sound level and sounds associated with biological significance, can affect diving behavior (Götz and Janik 2011).

3.4.3.1.6.3 Behavioral Reactions to Vessels

Sound emitted from large vessels, such as shipping and cruise ships, is the principal source of low-frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Richardson et al. 1995; Foote et al. 2004; Hildebrand 2005; Hatch and Wright 2007; Holt et al. 2008; Kerosky et al. 2013; Melcon et al. 2012). As noted previously, in the Inland Waters of Puget Sound, Erbe et al. (2012) estimated the maximum annual underwater sound exposure level from vessel traffic near Seattle was 215 dB re 1 µPa^2-s and Bassett et al. (2010) measured mean sound pressure levels at Admiralty Inlet from commercial shipping at 117 dB re 1 µPa with a maximum exceeded 135 dB re 1 µPa on some occasions.

In short-term studies, researchers have noted changes in resting and surface behavior states of cetaceans to whale watching vessels (Acevedo 1991; Aguilar de Soto et al. 2006; Arcangeli and Crosti 2009; Au and Green 2000; Christiansen et al. 2010; Erbe 2002; Williams et al. 2009; Noren et al. 2009; Stensland and Berggren 2007; Stockin et al. 2008). Noren et al. (2009) conducted research in the San Juan Islands in 2005 and 2006 and their findings suggested that close approaches by vessels impacted the whales’ behavior and that the whale-watching guideline minimum approach distance of 100 m may be insufficient in preventing behavioral responses. Most studies of this type are opportunistic and have only examined the short-term response to vessel sound and vessel traffic (Watkins 1981; Richardson et al. 1995; Magalhães et al. 2002; Noren et al. 2009). Long-term and cumulative implications of vessel sound on marine mammals remains largely unknown (National Marine Fisheries Service 2012a, b). Clark et al. (2009) provided a discussion on calculating the cumulative impacts of anthropogenic noise on baleen whales and estimated that in one Atlantic setting and with the noise from the passage of two vessels, the optimal communication space for North Atlantic right whale could be decreased by 84 percent (see also Hatch et al. 2013).

Bassett et al. (2012) recorded vessel traffic over a period of just under a year as large vessels passed within 20 km of a hydrophone site located at Admiralty Inlet in Puget Sound. During this period there were 1,363 unique Automatic Identification System transmitting vessels recorded. Navy vessels, given they are much fewer in number, are a small component of overall vessel traffic and vessel noise in most areas where they operate and this is especially the case in the Study Area (see Mintz and Filadelfo (2011) concerning a general summary for the U.S. EEZ). In addition, Navy combatant vessels have been designed to generate minimal noise and use ship quieting technology to elude detection by enemy passive acoustic devices (Southall et al. 2005; Mintz and Filadelfo 2011).

Mysticetes

Fin whales may alter their swimming patterns by increasing speed and heading away from a vessel, as well as changing their breathing patterns in response to a vessel approach (Jahoda et al. 2003). Vessels that remained 328 ft. (100 m) or farther from fin and humpback whales were largely ignored in one study in an area where whale watching activities are common (Watkins 1981). Only when vessels approached more closely did the fin whales in this study alter their behavior by increasing time at the surface and exhibiting avoidance behaviors. Other studies have shown when vessels are near, some but not all fin whales change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au and Green 2000; Castellote et al. 2012; Richter et al. 2003; Williams et al. 2002).

Based on passive acoustic recordings and in the presence of sounds from passing vessels, Melcon et al. (2012) reported that blue whales had an increased likelihood of producing certain types of calls. Castellote et al. (2012) demonstrated that fin whales’ songs had shortened duration and decreased bandwidth, center frequency, and peak frequency in the presence of high shipping noise levels such as those found in the Strait of Gibraltar. At present it is not known if these changes in vocal behavior corresponded to any other behaviors.

In the Watkins (1981) study, humpback whales did not exhibit any avoidance behavior but did react to vessel presence. In a study of regional vessel traffic, (Baker and Herman 1984) found that when vessels were in the area, the respiration patterns of the humpback whales changed. The whales also exhibited two forms of behavioral avoidance: horizontal avoidance (changing direction or speed) when vessels were between 1.24 and 2.48 mi. (2,000 and 4,000 m) away, and vertical avoidance (increased dive times and change in diving pattern) when vessels were within approximately 1.2 mi. (2,000 m; Baker and Herman 1984). Similar findings were documented for humpback whales when approached by whale watch vessels in Hawaii and having responses that including increased speed, changed direction to avoid, and staying submerged for longer periods of time (Au and Green 2000).

Recently, Gende et al. (2011) reported on observations of humpback whale in inland waters of Southeast Alaska subjected to frequent cruise ship transits (i.e., in excess of 400 transits in a 4-month season in 2009). The study was focused on determining if close encounter distance was a function of vessel speed. The reported observations, however, seem in conflict with other reports of avoidance at much greater distance so it may be that humpback whales in those waters are more tolerant of vessels (given their frequency) or are engaged in behaviors, such as feeding, that they are less willing to abandon. This example again highlights that context is critical for predicting and understanding behavioral reactions as concluded by Southall et al. (2007a, b) and Ellison et al. (2012).

Sei whales have been observed ignoring the presence of vessels and passing close to the vessel (National Marine Fisheries Service 1993). In the presence of approaching vessels, blue whales perform shallower dives accompanied by more frequent surfacing, but otherwise do not exhibit strong reactions (Calambokidis et al. 2009a). Minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots) at a distance of 5.5 nm; however, when the vessel drifted or moved at very slow speeds (about 1 knot), many whales approached it (Leatherwood et al. 1982).

Although not expected to be in the Study Area, North Atlantic right whales tend not to respond to the sounds of oncoming vessels (Nowacek et al. 2004). North Atlantic right whales continue to use habitats in high vessel traffic areas (Nowacek et al. 2004). Studies show that North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves (Terhune and Verboom 1999, Nowacek et al. 2004). Although this may minimize potential disturbance from passing ships, it does increase the whales’ vulnerability to potential ship strike. The regulated approach distance for North Atlantic right whales is 500 yards (yd.) (457 m) (National Oceanic and Atmospheric Administration 1997).

Using historical records, Watkins (1986) showed that the reactions of four species of mysticetes to vessel traffic and whale watching activities in Cape Cod had changed over the 25-year period examined (1957–1982). Reactions of minke whales changed from initially more positive reactions, such as coming towards the boat or research equipment to investigate, to more 'uninterested' reactions towards the end of the study. Finback [fin] whales, the most numerous species in the area, showed a trend from initially more negative reactions, such as swimming away from the boat with limited surfacing, to more uninterested (ignoring) reactions allowing boats to approach within 98.4 ft. (30 m). Right whales showed little change over the study period, with a roughly equal number of reactions judged to be negative and uninterested; no right whales were noted as having positive reactions to vessels. Humpback whales showed a trend from negative to positive reactions with vessels during the study period. The author concluded that the whales had habituated to the human activities over time (Watkins 1986).

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. An increase in feeding call rates and repetition by humpback whales in Alaskan waters was associated with vessel noise (Doyle et al. 2008); Melcón et al. (2012) also recently documented that blue whales increased the proportion of time spent producing certain types of calls when vessels were present. Conversely, decreases in singing activity by humpback whales have been noted near Brazil due to boat traffic (Sousa-Lima and Clark 2008). The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place in Hawaii, however, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Allen and Angliss 2010).

Odontocetes

Sperm whales generally react only to vessels approaching within several hundred meters; however, some individuals may display avoidance behavior, such as quick diving (Wursig et al. 1998; Magalhães et al. 2002). One study showed that after diving, sperm whales showed a reduced timeframe from when they emitting the first click than before vessel interaction (Richter et al. 2006). The smaller whale-watching and research vessels generate more noise in higher frequency bands and are more likely to approach odontocetes directly, and to spend more time near the individual whale. Reactions to Navy vessels are not well documented, but smaller whale-watching and research boats have been shown to cause these species to alter their breathing intervals and echolocation patterns.

Wursig et al. (1998) reported most *Kogia* species and beaked whales react negatively to vessels by quick diving and other avoidance maneuvers. Cox et al. (2006) noted very little information is available on the behavioral impacts of vessels or vessel noise on beaked whales. A single observation of vocal disruption of a foraging dive by a tagged Cuvier's beaked whale documented when a large noisy vessel was opportunistically present, suggests that vessel noise may disturb foraging beaked whales (Aguilar de Soto et al. 2006). Tyack et al. (2011) noted the result of a controlled exposure to pseudorandom noise suggests that beaked whales would respond to vessel noise and at similar received levels to those noted previously and for mid-frequency sonar.

Most delphinids react neutrally to vessels, although both avoidance and attraction behavior is known (Hewitt 1985; Wursig et al. 1998). Avoidance reactions include a decrease in resting behavior or change in travel direction (Bejder et al. 2006). Incidence of attraction includes harbor porpoises approaching a vessel and common, rough-toothed, and bottlenose dolphins bow riding and jumping in the wake of a vessel (Norris and Prescott 1961; Shane et al. 1986; Wursig et al. 1998; Ritter 2002). A study of vessel reactions by dolphin communities in the eastern tropical Pacific found that populations that were often the target of tuna purse-seine fisheries (spotted, spinner and common dolphins) show evasive behavior when approached; however populations that live closer to shore (within 100 nm; coastal spotted and bottlenose dolphins) that are not set on by purse-seine fisheries tend to be attracted to vessels (Archer et al. 2010a, b).

Killer whales, the largest of the delphinids, are targeted by numerous small whale-watching vessels in the Pacific Northwest and, from 1998 to 2012 during the viewing season, have had an annual monthly average of nearly 20 vessels of various types within 0.5 mile of their location from between the hours of 9 a.m. and 6 p.m. (Eisenhardt 2012). For the 2012 season, it was reported that 1,590 vessel incidents were possible violations of the federal vessel approach regulations or MMPA and ESA laws as well (Eisenhardt 2012). Research suggests that whale-watching guideline distances may be insufficient to prevent behavioral disturbances due to vessel noise (Noren et al. 2009). In 2012, there were 79 U.S. and Canadian commercial whale watch vessels in the Haro Strait region (Eisenhardt 2012).These vessels have measured source levels that ranged from 145 to 169 dB re 1 µPa at 1 m and have the sound they produce underwater has the potential to result in behavioral disturbance, interfere with communication, and affect the killer whales' hearing (Erbe 2002). Killer whales foraged significantly less and traveled significantly more when boats were within 328 ft. (100 m) of the whales (Kruse 1991; Trites and Bain 2000; Williams et al. 2002; Williams et al. 2009; Lusseau et al. 2009). These short-term feeding activity disruptions may have important long-term population-level effects (Lusseau et al. 2009; Noren et al. 2009). The reaction of the killer whales to whale-watching vessels may be in response to the vessel pursuing them, rather than to the noise of the vessel itself, or to the number of vessels in their proximity.

Similar behavioral changes (increases in traveling and other stress-related behaviors) have been documented in Indo-Pacific bottlenose dolphins in Zanzibar (Englund and Berggren 2002; Stensland and Berggren 2007; Christiansen et al. 2010). Short-term displacement of dolphins due to tourist boat presence has been documented (Carrera et al. 2008), while longer term or repetitive/sustained displacement for some dolphin groups due to chronic vessel noise has been noted (Haviland-Howell et al. 2007; Miksis-Olds et al. 2007). Most studies of the behavioral reactions to vessel traffic of bottlenose dolphins have documented at least short-term changes in behavior, activities, or vocalization patterns when vessels are near, although the distinction between vessel noise and vessel movement has not been made clear (Acevedo 1991; Janik and Thompson 1996; Berrow and Holmes 1999; Scarpaci et al. 2000; Gregory and Rowden 2001; Lusseau 2004; Mattson et al. 2005; Arcangeli and Crosti 2009).

Both finless porpoises (Li et al. 2008) and harbor porpoises (Polacheck and Thorpe 1990) routinely avoid and swim away from large motorized vessels. The vaquita, which is closely related to the harbor porpoise in the Study Area, appears to avoid large vessels at about 2,995 ft. (913 m) (Jaramillo-Legorreta et al. 1999). The assumption is that the harbor porpoise would respond similarly to large Navy vessels.

Odontocetes have been shown to make short-term changes to vocal parameters such as intensity (Holt et al. 2008) as an immediate response to vessel noise, as well as increase the pitch, frequency modulation, and length of whistling (May-Collado and Wartzok 2008). Likewise, modification of multiple vocalization parameters has been shown in belugas residing in an area known for high levels of commercial traffic. These animals decreased their call rate, increased certain types of calls, and shifted upward in frequency content in the presence of small vessel noise (Lesage et al. 1999). Another study detected a measurable increase in the amplitude of their vocalizations when ships were present (Scheifele et al. 2005). Killer whales off the northwestern coast of the United States have been observed to increase the duration of primary calls once a threshold in observed vessel density (e.g., whale watching) was reached, which has been suggested as a response to increased masking noise produced by the vessels (Foote et al. 2004). On the other hand, long-term modifications to vocalizations may be indicative of a learned response to chronic noise, or of a genetic or physiological shift in the populations. For example, the source level of killer whale vocalizations has been shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect; see Hotchkin and Parks 2013). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al. 2008).

Pinnipeds

Little is known about pinniped reactions to underwater non-impulse sounds (Southall et al. 2007a, b) including vessel noise. In a review of reports on reactions of pinnipeds to small craft and ships, Richardson et al. (1995) note that information is on pinniped reactions is limited and most reports are based on anecdotal observations. Specific case reports in Richardson et al. (1995) vary based on factors such as routine anthropogenic activity, distance from the vessel, engine type, wind direction, and ongoing subsistence hunting. As with reactions to sound reviewed by Southall et al. (2007a, b), pinniped responses to vessels are affected by the context of the situation and by the animal’s experience. In summary, pinniped’s reactions to vessels are variable and reports include a wide entire spectrum of possibilities from avoidance and alert to cases where animals in the water are attracted and cases on land where there is lack of significant reaction suggesting “habituation” or “tolerance” of vessels (Richardson et al. 1995).

A study of reactions of harbor seals hauled out on ice to cruise ship approaches in Disenchantment Bay, Alaska revealed that animals are more likely to flush and enter the water when cruise ships approach within 1,640 ft. (500 m) and four times more likely when the cruise ship approaches within 328 ft. (100

m) (Jansen et al. 2010). Navy vessels would generally not operate in vicinity of nearshore natural areas that are pinniped haul-out or rookery locations.

Sea Otters

Sea otters depend on visual acuity to forage and their eyes are able to focus both in air and underwater (Riedman and Estes 1990). Davis et al. (1988) conducted a study of southern sea otter's reactions to various underwater and in-air acoustic stimuli. The purpose of the study was to identify a means to purposefully move sea otters from a location in the event of an oil spill. Anthropogenic sound sources used in this behavioral response study included truck air horns and an acoustic harassment device (10–20 kHz at 190 dB) designed to keep dolphins and pinnipeds from being caught in fishing nets). The authors found that the sea otters often remained undisturbed, quickly became tolerant of the various sounds, and even when the desired response occurred (chased from a location) by the presence of a harassing sound, they generally moved only a short distance (109–219 yd. [100–200 m]) before resuming normal activity.

3.4.3.1.6.4 Behavioral Reactions to Aircraft and Missile Overflights

The following paragraphs summarize what is known about the reaction of various marine mammal species to overhead flights of many types of fixed-wing aircraft helicopters and missiles. Thorough reviews of the subject and available information are presented in Richardson et al. (1995), Efroymson et al. (2001), Luksenburg and Parsons (2009), and Holst et al. (2011). The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping) (Nowacek et al. 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Manci et al. 1988; Holst et al. (2011). Richardson et al. (1995) noted that marine mammal reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations lacking clear distinction between reactions potentially caused by the noise of the aircraft and the visual cue an aircraft presents. In addition it was suggested that variations in the responses noted were due to generally other undocumented factors associated with overflight (Richardson et al. 1995). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (centered on the animal, off to one side, circling, level and slow), environmental factors such as wind speed, sea state, cloud cover, and locations where native subsistence hunting continues.

Mysticetes

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Koski et al. 1998; Efroymson et al. 2001). Richardson et al. (1995) reported that while data on the reactions of mysticetes is meager and largely anecdotal, there is no evidence that single or occasional aircraft flying above mysticetes causes long-term displacement of these mammals. In general, overflights above 1,000 ft. (305 m) do not cause a reaction.

Bowhead whales in the Beaufort Sea exhibited a transient behavioral response to fixed-wing aircraft and vessels. Reactions were frequently observed at less than 1,000 ft. (305 m) above sea level, infrequently observed at 1,500 ft. (457 m), and not observed at 2,000 ft. (610 m) above sea level (Richardson et al. 1995). Bowhead whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns. Behavioral reactions decreased in frequency as the altitude of the helicopter increased to 492 ft. (150 m) or higher. It should be noted that bowhead whales may have more acute responses to anthropogenic activity than many other marine mammals since these animals are often presented with limited egress due to limited open water between ice floes. Additionally many of these animals may be hunted by Alaska Natives, which could lead to animals developing additional sensitivity to human noise and presence.

Odontocetes

Variable responses to aircraft have been observed in toothed whales, though overall little change in behavior has been observed during flyovers. Some toothed whales dove, slapped the water with their flukes or flippers, or swam away from the direction of the aircraft during overflights; others did not visibly react (Richardson et al. 1995).

During standard marine mammal surveys at an altitude of 750 ft. (229 m), some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after being sighted. Other authors have corroborated the variability in sperm whales' reactions to fixed-wing aircraft or helicopters (Green et al. 1992; Wursig et al. 1998; Richter et al. 2003; Richter et al. 2006; Smultea et al. 2008). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors (Richardson et al. 1995). A group of sperm whales responded to a circling aircraft (altitude of 800 to 1,100 ft. [244 to 335 m]) by moving closer together and forming a defensive fan-shaped semicircle, with their heads facing outward. Several individuals in the group turned on their sides, apparently to look up toward the aircraft (Smultea et al. 2008). Whale-watching aircraft apparently caused sperm whales to turn more sharply but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al. 2003). Navy aircraft do not fly at low altitude, hover over, or follow whales and so are not expected to evoke this type of response.

Smaller delphinids generally react to overflights either neutrally or with a startle response (Wursig et al. 1998). The same species that show strong avoidance behavior to vessel traffic (*Kogia* species and beaked whales) also react to aircraft (Wursig et al. 1998). Beluga whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns to a greater extent than mysticetes in the same area (Patenaude et al. 2002). These reactions increased in frequency as the altitude of the helicopter dropped below 492 ft. (150 m).

Pinnipeds

Richardson et al. (1995) noted that data on pinniped reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations. Richardson et al.'s (1995) summary of this variable data note that responsiveness generally was dependent on the altitude of the aircraft, the abruptness of the associated aircraft sound, and life cycle stage (breeding, molting, etc.). Hauled out pinnipeds exposed to aircraft sight or sound often react by becoming alert and in many cases rushing into the water. Stampedes resulting in mortality to pups (by separation or crushing) have been noted in some cases although it is rare. Holst et al. (2011) provides an up-to-date review of this subject.

Helicopters are used in studies of several species of seals hauled out and is considered an effective means of observation (Gjertz and Børset 1992; Bester et al. 2002; Bowen et al. 2006), although they have been known to elicit behavioral reactions such as fleeing (Hoover 1988). In other studies, harbor seals showed no reaction to helicopter overflights (Gjertz and Børset 1992).

Ringed seals near an oil production island in Alaska reacted to approaching Bell 212 helicopters generally by increasing vigilance, although one seal left its basking site for the water after a helicopter approached within approximately 328 ft. (100 m) (Blackwell et al. 2004). Seals in the study near an oil production platform were thought to be habituated and showed no reactions to industrial noise in water or in air, including impact pile-driving, during the rest of the observations.

For California sea lions and Steller sea lions at a rocky haul-out off Crescent City in northern California, helicopter approach to landing typically caused the most severe response (National Oceanic and Atmospheric Administration 2010). Responses were also dependent on the species with Steller sea lions being more “skittish” and California sea lions more tolerant. Depending on the spacing between subsequent approaches, animals hauled out in between and fewer animals reacted upon subsequent exposures (National Oceanic and Atmospheric Administration 2010).

Pinniped reactions to rocket launches and overflight at San Nicolas Island, California were studied for the time period of August 2001–October 2008 (Holst et al. 2011). Consistent with other reports, behavioral reactions were found to differ between species. California sea lions startled and increased vigilance for up to 2 minutes after a rocket overflight, with some individuals moving down the beach or returning to the water. Northern elephant seals showed little reaction to any overflight. Harbor seals had the most pronounced reactions of the three species observed with most animals within approximately 2.5 mi. (4 km) of the rocket trajectory leaving their haul-out sites for the water and not returning for several hours. The authors concluded that the effects of the rocket launches were minor with no effects on local populations evidenced by the increasing populations of pinnipeds on San Nicolas Island (Holst et al. 2011).

Sea Otters

There is no specific information available indicating that overflights of any kind have an impact on sea otters. Fixed-wing aerial surveys are often recommended as a means to monitor populations of sea otter. As of 2011, USFWS stated that they had no evidence that defense-related activities have had any adverse effects on the well-monitored experimental population of southern sea otters at San Nicolas Island or in the Southern California Range Complex (U.S. Fish and Wildlife Service 2011).

3.4.3.1.7 Repeated Exposures

Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with costs that can accumulate over time to cause long-term consequences for the individual. Conversely, some animals habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past has not accompanied any overt threat.

Repeated exposure to acoustic and other anthropogenic stimuli has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins in New Zealand responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin et al. 2008). The authors speculated that repeated interruptions of the dolphins foraging behaviors could lead to long-term implications for the population. Bejder et al. (2006) studied responses of bottlenose dolphins to vessel approaches and found stronger and longer lasting reactions in populations of animals that were exposed to lower levels of vessel traffic overall. The authors indicated that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area. Marine mammals that are more tolerant may stay in a disturbed area, whereas individuals that are more sensitive may leave for areas with less human disturbance. However, animals that remain in the area throughout the disturbance may be unable to leave the area for a variety of physiological or environmental reasons. Terrestrial examples of this abound as human disturbance and development displace more sensitive species, and tolerant animals move in to exploit the freed resources and fringe habitat. Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region if they do not become acclimated to the presence of the sound (Blackwell et al. 2004; Bejder et al. 2006; Teilmann et al. 2006). Gray whales in Baja California abandoned an historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. Whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant 1984). Over a shorter time scale, studies on the Atlantic Undersea Test and Evaluation Center (AUTEC) instrumented range in the Bahamas have shown that some Blaineville's beaked whales may be resident during all or part of the year in the area, and that individuals may move off of the range for several days during and following a sonar event. However animals are thought to continue feeding at short distances (a few kilometers) from the range out of the louder sound fields (less than 157 dB re 1 µPa) (McCarthy et al. 2011; Tyack et al. 2011). Mysticetes in the northeast tended to adjust to vessel traffic over a number of years, trending towards more neutral responses to passing vessels (Watkins 1986) indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Nevertheless, the long-term consequences of these habitat utilization changes are unknown, and likely vary depending on the species, geographic areas, and the degree of acoustic or other human disturbance.

Moore and Barlow (2013) have noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. There are scientific caveats and limitations to the data used for that analysis, as well as oceanographic and species assemblage changes not thoroughly addressed in Moore and Barlow (2013), although the authors suggest Navy sonar as one possible explanation for the apparent decline in beaked whale numbers over that broad area. In the small portion of the Pacific coast overlapping the Navy's Southern California Range Complex, long-term residency by individual Cuvier's beaked whales and documented higher densities of beaked whales provide indications that the proposed decline in numbers elsewhere along the Pacific coast is not apparent where the Navy has been intensively training and testing with sonar and other systems for decades. While it is possible that a downward trend in beaked whales may have gone unnoticed at the range complex (due to a lack of survey precision) or that beaked whale densities may have been higher before the Navy began using sonar more than 60 years ago, there is no data available to suggest that beaked whale numbers have declined on the range where Navy sonar use has routinely occurred. As Moore and Barlow (2013) point out, it remains clear that the Navy range in Southern California continues to support high densities of beaked whales.

3.4.3.1.8 Stranding

When a marine mammal swims or floats (live or dead) onto shore and becomes “beached” or incapable of returning to sea, the event is termed a “stranding” (Geraci et al. 1999; Geraci and Lounsbury 2005). Animals outside of their “normal” habitat are also sometimes considered “stranded” even though they may not have beached themselves. The legal definition for a stranding within the United States is that: (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is apparently in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance” (16 United States Code Section 1421h).

Marine mammals are subjected to a variety of natural and anthropogenic factors, acting alone or in combination, which may cause a marine mammal to strand on land or die at-sea (Geraci et al. 1999; Geraci and Lounsbury 2005). Even for the fractions of more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for the majority of strandings remain undetermined. Natural factors related to strandings include, for example, the availability of food, predation, disease, parasitism, climatic influences, and aging (Geraci et al. 1999; Culik 2004; Perrin and Geraci 2002; Hoelzel 2003; Geraci and Lounsbury 2005; Walker et al. 2005; Bradshaw et al. 2006; National Research Council of the National Academies 2003). Anthropogenic factors include, for example, pollution (Jepson et al. 2005; Hall et al. 2006a, b; Tabuchi et al. 2006; Commission 2010; Elfes et al. 2010), vessel strike (Laist et al. 2001; Jensen and Silber 2003; Geraci and Lounsbury 2005; de Stephanis and Urquiola 2006; Berman-Kowalewski et al. 2010), fisheries interactions (Read et al. 2006; Look 2011), entanglement (Baird and Gorgone 2005; Johnson et al. 2005; Saez et al. 2013), and noise (Richardson et al. 1995; National Research Council of the National Academies 2003; Cox et al. 2006).

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 1,400 cetacean strandings and 4,300 pinniped strandings (5,700 total) per year (National Marine Fisheries Service 2011a, b, c, d). Several “mass stranding” events—strandings that involve two or more individuals of the same species (excluding a single cow-calf pair)—that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. An in-depth discussion of strandings is presented in U.S. Department of the Navy (2013). For the general environment around the Study Area in particular, see, for example, Barbieri et al. (2013), Calambokidis and Huggins (2008), Cascadia Research (2010a, b, 2012a, b, 2013), Engelhard et al. (2012), Norman et al. (2004), Osborne (2003), Rice et al. (1986), Saez et al. (2013), and Willis and Baird et al. (1998).

Sonar use during exercises involving U.S. Navy (most often in association with other nations' defense forces) has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira Island, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Marine Mammal Commission 2006). These five mass stranding events have resulted in about 40 known stranding deaths among cetaceans, consisting mostly of beaked whales, with a potential link to sonar (International Council for the Exploration of the Sea 2005a, b, c). The U.S.-Navy-funded research involving Behavioral Response Studies in Southern California and the Bahamas discussed previously were motivated by the desire to understand any links between the use of mid-frequency sonar and cetacean behavioral responses, including the potential for strandings. Although these events have served to focus attention on the issue of impacts resulting from the use of sonar, as Ketten (2012) recently pointed out, “ironically, to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result [of] anthropogenic noise exposures, including sonar.”

In these previous circumstances, exposure to non-impulse acoustic energy has been considered a potential indirect cause of the death of marine mammals (Cox et al. 2006). One hypothesis regarding a potential cause of the strandings is tissue damage resulting from “gas and fat embolic syndrome” (Jepson et al. 2003; Fernandez et al. 2005; Jepson et al. 2005). Models of nitrogen saturation in diving marine mammals have been used to suggest that altered dive behavior might result in the accumulation of nitrogen gas such that the potential for nitrogen bubble formation is increased (Houser et al. 2001b, 2010a; Zimmer and Tyack 2007). If so, this mechanism might explain the findings of gas and bubble emboli in stranded beaked whales. It is also possible that stranding is a behavioral response to a sound under certain contextual conditions and that the subsequently observed physiological effects (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding rather than direct physical impact from exposure to sonar (Cox et al. 2006).

As additional background and specific to the NWTT Study Area, in May 2003 there was an incident involving the use of mid-frequency sonar by the USS SHOUP, which was portrayed in some media reports at the time as having potentially causing harbor porpoise strandings in the region. On 5 May 2003 in the area of Admiralty Inlet, the USS SHOUP began the use of mid-frequency sonar as part of a training event, which continued until later that afternoon and ended as the USS SHOUP transited Haro Strait heading north. Between 2 May and 2 June 2003, approximately 16 strandings involving 15 harbor porpoises (*Phocoena phocoena*) and 1 Dall's porpoise (*Phocoenoides dalli*) had been reported to the Northwest Marine Mammal Stranding Network, and allegations were made that these strandings had been caused by the USS SHOUP's use of sonar. A comprehensive review of all strandings and the events involving USS SHOUP on 5 May 2003, were subsequently presented in a report by U.S. Department of Navy (2004).

Additionally National Marine Fisheries Service undertook an series of necropsy analyses on the stranded animals to determine the cause of the strandings (National Marine Fisheries Service 2005b, Norman et al. 2004). Necropsies were performed on 10 of the porpoises and two heads were selected for computed tomographic imaging (Norman et al. 2004).

None of the 11 harbor porpoises demonstrated signs of acoustic trauma. A putative cause of death was determined for five of the porpoises based only on the necropsy results; two animals had blunt trauma injuries and three animals had indication of disease processes. A cause of death could not be determined in the remaining animals, which is consistent with the expected percentage of marine mammal necropsies conducted within the northwest region. It is important to note, that these determinations were based only on the evidence from the necropsy to avoid bias with regard to determinations of the potential presence or absence of acoustic trauma. For example, the necropsy investigators had no knowledge of other potential external causal factors, such as Specimen 33NWR05005 having been found tangled in a fishing net, which may have otherwise assisted in their determination regarding the likely cause of death for that animal. Additionally, seven of the porpoises collected and analyzed died prior to SHOUP departing to sea on 5 May 2003. Of these seven, one, discovered on 5 May 2003, was in a state of moderate decomposition, indicating it died before May 5; the cause of death was determined, most likely, to be Salmonella septicemia. Another porpoise, discovered at Port Angeles on 6 May 2003, was in a state of moderate decomposition, indicating that this porpoise also died prior to May 5. One stranded harbor porpoise discovered fresh on May 6 is the only animal that could potentially be linked in time to the USS SHOUP's May 5 active sonar use. Necropsy results for this porpoise found no evidence of acoustic trauma. The remaining eight strandings were discovered 1–3 weeks after the USS SHOUP's May 5 use of sonar. Two of the eight porpoises died from blunt trauma injury and a third suffered from parasitic infestation, which possibly contributed to its death (Norman et al. 2004). For the remaining five porpoises, NMFS was unable to identify the causes of death.

NMFS concluded from a retrospective analysis of stranding events that the number of harbor porpoise stranding events in the approximate month surrounding the USS SHOUP's use of sonar was higher than expected based on annual strandings of harbor porpoises (Norman et al. 2004). This conclusion in the NMFS report also conflicts with data from The Whale Museum, which has documented and responded to harbor porpoise strandings since 1980 (Osborne 2003). According to The Whale Museum, the number of strandings as of 15 May 2003 was consistent with what was expected based on historical stranding records and was less than that occurring in certain years. For example, since 1992, the San Juan Stranding Network has documented an average of 5.8 porpoise strandings per year. In 1997, there were 12 strandings in the San Juan Islands, with more than 30 strandings throughout the general Puget Sound area. In reporting their findings, NMFS acknowledged that the intense level of media attention to the 2003 strandings likely resulted in increased reporting effort by the public over that which is normally observed (Norman et al. 2004). NMFS also noted in its report that the "sample size is too small and biased to infer a specific relationship with respect to sonar usage and subsequent strandings." It was also clear that in 2003, the number of strandings in the May–June timeframe that year was also higher for the outer coast, indicating a much wider phenomena than use of sonar by USS SHOUP in Puget Sound for one day in May. It was in fact later determined by NMFS that the number of harbor porpoise strandings in the northwest had been increased beginning in 2003 and through 2006. On 3 November 2006, an Unusual Mortality Event in the Pacific Northwest was declared by NMFS (see U.S. Department of the Navy [2013], Cetacean Stranding Report for more detail on this Unusual Mortality Event).

The speculative association of the harbor porpoise strandings to the use of sonar by the USS SHOUP was inconsistent with prior stranding events linked to the use of mid-frequency sonar. Specifically, in prior events (strandings shortly after the use of sonar [less than 36 hours]), stranded individuals were spatially co-located. Although MFA sonar was used by the USS SHOUP, the distribution of harbor porpoise strandings by location and with respect to time surrounding the event do not support the suggestion that MFA sonar was a cause of harbor porpoise strandings. Rather, a lack of evidence of any acoustic trauma within the harbor porpoises, and the identification of probable causes of stranding or death in several animals, supports the conclusion that harbor porpoise strandings in 2003 in the Pacific Northwest were unrelated to the sonar activities by the USS SHOUP.

As International Council for the Exploration of the Sea (2005b) noted, taken in context of marine mammal populations in general, sonar is not a major threat, or significant portion of the overall ocean noise budget. This has also been demonstrated by monitoring in areas where Navy operates (McDonald et al. 2006; Bassett et al. 2010; Baumann-Pickering et al. 2010; Hildebrand et al. 2011; Tyack et al. 2011). Regardless of the direct cause, the Navy considers potential sonar related strandings important and continues to fund research and work with scientists to better understand circumstances that may result in strandings.

During a Navy training event on 4 March 2011 at the Silver Strand Training Complex in San Diego, California, four long-beaked common dolphins were killed by the detonation of an underwater explosive (Danil and St. Leger 2011). This area has been used for underwater demolitions training for at least 3 decades without incident. During this underwater detonation training event, a pod of 100–150 long-beaked common dolphins were observed moving towards the explosive event's 700 yd. (640 m) exclusion zone monitored by a personnel in a safety boat and participants in a dive boat. Within the exclusion zone, approximately 5 minutes remained on a time-delayed firing device connected to a single 8.76 lb. (3.8 kg) explosive charge weight (C-4 and detonation cord) set at a depth of 48 ft. (14.6 m), approximately 0.5–0.75 nm from shore. Although the dive boat was placed between the pod and the explosive in an effort to guide the dolphins away from the area, that effort was

<u>Criteria for Estimating Mortality Reflects a Conservative Overestimate:</u>

Navy's metric for modeling and quantifying "mortality" provides a conservative overestimate of the mortalities likely to occur. The onset mortality threshold is the minimum impulse exposure level predictive of extensive lung injury likely to result in 1 percent mortality of animals in a population; 99 percent would be expected to recover from the injury.

unsuccessful and three long-beaked common dolphins died as a result of being in proximity to the explosion. In addition, to the three dolphins found dead on 4 March at the event site, the remains of a fourth dolphin were discovered on 7 March (3 days later and approximately 42 mi. (68 km) from the location where the training event occurred), which was assessed as being related to this event (Danil and St. Leger 2011). Details such as the dolphins' depth and distance from the explosive at the time of the detonation could not be estimated from the 250 yd. (229 m) standoff point of the observers in the dive boat or the safety boat.

These dolphin mortalities are the only known occurrence of a U.S. Navy training event involving impulse energy (underwater detonation) that has resulted in injury to a marine mammal. Despite this being a rare occurrence, the Navy has reviewed training requirements, safety procedures, and potential mitigation measures and, along with NMFS, is determining appropriate changes to implement to reduce the potential for this to occur in the future. Discussions of procedures associated with these and other training and testing events are presented in Chapter 5, which details all mitigations.

In comparison to potential strandings or injury resulting from events associated with Navy activities, marine mammal strandings and injury from commercial vessel ship strike (e.g., Berman-Kowalewski et al. 2010; Silber et al. 2010), impacts from urban pollution (e.g., O'Shea & Brownell 1994; Hooker et al. 2007), and annual fishery-related entanglement, bycatch, injury, and mortality (e.g., Baird and Gorgone 2005; Forney and Kobayashi 2007; Saez et al. 2013), which have been estimated worldwide to be orders of magnitude greater (hundreds of thousands of animals versus tens of animals; Culik 2004, International Council for the Exploration of the Sea 2005b, Read et al. 2006) than the few potential injurious impacts that could be possible as a result of Navy activities. This does not negate the potential influence of mortality or additional stress to small, regionalized sub-populations which may be at greater risk from human related mortalities (fishing, vessel strike, sound) than populations with larger oceanic level distributions, but overall the Navy's impact in the oceans and inland water areas where training and testing occurs is small by comparison to other human activities.

3.4.3.1.9 Long-Term Consequences to the Individual and the Population

Long-term consequences to a population are determined by examining changes in the population growth rate. Individual effects that could lead to a reduction in the population growth rate include mortality or injury (that removes animals from the reproductive pool), hearing loss (which depending on severity could impact navigation, foraging, predator avoidance, or communication), chronic stress (which could make individuals more susceptible to disease), displacement of individuals (especially from preferred foraging or mating grounds), and disruption of social bonds (due to masking of conspecific signals or displacement). However, the long-term consequences of any of these effects are difficult to predict because individual experience and time can create complex contingencies, especially for intelligent, long-lived animals like marine mammals. While a lost reproductive opportunity could be a measureable cost to the individual, the outcome for the animal, and ultimately the population, can range from insignificant to significant. Any number of factors, such as maternal inexperience, years of poor food supply, or predator pressure, could produce a cost of a lost reproductive opportunity, but these events may be "made up" during the life of a normal healthy individual. The same holds true for exposure to human-generated noise sources. These biological realities must be taken into consideration when assessing risk, uncertainties about that risk, and the feasibility of preventing or recouping such risks. All too often, the long-term consequence of relatively trivial events like short-term masking of a conspecific's social sounds, or a single lost feeding opportunity, is exaggerated beyond its actual importance by focus on the single event and not the important variable, which is the individual and its lifetime parameters of growth, reproduction and survival.

The linkage between a stressor such as sound and its immediate behavioral or physiological consequences for the individual, and then the subsequent effects on that individual's vital rates (growth, survival and reproduction), and the consequences, in turn, for the population have been reviewed in National Research Council of the National Academies (2005). The Population Consequences of Acoustic Disturbance (PCAD) model (National Research Council of the National Academies 2005) proposes a quantitative methodology for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translate into biologically significant consequences to the population. Population models are well known from many fields in biology including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. The time-scale of the inputs in a population model for long-lived animals such as marine mammals is on the order of seasons, years, or life stages (e.g., neonate, juvenile, reproductive adult), and are often concerned only with the success of individuals from one time period or stage to the next. Unfortunately, for acoustic and explosive impacts to marine mammal populations, many of the inputs required by population models are not known.

Long-term impacts, noise impacts, habitat deterioration, and beaked whale responses to various stressors were evaluated as part of the assessment of potential impacts. Recently New et al. (2013) developed a mathematical model simulating a functional link between feeding energetics and a species' requirements for survival and reproductions for 21 species of beaked whale. New et al. (2013) report "reasonable confidence" in their model, although approximately 29 percent (6 of 21 beaked whale species modeled) failed to survive or reproduce, which the authors attribute to possible inaccuracies in the underlying parameters. Based on the model simulation, New et al. (2013) determined that if habitat quality and "accessible energy" (derived from the availability of either plentiful prey or prey with high energy content) are both high, then survival rates are high as well. If these variables are low, then adults may survive but calves will not. For the 29 percent of beaked whale species for which the model failed (within the assumed range of current inputs), the assumption was a 2-year calving period (or inter-calf interval), however, for species with longer gestation periods (such as the 17-month gestation period of Baird's beaked whale (*Berardius bairdii*), this inter-calf interval may be too short. For Blainville's beaked whale, Claridge (2013) has shown that calf age at separation is at least 3 years, and that the inter-calf interval at Abaco in the Bahamas may be 4 years. New et al. (2013) acknowledge that an assumed 2-year calving period in the modeling may not be long enough to build up the energetic resources necessary for mother and calf survival.

As another critical model assumption, prey preferences were modeled based on stomach content analyses of stranded animals, which the authors acknowledge are traditionally poor estimates of the diets of healthy animals, as stranded animals are often sick prior to stranding. Stomach content remnants of prey species do not digest equally, as only the hard parts of some prey types remain (e.g., fish otoliths, beaks of cephalopods) and thus often provide an incomplete picture of diet. Given these unknowns and the failure of the simulation to work for 29 percent of beaked whale species, the modeled survival rates of all beaked whales, particularly those modeled with prey having low energy content, may be better than simulated if higher-energy prey makes up a larger part of the diet than assumed by the model simulations.

In short, for the model output New et al. (2013) created to correctly represent links between the species and their environment, that model must identify all the critical and relevant ecological parameters as input variables, provide the correct values for those parameters, and then the model must appropriately integrate modeling functions to duplicate the complex relationships the model intends to represent. If an assumption (model input) such as calving period or prey preferences is incorrect (and there is presently no way to know), then the model would not be representing what may actually be occurring. New et al. (2013) report that their simulations suggest that adults will survive but not reproduce if anthropogenic disturbances result in being displaced to areas of "impaired foraging." Underlying this suggestion is the additional unstated assumption that habitat capable of sustaining a beaked whale is limited in proximity to where any disturbance has occurred and there are no data to indicate that is a valid assumption.

While the New et al. (2013) model provides a test case for future research, this pilot study has very little of the critical data necessary to form any conclusions applicable to current management decisions. The authors note the need for more data on prey species and reproductive parameters including gestation and lactation duration, as the model results are particularly affected by these assumptions. Therefore, any suggestion of biological sensitivity to the simulation's input parameters is uncertain. Given this level of uncertainty, the Navy will continue to follow developments in the mathematical modeling of energetics to estimate specific sensitivity to disturbance. As discussed in the EIS/OEIS, the Navy continues to fund the Behavioral Response Studies in the Bahamas and Southern California specifically to better understand, via direct field observations, the potential for anthropogenic activities to disturb marine mammals. In cooperation with NMFS, the Navy will continue to develop the most effective management and conservation actions to needed to protect marine mammals while accomplishing the Navy's mission to train and test safely and effectively.

Claridge (2013) used photo-recapture methods to estimate population abundance and demographics of Blainville's beaked whale (*Mesoplodon densirostris*) in the Bahamas at two sample locations; one within the bounds of the AUTEC where sonar training and testing occurs and the second along the edge of Abaco Island approximately 170 km to the north. To investigate the potential effect of beaked whale exposure to MFA sonar, Claridge assumed that the two sample sites should have should have equal potential abundances and hypothesized that a lower abundance found at the AUTEC was due to either reduced prey availability at AUTEC or due to population level effects from the exposure to MFA sonar at AUTEC. There are two major issues with this study. First, all of the re-sighted whales during the 5-year study at both sites were female. Claridge acknowledges that this can lead to a negative bias in the estimation of abundances. It has been shown in other cetacean species that females with calves may prefer "nursery" habitats or form nursery groups with other mother-calf pairs (e.g., Scott et al. 1990; Claridge 2006; Weir et al. 2008). It may be that the site at Abaco is a preferred site for females with calves, while the site at AUTEC is not, and therefore over the 5-year study period fewer females with calves were observed at AUTEC as these females went elsewhere in the area during the 3-year weaning period. In addition, Marques et al. (2009) estimated the Blainville's beaked whale population at AUTEC to be between 22.5 and 25.3 animals per 1,000 km^2. This density was estimated over 6 days using passive acoustic methods, which is a method Claridge identified as one that may be better for estimating beaked whale densities than visual methods. The results at AUTEC are also biased by reduced effort and a shorter overall study period that did not capture some of the emigration/immigration trends Claridge identified at Abaco. For these reasons among others, it is unclear whether there are significant differences in the abundances between the two sites. Second, Claridge assumed that the two sites are identical and therefore should have equal potential abundances; Abaco is a "control" site with the difference being the use of sonar at AUTEC. Although the sample boundaries at each location were drawn to create samples "of comparable size," there are differences between the two sample area locations as follows: the Abaco site is along a leeward shore, AUTEC is windward; the Abaco sample area is a long narrow margin along a canyon wall, the rectangular AUTEC sample site is a portion of a deep and landlocked U-shaped trough. In addition to the physical differences, Claridge notes that it remains unclear whether or not variation in productivity between sites influenced what she refers to as the substantial differences in abundance. Claridge reports that a study investigating prey distributions at her sample locations was unable to sample prey at the beaked whale foraging depth. Claridge dismisses the possibility of differences in prey availability between the sites noting that there is no supporting evidence that prey availability differs between the two sites. As this study illustrates, the multiple and complex factors required by investigations of potential long-term cause and effect from actions at sea require a comprehensive assessment of all factors influencing potential trends in species abundances that are not likely attributable to a single cause and effect.

The best assessment of long-term consequences from training and testing activities will be to monitor the populations over time within a given Navy range complex. A U.S. workshop on Marine Mammals and Sound (Fitch et al. 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed monitoring plans for protected marine mammals and sea turtles occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy’s current mitigation practices. For example, results from 2 years (2009–2010) of intensive monitoring by independent scientists and Navy observers in Southern California Range Complex and Hawaii Range Complex have recorded an estimated 161,894 marine mammals with no evidence of distress or unusual behavior observed during Navy activities (Section 3.4.4.1, Summary of Monitoring and Observations During Navy Activities, for a broader discussion on this topic). Continued monitoring efforts over time will be necessary to completely evaluate the long-term consequences of exposure to noise sources.

3.4.3.1.10 Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals

If proposed Navy activities introduce sound or explosive energy into the marine environment, an analysis of potential impacts to marine mammals is conducted. To do this, information about the numerical sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed.

3.4.3.1.11 Frequency Weighting

Frequency-weighting functions are used to adjust the received sound level based on the sensitivity of the animal to the frequency of the sound. The weighting functions de-emphasize sound exposures at frequencies to which marine mammals are not particularly sensitive. This effectively makes the acoustic thresholds frequency-dependent, which means they are applicable over a wide range of frequencies and therefore applicable for a wide range of sound sources. Frequency-weighting functions, called "M-weighting" functions, were proposed by Southall et al. (2007) to account for the frequency bandwidth of hearing in marine mammals. These M-weighting functions were derived for each marine mammal hearing group based on an algorithm using the range of frequencies that are within 80 dB of an animal or group's best hearing. The Southall et al. (2007) M-weighting functions are nearly flat between the lower and upper cutoff frequencies, and thus were believed to represent a conservative approach to assessing the effects of noise (Figure 3.4-3). For the purposes of this analysis, the Navy will refer to these as Type I auditory weighting functions. Otariid seal thresholds and weighting functions were applied to sea otter as described in Finneran and Jenkins (2012).

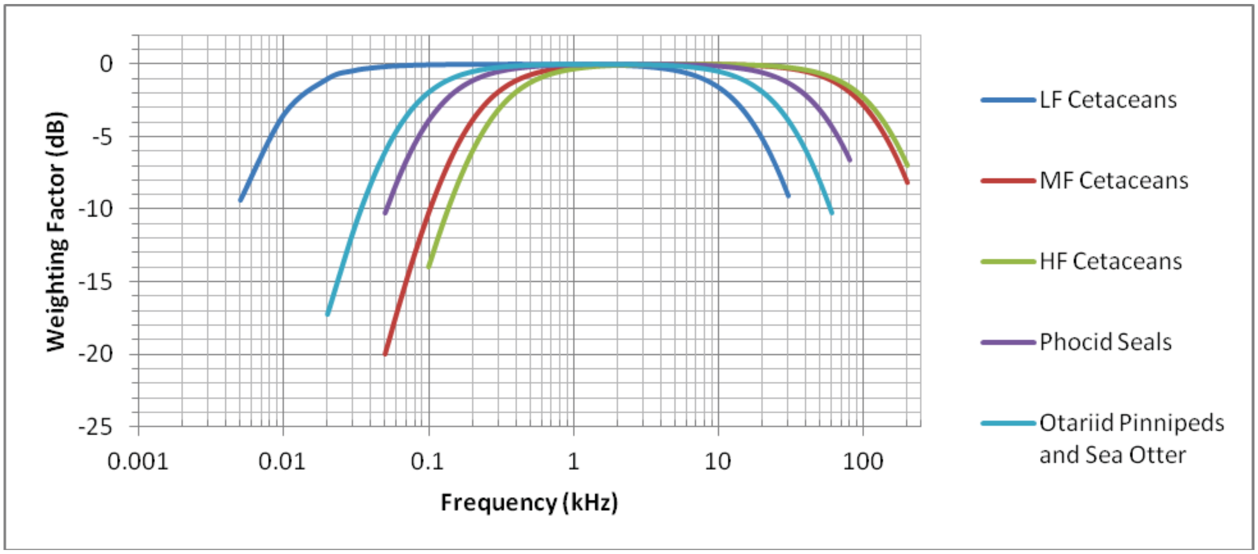


Figure 3.4-3: Type I Auditory Weighting Functions Modified from the Southall et al. (2007) M-Weighting Functions

Frequency Weighting Example:

A common dolphin, a mid-frequency cetacean (see 3.4.2.3.2), receives a 10 kHz ping from a sonar with a sound exposure level (SEL) of 180 dB re 1 µPa^2-s. To discern if this animal may suffer a TTS, the received level must first be adjusted using the appropriate Type II auditory weighting function for mid-frequency cetaceans (see Section 3.4.2.3.2). At 10 kHz, the weighting factor for mid-frequency cetaceans is -3 dB, which is then added to the received level (180 dB re 1 µPa^2-s + (-3 dB) = 177 dB re 1 µPa^2-s) to yield the weighted received level. This is compared to the Non-Impulse Mid-Frequency Cetacean TTS threshold (178 dB re 1 µPa^2-s; see Table 3.4-3). Since the adjusted received level is less than the threshold, TTS is not likely for this animal from this exposure.

While all data published since 2007 were reviewed to determine if any adjustments to the weighting functions were required, only two published experiments suggested that modification of the mid-frequency cetacean auditory weighting function was necessary (see Finneran and Jenkins [2012] for more details on that modification not otherwise provided below). The first experiment measured TTS in a bottlenose dolphin after exposure to pure tones with frequencies from 3 to 28 kHz (Finneran et al. 2010a). These data were used to derive onset-TTS values as a function of exposure frequency, and demonstrate that the use of a single numeric threshold for onset-TTS, regardless of frequency, is not correct. The second experiment examined how subjects perceived the loudness of sounds at different frequencies to derive equal loudness contours (Finneran and Schlundt 2011). These data are important because human auditory weighting functions are based on equal loudness contours. The dolphin equal loudness contours provide a means to generate auditory weighting functions in a manner directly analogous to the approach used to develop safe exposure guidelines for people working in noisy environments (National Institute for Occupational Safety and Health 1998).

Taken together, the recent higher-frequency TTS data and equal loudness contours provide the underlying data necessary to develop new weighting functions, referred to as Type II auditory weighting functions, to improve accuracy and avoid underestimating the impacts on animals at higher frequencies as shown in Figure 3.4-4. To generate the new Type II weighting functions, Finneran and Schlundt (2011) substituted lower and upper frequency values which differ from the values used by Southall et al. (2007).

The new weighting curve predicts appreciably higher (almost 20 dB) susceptibility for frequencies above 3 kHz for bottlenose dolphins, a mid-frequency cetacean. Since data below 3 kHz are not available, the original weighting functions from Southall et al. (2007) were substituted below this frequency. Low- and high-frequency cetacean weighting functions were extrapolated from the dolphin data as well, because of the suspected similarities of greatest susceptibility at best frequencies of hearing. Similar Type II weighting curves were not developed for pinnipeds since their hearing is markedly different from cetaceans, and because they do not hear as well at higher frequencies. Their weighting curves do not require the same adjustment (see Finneran and Jenkins 2012 for additional details).

The Type II auditory cetacean weighting functions (Figure 3.4-4) are applied to the received sound level before comparing it to the appropriate sound exposure level thresholds for TTS or PTS, or the impulse behavioral response threshold (note that for pinnipeds and sea otters, the Southall et al. (2007) weighting functions (Figure 3.4-4) are used in lieu of any new weighting functions). For some criteria, received levels are not weighted before being compared to the thresholds to predict effects. These include the peak pressure criteria for predicting TTS and PTS from underwater explosions; the acoustic impulse metrics used to predict onset-mortality and slight lung injury; and the thresholds used to predict behavioral responses from harbor porpoises and beaked whales from sonar and other active acoustic sources.

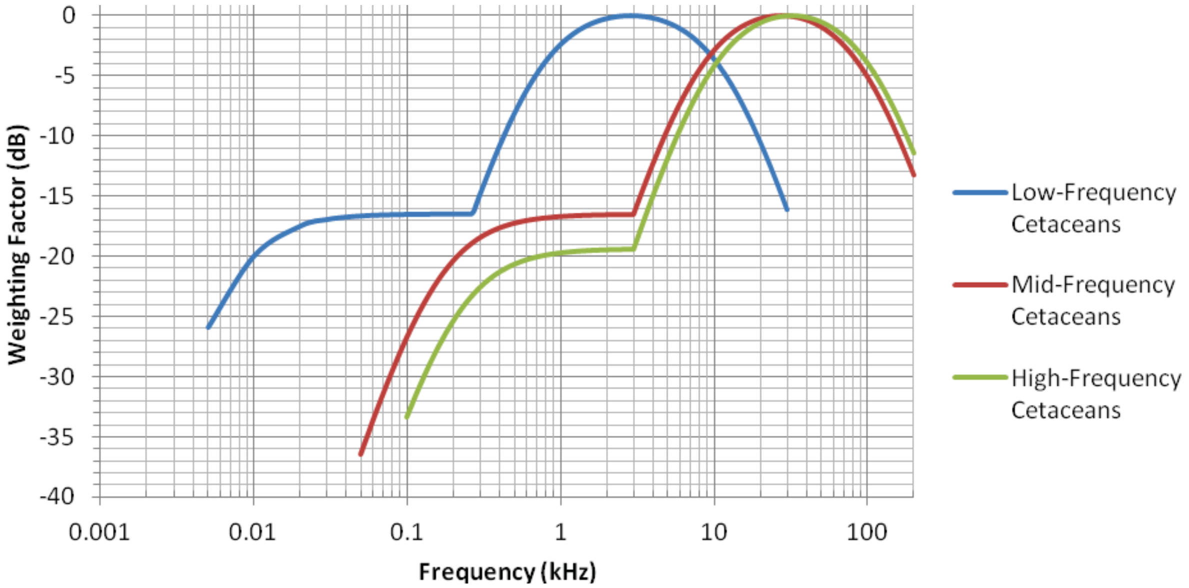


Figure 3.4-4: Type II Weighting Functions for Low-, Mid-, and High-Frequency Cetaceans

3.4.3.1.11.1 Summation of Energy from Multiple Sources

In most cases, an animal's received level will be the result of exposure to a single sound source. In some scenarios, however, multiple sources will be operating simultaneously, or nearly so, creating the potential for accumulation of energy from multiple sources. Energy is summed for multiple exposures of similar source types. For sonar, including use of multiple systems within any scenario, energy will be summed for all exposures within a cumulative exposure band, with the cumulative exposure bands defined in four bands: 0–1.0 kHz (low-frequency sources), 1.1–10.0 kHz (mid-frequency sources), 10.1–100.0 kHz (high-frequency sources), and above 100.0 kHz (very high-frequency sources). Sources operated at frequencies above 200 kHz are considered to be inaudible to all groups of marine mammals and are not analyzed in the quantitative modeling of exposure levels. After the energy has been summed within each frequency band, the band with the greatest amount of energy is used to evaluate the onset of PTS or TTS. For explosives, including use of multiple explosives in a single scenario, energy is summed across the entire frequency band.

3.4.3.1.11.2 Hearing Loss – Temporary and Permanent Threshold Shift

Criteria for physiological effects from sonar and other active acoustic sources are based on TTS and PTS with thresholds based on cumulative sound exposure levels (Table 3.4-4). The onset of TTS or PTS from exposure to impulse sources is predicted using a sound exposure level-based threshold in conjunction with a peak pressure threshold (Table 3.4-5). The horizontal ranges are then compared, with the threshold producing the longest range being the one used to predict effects. For multiple exposures within any 24-hour period, the received sound exposure level for individual events is accumulated for each animal.

Since no studies have been designed to intentionally induce PTS in marine mammals, onset-PTS levels have been estimated using empirical TTS data obtained from marine mammals and relationships between TTS and PTS established in terrestrial mammals.

Temporary and permanent threshold shift thresholds are based on TTS onset values for impulse and non-impulse sounds obtained from representative species of mid- and high-frequency cetaceans and pinnipeds. These data are then extended to the other marine mammals for which data are not available. The Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis Technical Report provides a detailed explanation of the selection of criteria and derivation of thresholds for temporary and permanent hearing loss for marine mammals (Finneran and Jenkins 2012). Section 3.4.3.1.3 (Hearing Loss) provided the specific meanings of temporary and permanent threshold shift as used in this EIS/OEIS.

Table 3.4-4: Acoustic Criteria and Thresholds for Predicting Physiological Effects to Marine Mammals Underwater from Sonar and Other Active Acoustic Sources

Hearing Group	Species	Onset temporary threshold shift	Onset permanent threshold shift
Low-Frequency Cetaceans	All mysticetes	178 dB re 1 µPa^2-s SEL (Type II weighting)	198 dB re 1 µPa^2-s SEL (Type II weighting)
Mid-Frequency Cetaceans	Dolphins, beaked whales, and medium and large toothed whales	178 dB re 1 µPa^2-s SEL (Type II weighting)	198 dB re 1 µPa^2-s SEL (Type II weighting)
High-Frequency Cetaceans	Porpoises and *Kogia* spp.	152 dB re 1 µPa^2-s SEL (Type II weighting)	172 dB re 1 µPa^2-s SEL (Type II weighting)
Phocid Seals (underwater)	Northern Elephant & Harbor Seals	183 dB re 1 µPa^2-s SEL (Type I weighting)	197 dB re 1 µPa^2-s SEL (Type I weighting)
Otariidae (underwater)	Sea Lion & Fur Seals	206 dB re 1 µPa^2-s SEL (Type I weighting)	220 dB re 1 µPa^2-s SEL (Type I weighting)
Mustelidae (underwater)	Sea Otters		

Notes: dB = decibels, SEL = Sound Exposure Level, dB re 1 µPa^2-s = decibels referenced to 1 micropascal squared second

Table 3.4-5: Criteria and Thresholds for Predicting Physiological Effects to Marine Mammals Underwater for Explosives

Group	Species	Onset TTS	Onset PTS	Onset Slight GI Tract Injury	Onset Slight Lung Injury[1]	Onset Mortality[1]
Low Frequency Cetaceans	All mysticetes	172 dB re 1 μPa^2-s SEL (Type II weighting) or 224 dB re 1 μPa Peak SPL (unweighted)	187 dB re 1 μPa^2-s SEL (Type II weighting) or 230 dB re 1 μPa Peak SPL (unweighted)	237 dB re 1 μPa (unweighted)	Note 1	Note 2
Mid-Frequency Cetaceans	Most delphinids, medium and large toothed whales	172 dB re 1 μPa^2-s SEL (Type II weighting) or 224 dB re 1 μPa Peak SPL (unweighted)	187 dB re 1 μPa^2-s SEL (Type II weighting) or 230 dB re 1 μPa Peak SPL (unweighted)			
High Frequency Cetaceans	Porpoises and *Kogia* spp.	146 dB re 1 μPa^2-s SEL (Type II weighting) or 195 dB re 1 μPa Peak SPL (unweighted)	161 dB re 1 μPa^2-s SEL (Type II weighting) or 201 dB re 1 μPa Peak SPL (unweighted)			
Phocidae	Northern elephant seals and harbor seals	177 dB re 1 μPa^2-s (Type I weighting) or 212 dB re 1 μPa Peak SPL (unweighted)	192 dB re 1 μPa^2-s (Type I weighting) or 218 dB re 1 μPa Peak SPL (unweighted)			
Otariidae	Sea lions and Fur seals	200 dB re 1 μPa^2-s (Type I weighting) or 212 dB re 1 μPa Peak SPL (unweighted)	215 dB re 1 μPa^2-s (Type I weighting) or 218 dB re 1 μPa Peak SPL (unweighted)			
Mustelidae	Sea Otters					

Note 1 $\boxed{= 39.1 M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec}$

Note 2 $\boxed{= 91.4 M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec}$

[1] Impulse calculated over a delivery time that is the lesser of the initial positive pressure duration or 20 percent of the natural period of the assumed-spherical lung adjusted for animal size and depth.

Notes: TTS = temporary threshold shift, PTS = permanent threshold shift, GI = gastrointestinal, M = mass of animals in kilograms, D_{Rm} = depth of receiver (animal) in meters, SEL = Sound Exposure Level, SPL = Sound Pressure Level (re 1 μPa), dB = decibels, dB re 1 μPa = decibels referenced to 1 micropascal, dB re 1 μPa^2-s = decibels referenced to 1 micropascal squared second

3.4.3.1.11.3 Temporary Threshold Shift for Sonar and Other Active Acoustic Sources

TTS involves no tissue damage, is by definition temporary, and therefore is not considered injury. TTS values for mid-frequency cetaceans exposed to non-impulse sound are derived from multiple studies (Schlundt et al. 2000; Finneran et al. 2005; Mooney 2009a; Finneran et al. 2010b; Finneran and Schlundt

2010) from two species, bottlenose dolphins and beluga whales. Especially notable are data for frequencies above 3 kHz, where bottlenose dolphins have exhibited lower TTS onset thresholds than at 3 kHz (Finneran and Schlundt 2010; Finneran 2011). This difference in TTS onset at higher frequencies is incorporated into the weighting functions (see Section 3.4.3.1.11, Frequency Weighting).

Previously, there were no direct measurements of TTS from non-impulse sound in high-frequency cetaceans. Lucke et al. (2009) measured TTS in a harbor porpoise exposed to a small seismic air gun and those results are reflected in the current impulse sound TTS thresholds described below. The beluga whale, which had been the only species for which both impulse and non-impulse TTS data exist has a non-impulse TTS onset value about 6 dB above the (weighted) impulse threshold (Schlundt et al. 2000; Finneran et al. 2002). Therefore, 6 dB was added to the harbor porpoise's impulse TTS threshold demonstrated by Lucke et al. (2009) to derive the non-impulse TTS threshold used in the current Navy modeling for high frequency cetaceans. Report on the first direct measurements of TTS from non-impulse sound has been recently presented by Kastelein et al. (2012b) for harbor porpoise. These new data are fully consistent with the current harbor porpoise thresholds used in the modeling of effects from non-impulse sources.

There are no direct measurements of TTS or hearing abilities for low-frequency cetaceans. The Navy uses mid-frequency cetacean thresholds to assess PTS and TTS for low-frequency cetaceans, since mid-frequency cetaceans are the most similar to the low frequency group (see Finneran and Jenkins (2012) on the development of the thresholds and criteria).

Pinniped TTS criteria are based on data provided by Kastak et al. (2005) for representative species of both of the pinniped hearing groups: harbor seals (Phocidae) and California sea lions (Otariidae). Kastak et al. (2005) used octave band noise centered at 2.5 kHz to extrapolate an onset TTS threshold. More recently Kastelein et al. (2012c) used octave band noise centered at 4 kHz to obtain TTS thresholds in the same two species resulting in similar levels causing onset-TTS as those found in Kastak et al. (2005). For sea otters, the otariid TTS threshold and weighting function are applied due to similarities in taxonomy and auditory performance.

The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict TTS.

3.4.3.1.11.4 Temporary Threshold Shift for Explosives

The TTS sound exposure level thresholds for cetaceans are consistent with the USS MESA VERDE ship shock trial that was approved by NMFS (73 Federal Register [FR] 143) and are more representative of TTS induced from impulses (Finneran et al. 2002) rather than pure tones (Schlundt et al. 2000). In most cases, a total weighted sound exposure level is more conservative than greatest sound exposure level in one-third octave bands, which was used prior to the USS MESA VERDE ship shock trials. There are no data on TTS obtained directly from low-frequency cetaceans, so mid-frequency cetacean impulse threshold criteria from Finneran et al. (2002) have been used. High frequency cetacean TTS thresholds are based on research by Lucke et al. (2009), who exposed harbor porpoises to pulses from a single air gun.

Pinniped criteria were not included for prior ship shock trials, as pinnipeds were not expected to occur at the shock trial sites, and TTS criteria for previous Navy EIS/OEISs also were not differentiated between cetaceans and pinnipeds (National Marine Fisheries Service 2008a, 2008b). TTS values for impulse sound criteria have not been obtained for pinnipeds, but there are TTS data for octave band sound from representative species of both major pinniped hearing groups (Kastak et al. 2005). Impulse sound TTS criteria for pinnipeds were estimated by applying the difference between mid-frequency cetacean TTS onset for impulse and non-impulse sounds to the pinniped non-impulse TTS data (Kastak et al. 2005), a methodology originally developed by Southall et al. (2007). Therefore, the TTS criteria for impulse sounds from explosions for pinnipeds is 6 dB less than the non-impulse onset-TTS criteria derived from Kastak et al. (2005).

For sea otters, the otariid TTS and PTS thresholds and weighting function are applied due to similarities in taxonomy and the likely hearing ability of sea otters when underwater.

3.4.3.1.11.5 Permanent Threshold Shift for Sonar and Other Active Acoustic Sources

There are no direct measurements of PTS onset in marine mammals. Well understood relationships between terrestrial mammalian TTS and PTS have been applied to marine mammals. Threshold shifts up to 40–50 dB have been induced in terrestrial mammals without resultant PTS (Ward et al. 1958, 1959a, b; Miller et al. 1963). These data would suggest that a PTS criteria of 40 dB would be reasonable for conservatively predicting (overestimating) PTS in marine mammals. Data from terrestrial mammal testing (Ward et al. 1958, 1959a, b) show growth of TTS by 1.5 to 1.6 dB for every 1 dB increase in exposure level. The difference between measureable TTS onset (6 dB) and the selected 40 dB upper safe limit of TTS yields a difference in TTS of 34 dB which, when divided by a TTS growth function of 1.6 indicates that an increase in exposure of 21 dB would result in 40 dB of TTS. For simplicity and additional conservatism we have rounded that number down to 20 dB (Southall et al. 2007).

Therefore, exposures to sonar and other active acoustic sources with levels 20 dB above those producing TTS are assumed to produce a PTS. For example, an onset-TTS criteria of 195 dB re 1 μPa^2-s would have a corresponding onset-PTS criteria of 215 dB re 1 μPa^2-s. This extrapolation process is identical to that recently proposed by Southall et al. (2007). The method overestimates or predicts greater effects than have actually been observed in tests on a bottlenose dolphin (Schlundt et al. 2006; Finneran et al. 2010a) and is therefore protective.

Kastak et al. (2007) obtained different TTS growth rates for pinnipeds than Finneran and colleagues obtained for mid-frequency cetaceans. NMFS recommended reducing the estimated PTS criteria for both groups of pinnipeds, based on the difference in TTS growth rate reported by Kastak et al. (2007) (14 dB instead of 20 dB).

The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict PTS.

3.4.3.1.11.6 Permanent Threshold Shift for Explosions

Since marine mammal PTS data from impulse exposures do not exist, onset PTS levels for these animals are estimated by adding 15 dB to the sound exposure level-based TTS threshold and by adding 6 dB to the peak pressure based thresholds. These relationships were derived by Southall et al. (2007) from impulse noise TTS growth rates in chinchillas. The appropriate frequency weighting function for each species group is applied when using the resulting sound exposure level-based thresholds, as shown in Figure 3.4-4, to predict PTS.

3.4.3.1.12 Behavioral Responses

The behavioral response criteria are used to estimate the number of that may exhibit a behavioral response. In this analysis, animals may be behaviorally harassed in each modeled scenario (using the

Navy Acoustic Effects Model [NAEMO]) or within each 24-hour period, whichever is shorter. Therefore, the same animal could have a significant behavioral reaction multiple times over the course of a year.

3.4.3.1.12.1 Sonar and Other Active Acoustic Sources

Potential behavioral effects from in-water sound from sonar and other active acoustic sources were predicted using a behavioral response function for most animals. The received sound level is weighted with Type I auditory weighting functions (Southall et al. 2007; see Figure 3.4-3) before the behavioral response function is applied. The harbor porpoise and beaked whales are the exception. They have unique criteria based on specific data that show these animals to be especially sensitive to sound. Harbor porpoise and beaked whale non-impulse behavioral criteria are used unweighted (without weighting the received level before comparing it to the threshold) (see Finneran and Jenkins 2012).

Behavioral Response Functions

The Navy worked with NMFS to define a mathematical function used to predict potential behavioral effects to mysticetes (Figure 3.4-5) and odontocetes (Figure 3.4-6) from mid-frequency sonar (National Marine Fisheries Service 2008). These analyses assume that the probability of eliciting a behavioral response to sonar and other active acoustic sources on individual animals would be a function of the received sound pressure level (dB re 1 µPa). The behavioral response function applied to mysticetes (Figure 3.4-5) differs from that used for odontocetes and pinnipeds (Figure 3.4-6) in having a shallower slope, which results in the inclusion of more behavioral events at lower received levels, consistent with observational data from North Atlantic right whales (Nowacek et al. 2007). Although the response functions differ, the intercepts on each figure highlight that each function has a 50 percent probability of harassment at a received level of 165 dB SPL. These analyses assume that sound poses a negligible risk to marine mammals if they are exposed to sound pressure levels below a certain basement value.

The values used in this analysis are based on three sources of data: TTS experiments conducted at the Navy Marine Mammal Program and documented in Finneran et al. (2001, 2003), Finneran et al. (2005), and Finneran and Schlundt (2004); reconstruction of sound fields produced by the USS Shoup associated with the behavioral responses of killer whales observed in Haro Strait (Fromm 2004a, b; U.S. Department of the Navy 2004; National Marine Fisheries Service 2005b); and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components documented in Nowacek et al. (2004).

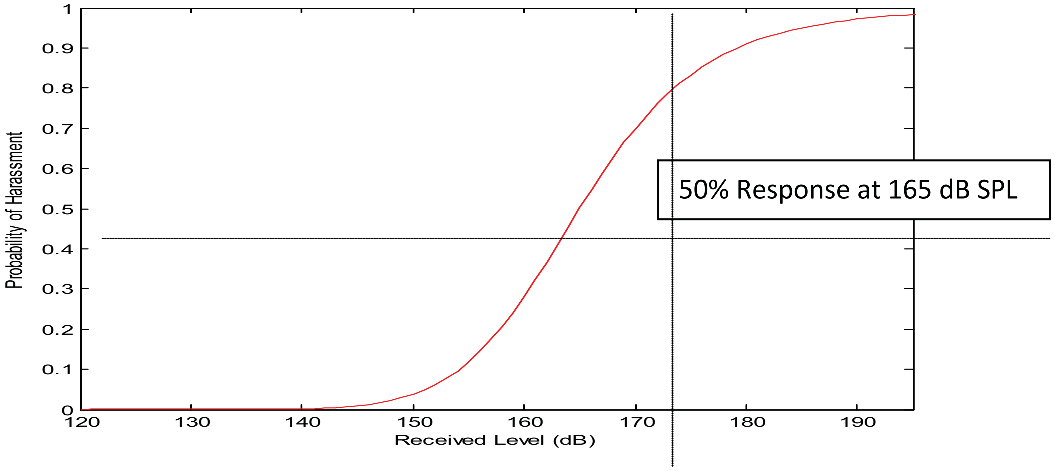


Figure 3.4-5: Behavioral Response Function Applied to Mysticetes

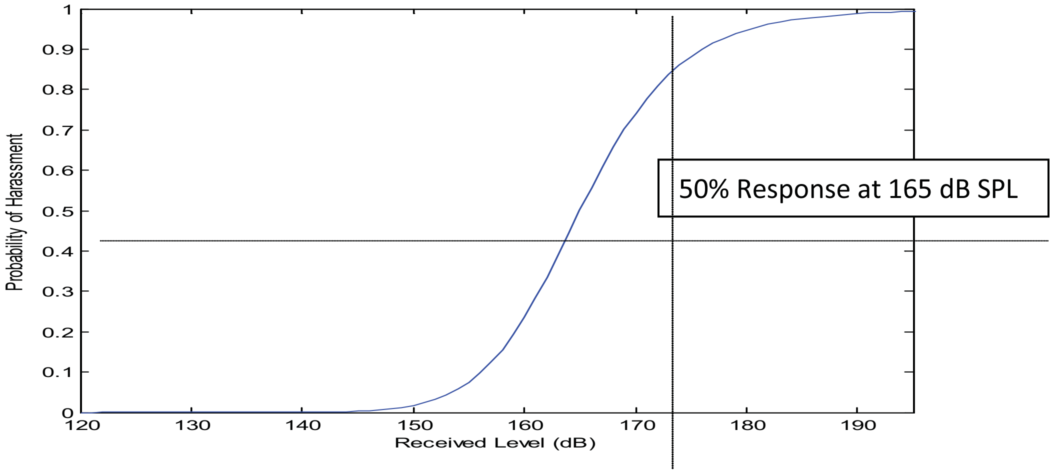


Figure 3.4-6: Behavioral Response Function Applied to Odontocetes, Pinnipeds, and Sea Otters

In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al. 1995; Wartzok 2003; Southall et al. 2007). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict. Therefore, the behavioral response functions represent a relationship that is deemed to be generally accurate, but may not be true in specific circumstances.

Specifically, the behavioral response function treats the received level as the only variable that is relevant to a marine mammal's behavioral response. However, many other variables, such as the marine mammal's gender, age, and prior experience; the activity it is engaged in during a sound exposure; its distance from a sound source; the number of sound sources; and whether the sound sources are approaching or moving away from the animal can be critically important in determining whether and how a marine mammal will respond to a sound source (Southall et al. 2007). At present, available data do not allow for incorporation of these other variables in the current behavioral response functions; however, the response function represents the best use of the data that are available. Furthermore, the behavioral response functions do not differentiate between different types of behavioral reactions (e.g., area avoidance, diving avoidance, or alteration of natural behavior) or provide information regarding the predicted consequences of the reaction.

The behavioral response function is used to estimate the percentage of an exposed population that is likely to exhibit behaviors that would qualify as harassment (as that term is defined by the MMPA applicable to military readiness activities, such as the Navy's testing and training with MFA sonar) at a given received level of sound. For example, at 165 dB SPL (dB re 1 µPa root mean square), the risk (or probability) of harassment is defined according to this function as 50 percent. This means that 50 percent of the individuals exposed at that received level would be predicted to exhibit a significant behavioral response.

Harbor Porpoises

The information currently available regarding this species suggests a very low threshold level of response for both captive and wild animals. Threshold levels at which both captive (Kastelein et al. 2000; Kastelein et al. 2005b) and wild harbor porpoises (Johnston 2002) responded to sound (e.g., acoustic harassment devices, acoustic deterrent devices, or other non-impulse sound sources) are very low (e.g., approximately 120 dB re 1 µPa). Therefore, a sound pressure level of 120 dB re 1 µPa is used in this analysis as a threshold for predicting behavioral responses in harbor porpoises (Table 3.4-6).

Table 3.4-6: Summary of Behavioral Thresholds for Marine Mammals

Group	Behavioral Thresholds for Sonar and Other Active Acoustic Sources	Behavioral Thresholds for Explosions
Low-Frequency Cetaceans	SPL: BRF_1 (Type I Weighting)	167 dB re 1 μPa^2-s SEL (Type II Weighting)
Mid-Frequency Cetaceans	SPL: BRF_2 (Type I Weighting)	167 dB re 1 μPa^2-s SEL (Type II Weighting)
High-Frequency Cetaceans	SPL: BRF_2 (Type I Weighting)	141 dB re 1 μPa^2-s SEL (Type II Weighting)
Phocid Seals (underwater)	SPL: BRF_2 (Type I Weighting)	172 dB re 1 μPa^2-s SEL (Type I Weighting)
Otariid and Mustelid (underwater)	SPL: BRF_2 (Type I Weighting)	172 dB re 1 μPa^2-s SEL (Type I Weighting)
Beaked Whales	(unweighted) SPL: 140 dB re 1 µPa	167 dB re 1 μPa^2-s SEL (Type II Weighting)
Harbor Porpoises	(unweighted) SPL: 120 dB re 1 µPa	141 dB re 1 μPa^2-s SEL (Type II Weighting)

Notes: BRF = Behavioral Response Function, dB re 1 µPa = decibels referenced to 1 micropascal, μPa^2-s = micropascal squared second, SPL = Sound Pressure Level, SEL = Sound Exposure Level

Beaked Whales

The inclusion of a special behavioral response criterion for beaked whales of the family Ziphiidae is new to these Phase II criteria. It has been speculated for some time that beaked whales might have unusual sensitivities to sound due to a few strandings in conjunction with mid-frequency sonar use, even in areas where other species were more abundant (D'Amico et al. 2009), but there were not sufficient data to support a separate treatment for beaked whales until recently. With the recent publication of results from beaked whale monitoring and experimental exposure studies on the Navy's instrumented AUTEC range in the Bahamas (McCarthy et al. 2011; Tyack et al. 2011), there are now statistically strong data demonstrating that beaked whales tend to avoid both actual naval mid-frequency sonar in real anti-submarine training scenarios as well as playbacks of killer whale vocalizations, and other anthropogenic sounds. Tyack et al. (2011) report that, in reaction to sonar playbacks, most beaked whales stopped echolocating, made long slow ascent, and moved away from the sound. During an exercise using mid-frequency sonar, beaked whales avoided the sonar acoustic footprint at a distance where the received level was "around 140 dB" (SPL) and once the exercise ended, beaked whales re-inhabited the center of exercise area within 2–3 days (Tyack et al. 2011). The Navy has therefore adopted a 140 dB re 1 µPa sound pressure level threshold for behavioral effects for all beaked whales (see Table 3.4-6).

Since the development of the criterion, analysis of the 2010 and 2011 field season data of the southern California Behavioral Responses Study have been published. The study, DeRuiter et al. (2013a), provides similar evidence of Cuvier's beaked whale sensitivities to sound based on two controlled exposures. Two whales, one in each season, were tagged and exposed to simulated MFA sonar at distances of 3.4–9.5 km. The 2011 whale was also incidentally exposed to MFA sonar from a distant naval exercise (approximately 118 km away). Received levels from the MFA sonar signals during the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa root mean square, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Because the sample size was limited (controlled exposures during a single dive in both 2010 and 2011), baseline behavioral data was obtained from different stocks and geographic areas (i.e., Hawaii and Mediterranean Sea), and the responses exhibited to controlled exposures were not exhibited by an animal exposed to some of the same received levels of real sonar exercises, the Navy relied on the studies at the AUTEC that analyzed beaked whale responses to actual naval exercises using MFA sonar to evaluate potential behavioral responses by beaked whales to proposed training and testing activities using sonar and other active acoustic sources.

3.4.3.1.12.2 Sound from Explosions

If more than one impulse event occurs within any given 24-hour period within a training or testing activity, criteria are applied to predict the number of animals that may have a behavioral reaction. For multiple impulse events the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold (in sound exposure level) (see Table 3.4-6). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulse TTS testing (Schlundt et al. 2000).

Some multiple impulse events, such as certain gunnery exercises, may be treated as a single impulse event because a few explosions occur closely spaced within a very short time (a few seconds). For single impulses at received sound levels below hearing loss thresholds, the most likely behavioral response is a brief alerting or orienting response. Since no further sounds follow the initial brief impulses, the consequence of the reaction is likely trivial and no Level B takes or significant harm as defined under ESA is considered to have occurred. This reasoning was applied to previous ship shock trials (63 FR 230; 66 FR 87; 73 FR 143) and is extended to the criteria used in this analysis.

Since impulse events can be quite short, it may be possible to accumulate multiple received impulses at sound pressure levels considerably above the energy-based criterion and still not be considered a behavioral take. The Navy treats all individual received impulses as if they were 1 second long for the purposes of calculating cumulative sound exposure level for multiple impulse events. For example, five impulses, each 0.1 second long, received at 178 dB sound pressure level would equal a 175 dB sound exposure level and would not be predicted as leading to a significant behavioral response. However, if the five 0.1-second pulses are treated as a 5-second exposure, it would yield an adjusted value of approximately 180 dB, exceeding the threshold. For impulses associated with explosions that have durations of a few microseconds, this assumption greatly overestimates effects based on sound exposure level metrics such as TTS and PTS and behavioral responses.

Appropriate weighting values will be applied to the received impulse in one-third octave bands and the energy summed to produce a total weighted sound exposure level value. For impulse behavioral criteria, the new weighting functions (see Figure 3.4-4) are applied to the received sound level before being compared to the threshold.

3.4.3.1.13 Mortality and Injury from Explosions

There is a considerable body of laboratory data on actual injury for impulse sound, usually from explosive pulses, obtained from tests with a variety of lab animals (mice, rats, dogs, pigs, sheep and other species). Onset Mortality, Onset Slight Lung Injury, and Onset Slight Gastrointestinal (GI) Tract Injury represent a series of effects with decreasing likelihood of serious injury or lethality. Primary impulse injuries from explosive blasts are the result of differential compression and rapid re-expansion of adjacent tissues of different acoustic properties (e.g., between gas-filled and fluid-filled tissues or between bone and soft tissues). These injuries usually manifest themselves in the gas-containing organs (lung and gut) and auditory structures (e.g., rupture of the eardrum across the gas-filled spaces of the outer and inner ear) (Craig and Hearn 1998; Craig Jr. 2001).

Criteria and thresholds for predicting mortality and injury to marine mammals from impulse sources were initially developed for the U.S. Navy shock trials of the SEAWOLF submarine (Craig and Hearn 1998) and WINSTON S. CHURCHILL surface ship (Craig Jr. 2001). These criteria and thresholds were also adopted by NMFS in several Final Rules issued under the MMPA (63 FR 230; 66 FR 87; 73 FR 121; 73 FR 199). These criteria and thresholds were revised as necessary based on new science and used for the shock trial of the U.S. Navy amphibious transport dock ship MESA VERDE (Finneran and Jenkins 2012) and were subsequently adopted by NMFS in their MMPA Final Rule authorizing the MESA VERDE shock trial (73 FR 143). Upper and lower frequency limits of hearing are not applied for lethal and injurious exposures. These criteria and their origins are explained in greater detail in Finneran and Jenkins (2012), who cover the development of the thresholds and criteria for assessment of impacts.

Species-specific minimal animal masses are used for determining impulse-based thresholds because they most closely represent effects on individual species. The Navy's Thresholds and Criteria Technical Report (Finneran and Jenkins 2012) provides a nominal conservative body mass for each species based on newborn weights. In some cases body masses were extrapolated from similar species rather than the listed species. The scaling of lung volume to depth is conducted for all species since data are from experiments with terrestrial animals held near the water's surface.

Because the thresholds for onset of mortality and onset of slight lung injury are proportional to the cube root of body mass, the use of all newborn, or calf, weights rather than representative adult weights results in an over-estimate of effects to animals near an explosion. The range to onset mortality for a newborn compared to an adult animal of the same species can range from less than twice to over four times as far from an explosion, depending on the differences in calf versus adult sizes for a given species and the size of the explosion. Considering that injurious high pressures due to explosions propagate away from detonations in a roughly spherical manner, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.

The use of onset mortality and onset slight lung injury is a conservative method to estimate potential mortality and recoverable (non-mortal, non-PTS) injuries. When analyzing impulse-based effects, all animals within the range to these thresholds are assumed to experience the effect. The onset mortality and onset slight lung injury criteria are based on the impulse at which these effects are predicted for 1 percent of animals; the portion of animals affected would increase closer to the explosion. As discussed above, due to these conservative criteria used to predict these effects, it is likely that fewer animals would be affected than predicted under the Navy's acoustic analysis. Therefore, these criteria conservatively over-estimate the number of animals that could be killed or injured.

3.4.3.1.13.1 Onset of Gastrointestinal Tract Injury

Evidence indicates that gas-containing internal organs, such as lungs and intestines, were the principle damage sites from shock waves in submerged terrestrial mammals (Clark and Ward 1943; Greaves et al. 1943; Richmond et al. 1973; Yelverton et al. 1973). Furthermore, slight injury to the gastrointestinal tract may be related to the magnitude of the peak shock wave pressure over the hydrostatic pressure and would be independent of the animal's size and mass (Goertner 1982). Slight contusions to the gastrointestinal tract were reported during small charge tests (Richmond et al. 1973), when the peak was 237 dB re 1 µPa.

There are instances where injury to the gastrointestinal tract could occur at a greater distance from the source than slight lung injury, especially for animals near the surface. Gastrointestinal tract injury from small test charges (described as "slight contusions") was observed at peak pressure levels as low as 104 pounds per square inch (psi), equivalent to a sound pressure level of 237 dB re 1 µPa (Richmond et al. 1973). This criterion was previously used by Navy and NMFS for ship shock trials (Finneran and Jenkins 2012; National Marine Fisheries Service 63 FR 230, 66 FR 87, 73 FR 143).

3.4.3.1.13.2 Slight Lung Injury and Mortality

In air or submerged, the most commonly reported internal bodily injury was hemorrhaging in the fine structure of the lungs. Biological damage is governed by the impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973; Yelverton et al. 1973; Yelverton et al. 1975; Yelverton and Richmond 1981). Therefore, impulse was used as a metric upon which internal organ injury could be predicted.

Explosive thresholds for slight injury and onset mortality are indexed to 75 and 93 lb. (34 and 42 kg) for mammals, respectively (Richmond et al. 1973). The regression curves based on these experiments were plotted, such that a prediction of mortality to larger animals could be determined as a function of positive impulse and mass (Craig Jr. 2001). After correction for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass, as used in the Goertner injury model (Goertner 1982), the minimum impulse for predicting onset of extensive lung injury for "1 percent Mortality" (defined as most survivors had moderate blast injuries and should survive on their own) and slight lung injury for "0 percent Mortality" (defined as no mortality, slight blast injuries) (Yelverton and Richmond 1981) were derived for each species. The Navy uses the minimum impulse level predictive of extensive lung injury, the exposure level likely to result in 1 percent mortality of animals in a population (99 percent would be expected to recover from the injury) as the onset of mortality. The scaling of lung volume to depth is conducted for all species, since data are from experiments with terrestrial animals held near the water's surface, and marine mammals' gaseous cavities compress with depth, making them less vulnerable to impulse injury. The received impulse necessary for onset mortality or slight lung injury must be delivered over a time period that is the lesser of the positive pressure duration, or 20 percent of the natural period of the assumed-spherical lung adjusted for the size and depth of the animal. Therefore, as depth increases or animal size decreases, the impulse delivery time to experience an effect decreases (Goertner 1982).

Species-specific masses are used for determining impulse-based thresholds because they most closely represent effects to individual species. The Navy's Thresholds and Criteria Technical Report (Finneran and Jenkins 2012) provides a nominal conservative body mass for each species based on newborn weights. In some cases body masses were extrapolated from similar species rather than the listed species. The scaling of lung volume to depth is conducted for all species since data are from experiments with terrestrial animals held near the water's surface. Because the thresholds for onset of mortality and onset of slight lung injury are proportional to the cube root of body mass, the use of all newborn, or calf, weights rather than representative adult weights results in an over-estimate of effects to animals near an explosion. The range to onset mortality for a newborn compared to an adult animal of the same species can range from less than twice to over four times as far from an explosion, depending on the differences in calf versus adult sizes for a given species and the size of the explosion. Considering that injurious high pressures due to explosions propagate away from detonations in a roughly spherical manner, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.

3.4.3.1.14 Quantitative Analysis

The Navy performed a quantitative analysis to estimate the number of marine mammals that could be affected by acoustic sources or explosives used during Navy training and testing activities. Inputs to the quantitative analysis include marine mammal density estimates; marine mammal depth occurrence distributions; oceanographic and environmental data; marine mammal hearing data; and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer modeled estimates and a post-model analysis to determine the number of potential mortalities and harassments. The model calculates sound energy propagation from sonar, other active acoustic sources, and explosives during naval activities; the sound or impulse received by animat dosimeters representing marine mammals distributed in the area around the modeled activity; and whether the sound or impulse received by a marine mammal exceeds the thresholds for effects. The model estimates are then further analyzed to consider animal avoidance and implementation of mitigation measures, resulting in final estimates of potential effects due to Navy training and testing.

Various computer models and mathematical equations can be used to predict how energy spreads from a sound source (e.g., sonar or underwater detonation) to a receiver (e.g., dolphin or sea turtle). See Introduction to Acoustics (Section 3.0.4) and Acoustic Primer (Appendix G) for background information about how sound travels through the water. Basic underwater sound models calculate the overlap of energy and marine life using assumptions that account for the many, variable, and often unknown factors that can influence the result. Assumptions in previous and current Navy models have intentionally erred on the side of overestimation when there are unknowns or when the addition of other variables was not likely to substantively change the final analysis. For example, because the ocean environment is extremely dynamic and information is often limited to a synthesis of data gathered over wide areas and requiring many years of research, known information tends to be an average of a seasonal or annual variation. El Niño Southern Oscillation events of the ocean-atmosphere system are an example of dynamic change where unusually warm or cold ocean temperatures are likely to redistribute marine life and alter the propagation of underwater sound energy. Previous Navy modeling (U.S. Department of the Navy 2009) therefore made some assumptions indicative of a maximum theoretical propagation for sound energy (such as a perfectly reflective ocean surface and a flat seafloor).

More complex computer models build upon basic modeling by factoring in additional variables in an effort to be more accurate by accounting for such things as variable bathymetry and an animal's likely presence at various depths.

- NAEMO accounts for the variability of the sound propagation data in both distance and depth when computing the received sound level on the animals. Previous models captured the variability in sound propagation over range and used a conservative approach to account for only the maximum received sound level within the water column.

- NAEMO bases the distribution of animats (virtual representation of an animal) over the operational area on density maps, which provides a more natural distribution of animals. Previous models assumed a uniform distribution of animals over the operational area.
- NAEMO distributes animats throughout the three-dimensional water space proportional to the known time that animals of that species spend at varying depths. Previous models assumed animals were placed at the depth where the maximum sound received level occurred for each distance from a source.
- NAEMO conducts a statistical analysis to compute the estimated effects on animals. Previous models assumed all animals within a defined distance would be affected by the sound.

The Navy has developed a set of data and new software tools for quantification of estimated marine mammal impacts from Navy activities. This new approach is the resulting evolution of the basic model previously used by Navy and reflects a more complex modeling approach as described below. Although this more complex computer modeling approach accounts for various environmental factors affecting acoustic propagation, the current software tools do not consider the likelihood that a marine mammal would attempt to avoid repeated exposures to a sound or avoid an area of intense activity where a training or testing event may be focused. Additionally, the software tools do not consider the implementation of mitigation (e.g., stopping sonar transmissions when a marine mammal is within a certain distance of a ship or mitigation zone clearance prior to detonations). In both of these situations, naval activities are modeled as though an activity would occur regardless of proximity to marine mammals and without any horizontal movement by the animal away from the sound source or human activities. Therefore, the final step of the quantitative analysis of acoustic effects is to consider the implementation of mitigation and the possibility that marine mammals would avoid continued or repeated sound exposures. This final step in the modeling process is meant to better quantify the predicted effects by accounting for likely animal avoidance behavior and implementation of standard Navy mitigations.

3.4.3.1.14.1 Marine Species Density Data

A quantitative analysis of impacts on a species requires data on the abundance and distribution of the species population in the potentially impacted area. The most appropriate metric unit for this type of analysis is density, which is described as the number of animals present per unit area.

There is no single source of density data for every area, species, and season because of the fiscal costs, resources, and effort involved in NMFS providing enough survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the Study Area, the Navy needed to compile data from multiple sources. To develop a database of marine species density estimates, the Navy, in consultation with NMFS experts, adopted a protocol to select the best available data sources based on species, area, and season (see the Navy’s Pacific Marine Species Density Database Technical Report; U.S. Department of the Navy 2014a). The resulting Geographic Information System (GIS) database includes one single spatial and seasonal density value for every marine mammal and sea turtle species present within the Study Area.

The Navy Marine Species Density Database includes a compilation of the best available density data from several primary sources and published works including survey data from NMFS within the U.S. EEZ. NMFS is the primary agency responsible for estimating marine mammal and sea turtle density within the U.S. EEZ. NMFS publishes annual Stock Assessment Reports for various regions of U.S. waters and covers all stocks of marine mammals within those waters. The majority of species that occur in the Study Area are covered by the Pacific Region Stock Assessment Report (Carretta et al. 2013), with a few species (e.g., Steller sea lions) covered by the Alaska Region Stock Assessment Report (Allen and Angliss 2013). Other independent researchers often publish density data or research covering a particular marine mammal species, which is integrated into the NMFS Stock Assessment Reports.

For most cetacean species, abundance is estimated using line-transect methods that employ a standard equation to derive densities based on sighting data collected from systematic ship or aerial surveys. More recently, habitat-based density models have been used effectively to model cetacean density as a function of environmental variables (e.g., Barlow et al. 2009). Where the data supports habitat based density modeling, the Navy's database uses those density predictions. Habitat-based density models allow predictions of cetacean densities on a finer spatial scale than traditional line-transect analyses because cetacean densities are estimated as a continuous function of habitat variables (e.g., sea surface temperature, water depth). Within most of the world's oceans, however there have not been enough systematic surveys to allow for line-transect density estimation or the development of habitat models. To get an approximation of the cetacean species distribution and abundance for unsurveyed areas, in some cases it is appropriate to extrapolate data from areas with similar oceanic conditions where extensive survey data exist. Habitat Suitability Index or Relative Environmental Suitability have also been used in data-limited areas to estimate occurrence based on existing observations about a given species' presence and relationships between basic environmental conditions (Kaschner et al. 2006).

Methods used to estimate pinniped at-sea density are generally quite different than those described above for cetaceans. Pinniped abundance is generally estimated via shore counts of animals at known rookeries and haul-out sites. For example, for species such as the California sea lion, population estimates are based on counts of pups at the breeding sites (Carretta et al. 2013). However, this method is not appropriate for other species such as harbor seals, whose pups enter the water shortly after birth. Population estimates for these species are typically made by counting the number of seals ashore and applying correction factors based on the proportion of animals estimated to be in the water (Carretta et al. 2013). Population estimates for pinniped species that occur in the Study Area are provided in the Pacific Region Stock Assessment Report (Carretta et al. 2013). Translating these population estimates to in-water densities presents challenges because the percentage of seals or sea lions at sea compared to those on shore is species-specific and depends on gender, age class, time of year (molt and breeding/pupping seasons), foraging range, and for species such as harbor seal, time of day and tide level. These parameters were identified from the literature and used to establish correction factors which were then applied to estimate the proportion of pinnipeds that would be at sea within the Study Area for a given season.

North Pacific right whales

For North Pacific right whales, as presented in detail in Section 3.4.2.6 (North Pacific Right Whale [*Eubalaena japonica*]), the population is so low (n=31), they are generally found only in the Bering Sea, and the square kilometer area of potential occurrence is very large (including the Bering Sea and much of the North Pacific). A density for the North Pacific right whale is therefore not available or warranted for the impact analyses given any derived density would be too low to be informative in acoustic modeling based on predicting estimated effects much less than one (1.0) for species that are much more numerous (e.g., blue whale). Given the overall low number of animals in the population and that a North Pacific right whale has not been seen in the Study Area since 1992 (indicating a highly unlikely presence), the Navy has determined possible effects to North Pacific right whale from Navy training and testing in the Study Area are discountable. Predicted effects presented in subsequent sections are based on this qualitative assessment.

Northern sea otters

As presented in detail in Section 3.4.2.34 (Northern Sea Otter [*Enhydra lutris kenyoni*]), the presence of sea otters in the Western Behm Canal (Alaska) portion of the Study Area is considered extralimital. There have been confirmed sightings of scattered individuals in the Inland Waters of the Study Area, where they are considered rare, and given that sea otters seldom range more than 1.2 mi. (2 km) from shore and are not known to migrate, their occurrence is also considered rare in the offshore portion of the Study Area. Sea otters are likely to be in the coastal margin of the Offshore Area (e.g., Quinault Range; see Section 2.1.1.2, Sea and Undersea Space), which is used for some testing activities.

There is no density data available for sea otters in the Study Area. In addition, sea otters inhabit an acoustically complex shallow water environment that is beyond the predictive capability of current acoustic modeling programs. Therefore, even if there were density data for sea otters in the Study Area, attempting to acoustically model underwater sound propagation and sound levels would not be justified. Additionally, almost all the proposed activities would occur far from any likely sea otter presence and sea otters spend little time underwater (see Watwood and Buonantony 2012), thus very much limiting the potential for exposure to underwater sound from Navy activities in any case. Even if they were exposed to sound from Navy activities, research indicates sea otters often remain undisturbed, quickly become tolerant of various sounds, and, even when purposefully harassed, they generally move only a short distance (100–200 m) before resuming normal activity (Davis et al. 1988).

Therefore, the Navy has determined that possible effects from underwater sound to Northern sea otter from Navy training and testing in the Study Area are discountable given that (1) sea otter presence may coincide with only a small fraction of the proposed activities; (2) sea otters spend little time underwater where they would be exposed to the acoustic stressors being considered; and (3) research indicates sea otters are unlikely to be impacted by such sounds. Predicted effects presented in subsequent sections are based on this qualitative assessment.

For the 13 stocks involving nine marine mammal species in the Study Area (killer whale, harbor porpoise, Northern fur seal, Pygmy sperm whales and dwarf sperm whales, Cuvier's beaked whales and Mesoplodon beaked whales, Gray whales, and Guadalupe fur seals), there is insufficient data for a species or stock-specific density to be derived. Some of these species/stocks were represented in the modeling by a single density. Therefore, as detailed in the following paragraphs, to quantify the likely number of effects to these stocks/species, the modeling based on a common species density was prorated to the stocks. In the case of Guadalupe fur seal a surrogate species was assumed to provide an appropriate conservative estimate of effects as described in the subsection below.

Killer whales (Alaska Resident and Northern Resident killer whale stocks)

In the Western Behm Canal (Alaska) portion of the Study Area, there is overlap of the Alaska Resident and Northern Resident killer whale stocks, with each stock at the limit of its known range. There is no density available for the small number of Northern Resident animals that may be present in the Western Behm Canal. Consistent with the procedure used previously to derive the number of predicted exposures for a stock for which there is no density information available, the Navy derived a ratio based on the abundance estimates for Alaska Resident (n=2,084) and Northern Resident (n=216) stocks of killer whales. The ratio of the Alaska Resident stock (0.89) to that of the Northern Resident stock (0.11) was then used to prorate the total modeled killer whale acoustic exposures in Western Behm Canal to each of those two stocks.

Harbor porpoise (Northern Oregon/Washington Coast and Northern California/Southern Oregon stocks)

For harbor porpoise in the offshore portion of the Study Area, there is overlap of the Northern Oregon/Washington Coast stock and the Northern California/Southern Oregon stock, but there is only a single density available for acoustic impact modeling. Modeled effects to harbor porpoise in the offshore portion of the Study Area were therefore assigned to the appropriate stock using a derived ratio based on the abundance estimates for the two stocks as reported in the 2012 Pacific Stock Assessment Report (Carretta et al. 2013; Northern Oregon/Washington Coast stock: n=15,674; Northern California/Southern Oregon stock: n=39,581). The ratio of the Northern Oregon/Washington Coast stock (0.40) to that of the Northern California/Southern Oregon stock (0.60) was then used to prorate the total modeled exposures in order to estimate acoustic exposures for each of these stocks in the offshore portion of the Study Area.

Northern fur seals (Eastern Pacific and California stocks)

For northern fur seals in the Study Area, there is insufficient information available to allow for a density that is broken out by the Eastern Pacific stock and California stock. The Navy derived a ratio based on the abundance estimates for these two northern fur seal stocks as reported in the 2012 Pacific Stock Assessment Report (Carretta et al. 2014; Eastern Pacific stock: n=653,171; California stock: n=9,968). The ratio of the Eastern Pacific stock (0.985) to that of the California stock (0.015) was then used to prorate the total modeled exposures in order to estimate acoustic exposures for each of these stocks of northern fur seal in the Study Area.

Pygmy sperm whales and dwarf sperm whales

As detailed in U.S. Department of the Navy (2014a), pygmy sperm whales and dwarf sperm whales are *Kogia* species that are difficult to detect and distinguish from one another during surveys. As a result, NMFS is only able to provide density data for *Kogia* as a guild. For this reason, a single *Kogia* density was used to represent the two species (pygmy sperm whale and dwarf sperm whale) for acoustic impact modeling purposes.

Cuvier's beaked whales and *Mesoplodon* beaked whales

There is insufficient data to derive an individual Cuvier's beaked whale density in the offshore portion of the Study Area, however, Cuvier's beaked whales were considered in the modeling of activities in that area since they were grouped in with the *Mesoplodon* beaked whale density and distribution. Based on ship surveys conducted in waters off Washington and Oregon from 1991 to 2008 (reported in Barlow 2010), the abundances for these stocks are as follows: Cuvier's beaked whales, n=137; Mesoplodon beaked whales, n=565. Therefore, to derive Cuvier's beaked whale numbers from the modeling results for *Mesoplodon* beaked whales, the Navy has derived a ratio based on the abundance estimates for the two resulting in 20 percent of the *Mesoplodon* beaked whale modeled effects being counted as effects to Cuvier's beaked whale. In the Western Behm Canal (Alaska) portion of the Study Area, there was sufficient data for derivation of a Cuvier's beaked whale density and acoustic modeling for activities in that location was conducted without the need for other considerations.

Gray whales (Western North Pacific stock)

As described in detail in Section 3.4.2.12 (Gray Whales [*Eschrichtius robustus*]), the migration routes of the Western North Pacific stock of gray whales are poorly known. Research indicates that in the western Pacific, the coastal waters of eastern Russia, the Korean Peninsula, and Japan are part of their presently identified migratory route and the coastal waters of Canada and the United States, to at least Baja

California in Mexico are part of their identified migratory route in the eastern Pacific (Weller et al. 2002, 2012, 2013).

Gray whales are generally slow-moving animals (Jefferson et al. 2008). Migrating gray whales sometimes exhibit a unique “snorkeling” behavior, whereby they surface cautiously, exposing only the area around the blowhole, exhale quietly without a visible blow, and sink silently beneath the surface (Jones and Swartz 2009). Mate and Urban-Ramirez (2003) report an average gray whale speed of approximately 2.8 knots (5.2 km/hour) based on a tagged migrating animal. At this swim speed and assuming a coastal migration route through the NWTT Study Area similar to that presented in Sumich and Snow (2011), it should take approximately 8 days for a gray whale to cross through the offshore portion of the Study Area (approximately 510 nm). It is assumed they will do this twice a year during their annual southbound and northbound migration legs.

Given the emergent nature of the science associated with the Western North Pacific stock of gray whales, there is no data that provides an estimate of the number of animals in this stock that may be present when migrating through the Study Area. Based on the estimated population of approximately 155 individuals (International Union for Conservation of Nature 2012) and the data in Weller at al. (2013), the Navy conservatively estimates 23 Western North Pacific gray whales may migrate along the U.S. Pacific coast. Therefore, based on the Navy’s estimate for the number of Western North Pacific stock of gray whales possibly in the Study Area and the latest abundance for the Eastern North Pacific stock (n=19,126), the resulting ratio of the Western North Pacific stock (0.12 percent) to that of the Eastern North Pacific stock (99.88 percent) was used to prorate the modeled exposures for the Eastern North Pacific gray whale (for which a density was derived) in order to estimate acoustic effects to the Western North Pacific stock of gray whale.

Guadalupe fur seals

There is insufficient information available for the accurate derivation of a density or abundance representing the likely presence of Guadalupe fur seals in the offshore portion of the Study Area given the emergent nature of the data associated with the return of this species to the Washington/Oregon coast. Although rare, Guadalupe fur seals are known to be present. In 2012, there were 58 Guadalupe fur seals found stranded on Washington/Oregon coast (Lambourn 2013, pers. comm.). Under the assumption that not more than 50 percent of animals (mostly young of the year) have stranded, the number of strandings in 2012 suggests there are approximately 116 Guadalupe fur seals present offshore in the Study Area. Given the offshore portion of the Study Area is approximately 416,845 km^2 in area, this suggested number of animals present based on standings would translate to a density of 0.00028 Guadalupe fur seal per km^2 in the Offshore Area. In comparison, in the warm season there should be 663 California stock[1] of northern fur seal present in the same Offshore Area having a calculated density of 0.00159 per km^2 or approximately 5.5 times that estimated for Guadalupe fur seal. Given there is density data and acoustic effects modeling for northern fur seal, in a conservative approach (assumed to overestimate actual impacts) that provides for a quantification of effects to Guadalupe fur seals, the Navy has taken the acoustic effects modeling results for California stock northern fur seals as a surrogate for Guadalupe fur seals. This is suggested as a reasonable approach since the most recent stranding data suggests it should provide a conservative estimate of effects to Guadalupe fur seals. In addition, the seasonal presence for the two species/stocks is likely the same and

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[1] The warm season density for northern fur seals in this area used in modeling is 0.106 per km^2 or approximately 44,186 animals in the Study Area. The ratio of the Eastern Pacific stock (0.985) to that of the San Miguel stock (0.015) indicates there should be a San Miguel stock northern fur seal density of 0.00159 per km^2 and 663 animals from that stock in this area based on that warm season density.

both have a similar distance to cover from the Study Area migrating south to their rookery (for the California stock of northern fur seal, approximately 1,100 nm to the main rookery at San Miguel Island; and for Guadalupe fur seal, approximately 1,400 nm to Guadalupe Island). Given the latest abundance for California stock of northern fur seals as provided by Carretta et al. (2013) is n=9,968 (from a 2007 survey) and as provided in Esperon-Rodriguez and Gallo-Reynoso (2012) for Guadalupe fur seals is "14,000–15,000" (from a 2008 survey), it is assumed that potential differences in relative abundances for the two species in the Study Area are evened-out by the additional 360 mi. distance from the Guadalupe Island rookery. For these reasons, the Navy will assume that the acoustic effects modeling results for the California stock of northern fur seal are a reasonable approximation and conservative estimation of effects to Guadalupe fur seals in the Study Area as a result of Navy training and testing activities.

3.4.3.1.14.2 Upper and Lower Frequency Limits

The Navy has adopted a single frequency cutoff at each end of a functional hearing group's frequency range based on the most liberal interpretations of their composite hearing abilities (see Finneran and Jenkins (2012) for details involving derivation of these values. These are not the same as the values used to calculate weighting curves, but exceed the demonstrated or anatomy-based hypothetical upper and lower limits of hearing within each group. Table 3.4-7 provides the lower and upper frequency limits for each species group. Sounds with frequencies below the lower frequency limit, or above the upper frequency limit, are not analyzed with respect to auditory effects for a particular group.

Table 3.4-7: Lower and Upper Cutoff Frequencies for Marine Mammal Functional Hearing Groups Used in this Acoustic Analysis

Functional Hearing Group	Limit (Hz)	
	Lower	Upper
Low-Frequency Cetaceans	5	30,000
Mid-Frequency Cetaceans	50	200,000
High-Frequency Cetaceans	100	200,000
Phocid seals (underwater)	50	80,000
Otariid pinnipeds & Sea otters (underwater)	50	60,000

Note: Hz = Hertz

3.4.3.1.14.3 Navy Acoustic Effects Model

For this analysis of Navy training and testing activities in the Study Area, the Navy uses software tools, up to date marine mammal density data, and other oceanographic data for the quantification of predicted acoustic impacts to marine mammals. These tools and databases collectively form the NAEMO. Details of this model's processes and the description and derivation of the inputs are presented in the Navy's Determination of Acoustic Effects Technical Report (Marine Species Modeling Team 2013). The NAEMO improves upon previous modeling efforts in several ways. First, unlike the method used previously (e.g., U.S. Department of the Navy 2009, 2012a) that modeled sources individually, the NAEMO has the capability to run all sources within a scenario simultaneously, providing a more realistic depiction of the potential effects of an activity. Second, previous models calculated sound received levels within set volumes of water and spread animals uniformly across the volumes. In the NAEMO, virtual animals or "animats" are distributed non-uniformly based on higher resolution species-specific density, depth distribution, and group size information; and animats serve as dosimeters, recording energy received at their location in the water column. Third, a fully three-dimensional environment is used for calculating sound propagation and animat exposure in the NAEMO, rather than a two-dimensional environment where the worse case sound pressure level across the water column is always encountered. Finally, current efforts incorporate site-specific bathymetry, sound speed profiles, wind speed, and bottom properties into the propagation modeling process rather than the flat-bottomed provinces used during earlier modeling (Marine Species Modeling Team 2013). The following paragraphs provide an overview of the NAEMO process and its more critical data inputs.

Using the best available information on the predicted density of marine mammals in the area being modeled, the NAEMO derives an abundance (total number individuals) and distributes the resulting number of animats into an area bounded by the maximum distance that energy propagates out to a criterion threshold value (acoustic energy footprint). For example, for non-impulse sources, all animats that are predicted to occur within a range that could receive sound pressure levels greater than or equal to 120 dB re 1 µPa are distributed. These animats are distributed based on density differences across the area, the group (pod) size, and known depth distributions (dive profiles; see Marine Species Modeling Team (2013) for a detailed discussion on animal dive profiles). Animats change depths every 4 minutes but do not otherwise mimic actual animal behaviors, such as avoidance or attraction to a stimulus, or foraging, social, or traveling behaviors.

Schecklman et al. (2011) argue that static distributions underestimate acoustic exposure compared to a model with fully three-dimensionally moving animals. However, their static method is different from the NAEMO in several ways. First, they distribute the entire population at depth with respect to the species-typical depth distribution histogram, and those animats remain static at that position throughout the entire simulation. In the NAEMO, animats are placed horizontally dependent upon non-uniform density information, and then move up and down over time within the water column by interrogating species-typical depth distribution information. Second, for the static method they calculate acoustic received level for designated volumes of the ocean and then sum the animats that occur within that volume, rather than using the animats themselves as dosimeters, as in the NAEMO. Third, Schecklman et al. (2011) ran 50 iterations of the moving distribution to arrive at an average number of exposures, but because they rely on uniform horizontal density (and static depth density), only a single iteration of the static distribution is realized. In addition to moving the animats vertically, the NAEMO overpopulates the animats over a non-uniform density and then resamples the population a number of times to arrive at an average number of exposures as well. Tests comparing fully moving distributions and static distributions with vertical position changes at varying rates were carried out during development of the NAEMO. For position updates occurring more frequently than every 5 minutes, the number of estimated exposures were similar between the NAEMO and the fully moving distribution, however, computational time was much longer for the fully moving distribution.

The NAEMO calculates the likely propagation for various levels of energy (sound or pressure) resulting from each non-impulse or impulse source used during a training or testing event. This is done by taking into account the actual bathymetric relief and bottom types (e.g., reflective), and estimated sound speeds and sea surface roughness at an event’s location. Platforms (such as a ship using one or more sound sources) are modeled as moving across an area whose size is representative of what would normally occur during a training or testing scenario. The model uses typical platform speeds and event durations. Moving source platforms either travel along a predefined track or move along straight-line tracks from a random initial course, reflecting at the edges of a predefined boundary. Static sound sources are stationary in a fixed location for the duration of a scenario. Modeling locations were chosen based on historical data where activities have been ongoing and in an effort to include as much environmental variation within the Study Area as is reasonably available and can be incorporated into the model.

The NAEMO then records the energy received by each animat within the energy footprint of the event and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects to the animats within a scenario are then tallied and the highest order effect (based on severity of criteria; e.g., PTS over TTS) predicted for a given animat is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine animal could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the study area, sound may propagate beyond the boundary of the study area. Any exposures occurring outside the boundary of the study area are counted as if they occurred within the study area boundary. The NAEMO provides the initial predicted impacts to marine species (based on application of multiple conservative assumptions which are assumed to overestimate impacts), which are then further analyzed to produce final estimates used in the Navy's MMPA application for Letter of Authorization and ESA risk analyses (Section 3.4.3.2.1.2, Avoidance Behavior and Mitigation Measures as Applied to Sonar and other Active Acoustic Sources, for further information on additional analyses).

3.4.3.1.14.4 Model Assumptions and Limitations

There are limitations to the data used in the NAEMO, and the results must be interpreted with consideration for these known contexts. Output from the NAEMO relies heavily on the quality of both the input parameters and impact thresholds and criteria. When there was a lack of definitive data to support an aspect of the modeling (such as lack of well described diving behavior for all marine species), conservative assumptions believed to overestimate the number of exposures were chosen:

- Animats are modeled as being underwater and facing the source and therefore always predicted to receive the maximum sound level at their position within the water column (e.g., the model does not account for conditions such as body shading, porpoising out of the water, or an animal such as a pinniped raising its head above water). Some odontocetes have been shown to have directional hearing, with best hearing sensitivity facing a sound source and higher hearing thresholds for sounds propagating toward the rear or side of an animal (Kastelein et al. 2005a; Mooney et al. 2008; Popov and Supin 2009)
- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological effects such as hearing loss, especially for slow moving or stationary sound sources in the model.
- Animats are stationary horizontally and therefore are not modeled as moving away from any sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels close to the source, especially those exposures that may result in permanent hearing loss (PTS).
- Animats are assumed to receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury) assume an impulse delivery time adjusted for animal size and depth. Therefore, these impacts are overestimated at farther distances and increased depths.
- Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the temporary or permanent hearing loss, because there are not sufficient data to estimate a hearing recovery function for the time between exposures.
- Mitigation measures implemented during many training and testing activities were not considered in the model (Chapter 5, Standard Operating Procedures, Mitigation, and

Monitoring). In reality, sound-producing activities would be reduced, stopped, or delayed if marine mammals are detected within the mitigation zones around sound sources.

Because of these inherent model limitations and simplifications, initial predicted model results must be further analyzed, considering such factors as the range to specific effects, likely avoidance by marine mammals, and the likelihood of successfully implementing mitigation measures. This analysis uses a number of factors in addition to the acoustic model results to more accurately estimate the acoustic effects to marine mammals as described in the following sections (Section 3.4.3.2.1.2, Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources; 3.4.3.1.15, Marine Mammal Avoidance of Sound Exposures; and Section 3.4.3.1.16, Implementing Mitigation Measures to Reduce Sound Exposures).

3.4.3.1.15 Marine Mammal Avoidance of Sound Exposures

Marine mammals may avoid sound exposures by either avoiding areas with high levels of anthropogenic activity or moving away from a sound source. Because the NAEMO does not consider horizontal movement of animats, including avoidance of human activity or sounds, it over-estimates the number of marine mammals that would be exposed to sound sources that could cause injury. Therefore, the potential for avoidance is considered in the post-model analysis. The consideration of avoidance during use of sonar and other active acoustic sources and during use of explosives is described below and discussed in more detail in Sections 3.4.3.2.1 (Impacts from Sonar and other Active Acoustic Sources) and in Section 3.4.3.2.2 (Impacts from Explosives).

3.4.3.1.15.1 Avoidance of Human Activity

Cues preceding the commencement of an event (e.g., multiple vessel presence and movement, aircraft overflight) may result in some animals departing the immediate area, even before active sound sources begin transmitting. Harbor porpoises and beaked whales have been observed to be especially sensitive to human activity, which is accounted for by using a low threshold for behavioral disturbance due to exposure to sonar and other active acoustic sources. Harbor porpoises routinely avoid and swim away from large motorized vessels (Barlow 1988; Evans et al. 1994; Palka and Hammond 2001; Polacheck and Thorpe 1990). The vaquita, which is closely related to the harbor porpoise, appears to avoid large vessels at about 2,995 ft. (913 m) (Jaramillo-Legorreta et al. 1999). The assumption is that the harbor porpoise would respond similarly to large Navy vessels. Beaked whales have also been documented to exhibit avoidance of human activity (Pirotta et al. 2012; Tyack et al. 2011).

Therefore, for certain naval activities proceeded by high levels of vessel activity (multiple vessels) or hovering aircraft, harbor porpoises and beaked whales are assumed to avoid the activity area prior to the start of a sound-producing activity. Model-estimated effects during these types of activities are adjusted so that high level sound impacts to harbor porpoises and beaked whales (those causing PTS during use of sonar and other active acoustic sources and those causing mortality due to explosives) are considered to be TTS and recoverable injury, respectively, due to animals moving away from the activity and into a lower effect range.

3.4.3.1.15.2 Avoidance of Repeated Exposures

Marine mammals would likely avoid repeated high level exposures to a sound source that could result in injury (i.e., PTS). Therefore, the model-estimated effects are adjusted to account for marine mammals swimming away from a sonar or other active sources and away from multiple explosions to avoid repeated high level sound exposures. Avoidance of repeated exposures is discussed further in Section

3.4.3.2.1.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and other Active Acoustic Sources).

3.4.3.1.16 Implementing Mitigation to Reduce Sound Exposures

The Navy implements mitigation measures (described in Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) during sound-producing activities, including halting or delaying use of a sound source or explosives when marine mammals are observed in the mitigation zone. The NAEMO estimates acoustic effects without any shutdown or delay of the activity in the presence of marine mammals; therefore, the model over-estimates impacts to marine mammals within mitigation zones. The post-model adjustment factors in and quantifies the potential for highly effective mitigation to reduce the likelihood or risk of PTS due to exposure to sonar and other active acoustic sources and injuries and mortalities due to explosives. A detailed explanation of this analysis is provided in the technical report *Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for Northwest Training and Testing Activities* (U.S. Department of the Navy 2014b).

Two factors are considered when quantifying the effectiveness of mitigation: (1) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity; and (2) the sightability of each species that may be present in the mitigation zone, which is affected by species-specific characteristics. The mitigation zones proposed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) encompass the estimated ranges to injury (including the range to mortality for explosives) for a given source.

Mitigation is considered in the quantified reduction of model predicted effects when the mitigation zone can be fully or mostly observed prior to and during a sound-producing activity. Mitigation for each training or testing event is considered in its entirety, taking into account the different ways an event's activities may take place as part of that event (some scenarios involve different mitigation zones, platforms, or number of Lookouts). The ability to observe the range to mortality (for explosive activities only) and the range to potential injury (for all sound-producing activities) were estimated for each training or testing event. Mitigation was considered in the acoustic analysis as follows:

- If the entire mitigation zone can be continuously visually observed based on the platform(s), number of Lookouts, and size of the range to effects zone, the mitigation is considered fully effective (Effectiveness = 1).
- If over half of the mitigation zone can be continuously visually observed or if there is one or more of the scenarios within the activity for which the mitigation zone cannot be continuously visually observed (but the range to effects zone can be visually observed for the majority of the scenarios), the mitigation is considered mostly effective (Effectiveness = 0.5).
- If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, the mitigation is not considered as an adjustment factor in the acoustic effects analysis.

The ability of Navy Lookouts to detect marine mammals in or approaching the mitigation zone is dependent on the animal's presence at the surface and the characteristics of the animal that influence its sightability. The Navy considered what applicable data were available to numerically approximate the sightability of marine mammals and determined that the standard "detection probability" referred to as g(0) was most appropriate. The abundance of marine mammals is typically estimated using line-transect analyses (Buckland et al. 2001), in which g(0) is the probability of detecting an animal or group of animals on the transect line (the straight-line course of the survey ship or aircraft). This detection probability is derived from systematic line-transect marine mammal surveys based on species-specific estimates for vessel and aerial platforms. Estimates of g(0) are available from peer-reviewed marine mammal line-transect survey reports, generally provided through research conducted by the National Marine Fisheries Service Science Centers. The g(0) values used in this analysis are provided in Table 3.4-8.

Table 3.4-8: Sightability Based on g(0) Values for Species in the Study Area

Species/Stocks	Family	Vessel Sightability	Aircraft Sightability
Baird's Beaked Whale	Ziphiidae	0.96	0.18
Blue Whale, Fin Whale, Sei Whale	Balaenopteridae	0.921	0.407
Bottlenose Dolphin	Delphinidae	0.76	0.67
California Sea Lion	Otariidae	0.299	0.299
Cuvier's Beaked Whale;	Ziphidae	0.23	0.074
Dall’s Porpoise	Phocoenidae	0.822	0.221
Dwarf Sperm Whale, Pygmy Sperm Whale, *Kogia* spp.	Kogiidae	0.35	0.074
Gray Whale	Eschichtiidae	0.921	0.482
Guadalupe Fur Seal	Otariidae	0.299	0.299
Harbor Porpoise	Phocoenidae	0.769	0.292
Harbor Seal	Phocidae	0.281	0.281
Humpback Whale	Balaenopteridae	0.921	0.495
Killer Whale	Delphinidae	0.921	0.95
Mesoplodon spp.	Ziphiidae	0.45	0.11
Minke Whale	Balaenopteridae	0.856	0.386
North Pacific Right Whale	Balaenidae	0.645	0.41
Northern Elephant Seal	Phocidae	0.105	0.105
Northern Fur Seal	Otariidae	0.299	0.299
Northern Right Whale Dolphin	Delphinidae	0.856	0.67
Pacific White-Sided Dolphin	Delphinidae	0.856	0.67
Risso’s Dolphin, Striped Dolphin	Delphinidae	0.76	0.67
Short-Beaked Common Dolphin	Delphinidae	0.865	0.67
Short-Finned Pilot Whale	Delphinidae	0.76	0.67
Sperm Whale	Physeteridae	0.87	0.32
Steller Sea Lion	Otariidae	0.299	0.299

Notes: For species having no data, the g(0) for Cuvier’s aircraft value (where g(0)=0.074) was used; or in cases where there was no value for vessels, the g(0) for aircraft was used as a conservative underestimate of sightability following the assumption that the availability bias from a slower moving vessel should result in a higher g(0). The published California Sea Lion aircraft g(0) is used for Steller Sea Lion, Guadalupe Fur Seal, and Northern Fur Seal since all are in the otariidae family and there is no g(0) data for these other species. Pinniped g(0) are not available for vessels so the aircraft value has been used as a conservative under estimate of sightability. North Atlantic right whale data (Palka 2005) has been used for North Pacific right whale.
Sources: Barlow 2006; Barlow et al. 2006; Barlow and Forney 2007; Carretta et al. 2000; Forney and Barlow 1998; Laake et al. 1997; Palka 2005.

There are two separate components of g(0): perception bias and availability bias (Marsh and Sinclair 1989). Perception bias accounts for marine mammals that are on the transect line and detectable, but are simply missed by the observer (Barlow 2013). Various factors influence the perception bias component of g(0), including species-specific characteristics (e.g., behavior and appearance, group size, and blow characteristics), viewing conditions during the survey (e.g., sea state, wind speed, wind direction, wave height, and glare), observer characteristics (e.g., experience, fatigue, and concentration), and platform characteristics (e.g., pitch, roll, speed, and height above water). To derive estimates of perception bias, typically an independent observer is present who looks for marine mammals missed by the primary observers. Mark-recapture methods are then used to estimate the probability that animals are missed by the primary observers. Availability bias accounts for animals that are missed because they are not at the surface at the time the survey platform passes by, which may, for example, occur with deep diving whales (e.g., sperm whale and beaked whale). The availability bias portion of g(0) is independent of prior marine mammal detection experience since it only reflects the probability of an animal being at the surface within the survey track and therefore available for detection.

Some g(0) values are estimates of perception bias only, some are estimates of availability bias only, and some reflect both, depending on the species and data currently available. The Navy used g(0) values with both perception and availability bias components if those data were available. If both components were not available for a particular species, the Navy determined that g(0) values reflecting perception bias or availability bias, but not both, still represented the best statistically derived factor for assessing the likelihood of marine mammal detection by Navy Lookouts.

As noted above, line-transect surveys and subsequent analyses are typically used to estimate cetacean abundance. To systematically sample portions of an ocean area (such as the coastal waters off the continental United States), marine mammal surveys are designed to uniformly cover the survey area and are conducted at a constant speed (generally 10 knots for ships and 100 knots for aircraft). Survey transect lines typically follow a pattern of straight lines or grids. Generally there are two primary observers searching for marine mammals. Each primary observer looks for marine mammals in the forward 90-degree quadrant on their side of the survey platform. Based on data collected during the survey, scientists determine the factors that affected the detection of an animal or group of animals directly along the transect line.

Visual marine mammal surveys (used to derive g(0)) are conducted during daylight.[2] Marine mammal surveys are typically scheduled for a season when weather at sea is more likely to be good; however, observers on marine mammal surveys will generally collect data in sea-state conditions up to Beaufort 6 and do encounter rain and fog at sea, which may also reduce marine mammal detections (Barlow 2006). For most species, g(0) values are based on the detection probability in conditions from Beaufort 0 to Beaufort 5, which reflect the fact that marine mammal surveys are often conducted in less than ideal conditions (Barlow 2003; Barlow and Forney 2007). The ability to detect some species (e.g., some beaked whales, *Kogia* spp., and Dall's porpoise) decreases dramatically with increasing sea states, so g(0) estimates for these species are usually restricted to observations in sea-state conditions of Beaufort 0 to Beaufort 2 (Barlow 2003, 2013).

Navy training and testing events differ from systematic line-transect marine mammal surveys in several respects. These differences suggest the use of g(0), as a sightability factor to quantitatively adjust model-predicted effects based on mitigation, is likely to result in an underestimate of the protection afforded by the implementation of mitigation as follows:

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[2] At night, passive acoustic data may still be collected during a marine mammal survey.

- Mitigation zones for Navy training and testing events are significantly smaller (typically less than 1,000 yd. radius) than the area typically searched during line-transect surveys, which includes the maximum viewable distance out to the horizon.
- In some cases, Navy events can involve more than one vessel or aircraft (or both) operating in proximity to each other or otherwise covering the same general area. Additional vessels and aircraft can result in additional watch personnel observing the mitigation zone (e.g., ship shock trials). This would result in more observation platforms and observers looking at the mitigation zone than the two primary observers used in marine mammal surveys upon which g(0) is based. For some Navy activities taking place in the Inland Waters of the Study Area, additional Navy shore-based observers may also be present.
- A systematic marine mammal line-transect survey is designed to sample broad areas of the ocean, and generally does not retrace the same area during a given survey. Therefore, in terms of g(0), the two primary observers have only a limited opportunity to detect marine mammals that may be present during a single pass along the trackline (i.e., deep diving species may not be present at the surface as the survey transits the area). In contrast, many Navy training and testing activities involve area-focused events (e.g., anti-submarine warfare tracking exercise), where participants are likely to remain in the same general area during an event. In other cases Navy training or testing activities are stationary (i.e., pierside sonar testing or use of dipping sonar), which allow Lookouts to focus on the same area throughout the activity. Both of these circumstances result in a longer observation period of a focused area with more opportunities for detecting marine mammals than are offered by a systematic marine mammal line-transect survey that only passes through an area once.

Although Navy Lookouts on ships have hand-held binoculars and on some ships, pedestal-mounted binoculars very similar to those used in marine mammal surveys, there are differences between the scope and purpose of marine mammal detections during research surveys along a trackline and Navy Lookouts observing the water near a Navy training or testing activity to facilitate implementation of mitigation. The distinctions require careful consideration when comparing the Navy Lookouts and Navy shore based observers to marine mammal surveys.[3]

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[3] Barlow and Gisiner (2006) provide a description of typical marine mammal survey methods from ship and aircraft and then provide "a crude estimate" of the difference in detection of beaked whales between trained marine mammal observers and seismic survey mitigation, which is not informative with regard to Navy mitigation procedures for the following reasons. The authors note that seismic survey differs from marine mammal surveys in that, "(1) seismic surveys are also conducted at night; (2) seismic surveys are not limited to calm sea conditions; (3) mitigation observers are primarily searching with unaided eyes and 7x binoculars; and (4) typically only one or possibly two observers are searching." When Navy implements mitigation for which adjustments to modeling output were made, the four conditions Barlow and Gisiner (2006) note are not representative of Navy procedures nor necessarily a difference in marine mammal line-transect survey procedures. The Navy accounts for reduced visibility (i.e., activities that occur at night, etc.) by assigning a lower value to the mitigation effectiveness factor. On Navy ships, hand-held binoculars are always available, and pedestal mounted binoculars, very similar to those used in marine mammal surveys, are generally available to Navy Lookouts on board vessels over 60 ft. Also, like marine mammal observers, Navy Lookouts are trained to use a methodical combination of unaided eye and optics as they search the surface around a vessel. The implication that marine mammal surveys only occur in "calm sea conditions" is not accurate since the vast majority of marine mammal surveys occur in conditions up to sea states of Beaufort 5. The specific g(0) values analyzed by Barlow and Gisiner (2006) were derived from survey data for Cuvier's and *Mesoplodon* beaked whales detected in sea states of Beaufort 0–2 during daylight hours. However, marine mammal surveys are not restricted to sea states of Beaufort 0–2 and many species' g(0) values are based on conditions up to and including Beaufort 5; therefore, the conclusions reached by Barlow and Gisiner (2006) regarding the effect of sea state conditions on sightability do not apply to other species. Finally, when Lookouts are present, there are always more than the "one or two personnel" described by Barlow and Gisiner (2006) observing the area ahead of a Navy vessel (additional bridge watch personnel are also observing the water around the vessel).

- A marine mammal observer is responsible for detecting marine mammals in their quadrant of the trackline out to the limit of the available optics. Although Navy Lookouts and shore based observers are responsible for observing the water for safety of ships and aircraft, during specific training and testing activities, they need only detect marine mammals in the relatively small area that surrounds the mitigation zone (in most cases less than 1,000 yd. from the ship) for mitigation to be implemented.
- Navy Lookout personnel aboard aircraft and on watch onboard vessels at the surface, and shore based observers will have less experience detecting marine mammals than marine mammal observers used for line-transect survey. However, Navy personnel responsible for observing the water for safety of ships and aircraft do have significant experience looking for objects (including marine mammals) on the water's surface, and Lookouts are trained using the NMFS-approved Marine Species Awareness Training.
- Navy shore based observers associated with some testing activities in the Inland Waters are manning a fixed location providing visual surveillance of the event location. These shore-based observers are trained in marine mammal recognition by qualified NMFS-approved organizations in addition to the NMFS-approved Marine Species Awareness Training.

Although there are distinct differences between marine mammal surveys and Navy training and testing, the use of g(0) as an approximate sightability factor for quantitatively adjusting model-predicted impacts due to mitigation (mitigation effectiveness x g(0)) is an appropriate use of the best available science based on the way it has been applied. Consistent with the Navy's impact assessment processes, the Navy applied g(0) in a conservative manner (erring on the side of overestimating the number of impacts) to quantitatively adjust model-predicted effects to marine mammals within the applicable mitigation zones during Navy training and testing activities. Conservative application of g(0) includes:

- In addition to a sightability factor (based on g(0)), the Navy also applied a mitigation effectiveness factor to acknowledge the uncertainty associated with applying the g(0) values derived from marine mammal surveys to specific Navy training and testing activities where the ability to observe the whole mitigation zone is less than optimal (generally due to the size of the mitigation zone).
- For activities that can be conducted at night, the Navy assigned a lower value to the mitigation effectiveness factor. For example, if an activity can take place at night half the time, then the mitigation effectiveness factor was only given a value of 0.5.
- The Navy did not quantitatively adjust model-predicted effects for activities that were given a mitigation effectiveness factor of zero. A mitigation effectiveness factor of zero was given to activities where less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone. However, some protection from applied mitigation measures would be afforded during these activities, even though they are not accounted for in the quantitative reduction of model-predicted impacts.
- The Navy did not quantitatively adjust model-predicted effects based on detections made by other personnel that may be involved with an event (such as range support personnel aboard a torpedo retrieval boat or support aircraft), even though information about marine mammal sightings are shared among units participating in the training or testing activity. In other words, the Navy only quantitatively adjusted the model-predicted effects based on the required number of Lookouts.

- The Navy only quantitatively adjusted model-predicted effects within the range to mortality (explosives only) and injury (all sound-producing activities), and not for the range to TTS or other behavioral effects (see Table 5.3-2 in Chapter 5 for a comparison of the range to effects for PTS, TTS, and the recommended mitigation zone). Despite employing the required mitigation measures during an activity that will also reduce some TTS exposures, the Navy did not quantitatively adjust the model-predicted TTS effects as a result of implemented mitigation.
- The total model-predicted number of animals affected is not reduced by the post-model mitigation analysis, since all reductions in mortality and injury effects are then added to and counted as TTS effects.
- Mitigation involving a power-down or cessation of sonar, or delay in use of explosives, as a result of a marine mammal detection, protects the observed animal and all unobserved (below the surface) animals in the vicinity. The quantitative adjustments of model-predicted impacts, however, assume that only animals on the water surface, approximated by considering the species-specific g(0) and activity-specific mitigation effectiveness factor, would be protected by the applied mitigation (i.e., a power down or cessation of sonar or delaying the event). The quantitative post-model mitigation analysis, therefore, does not capture the protection afforded to all marine mammals that may be near or within the mitigation zone.

The Navy recognizes that g(0) values are estimated specifically for line-transect analyses; however, g(0) is still the best statistically derived factor for assessing the likely marine mammal detection abilities of Navy Lookouts. Based on the points summarized above, as a factor used in accounting for the implementation of mitigation, g(0) is therefore considered to be the best available scientific basis for the Navy's representation of the sightability of a marine mammal as used in this analysis.

The g(0) value used in the mitigation analysis is based on the platform(s) with Lookouts utilized in the activity; shore-based observers are assumed to be equal to shipboard observers. In the case of multiple platforms, the higher g(0) value for either the aerial or vessel platform is selected. For species for which there is only a single published, that single value is used. For species for which there is a range of published g(0) values for a given area (such as the Pacific), the lowest value has been used. For species for which there is no data available, a g(0) estimate has be extrapolated from similar species/guilds based on the published g(0) values (for details regarding the discussion in this paragraph, see Table 3.4-8 "Notes").

The post-model acoustic effect analysis quantification process is summarized in Table 3.4-9 and presented in detail in the technical report *Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for Northwest Training and Testing Activities* (2014b). In brief, the mitigation effectiveness score for an event is multiplied by the estimated sightability of each species to quantify the number of animals that were originally modeled as a mortality (explosives only) or injury (all sound-producing activities) exposure but would, in reality, be observed by Lookouts or shore-based observers prior to or during a sound-producing activity. Observation of marine mammals prior to or during a sound-producing event would be followed by stop or delay of the sound-producing activity, which would reduce actual marine mammal sound exposures. The final quantified results of the acoustic effects analysis for non-impulse sources are presented in Section 3.4.3.2.1.3 (Predicted Impacts for Sonar and Other Active Acoustic Sources) and for explosive sources in Section 3.4.3.2.2.3 (Predicted Impacts).

Table 3.4-9: Post-Model Acoustic Effects Quantification Process

Is the sound source sonar, other active acoustic source, or explosives?	
Sonar and Other Active Acoustic Sources	**Explosives**
S-1. Is the activity preceded by multiple vessel activity or hovering helicopter?	**E-1. Is the activity preceded by multiple vessel activity or hovering helicopter?**
Species sensitive to human activity (i.e., harbor porpoises and beaked whales) are assumed to avoid the activity area, putting them out of the range to Level A harassment. Model-estimated permanent threshold shift (PTS) to these species during these activities is unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to move into the range of potential TTS). The activities preceded by multiple vessel movements or hovering helicopters are listed in Table 3.4-14 and Table 3.4-15 in 3.4.3.2.1.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources).	Species sensitive to human activity (i.e., harbor porpoises and beaked whales) are assumed to avoid the activity area, putting them out of the range to mortality. Model-estimated mortalities to these species during these activities are unlikely to actually occur and, therefore, are considered to be injuries (animal is assumed to move into the range of potential injury). The activities preceded by multiple vessel movements or hovering helicopters are listed in Table 3.4-21 in 3.4.3.2.2.2 (Avoidance Behavior and Mitigation Measures as Applied to Explosions).
S-2. Can Lookouts observe the activity-specific mitigation zone (Chapter 5) up to and during the sound-producing activity?	**E-2. Can Lookouts observe the activity-specific mitigation zone (Chapter 5) up to and during the sound-producing activity?**
If Lookouts are able to observe the mitigation zone up to and during a sound-producing activity, the sound-producing activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone (per the mitigation procedures in Chapter 5). Therefore, model-estimated PTS exposures are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated PTS are instead assumed to be TTS (animal is assumed to move into the range of TTS). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated Lookout(s). For activities with Lookouts on both platforms, the higher g(0) is used for analysis. Sightability values are provided above in Table 3.4-8. The Mitigation Effectiveness values are provided in Table 3.4-13 in Section 3.4.3.2.1.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources).	If Lookouts are able to observe the mitigation zone up to and during an explosion, the explosive activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone (per the mitigation procedures in Chapter 5). Therefore, model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated mortalities or injuries are instead assumed to be injuries or behavioral disturbances, respectively (animals are assumed to move into the range of a lower effect). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated Lookout(s). For activities with Lookouts on both platforms, the higher g(0) is used for analysis. Sightability values are provided above in Table 3.4-8. The Mitigation Effectiveness values for activities involving explosions are provided in Table 3.4-22 in Section 3.4.3.2.2.2 (Avoidance Behavior and Mitigation as Applied to Explosives)

Table 3.4-9: Post-Model Acoustic Effects Quantification Process (continued)

Is the sound source sonar, other active acoustic source, or explosives?	
Sonar and Other Active Acoustic Sources	**Explosives**
S-3. Does the activity cause repeated sound exposures which an animal would likely avoid?	**E-3. Does the activity cause repeated sound exposures which an animal would likely avoid?**
The Navy Acoustic Effects Model assumes that animals do not move away from a sound source and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the sound source. Therefore, only the initial exposures resulting in model-estimated PTS to high-frequency cetaceans, low frequency cetaceans, and phocids are expected to actually occur (after accounting for mitigation in step S-2). Model estimates of PTS beyond the initial pings are considered to actually be TTS, as the animal is assumed to move out of the range to PTS and into the range of TTS. Marine mammals in the mid-frequency hearing group would have to be close to the most powerful moving source (less than 10 meters) to experience PTS. These model-estimated PTS exposures of mid-frequency cetaceans are unlikely to actually occur and, therefore, are considered to be temporary threshold shift (TTS) (animal is assumed to move into the range of TTS).	The Navy Acoustic Effects Model assumes that animals do not move away from multiple explosions and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the site of multiple explosions. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur (after accounting for mitigation in step E-2). Model estimates of PTS are reduced to account for animals moving away from an area with multiple explosions, out of the range to PTS, and into the range of TTS. Activities with multiple explosions are listed in Table 3.4-21 in Section 3.4.3.2.2.2 (Avoidance Behavior and Mitigation as Applied to Explosives).

The incorporation of mitigation factors for the reduction of predicted effects used a conservative approach (erring on the side of overestimating the number of effects) since reductions as a result of implemented mitigation were only applied to those events having a very high likelihood of detecting marine mammals. It is important to note that there are additional protections offered by mitigation procedures which will further reduce effects to marine mammals, but these are not considered in the quantitative adjustment of the model predicted effects.

3.4.3.1.17 Marine Mammal Monitoring During Navy Training

The current behavioral exposure criteria under the response function also assumes there will be a range of reactions from minor or inconsequential to severe. Section 3.0.2.2 (Navy Integrated Comprehensive Monitoring Program) summarizes the monitoring data that has been collected thus far within the Study Area. For further discussion, also see Section 3.4.4.1 (Summary of Monitoring and Observations During Navy Activities). Results of monitoring may provide indications that the severity of reactions suggested by the current modeling and thresholds has been overestimated.

3.4.3.1.18 Application of the Marine Mammal Protection Act to Potential Acoustic and Explosive Effects

The MMPA prohibits the unauthorized harassment of marine mammals and provides the regulatory processes for authorization for any such incidental harassment that might occur during an otherwise lawful activity. Harassment that may result from Navy training and testing activities described in this EIS/OEIS is unintentional and incidental to those activities.

For military readiness activities, MMPA Level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Injury, as defined in this EIS/OEIS is the destruction or loss of biological tissue from a marine mammal. The destruction or loss of biological tissue will result in an alteration of physiological function that exceeds the normal daily physiological variation of the intact tissue. For example, increased localized histamine production, edema, production of scar tissue, activation of clotting factors, white blood cell response, etc., may be expected following injury. Therefore, this EIS/OEIS assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings (National Oceanic and Atmospheric Administration 2010), all injuries (except those serious enough to be expected to result in mortality) are considered MMPA Level A harassment.

PTS is non-recoverable and, by definition, results from the irreversible impacts to auditory sensory cells, supporting tissues, or neural structures within the auditory system. PTS therefore qualifies as an injury and is classified as Level A harassment under the wording of the MMPA. The smallest amount of PTS (onset-PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset-PTS is used to define the outer limit of the MMPA Level A exposure zone. Model-predicted slight lung injury, and gastrointestinal tract injuries are also considered MMPA Level A harassment in this analysis.

Public Law 108-136 (2004) amended the MMPA definitions of, Level B harassment for military readiness activities to be “any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered.” Unlike MMPA Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may cause MMPA Level B harassment.

TTS is recoverable and is considered to result from the temporary, non-injurious fatigue of hearing-related tissues. The smallest measurable amount of TTS (onset TTS) is taken as the best indicator for slight temporary sensory impairment. Because it is considered non-injurious, the acoustic exposure associated with onset-TTS is used to define the outer limit of the portion of the MMPA Level B exposure zone attributable to physiological effects. Since short-term reduction in hearing acuity could be considered a temporary decrement, reduction in hearing acuity could be considered temporary and similar in scope to a period of hearing masking or behavioral disturbance. As such, it is considered by the Navy and NMFS as a Level B effect overlapping the range of sounds producing behavioral effects.

The harassment status of slight behavior disruption has been addressed in workshops, previous actions, and rulings (National Oceanic and Atmospheric Administration 2011a, b; U.S. Department of the Navy 2004). The conclusion is that a momentary behavioral reaction of an animal to a brief, time-isolated acoustic event does not qualify as MMPA Level B harassment. This analysis uses behavioral criteria to predict the number of animals likely to experience a significant behavioral reaction and, therefore, an MMPA Level B harassment.

NMFS also includes mortality, or serious injury likely to result in mortality, as a possible outcome to consider in addition to MMPA Level A and MMPA Level B harassment. An individual animal predicted to experience simultaneous multiple injuries, multiple disruptions, or both, is typically counted as a single take (National Oceanic and Atmospheric Administration 2008a, 2011). NMFS has generally identified a 24-hour period as the amount of time in which an individual can be harassed no more than once. Behavioral harassment, under the response function presented in this request, uses received sound pressure level over a 24-hour period as the metric for determining the probability of harassment.

3.4.3.1.19 Application of the Endangered Species Act to Marine Mammals

Generalized information on definitions and the application of the ESA are presented in Section 3.0.1 (Regulatory Framework) along with the acoustic conceptual framework (Appendix H) used in this analysis. Consistent with NMFS Section 7 analyses under the ESA (e.g., see National Marine Fisheries Service 2007), the spatial and temporal overlap of activities with the presence of listed species is assessed in this EIS/OEIS. The definitions used by the Navy in making the determination of effect under Section 7 of the ESA are based on the U.S. Fish and Wildlife Service and NMFS *Endangered Species Consultation Handbook* (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998), and recent NMFS Biological Opinions involving many of the same activities and species.

- “No effect” is the appropriate conclusion when a listed species or its designated critical habitat will not be affected, either because the species will not be present or because the project does not have any elements with the potential to affect the species or modify designated critical habitat. “No effect” does not include a small effect or an effect that is unlikely to occur.
- If a stressor and species presence overlap, but predicted effects are insignificant (in size) or discountable (extremely unlikely), a “may affect” but not likely to adversely affect” determination is appropriate. "May affect" is appropriate when animals are within a range where they could potentially detect or otherwise be affected by the sound (e.g., the sound is above background ambient levels).
  - Insignificant effects relate to the size of the impact and should never reach the scale where take occurs.
  - Discountable effects are those extremely unlikely to occur and based on best judgment, a person would not (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.
- If a stressor and species presence overlap, and a predicted effect is not insignificant, discountable, or beneficial, a “may affect, likely to adversely affect” determination is appropriate.

There are no harassment or injury criteria established for marine mammals under the ESA because the ESA requires an assessment starting with mere exposure potential. Acoustic modeling is used to predict the number of ESA-listed marine mammals exposed to sound resulting from Navy training and testing activities, without any behavioral or physiological criteria applied. In order to determine if adverse effects may result pursuant to the ESA, the Navy assumed that any exposures that resulted in MMPA harassment equated to “may affect, likely to adversely affect” when the definitions of “take” under both statutes were taken into consideration.

The Southern Resident killer whale is the only ESA-listed marine mammal with designated critical habitat within the Study Area.

3.4.3.2 Impact Analyses for Acoustic Stressors

3.4.3.2.1 Impacts from Sonar and Other Active Acoustic Sources

Sonar and other active acoustic sources proposed for use are transient in most locations as active sonar activities move throughout the Study Area. Sonar and other active acoustic sources emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of sonar systems are described in Section 3.0.4.2.2.1 (Sources Qualitatively Analyzed).

Exposure of marine mammals to non-impulse sources such as active sonar would not result in primary blast injuries or barotraumas. Sonar induced acoustic resonance and bubble formation phenomena are unlikely to occur under realistic conditions in the ocean environment, as discussed in Section 3.4.3.1.2.1 (Direct Injury). Direct injury from sonar and other active acoustic sources (other than potential PTS) would not occur under conditions present in the natural environment, and therefore, is not considered further in this analysis.

Research and observations of auditory masking in marine mammals is discussed in Section 3.4.3.1.4 (Auditory Masking). Anti-submarine warfare sonar can produce intense underwater sounds in the Study Area. These sounds are likely within the audible range of most marine mammals, but are normally very limited in the temporal, frequency, and spatial domains. The duration of individual sounds is short; sonar pulses can last up to a few seconds each but most are shorter than 1 second. The duty cycle is low with most tactical anti-submarine warfare sonar typically transmitting about once per minute. Furthermore, events are geographically and temporally dispersed since the platforms are moving and most event durations are limited to a few hours. Tactical sonar's transmit frequencies are typically narrow band (typically less than one-third octave; within a few hundred Hz). These factors reduce the likelihood or severity of these sources causing significant auditory masking in marine mammals.

Some active acoustic sources (e.g., some countermeasures) have a high duty cycle. These sources employ high frequencies (10 kHz and above) that attenuate rapidly in the water, thus producing only a small area of potential auditory masking. Higher frequency active acoustic sources are typically above the estimated upper hearing range of mysticetes used in this analysis (30 kHz; see Section 3.4.2.3, Vocalization and Hearing of Marine Mammals), therefore mysticetes are unlikely to be able to detect the higher frequency active acoustic sources, and these sources would not interfere with their communication or detection of biologically relevant sounds. Odontocetes may experience some limited masking at closer ranges as the frequency band of many higher frequency sources overlap the hearing and vocalization abilities of some odontocetes, however the frequency band of these sources is also limited which limits the likelihood of auditory masking. With any of these activities, again, the limited duration of the overall activities limit the potential for auditory masking effects from proposed activities on marine mammals.

The most probable effects from exposure to sonar and other active acoustic sources are PTS, TTS, and behavioral reactions (see Section 3.4.3.1.2, Analysis Background and Framework). The NAEMO is used to produce initial estimates of the number of animals that may receive these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation. These are discussed below.

Another concern is the number of times an individual marine mammal is exposed and potentially reacts to a sonar or other active acoustic source over the course of a year or within a specific geographic area. Animals that are resident during all or part of the year on Navy inland ranges are the most likely to experience multiple exposures. Repeated and chronic noise exposures to marine mammals and their observed reactions are discussed in this analysis where applicable.

3.4.3.2.1.1 Range to Effects

The following section provides the predicted range (distance) over which specific physiological or behavioral effects are expected to occur based on the acoustic criteria (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals) and the acoustic propagation calculations from the NAEMO (see Section 3.4.3.1.14.3, Navy Acoustic Effects Model).

The range to specific effects are used to assess model results and determine adequate mitigation ranges to avoid higher level effects, especially physiological effects. Additionally, these data can be used to analyze the likelihood of an animal being able to avoid the effects of an oncoming sound source by simply moving a short distance away (e.g., a few hundred meters). Figure 3.4-7 shows a representation of effects with distance from a hypothetical sonar source. Notice the proportion of animals that are likely to have a behavioral response (yellow block labeled "Level B [risk-function]") decreases with increasing distance from the source.

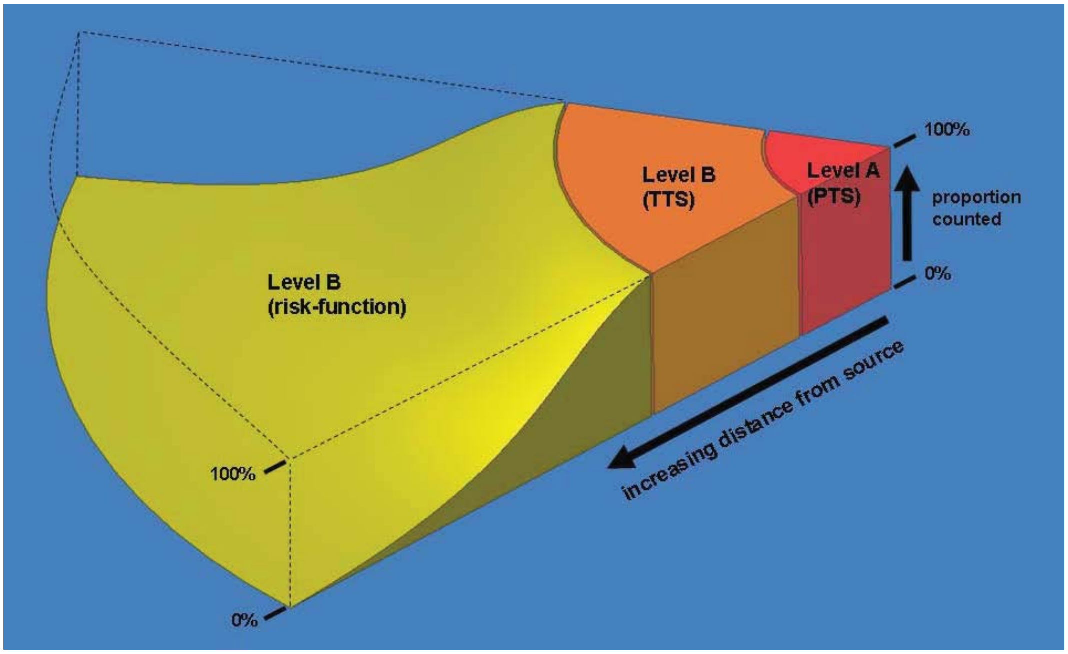

Figure 3.4-7: Hypothetical Range to Specified Effects for a Sonar Source

Although the Navy uses a number of sonar and non-impulse sources, the three sonar bins provided below (i.e., MF1, MF4, and MF5) represent three of the most powerful sources (see Section 3.0.4.2.2, Classification of Acoustic and Explosive Sources, for a discussion of sonar and other active acoustic source bins included in this analysis). These three sonar bins are often the dominant source in the activity in which they are included, especially for smaller unit level training exercises and many testing activities. Therefore, these ranges provide realistic maximum distances over which the specific effects would be possible.

PTS: The ranges to the PTS threshold (i.e., range to the onset of PTS: the maximum distance to which PTS would be expected for an ocean environment) are shown in Table 3.4-10, relative to the marine mammal's functional hearing group. For a SQS-53 sonar transmitting for 1 second at 3 kHz and a representative source level of 235 dB re 1 μPa^2-s at 1 m, the range to PTS for the most sensitive species (the high-frequency cetaceans) extends from the source to a range of 100 m (109 yd.). Since any surface ship hull-mounted sonar (e.g., Bin MF1; such as the SQS-53) engaged in anti-submarine warfare training would be moving at 10–15 knots (5.1–7.7 m/second) and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 260 m (284 yd.) during the time between those pings (note: 10 knots is the speed used in the NAEMO). As a result, there is little overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). For all other functional hearing groups (low-frequency cetaceans, mid-frequency cetaceans, and phocid seals) single-ping PTS zones are within 100 m (109 yd.) of the sound source. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship within the PTS zone, however, as indicated in Table 3.4-10, the distances required make PTS exposure less likely. For a Navy vessel moving at a nominal 10 knots, it is unlikely a marine mammal could maintain the speed to parallel the ship and receive adequate energy over successive pings to result in a PTS exposure. For all sources except for the most powerful hull-mounted sonar (e.g., SQS-53 [in Bin MF1]) ranges to PTS are well within 50 m (55 yd.), even for multiple pings (up to five pings) and the most sensitive functional hearing group (high-frequency cetaceans).

Table 3.4-10: Approximate Ranges to Permanent Threshold Shift Criteria for Each Functional Hearing Group for a Single Ping from Three of the Most Powerful Sonar Systems within Representative Ocean Acoustic Environments

Functional Hearing Group	Ranges to the Onset of PTS for One Ping (meters)[1]		
	Sonar Bin MF1 (e.g., SQS-53; ASW Hull-Mounted Sonar)	Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)	Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)
Low-Frequency Cetaceans	70	10	≤ 2
Mid-Frequency Cetaceans	10	≤ 2	≤ 2
High-Frequency Cetaceans	100	20	10
Phocid Seals	80	10	≤ 2
Otariid Seals & Sea Lions, & Mustelid (Sea Otters)	10	≤ 2	≤ 2

Notes: ASW= anti-submarine warfare, PTS = permanent threshold shift

TTS: Table 3.4-11 illustrates the ranges to the onset of TTS (i.e., the maximum distances to which TTS would be expected) for one, five, and ten pings from three representative sonar systems. Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer; this can also be thought of as a larger volume acoustic footprint for TTS effects. Because the effects threshold is total summed sound energy and because of the longer distances, successive pings can add together, further increasing the range to onset-TTS. Therefore, it is possible for animals to remain in these areas over several successive pings and potentially receive a TTS exposure.

Behavioral: The distances over which the sound pressure level from four representative sonar sources is within the indicated 6 dB bins, and the percentage of animals that may exhibit a significant behavioral response under the mysticete and odontocete behavioral response function, are shown in Table 3.4-12 and Table 3.4-13 respectively See Section 3.4.3.1.2 (Analysis Background and Framework) for details on the derivation and use of the behavioral response function as well as the step function thresholds for harbor porpoises and beaked whales of 120 dB re 1 µPa and 140 dB re 1 µPa, respectively.

Range to 120 dB re 1 µPa varies by system, output setting, and environmental conditions, but can exceed 100 nm for the most powerful hull-mounted mid-frequency sonar; however, only a very small percentage of animals would be predicted to react at received levels between 120 and 144 dB re 1 µPa, with the exception of harbor porpoises. All harbor porpoises that are predicted to receive 120 dB re 1 µPa or greater would be assumed to exhibit a behavioral response. Likewise, beaked whales would be predicted to have behavioral reactions at distances to approximately 73 km in reaction to received level of 140 dB re 1 µPa or greater.

Table 3.4-11: Approximate Ranges to the Onset of Temporary Threshold Shift for Three Representative Sonar Over a Representative Range of Ocean Environments

Functional Hearing Group	Approximate Ranges to the Onset of TTS (meters)[1]								
	Sonar Bin MF1 (e.g., SQS-53; ASW Hull-Mounted Sonar)[2]			Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)			Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		
	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings
Low-frequency cetaceans	560–2,280	1,230–6,250	1,620–8,860	220–240	490–1,910	750–2,700	110–120	240–310	340–1,560
Mid-frequency cetaceans	150–180	340–440	510–1,750	< 50	< 50	< 50	< 50	< 50	< 50
High-frequency cetaceans	2,170–7,570	4,050–15,350	5,430–19,500	90	180–190	260–950	< 50	< 50	< 50
Phocid seals and manatees	72–1,720	200–3,570	350–4,850	< 50	100	150	< 50	< 50	< 50

[1] Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals are expected to receive TTS extends from onset-PTS to the distance indicated.

[2] This worst case example for 5 and 10 pings is only applicable for a hull-mounted sonar that is stationary, such as might occur during pierside sonar maintenance. If a vessel is moving, the time between pings and the distance covered at a nominal 10–15 knots would generally not result in overlap of sufficient sound energy for the range to PTS or TTS to expand significantly due to the accumulation of energy from subsequent pings.

Notes: ASW = anti-submarine warfare, PTS = permanent threshold shift, TTS = temporary threshold shift

The range to effects for activities using sonar and other active acoustic sources used in the Inland Waters of the Study Area differ from the hull-mounted mid-frequency sources used in the open ocean as discussed in the preceding paragraphs and tables. The use of hull-mounted (surface ship and submarine) mid-frequency sonar in the Inland Waters is limited to sonar maintenance and testing, constituting approximately 2 percent of the total sonar and other active acoustic source hours. For pierside maintenance and testing of hull-mounted mid-frequency sources in the Inland Waters, modeling provides an overestimate of the range to effects because it cannot adequately account for the complex interactions of the sound energy into very shallow water and associated shorelines, the loss into dampening structures (i.e., such as adjacent pilings, jetties, or seawalls), or occasions when a ship or submarine is moored bow in so that the sonar is transmitted toward the nearby shoreline. Due to these and other factors the underwater acoustic environment of the Inland Waters is much more complex than the open ocean, and the extreme variability of ranges does not easily convey a representative approximation of average range to effects as presented above for the open ocean. In comparison to hull-mounted and tactical mid-frequency sources presented in Table 3.4-10, the remaining activities in inland water areas involve many sources using high frequency sound (e.g., swimmer detection sonar) that are absorbed faster than mid-frequency sound and all sources used in the Inland Waters are much lower power than hull-mounted mid-frequency sonar. Additionally the testing activities within the Inland Waters occur in confined waters that are typically calmer and any marine mammals would routinely surface to breathe, increasing the likelihood of visual detection and effective application of mitigation measures. Given these factors, the majority of sonar and other active acoustic sources used in the geographically constricted Inland Waters of the study area are less likely to result in physiological (TTS and PTS) effects to marine mammals at long ranges. Additionally, any behavioral effects associated with these types of sources would likely be limited to the general vicinity of the specific activity (e.g., Hood Canal, Dabob Bay, Keyport, or Carr inlet) due to land blocking the acoustic transmission path of the sound source.

Table 3.4-12: Range to Received Sound Pressure Level in 6-Decibel Increments and Percentage of Behavioral Harassments for Low-Frequency Cetaceans under the Mysticete Behavioral Response Function for Three Representative Sonar Systems (Average Values for the Study Area)

Received Level in 6 dB Increments	Bin MF1 (e.g., SQS-53; ASW Hull-Mounted Sonar)		Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)		Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)	
	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment
120 <= SPL < 126	178,750–156,450	0.00%	100,000–92,200	0.00%	22,800–15,650	0.00%
126 <= SPL < 132	156,450–147,500	0.00%	92,200–55,050	0.11%	15,650–11,850	0.05%
132 <= SPL < 138	147,500–103,700	0.21%	55,050–46,550	1.08%	11,850–6,950	2.84%
138 <= SPL < 144	103,700–97,950	0.33%	46,550–15,150	35.69%	6,950–3,600	16.04%
144 <= SPL < 150	97,950–55,050	13.73%	15150–5,900	26.40%	3,600–1,700	33.63%
150 <= SPL < 156	55,050–49,900	5.28%	5,900–2,700	17.43%	1,700–250	44.12%
156 <= SPL < 162	49,900–10,700	72.62%	2,700–1,500	9.99%	250–100	2.56%
162 <= SPL < 168	10,700–4,200	6.13%	1,500–200	9.07%	100–< 50	0.76%
168 <= SPL < 174	4,200–1,850	1.32%	200–100	0.18%	< 50	0.00%
174 <= SPL < 180	1,850–850	0.30%	100–< 50	0.05%	< 50	0.00%
180 <= SPL < 186	850–400	0.07%	< 50	0.00%	< 50	0.00%
186 <= SPL < 192	400–200	0.01%	< 50	0.00%	< 50	0.00%
192 <= SPL < 198	200–100	0.00%	< 50	0.00%	< 50	0.00%

Notes: ASW = anti-submarine warfare, dB = decibels, m = meters, SPL = sound pressure level

Table 3.4-13: Range to Received Sound Pressure Level in 6-Decibel Increments and Percentage of Behavioral Harassments for Mid-Frequency Cetaceans under the Odontocete Behavioral Response Function for Three Representative Sonar Systems (Average Values for the Study Area)

Received Level in 6 dB Increments	Bin MF1 (e.g., SQS-53; ASW Hull-Mounted Sonar)		Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)		Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)	
	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment
120 <= SPL < 126	179,400–156,450	0.00%	100,000–92,200	0.00%	23,413–16,125	0.00%
126 <= SPL < 132	156,450–147,500	0.00%	92,200–55,050	0.11%	16,125–11,500	0.06%
132 <= SPL < 138	147,500–103,750	0.21%	55,050–46,550	1.08%	11,500–6,738	2.56%
138 <= SPL < 144	103,750–97,950	0.33%	46,550–15,150	35.69%	6,738–3,825	13.35%
144 <= SPL < 150	97,950–55,900	13.36%	15,150–5,900	26.40%	3,825–1,713	37.37%
150 <= SPL < 156	55,900–49,900	6.12%	5,900–2,700	17.43%	1,713–250	42.85%
156 <= SPL < 162	49,900–11,450	71.18%	2,700–1,500	9.99%	250–150	1.87%
162 <= SPL < 168	11,450–4,350	7.01%	1,500–200	9.07%	150–< 50	1.93%
168 <= SPL < 174	4,350–1,850	1.42%	200–100	0.18%	< 50	0.00%
174 <= SPL < 180	1,850–850	0.29%	100–< 50	0.05%	< 50	0.00%
180 <= SPL < 186	850–400	0.07%	< 50	0.00%	< 50	0.00%
186 <= SPL < 192	400–200	0.01%	< 50	0.00%	< 50	0.00%
192 <= SPL < 198	200–100	0.00%	< 50	0.00%	< 50	0.00%

Notes: (1) ASW = anti-submarine warfare, dB = decibels, m = meters, SPL = sound pressure level; (2) Odontocete behavioral response function is also used for high-frequency cetaceans, phocid seals, otariid seals and sea lions, and sea otters.

3.4.3.2.1.2 Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources

As discussed above (see Section 3.4.3.1.14.4, Model Assumptions and Limitations), within the NAEMO, animats (virtual animals) do not move horizontally or react in any way to avoid sound at any level. In reality, various researchers have demonstrated that cetaceans can perceive the location and movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Watkins 1986; Richardson et al. 1995; Wursig et al. 1998; Jansen et al. 2010; Tyack et al. 2011). See Section 3.4.3.1.2 (Analysis Background and Framework) for a review of research and observations of marine mammals' reactions to sound sources including sonar, ships, and aircraft. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area immediately around the sound source is the assumed behavioral response for most cases. Additionally, the NAEMO does not account for the implementation of mitigation, discussed in detail in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), which would prevent many of the model-estimated PTS effects. Therefore, the model-estimated PTS effects due to sonar and other active acoustic sources are further analyzed considering avoidance and implementation of mitigation measures described in Section 3.4.3.1.14 (Quantitative Analysis).

For example, if sound-producing activities are preceded by multiple vessel traffic or hovering aircraft, harbor porpoises and beaked whales are assumed to move beyond the range to PTS before sound transmission begins, as discussed in Section 3.4.3.1.15.1 (Avoidance of Human Activity). Table 3.4-10 shows the ranges to PTS for three of the most common and powerful sound sources proposed for use when training and testing in the Study Area. The source class Bin MF1 includes the most powerful anti-submarine warfare system for a surface combatant, the SQS-53. The range to PTS for all systems is generally much less than 50 m (55 yd.), with the exception of high-frequency cetaceans exposed to bin MF1 with a PTS range of approximately 100 m (109 yd.). Because the NAEMO does not include avoidance behavior, the preliminary model-estimated effects are based on unlikely behavior for these species—that they would tolerate staying in an area of high human activity. Beaked whales that were model-estimated to experience PTS due to sonar and other active acoustic sources are assumed to actually move away from the activity and into the range of TTS prior to the start of the sound-production for the activities listed in Table 3.4-14 and Table 3.4-15. For activities where multiple vessel traffic or hovering aircraft do not precede the sound transmissions, model-predicted PTSs were not reduced based on this factor.

Table 3.4-14: Training Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

Training
Civilian Port Defense
Mine Countermeasures Exercise – Ship Sonar
Tracking Exercise/Torpedo Exercise – Helicopter

Table 3.4-15: Testing Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

Testing
Airborne Mine Hunting Test
Anti-Submarine Warfare Mission Package Testing
Anti-Submarine Warfare Tracking Test – Helicopter
Cold Water Training
Component System Testing
Countermeasure Testing
General Test/Experimental Test Vehicle
Littoral Combat Ship Mission Package Testing – Anti-Submarine Warfare
Mine Countermeasure Mission Package Testing
Mine Countermeasure/Neutralization Testing
Mine Detection/Classification Testing
System – Subsystem and Component Acoustic Testing Pierside
System – Subsystem and Component Development Testing and Training
Torpedo Exercise (all)
Torpedo (Explosive) Testing
Underwater Vessel Acoustic Measurement (all)
Underwater Unmanned Vehicle (all)

The NAEMO does not consider implemented mitigation measures (as presented in detail in Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). To account for the implementation of mitigation measures, the acoustic effects analysis assumes a model-estimated PTS would not occur if an animal at the water surface would likely be observed during those activities with Lookouts up to and during use of the sound source, considering the sightability of a species based on g(0) (see Table 3.4-8 in Section 3.4.3.1.16 (Implementing Mitigation to Reduce Sound Exposures), the range to PTS for each hearing group and source (see examples in Table 3.4-10), and mitigation effectiveness (Table 3.4-16). The range to PTS is generally less than 50 m (55 yd.), and the largest single ping range to PTS for the most powerful sonar system is approximately 100 m (109 yd.), so Lookouts need only to detect animals before they are within a very close range of a sound source to prevent PTS. The preliminary model-estimated PTS numbers are reduced by the portion of animals that are likely to be seen (Mitigation Adjustment Factor x Sightability). Model-predicted PTS effects are adjusted based on these factors and added to the model predicted TTS exposures. This is a conservative approach that will still result in an overestimation of PTS effects since the range to PTS is generally much less than 50 m (55 yd.). Lookouts need only detect animals before they are within this very close range to implement mitigation to prevent PTS, and the g(0) detection probabilities used as a sightability factor are based on having to detect animals at much greater distance (many kilometers; as presented previously in Section 3.4.3.1.16, Implementing Mitigation to Reduce Sound Exposures).

Table 3.4-16: Mitigation Adjustment Factors for Activities Using Sonar and Other Active Acoustic Sources Integrated into Modeling Analyses

Activity[1]	Factor for Adjustment of Preliminary Modeling Estimates[2]	Mitigation Platform Used for Assessment
Training		
Civilian Port Defense	1	Vessel
Submarine Sonar Maintenance	0.5	Vessel
Surface Ship Sonar Maintenance	1	Vessel
Tracking Exercise – Helicopter	1	Vessel
Tracking Exercise – Surface	1	Aircraft
Testing		
Acoustic Test Facility	1	Vessel
Cold Water Training	1	Vessel
Component System Testing	1	Vessel
Countermeasure Testing	1	Vessel
Electromagnetic Measurement	1	Vessel
General Test/Experimental Test Vehicle	1	Vessel
Littoral Combat Ship Mission Package Testing – Anti-Submarine Warfare	1	Vessel
LFBB	1	Vessel
Measurement System Repair/Replacement	1	Vessel
Pierside Integrated Swimmer Defense	1	Vessel
Pierside Sonar Testing	1	Vessel
POPS	1	Vessel
Proof-of-Concept Testing	1	Vessel
SSBN-PRST	1	Vessel
Surface Vessel Acoustic Measurement – SAS	1	Vessel
Swimmer Detection	1	Vessel
System – Subsystem and Component Acoustic Testing Pierside	1	Vessel
System – Subsystem and Component Development Testing and Training	1	Vessel
System – Subsystem and Component Performance Testing At-Sea	1	Vessel
Submarine Sonar Testing	0.5	Vessel
Submarine Sonar Testing/Maintenance	0.5	Vessel
Target Strength Testing	1	Vessel
Torpedo Exercise (all)	1	Vessel
Torpedo (Explosive) Testing	1	Vessel
Underwater Vessel Acoustic Measurement (all)	1	Vessel
Underwater Unmanned Vehicle (all)	1	Vessel

[1] The adjustment factor for all other activities (not listed) is zero; there is no adjustment of the preliminary modeling estimates as a result of implemented mitigation.

[2] If less than half of the mitigation zone cannot be continuously visually observed due to the type of mitigation platform used for this assessment, number of Lookouts, and size of the mitigation zone, mitigation is not used as an adjustment factor in the acoustic effects analysis, and the activity is not listed in this table.

Animal avoidance of the area immediately around the sonar or other active acoustic system, coupled with mitigation measure designed to avoid exposing animals to high energy levels, would make the majority of model-estimated PTS to mid-frequency cetaceans unlikely. The maximum ranges to onset PTS for mid-frequency cetaceans (see Table 3.4-10) do not exceed 10 m (11 yd.) in any environment modeled for the most powerful non-impulse acoustic sources, hull-mounted sonar (e.g., Bin MF1; SQS-53C). Ranges to PTS for low-frequency cetaceans and high-frequency cetaceans (see Table 3.4-10) do not exceed approximately 77 and 109 yd. (70 and 100 m), respectively. Considering vessel speed during anti-submarine warfare activities normally exceeds 10 knots, and sonar pings occur about every 50 seconds, even for the MF1 an animal would have to maintain a position within a 22 yd. (20 m) radius in front of, or alongside moving the ship for over 3 minutes (given the time between five pings) to experience PTS. In addition, the animal(s) or pod would have to remain unobserved; otherwise, implemented mitigation would result in the sonar transmissions being shut down and thus ending any further exposure. Finally, the majority of marine mammals (odontocetes) have been demonstrated to have directional hearing, with best hearing sensitivity when facing a sound source (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005b). An odontocete avoiding a source would receive sounds along a less sensitive hearing orientation (its tail pointed toward the source), potentially reducing impacts. All model-estimated PTS exposures of mid-frequency cetaceans, therefore, are considered to actually be TTS due to the likelihood that an animal would be observed if it is present within the very short range to PTS effects.

The NAEMO does not account for several factors (see Section 3.0.4.2.2, Classification of Acoustic and Explosive Sources, and Section 3.4.3.1.14.4, Model Assumptions and Limitations) that must be considered in the overall acoustic analysis. The results in the following tables are the predicted exposures from the NAEMO adjusted by the animal avoidance and mitigation factors discussed in the section above (Section 3.4.3.2.1.2, Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources). Mitigation measures are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), and provide additional protections that are not considered in the numerical results below.

Marine mammals in other functional hearing groups (i.e., low-frequency cetaceans and high-frequency cetaceans, and pinnipeds), if present but not observed by Lookouts, are assumed to leave the area near the sound source after the first few pings, thereby reducing sound exposure levels and the potential for PTS. Based on nominal marine mammal swim speeds and normal operating parameters for Navy vessels it was determined that an animal can easily avoid PTS zones within the timeframe it takes an active sound source to generate one to two pings. As a conservative measure, and to account for activities where there may be a pause in sound transmission, PTS was accounted for over three to four pings of an activity. Additionally and as presented above, during the first few pings of an event, or after a pause in sonar operations, if animals are caught unaware and it was not possible to implement mitigation measures (e.g., animals are at depth and not visible at the surface) it is possible that they could receive enough acoustic energy for that to result in a PTS exposure. Only these initial PTS exposures at the beginning of the activity or after a pause in sound transmission are expected to actually occur. The remaining model-estimated PTS are considered to be TTS due to animal avoidance.

3.4.3.2.1.3 Predicted Impacts for Sonar and Other Active Acoustic Sources

Table 3.4-17 and Table 3.4-18 present the predicted impacts to marine mammals separated between training and testing activities for sonar and other active acoustic sources. Under Alternative 1, there is one non-annual training event that is biennial (e.g., Civilian Port Defense exercise) and it is analyzed as occurring every other year, or three times during the 5-year period considered in this analysis. There are no non-annual training events under the No Action Alternative or Alternative 2 and there are no non-annual testing events. Annual totals presented in the tables are the summation of all annual events, plus for Alternative 1—the proposed non-annual event, occurring in a 12-month period (as a maximum year).

These predicted effects are the result of the acoustic analysis, including acoustic effects modeling followed by consideration of animal avoidance of multiple exposures, avoidance by sensitive species of areas with a high level of activity, and Navy mitigation measures. Mitigation measures are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). These measures provide additional protections, many of which are not considered in the numerical results below since reductions as a result of implemented mitigation were only applied to those events having a very high likelihood of detecting marine mammals. It is important to note that there are additional protections offered by mitigation procedures which would further reduce effects to marine mammals, but are not considered in the quantitative adjustment of the model predicted effects.

It is also important to note that effects presented in Table 3.4-17 and Table 3.4-18 are the total number of annual effects and not necessarily the number of individuals exposed. As discussed in Section 3.4.3.1.12 (Behavioral Responses), an animal could be predicted to receive more than one predicted effect over the course of a year.

In addition, acoustic modeling indicates that under some alternatives there would be zero predicted effects to some species. In some cases the species may be absent in the season an activity is to occur, or activities under an alternative take place in locations a species does not inhabit. In other cases with zero predicted effects, marine mammals may be exposed to a stressor associated with an activity (such as the acoustic energy from a distant but audible underwater sound source), but the predicted exposure is of insufficient sound pressure level or too brief to rise in energy above an established impact threshold and criteria (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). In short, because some exposures do not exceed the current impact thresholds, they are considered insignificant and quantified as zero effects.

The southern resident killer whale is the only species with critical habitat located in the Study Area. The use of sonar and other active acoustic sources may occur within the southern resident killer whale's designated critical habitat areas year round. The primary constituent elements of the southern resident killer whale's critical habitat have been identified as (1) Water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging (National Marine Fisheries Service 2006). The primary constituent elements of the southern resident killer whale's designated critical habitat are not expected to be impacted by the proposed Navy activities involving use of sonar and other active acoustic sources.

3.4.3.2.1.4 No Action Alternative

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), training activities under the No Action Alternative include activities that produce in-water noise from the use of sonar and other active acoustic sources. Activities would occur in the Offshore Area and would mainly take place off the coast of Washington in the same range areas as have been used for decades. The majority of predicted effects to marine mammals under the No Action Alternative (99.3 percent) are as a result of Tracking Exercises by surface ships and marine patrol aircraft in the offshore portion of the Study Area.

Under the No Action Alternative, there are no training activities involving sonar and other active acoustic sources in the Inland Waters of the Study Area. There are no training activities involving use of sonar and other active acoustic sources in the Southeast Alaska-Western Behm Canal portion of the Study Area so there are no summary discussions in the remainder of this subsection detailing the lack of effects from training to stocks specific to Southeast Alaska.

Table 3.4-17 provides a summary of the total estimated effects from sonar and other active acoustic sources for Navy training that would be conducted over the course of a year under the three alternatives.

Mysticetes

All mysticetes (baleen whales) are classified as low-frequency cetaceans (see Section 3.4.2.3.3, Low-Frequency Cetaceans). Predicted acoustic effects to mysticetes from training activities under the No Action Alternative from sonar and other active sound sources are primarily (approximately 99 percent) from anti-submarine warfare events involving surface ships and hull-mounted sonar within the offshore portion of the Study Area. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for hull-mounted sonar (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of several thousand yards (kilometers); see Section 3.4.3.2.1.1 (Range to Effects). If there was no background noise (such as that from vessel traffic, breaking waves, or other vocalizing marine mammals) masking the active ping occurring approximately every 50 seconds, the ping could reach and possibly be heard underwater at distances exceeding approximately 54 mi. (100 km), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. The low received level (approximately 120 dB SPL) from the sonar at a distance exceeding approximately 54 mi. (100 km) is modeled as having some behavioral effects although masking by other ambient sounds, such as other vocalizing whales (see Au et al. 2000) or other potential biological sources (see D'Spain and Batchelor 2006), make reaction to the sound from sonar and other active sound sources by mysticetes at that distance less likely. It is unlikely that any of the acoustic stressors within these events would cause a behavioral reaction to a mysticete resulting in long-term consequences to the individual.

Research and observations show that if mysticetes are exposed to sonar or other active acoustic sources they may react in a number of ways depending on the characteristics of the sound source, their experience with the sound source, and whether they are migrating or on seasonal grounds (i.e., breeding or feeding). Reactions may include alerting, breaking off feeding dives and surfacing, diving or swimming away (see, for example, Goldblogen et al. 2013), or no response at all. Additionally, migrating mysticetes moving through the Study Area may divert around sound sources that are located within their path or may ignore a sound source depending on the context of the exposure.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers and is therefore as a condition potentially affecting an animal's behavior. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

The acoustic modeling and post-modeling analyses predict there would be no non-impulse sound exposure to mysticetes resulting in PTS.

North Pacific Right Whales (Endangered Species Act-Listed)

The population of North Pacific right whale is very few in number and they are generally only found in the Bering Sea, with sightings of a single North Pacific right whale off Kodiak Island (Alaska) on three occasions over the last 15 years. As presented in detail in Section 3.4.2.6 (North Pacific Right Whale [*Eubalaena japonica*]), a single right whale was seen in 1983 at the entrance to the Strait of Juan de Fuca

(Osborne et al. 1988) and in the most recent sighting within the Study Area, a single right whale was sighted over Quinault Canyon in 1992 (Green et al. 1992; Rowlett et al. 1994). Recently (June 2013), a single right whale was sighted in waters off Haida Gwaii, British Colombia (located approximately 200 nm north of the Study Area; Hume 2013) and, in October that same year (2013), another single right whale sighted in a group of humpbacks off the entrance to the Strait of Juan de Fuca (Pynn 2013). Given that sightings of North Pacific right whale are still considered very rare, the species is not expected to be present in the Study Area and not expected to overlap in time or location with occurrences of Navy training events involving sonar and other active acoustic sources so these activities would have no effect on North Pacific right whale.

Humpback Whales (Endangered Species Act-Listed)

Humpback whales could be in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. Humpback whales found in the Offshore Area and the Inland Waters of Puget Sound area are recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that humpback whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in one TTS and two behavioral reactions annually. The Central North Pacific stock of humpback whales would not be exposed to sound that would exceed the current impact thresholds.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal’s hearing of biologically relevant sounds.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) suggest that if humpback whales are exposed to sonar and other active acoustic sources, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Overall, number of predicted behavioral reactions is low and occasional behavioral reactions are unlikely to cause long-term consequences for individual animals or populations.

Blue Whales (Endangered Species Act-Listed)

Blue whales are only present in the offshore portion of the Study Area. Blue whales may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. Blue whales found in offshore portion of the Study Area are recognized as part of the Eastern North Pacific stock and the acoustic analysis predicts that they may be exposed to sonar and other active acoustic sources associated with training activities that may result in 1 behavioral reaction annually. Long-term consequences for individuals or populations would not be expected.

Fin Whales (Endangered Species Act-Listed)

Fin whales could be present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. Fin whales found in the Offshore Area and the Inland Waters of Puget Sound area are recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that fin whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in 2 TTS and 4 behavioral reactions annually. Long-term consequences for individuals or populations would not be expected. The Northeast Pacific stock of fin whales would not be exposed to sound that would exceed the current impact thresholds.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sonar and other active acoustic sources associated with training activities throughout the year in the Offshore Area. The acoustic analysis predicts that sei whales would not be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area at levels which would exceed the current impact thresholds (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). Long-term consequences for individuals or populations would not be expected.

Gray Whales (Eastern North Pacific Stock and Endangered Species Act-Listed Western North Pacific Stock)

Gray whales may be exposed to sonar or other active acoustic stressors when their presence coincides with training activities in the Study Area. Acoustic modeling predicts that the Eastern North Pacific gray whales could be exposed to sound that would exceed the current impact thresholds. The Western North Pacific stock of gray whales would not be exposed to sound that would exceed the current impact thresholds. As presented above for mysticetes in general, for both stocks and individuals within these stocks, long-term consequences would not be expected.

Minke Whales

Minke whales may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. Minke whales may be present in all portions of the Study Area. Minke whales found in the Offshore Area and the Inland Waters of Puget Sound area recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that minke whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in 1 TTS and 3 behavioral reactions. The Alaska stock of minke whales would not be exposed to sound that would exceed the current impact thresholds. As described for humpback whales above, these predicted effects to minke whales are unlikely to cause long-term consequences for individual animals or populations.

Odontocetes

Predicted impacts to odontocetes from training activities under the No Action Alternative from sonar and other active acoustic sources could occur in the Offshore Area are about 80 percent from anti-submarine warfare tracking events involving marine patrol aircraft using sonobuoys and 20 percent from surface ships and submarines using hull-mounted sonar. As discussed in Section 3.4.3.2.1.1 (Range to Effects), for mid-frequency odontocetes (cetaceans constituting the majority of marine mammals present including, for example, killer whales), ranges to TTS for hull-mounted sonar (e.g., sonar bin MF1; SQS-53 hull-mounted sonar) is within a maximum of approximately 200 yd. (200 m) for a single ping. For high-frequency cetaceans (i.e., Dall's porpoises and harbor porpoises), ranges to TTS for multiple pings during MF1 pierside maintenance can stretch to distances of over 5 mi. (10 km) if a series of conservative factors are assumed. At sea, if there was no background noise (such as that from vessel traffic, breaking waves, or other vocalizing marine mammals) masking the active ping occurring approximately every 50 seconds, the most powerful surface ship hull-mounted sonar, under rather optimal sound propagation conditions, could reach and possibly be heard underwater at distances exceeding approximately 107 mi. (170 km). The low received level (approximately 120 dB SPL) at that distance is modeled as having some behavioral effects possible, although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Modeling predicts behavioral effects at long distance and low received levels but does not take into account background ambient noise levels or other competing biological sounds, which may mask sound from distant Navy sources. D'Spain and Batchelor (2006) measured a source spectral density of 105–120 dB re

1 µPa^2-s/Hz at 1 m (in the mid-frequency range) and calculated an estimated source level of 135–150 dB re 1 µPa at 1 m from various biologics (fish and marine mammals) contributing to those underwater ambient sound levels recorded to the southeast of San Clemente Island, California.

Activities involving anti-submarine warfare training often involve multiple participants and activities associated with the event. More sensitive species of odontocetes such as beaked whales, harbor porpoise, Dall's porpoises, and dwarf and pygmy sperm whales may avoid the area for the duration of the event (see Section 3.4.3.2.1.2 (Avoidance Behavioral and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources) and Section 3.4.3.1.12 (Behavioral Responses) for a discussion of these species observed reactions sonar and other active acoustic sources). After the event ends, displaced animals would likely return to the area within a few days as seen in the Bahamas study with Blainville's beaked whales (Tyack et al. 2011). This would allow the animal to recover from any energy expenditure or missed resources, reducing the likelihood of long-term consequences for the individual or population. It is unlikely that any of the acoustic stressors within Tracking Exercises events would cause significant behavioral reactions in odontocetes because the few predicted impacts are spread out in time and space. Long-term consequences for individuals or populations would not be expected.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

For PTS, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012). Furthermore, likely avoidance of intense activity and sound coupled with mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the potential for PTS exposures to occur. Considering these factors, long-term consequences for individuals or populations would not be expected.

Sperm Whales (Endangered Species Act-Listed)

Sperm whales are classified as mid-frequency cetaceans (see Section 3.4.2.3.2, Mid-Frequency Cetaceans). Sperm whales are likely only in the offshore portion of the Study Area although also possibly present but rare and in the Southeast Alaska (Western Behm Canal) portion of the Study Area. Sperm whales found in the Offshore Area are recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that sperm whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in 26 behavioral reactions annually. These behavioral reactions are unlikely to cause long-term consequences for individual animals or populations.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) suggest that if sperm whales are exposed to sonar and other active acoustic sources, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Overall, number of predicted behavioral reactions is low and occasional behavioral reactions are unlikely to cause long-term consequences for individual animals or populations.

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy sperm whales and dwarf sperm whales (*Kogia spp*.) are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Pygmy sperm whales and dwarf sperm whales are only present in the offshore portion of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities. Each species of *Kogia* in the Study Area are part of the California, Oregon, Washington stock. For purposes of this analysis and because the number of dwarf sperm whales remain unknown, the acoustic modeling was undertaken for the genus *Kogia*. The acoustic analysis predicts that *Kogia* may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in two behavioral reactions annually. These predicted effects to *Kogia* are unlikely to cause long-term consequences for individual animals or populations.

Killer Whales – Eastern North Pacific Southern Resident (Endangered Species Act-Listed)

Killer whales from the Eastern North Pacific Southern Resident stock may be exposed to sonar and other active acoustic sources associated with training activities while they reside in the Study Area. The majority of these exposures would occur in the Inland Waters area of Puget Sound. The acoustic analysis predicts the Eastern North Pacific Southern Resident stock would not be exposed sonar and other active acoustic sources associated with training activities, which would exceed the current impact thresholds.

Other Killer Whales (Alaskan Resident, Northern Resident, West Coast Transient, and Eastern North Pacific Offshore)

Killer whales (other than the Eastern North Pacific Southern Resident stock) may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The majority of these predicted effects would occur off the coast of Washington where the acoustic analysis predicts that the Eastern North Pacific Offshore stock could be exposed to sound that may result in four behavioral reactions annually. The acoustic analysis predicts that the other killer whale stocks in the Study Area would not be exposed to sonar and other active acoustic sources associated with training activities, which would exceed the current impact thresholds. As described for sperm whales above, these predicted effects to killer whales are unlikely to cause long-term consequences for individual animals or populations.

Other Dolphins and Small Whales (Delphinids)

Dolphins may be exposed to sonar or other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts that delphinids (seven species total) could be exposed to sound that may result in 123 TTS and 2,029 behavioral reactions. These predicted effects would occur in the offshore portion in the Study area. As described for sperm whales above, these predicted effects to delphinids are unlikely to cause long-term consequences for individual animals or populations.

Harbor Porpoise

Harbor porpoises may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts that harbor porpoises could be exposed to sound that may result in 18,605 behavioral reactions annually. The majority of these predicted effects involve the Northern Oregon/Washington Coast stock (60 percent) and the Northern California/Southern Oregon stock (40 percent). For the Inland Waters area (Puget Sound) and the Washington Inland Waters stock of harbor porpoise, acoustic analysis predicts they would not be exposed to sonar and other active acoustic sources associated with training activities, which would exceed the current impact thresholds.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) of harbor porpoises for other locations show that this small species is wary of human activity and will avoid anthropogenic sound sources in many situations at levels down to 120 dB re 1 µPa. Harbor porpoises may startle and leave the immediate area of the training event but return within a few days after the event ends. Significant behavioral reactions seem more likely than with most other odontocetes. Animals that do exhibit a significant behavioral reaction would likely recover from any incurred costs. Harbor porpoise continue to inhabit the waters of Hood Canal in low numbers, which has for decades served as the location for training and testing events using sonar and other active acoustic sources. Based on this information, the use of sonar and other active acoustic sources is unlikely to result in long-term consequences for individuals or populations of harbor porpoise in the Study Area.

Dall's Porpoise

Dall's porpoise are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Dall's porpoise may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts that Dall's porpoises could be exposed to sound that may result in 884 TTS, and 125 behavioral reactions. These predicted effects involve the California, Oregon, Washington stock inhabiting the Offshore Area and Inland Waters portion of the Study Area. The Alaska stock of Dall's porpoise would not be exposed to sound that would exceed the current impact thresholds. As described for sperm whales above, these predicted effects to Dall's porpoise are unlikely to cause long-term consequences for individual animals or populations.

Beaked Whales

Beaked whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. The majority of beaked whales in the Study Area are located in the Offshore Area. The acoustic analysis predicts that beaked whales in the Offshore Area (six species total) could be exposed to sound that may result in 483 behavioral reactions. There are no beaked whales in the Inland Waters of the Study area.

Research and observations show that if beaked whales are exposed to mid-frequency sound sources they may startle, break off feeding dives, and avoid the area of the sound source to levels of 157 dB re 1 µPa, or below (McCarthy et al. 2011). Furthermore, in research done at the Navy's fixed tracking range in the Bahamas, animals leave the immediate area of the anti-submarine warfare training exercise but return within a few days after the event ends. Populations of beaked whales and other odontocetes in the Bahamas, and on other Navy instrumented ranges that have been operating for decades, appear to be stable (Section 3.4.4.1, Summary of Marine Mammal Monitoring During Navy Activities). Significant behavioral reactions seem likely in most cases if beaked whales are exposed to sonar and other active acoustic sources within a few tens of kilometers (see Section 3.4.3.2.1.1, Range to Effects), especially for prolonged periods (a few hours or more) since this is one of the most sensitive marine mammal groups to anthropogenic sound of any species or group studied to date.

Based on the best available science and the continued presence of beaked whales inhabiting intensively used Navy ranges, the Navy believes that effects to beaked whales due to sonar and other active acoustic training activities would generally not have long-term consequences for individuals or populations. Neither NMFS nor the Navy anticipates that marine mammal strandings or mortality would result from the use of sonar and other active acoustic sources during Navy exercises within the Study Area. Additionally, through the MMPA process (which allows for adaptive management), NMFS and the Navy will determine the appropriate way to proceed in the event that a causal relationship were to be found between Navy activities and a future stranding.

Pinnipeds

For pinnipeds in the Study Area, all of these predicted effects as a result of exposure to sonar and other active acoustic sources associated with training activities occur as a result of Anti-Submarine Warfare Tracking Exercise training events occurring in the offshore portion of the Study Area. Predicted effects include TTS and behavioral reactions. Research has demonstrated that for pinnipeds as for other mammals, recovery from a hearing threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. More severe shifts may not fully recover and thus would be considered PTS. Threshold shifts do not necessarily affect all hearing frequencies equally, so threshold shifts may not necessarily interfere with an animal's ability to hear biologically relevant sounds. As discussed previously, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012).

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources) ranges to some behavioral impacts could take place at distances exceeding 100 km, although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, approach, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

Otariids (Steller Sea Lions, Guadalupe Fur Seals, California Sea Lions, and Northern Fur Seals)

Steller Sea Lions

Steller sea lions are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. All Steller sea lions in the Study Area are considered part of the Eastern U.S. stock, which is not listed under the ESA. The acoustic analysis predicts Steller sea lions may be exposed to sonar and other active acoustic sources associated with training activities that may result in 118 behavioral reactions. For Steller sea lions and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely. There is no Steller sea lion critical habitat within the Study Area.

Guadalupe Fur Seals (Endangered Species Act-Listed as Threatened)

Guadalupe fur seals are present within the offshore portion of the Study Area during the warm season (summer and early autumn) and during that portion of the year may be exposed to sonar and other active acoustic sources associated with training activities. They are considered "seasonal" migrants since they return to rookeries in Mexican waters in the cold season. The Guadalupe fur seal is considered a single Mexico stock and is listed as threatened under the ESA (Carretta et al. 2013). It is estimated that Guadalupe fur seals could be exposed to sound from sonar and other active acoustic sources that may result in 11 behavioral reactions. Significant behavioral reactions would not be expected and long-term consequences for individuals or populations are unlikely. Critical habitat has not been designated for Guadalupe fur seal.

California Sea Lions

California sea lions are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. All California sea lions in the Study Area are considered part of the U.S. stock. The acoustic analysis predicts California sea lions may be exposed to sonar and other active acoustic sources associated with training activities that may result in 228 behavioral reactions. For California sea lions and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Northern Fur Seals

Northern fur seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts northern fur seals from the Eastern Pacific stock may be exposed to sonar and other active acoustic sources associated with training activities that may result in 787 behavioral reactions. The California stock may be exposed to sonar and other active acoustic sources associated with training activities that may result in 11 behavioral reactions. For northern fur seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Phocids (Northern Elephant Seals and Harbor Seals)

Northern Elephant Seals

Northern elephant seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. All Northern elephant seals in the Study Area are considered part of the California Breeding stock. The acoustic analysis predicts Northern elephant seals may be exposed to sonar and other active acoustic sources associated with training activities that may result in 55 TTS and 335 behavioral reactions. For Northern elephant seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Harbor Seals

Harbor seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. Very minimal training activity (e.g., mostly sonar maintenance) occurs in the inland water areas where the majority of harbor seal haul-outs are located. The acoustic analysis predicts harbor seals would not be exposed to sonar and other active acoustic sources associated with training activities, which would exceed the current impact thresholds. For harbor seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Mustelid (Northern Sea Otters)

Northern sea otters inhabit very shallow water nearshore coastal habitat that is not a location where training activities involving use of sonar and other active acoustic sources would occur. In addition, normal sea otter behavior consists of short foraging dives followed by surface behaviors when their ears are above water. As a result, effects to Northern sea otter from Navy training events involving sonar and other active acoustic sources are discountable since they are extremely unlikely to occur.

Conclusion

Training activities under the No Action Alternative include the use of sonar and other active acoustic sources as described in Table 2.8-1 and Section 3.0.5.3.1 (Acoustic Stressors). These activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of sonar and other active acoustic sources for training activities as described in the No Action Alternative:

- *May expose marine mammals up to 23,840 times annually to sound levels that would be considered Level B harassment*
- *Would not expose marine mammals to sound levels that would be considered Level A harassment*

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities as described in the No Action Alternative:

- *May affect, and is likely to adversely affect humpback whale, blue whale, fin whale, sperm whale, and Guadalupe fur seal*
- *May affect, but is not likely to adversely affect, sei whale, Western North Pacific gray whale, and southern resident killer whale*
- *Would have no effect on North Pacific right whale*
- *Would have no effect on southern resident killer whale critical habitat*

Table 3.4-17: Annual Training Effects for Sonar and Other Active Acoustic Sources

Species	Stock	No Action Alternative			Alternative 1			Alternative 2		
		Behavioral	TTS	PTS	Behavioral	TTS	PTS	Behavioral	TTS	PTS
North Pacific right whale	Eastern North Pacific	0	0	0	0	0	0	0	0	0
Humpback whale	CA/OR/WA	2	1	0	7	5	0	7	5	0
	Central North Pacific	0	0	0	0	0	0	0	0	0
Blue whale	Eastern North Pacific	1	0	0	3	2	0	3	2	0
Fin whale	Northeast Pacific	0	0	0	0	0	0	0	0	0
	CA/OR/WA	4	2	0	14	10	0	14	10	0
Sei whale	Eastern North Pacific	0	0	0	0	0	0	0	0	0
Minke whale	Alaska	0	0	0	0	0	0	0	0	0
	CA/OR/WA	3	1	0	9	9	0	9	9	0
Gray whale	Eastern North Pacific	0	0	0	0	6	0	0	6	0
	Western North Pacific	0	0	0	0	0	0	0	0	0
Sperm whale	North Pacific	0	0	0	0	0	0	0	0	0
	CA/OR/WA	26	0	0	80	0	0	80	0	0
Kogia (spp.)	CA/OR/WA	0	2	0	13	56	0	13	56	0
Killer whale	Alaskan Resident	0	0	0	0	0	0	0	0	0
	Northern Resident	0	0	0	0	0	0	0	0	0
	West Coast Transient	0	0	0	5	3	0	5	3	0
	East. N. Pac. Offshore	4	0	0	12	1	0	12	1	0
	Southern Resident	0	0	0	2	0	0	2	0	0
Short-finned pilot whale	CA/OR/WA	0	0	0	0	0	0	0	0	0
Short-beaked common dolphin	CA/OR/WA	289	16	0	664	51	0	664	51	0
Bottlenose dolphin	CA/OR/WA	0	0	0	0	0	0	0	0	0
Striped dolphin	CA/OR/WA	6	0	0	0	0	0	0	0	0
Pacific white-sided dolphin	North Pacific	0	0	0	19	2	0	19	2	0
	CA/OR/WA	1,137	75	0	3,176	248	0	3,176	248	0
Northern right whale dolphin	CA/OR/WA	377	23	0	1,212	97	0	1,212	97	0
Risso's dolphin	CA/OR/WA	220	9	0	613	33	0	613	33	0

Table 3.4-17: Annual Training Effects for Sonar and Other Active Acoustic Sources (continued)

Species	Stock	No Action Alternative			Alternative 1			Alternative 2		
		Behavioral	TTS	PTS	Behavioral	TTS	PTS	Behavioral	TTS	PTS
Harbor porpoise	Southeast Alaska	0	0	0	0	0	0	0	0	0
	Northern OR/WA Coast	7,442	0	0	2,139	8	0	2,139	8	0
	N. CA/S. OR	11,163	0	0	3,209	12	0	3,209	12	0
	WA Inland Waters	0	0	0	571	841	1	571	841	1
Dall's porpoise	Alaska	0	0	0	0	0	0	0	0	0
	CA/OR/WA	125	884	0	758	2,714	2	758	2,714	2
Cuvier's beaked whale	Alaska	0	0	0	0	0	0	0	0	0
	CA/OR/WA	69	0	0	311	0	0	311	0	0
Baird's beaked whale	Alaska	0	0	0	0	0	0	0	0	0
	CA/OR/WA	135	0	0	522	0	0	522	0	0
Mesoplodon beaked whales	CA/OR/WA	279	0	0	1,245	2	0	1,245	2	0
Steller sea lion	Eastern U.S.	118	0	0	398	0	0	398	0	0
Guadalupe fur seal	Mexico	11	0	0	37	0	0	37	0	0
California sea lion	U.S.	228	0	0	796	7	0	796	7	0
Northern fur seal	Eastern Pacific	787	0	0	2,452	1	0	2,452	1	0
	California	11	0	0	37	0	0	37	0	0
Northern elephant seal	California Breeding	335	55	0	990	250	0	990	250	0
Harbor seal	SE Alaska-Clarence St.	0	0	0	0	0	0	0	0	0
	OR/WA Coastal	0	0	0	0	0	0	0	0	0
	WA Inland Waters	0	0	0	174	373	4	174	373	4
Northern sea otter	SE Alaska	0	0	0	0	0	0	0	0	0
	Washington	0	0	0	0	0	0	0	0	0

Notes: CA = California, N = North, Pac = Pacific, PTS = Permanent Threshold Shift, S = South, SE = Southeast, St. = Strait, TTS = Temporary Threshold Shift, OR = Oregon, U.S. = United States, WA = Washington

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), testing activities under the No Action Alternative include activities that produce in-water noise from the use of sonar and other active acoustic sources. Activities could occur in the Offshore Area and Inland Waters-Puget Sound, but would mainly occur on established testing ranges within Puget Sound. The majority (approximately 77 percent) of predicted effects to marine mammals under the No Action Alternative for testing activities are as a result of sound sources on underwater test vehicles, underwater unmanned vehicles, and torpedoes in the Inland Waters area. Approximately 6 percent of the total effects are predicted to occur in the Offshore Area during testing under the No Action Alternative.

Testing activities in Southeast Alaska-Western Behm Canal that produce in-water noise from the use of sonar and other active acoustic sources are not included in the No Action Alternative.

Table 3.4-18 provides a summary of the total estimated effects from sonar and other active acoustic sources for Navy testing that would be conducted over the course of a year under the three alternatives. Acoustic modeling indicates that in many cases, animals would either not be exposed to the use of sonar and other active acoustic sources associates with testing activities or that the sound exposure would exceed the current impact thresholds (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals).

Mysticetes

All mysticetes (baleen whales) are classified as low-frequency cetaceans (see Section 3.4.2.3.3, Low-Frequency Cetaceans). The acoustic analysis predicts that mysticetes (humpback, blue, fin, sei, minke, and gray whales) would not be exposed to sonar and other active acoustic sources associated with testing activities in the Study Area, which would exceed the current impact thresholds (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). The majority of testing events occur in the Inland Waters where mysticetes are extralimital or rare. The remaining testing activities generally occur relatively near to shore where a portion of the acoustic energy spread is blocked by land. Long-term consequences for individuals or populations would not be expected.

North Pacific Right Whales (Endangered Species Act-Listed)

As presented in detail in Section 3.4.2.6 (North Pacific Right Whale [*Eubalaena japonica*]), North Pacific right whale are not expected to be present in the Study Area during events involving the use of sonar and other active acoustic sources. As a result, Navy events involving sonar and other active acoustic sources would have no effect on North Pacific right whale.

Odontocetes

Sperm Whales (Endangered Species Act-Listed)

Sperm whales are classified as mid-frequency cetaceans (see Section 3.4.2.3.2, Mid-Frequency Cetaceans). The acoustic analysis predicts that sperm whales would not be exposed to sonar and other active acoustic sources associated with testing activities in the Study Area, which would exceed the current impact thresholds. Sperm whales inhabit deep ocean areas and the majority of testing events occur in the Inland Waters where sperm whales are extralimital and the remaining testing activities generally occur relatively near to shore where a portion of the acoustic energy spread is blocked by land. Long-term consequences for individuals or populations would not be expected.

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy sperm whales and dwarf sperm whales are only present in the offshore portion of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities. Each species of *Kogia* in the Study Area are part of the California, Oregon, Washington stock. For purposes of this analysis and because the number of dwarf sperm whales remain unknown, the acoustic modeling was undertaken for the genus *Kogia*. The acoustic analysis predicts that *Kogia* may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 2 TTS annually. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's hearing of biologically relevant sounds. These predicted effects to *Kogia* are unlikely to cause long-term consequences for individual animals or populations.

Killer Whales – Eastern North Pacific Southern Resident (Endangered Species Act-Listed)

Killer whales from the Eastern North Pacific Southern Resident stock may be exposed to sonar and other active acoustic sources associated with testing activities while they reside in the Study Area. The majority of testing events occur in areas such as Hood Canal, where southern resident killer whales are not believed to be present; other testing activities occur offshore, where they are only present briefly during their annual migration period. The acoustic analysis predicts the Eastern North Pacific Southern Resident stock would not be exposed to sonar and other active acoustic sources associated with testing activities, which would exceed the current impact thresholds. Activities involving the use of sonar and other active acoustic sources would have no effect on southern resident killer whale critical habitat.

Other Killer Whales (Alaskan Resident, Northern Resident, West Coast Transient, and Eastern North Pacific Offshore)

Killer whales (other than the Eastern North Pacific Southern Resident stock) may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The majority of these predicted effects would occur in the Inland Waters of Puget Sound where the acoustic analysis predicts that the West Coast Transient stock could be exposed to sound that may result 89 TTS and 17 behavioral reactions. The Eastern North Pacific offshore stock, Alaska Resident stock, and Northern Resident stock of killer whales would not be exposed to sound that would exceed the current impact thresholds. As described for *Kogia* above, these predicted effects to killer whales are unlikely to cause long-term consequences for individual animals or populations.

Other Dolphins and Small Whales (Delphinids)

Dolphins may be exposed to sonar or other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that delphinids (seven species total) could be exposed to sound that may result in 1 TTS and 118 behavioral reactions. These predicted effects would only occur in the offshore portion of the Study Area and are unlikely to cause long-term consequences for individual animals or populations.

Harbor Porpoise

Harbor porpoises may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that harbor porpoises could be exposed to sound that may result in 1 PTS, 2,474 TTS, and 1,170 behavioral reactions. The majority of these predicted effects involve the Washington Inland stock (80 percent) since the majority of the testing activities occur in the Inland Waters of the Study Area. The remainder (20 percent) of these exposures would be to the Northern Oregon/Washington Coast stock and the Northern California/Southern

Oregon stock in the offshore waters of the Study Area. The Southeast Alaska stock of harbor porpoise would not be exposed to sound that would exceed the current impact thresholds.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations. Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) of harbor porpoises for other locations show that this small species is wary of human activity and will avoid anthropogenic sound sources in many situations at levels down to 120 dB re 1 µPa. Harbor porpoises may startle and leave the immediate area of the testing event but return within a few days after the event ends. Significant behavioral reactions seem more likely than with most other odontocetes. Animals that do exhibit a significant behavioral reaction would likely recover from any incurred costs. Harbor porpoise continue to inhabit the waters of Hood Canal in low numbers (including Dabob Bay), which has for decades served as the location for training and testing events using sonar and other active acoustic sources. Based on this information, the use of sonar and other active acoustic sources is unlikely to result in long-term consequences for the individual or population.

Dall's Porpoise

Dall's porpoise are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Dall's porpoise may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that Dall's porpoise in the California, Oregon, Washington stock could be exposed to sound that may result in 517 TTS and 1 behavioral reaction. The majority of these predicted effects (74 percent) occur in the offshore portion of the Study Area. The Alaska stock of Dall's porpoise would not be exposed to sound that would exceed the current impact thresholds. As described for *Kogia* above, these predicted effects to Dall's porpoise are unlikely to cause long-term consequences for individual animals or populations.

Beaked Whales

Beaked whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. The majority of beaked whales in the Study Area are located in the Offshore Area. The acoustic analysis predicts that beaked whales in the Offshore Area (six species total) could be exposed to sound that may result in 8 behavioral reactions. There are no beaked whales in the Inland Waters of the Study Area where the majority of testing activities occurs. Research and observations show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source to levels of 157 dB re 1 µPa, or below (McCarthy et al. 2011). Furthermore, in research done at the Navy's fixed tracking range in the Bahamas, animals leave the immediate area of the anti-submarine warfare training exercise but return within a few days after the event ends. Populations of beaked whales and other odontocetes on the Bahamas, and other Navy fixed ranges that have been operating for tens of years, appear to be stable (Section 3.4.4.1, Summary of Marine Mammal Monitoring during Navy Activities). Significant behavioral reactions seem likely in most cases if beaked whales are exposed to sonar and other active acoustic sources within a few tens of kilometers (see Section 3.4.3.2.1.1, Range to Effects), especially for prolonged periods (a few hours or more) since this is one of the most sensitive marine mammal groups to anthropogenic sound of any species or group studied to date.

Based on the best available science, the Navy believes that beaked whales that exhibit a significant behavioral reaction due to sonar and other active acoustic testing activities would generally not have long-term consequences for individuals or populations. Navy does not anticipate that marine mammal strandings or mortality would result from the operation of sonar and other active acoustic sources during Navy testing within the Study Area.

Pinnipeds

Research has demonstrated that for pinnipeds as for other mammals, recovery from a hearing threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. More severe shifts may not fully recover and thus would be considered PTS. Threshold shifts do not necessarily affect all hearing frequencies equally, so threshold shifts may not necessarily interfere with an animal’s ability to hear biologically relevant sounds. For PTS, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range (a PTS exposure) would have long-term consequences for that individual given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012). Furthermore, mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts. Considering these factors, long-term consequences for individuals or populations would not be expected.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

Otariids (Steller Sea Lions, Guadalupe Fur Seals, California Sea Lions, and Northern Fur Seals)

Steller Sea Lions

Steller sea lions are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. All Steller sea lions in the Study Area are considered part of the Eastern U.S. stock, which is not listed under the ESA. The acoustic analysis predicts Steller sea lions may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 142 behavioral reactions. For Steller sea lions and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely. None of the locations designated as critical habitat for Steller sea lion are present within the Study Area.

Guadalupe Fur Seals (Endangered Species Act-Listed as Threatened)

Guadalupe fur seals are present within the offshore portion of the Study Area during the warm season (summer and early autumn) and during that portion of the year may be exposed to sonar and other active acoustic sources associated with testing activities. They are considered “seasonal” migrants since they return to rookeries in Mexican waters in the cold season. The Guadalupe fur seal is considered a single Mexico stock and is listed as threatened under the ESA (Carretta et al. 2013). It is estimated that Guadalupe fur seals would not be exposed to sound that would exceed the current impact thresholds. Critical habitat has not been designated for Guadalupe fur seals.

California Sea Lions

California sea lions are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. All California sea lions in the Study Area are considered part of the U.S. stock. The acoustic analysis predicts California sea lions may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 36 TTS and 917 behavioral reactions. For California sea lions and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Northern Fur Seals

Northern fur seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts northern fur seals from the Eastern Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 17 behavioral reactions. The California stock would not be exposed to sound that would exceed the current impact thresholds. For northern fur seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Phocids (Northern Elephant Seals and Harbor Seals)

Northern Elephant Seals

Northern elephant seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. All Northern elephant seals in the Study Area are considered part of the California Breeding stock. The acoustic analysis predicts Northern elephant seals may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 12 behavioral reactions. For Northern elephant seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Harbor Seals

Harbor seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts harbor seals from the Oregon/Washington Coastal stock may be exposed to sonar and other active acoustic sources associated with testing activities in the offshore portion of the Study Area that may result in 12 behavioral reactions. In addition, acoustic analysis predicts harbor seals from the Washington Inland Waters stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Inland Waters portion of the Study Area that may result in 8 PTS, 3,117 TTS and 1,963 behavioral reactions. The Southeast Alaska (Clarence Strait) stock of harbor seals would not be exposed to sound that would exceed the current impact thresholds. For harbor seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Mustelid (Northern Sea Otters)

Northern sea otters inhabit very shallow water nearshore habitat that is not a location where testing activities involving use of sonar and other active acoustic sources would generally occur. In addition, normal sea otter behavior consists of short foraging dives followed by surface behaviors when their ears are above water. As a result, effects to Northern sea otter from Navy testing events involving sonar and other active acoustic sources are discountable since they are extremely unlikely to occur.

Conclusion

Testing activities under the No Action Alternative include the use of sonar and other active acoustic sources as described in Section 3.0.5.3.1 (Acoustic Stressors). These activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of sonar and other active acoustic sources for testing activities as described in the No Action Alternative:

- *May expose marine mammals up to 10,613 times annually to sound levels that would be considered Level B harassment*
- *May expose 1 harbor porpoise annually and harbor seals up to 8 times annually to sound levels that would be considered Level A harassment*

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities as described in the No Action Alternative:

- *May affect, but is not likely to adversely affect, humpback whale, blue whale, fin whale, sei whale, Western North Pacific gray whale, sperm whale, southern resident killer whale, and Guadalupe fur seal*
- *Would have no effect on North Pacific right whale*
- *Would have no effect on southern resident killer whale critical habitat*

Table 3.4-18: Annual Testing Effects for Sonar and Other Active Acoustic Sources

Species	Stock	No Action Alternative			Alternative 1			Alternative 2		
		Behavioral	TTS	PTS	Behavioral	TTS	PTS	Behavioral	TTS	PTS
North Pacific right whale	Eastern North Pacific	0	0	0	0	0	0	0	0	0
Humpback whale	CA/OR/WA	0	0	0	5	39	0	5	42	0
	Central North Pacific	0	0	0	1	0	0	2	0	0
Blue whale	Eastern North Pacific	0	0	0	0	6	0	1	7	0
Fin whale	Northeast Pacific	0	0	0	2	0	0	2	0	0
	CA/OR/WA	0	0	0	4	30	0	5	32	0
Sei whale	Eastern North Pacific	0	0	0	0	2	0	0	3	0
Minke whale	Alaska	0	0	0	0	0	0	0	0	0
	CA/OR/WA	0	0	0	1	17	0	2	19	0
Gray whale	Eastern North Pacific	0	0	0	0	11	0	1	12	0
	Western North Pacific	0	0	0	0	0	0	0	0	0
Sperm whale	North Pacific	0	0	0	0	0	0	0	0	0
	CA/OR/WA	0	0	0	11	67	0	12	73	0
Kogia (spp.)	CA/OR/WA	0	2	0	0	106	1	0	117	1
Killer whale	Alaskan Resident	0	0	0	2	0	0	3	0	0
	Northern Resident	0	0	0	0	0	0	0	0	0
	West Coast Transient	17	89	0	32	170	0	36	197	0
	East. N. Pac. Offshore	0	0	0	4	18	0	5	20	0
	Southern Resident	0	0	0	0	0	0	0	0	0
Short-finned pilot whale	CA/OR/WA	0	0	0	0	0	0	0	0	0
Short-beaked common dolphin	CA/OR/WA	26	0	0	262	1,366	0	289	1,502	0
Bottlenose dolphin	CA/OR/WA	0	0	0	0	0	0	0	0	0
Striped dolphin	CA/OR/WA	0	0	0	5	9	0	5	10	0
Pacific white-sided dolphin	North Pacific	0	0	0	3	0	0	5	0	0
	CA/OR/WA	55	1	0	719	4,150	0	787	4,560	0
Northern right whale dolphin	CA/OR/WA	22	0	0	286	1,752	0	313	1,923	0
Risso's dolphin	CA/OR/WA	15	0	0	166	988	0	181	1,085	0

Table 3.4-18: Annual Testing Effects for Sonar and Other Active Acoustic Sources (continued)

Species	Stock	No Action Alternative			Alternative 1			Alternative 2		
		Behavioral	TTS	PTS	Behavioral	TTS	PTS	Behavioral	TTS	PTS
Harbor porpoise	Southeast Alaska	0	0	0	526	400	0	656	514	0
	Northern OR/WA Coast	206	79	0	11,491	5,721	15	12,597	6,270	17
	N. CA/S. OR	309	119	0	17,237	8,582	23	18,895	9,405	25
	WA Inland Waters	655	2,276	1	1,140	4,196	6	1,286	4,715	8
Dall's porpoise	Alaska	0	0	0	0	1,200	0	0	1,571	0
	CA/OR/WA	1	517	0	33	10,104	43	36	11,137	47
Cuvier's beaked whale	Alaska	0	0	0	15	0	0	22	0	0
	CA/OR/WA	1	0	0	83	8	0	91	9	0
Baird's beaked whale	Alaska	0	0	0	25	0	0	34	0	0
	CA/OR/WA	2	0	0	130	19	0	143	21	0
Mesoplodon beaked whales	CA/OR/WA	5	0	0	334	35	0	367	39	0
Steller sea lion	Eastern U.S.	142	0	0	504	0	0	564	0	0
Guadalupe fur seal	Mexico	0	0	0	27	0	0	30	0	0
California sea lion	U.S.	917	36	0	1,920	153	0	2,137	227	0
Northern fur seal	Eastern Pacific	17	0	0	1,827	3	0	2,008	3	0
	California	0	0	0	27	0	0	30	0	0
Northern elephant seal	California Breeding	12	0	0	243	1,082	2	268	1,185	2
Harbor seal	SE Alaska-Clarence St.	0	0	0	20	2	0	28	4	0
	OR/WA Coastal	12	0	0	119	1,536	4	130	1,689	4
	WA Inland Waters	1,963	3,117	8	2,244	7,324	25	2,371	8,482	37
Northern sea otter	SE Alaska	0	0	0	0	0	0	0	0	0
	Washington	0	0	0	0	0	0	0	0	0

Notes: CA = California, PTS = Permanent Threshold Shift, S = South, SE = Southeast, St. = Strait, TTS = Temporary Threshold Shift, OR = Oregon, U.S. = United States, WA = Washington

3.4.3.2.1.5 Alternative 1

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), training activities under Alternative 1 include activities that produce in-water noise from the use of sonar and other active acoustic sources. Activities could occur throughout the Study Area (Offshore Area, Inland Waters-Puget Sound, and Southeast Alaska-Western Behm Canal), but would mainly occur off the coast of Washington. The majority of predicted effects to marine mammals under Alternative 1 (approximately 80 percent) are as a result of Tracking Exercises by surface ships, submarines, and marine patrol aircraft in the offshore portion of the Study Area. Under Alternative 1, there is the additional incorporation of sonar maintenance for surface ships and submarines at pierside locations and offshore, and the introduction of the Civilian Port Defense exercise (a non-annual, biennial event) in the inland portion of the Study Area. New training activities proposed under Alternative 1 and notable changes from the No Action Alternative for sonar and other active acoustic sources are shown in Table 2.8-1 and Table 3.4-3 and summarized as follows:

- Incorporation of sonar maintenance for surface ships and submarines at pierside locations and offshore.
- Introduction of the Civilian Port Defense exercise occurring in the Inland Waters of the Study Area as a non-annual (biennial) event.
- An increase in the hours analyzed for sonar and other active acoustic source hours by approximately 52 percent.

Table 3.4-17 provides a summary of the total estimated exposures from sonar and other active acoustic sources for Navy training that would be conducted under the three alternatives for a maximum annual year. The maximum year represents the total annual exposures predicted to occur in a year that includes the biennial Civilian Port Defense exercise. The exposures for the biennial Civilian Port Defense exercise have been presented separately in Table 3.4-19. To derive the number of annual exposures for years when the biennial Civilian Port Defense exercise does not occur, the predicted 1,000 TTS and 783 behavioral exposures (Table 3.4-19) from the Civilian Port Defense exercise can be subtracted from the total (maximum year) annual exposures shown in Table 3.4-17.

Table 3.4-19: Civilian Port Defense Exercise Training Exposures Occurring Biennially

Species	Stock	Behavioral	TTS	PTS
North Pacific right whale	Eastern North Pacific	0	0	0
Humpback whale	CA/OR/WA	0	0	0
	Central North Pacific	0	0	0
Blue whale	Eastern North Pacific	0	0	0
Fin whale	Northeast Pacific	0	0	0
	CA/OR/WA	0	0	0
Sei whale	Eastern North Pacific	0	0	0
Minke whale	Alaska	0	0	0
	CA/OR/WA	0	0	0
Gray whale	Eastern North Pacific	0	0	0
	Western North Pacific	0	0	0

Table 3.4-19: Civilian Port Defense Exercise Training Exposures Occurring Biennially (continued)

Species	Stock	Behavioral	TTS	PTS
Sperm whale	North Pacific	0	0	0
	CA/OR/WA	0	0	0
Kogia (spp.)	CA/OR/WA	0	0	0
Killer whale	Alaskan Resident	0	0	0
	Northern Resident	0	0	0
	West Coast Transient	2	0	0
	East. N. Pac. Offshore	0	0	0
	Southern Resident	2	0	0
Short-finned pilot whale	CA/OR/WA	0	0	0
Short-beaked common dolphin	CA/OR/WA	0	0	0
Bottlenose dolphin	CA/OR/WA	0	0	0
Striped dolphin	CA/OR/WA	0	0	0
Pacific white-sided dolphin	North Pacific	0	0	0
	CA/OR/WA	0	0	0
Northern right whale dolphin	CA/OR/WA	0	0	0
Risso's dolphin	CA/OR/WA	0	0	0
Harbor porpoise	Southeast Alaska	0	0	0
	Northern OR/WA Coast	0	0	0
	N. CA/S. OR	0	0	0
	WA Inland Waters	571	766	0
Dall's porpoise	Alaska	0	0	0
	CA/OR/WA	1	233	0
Cuvier's beaked whale	Alaska	0	0	0
	CA/OR/WA	0	0	0
Baird's beaked whale	Alaska	0	0	0
	CA/OR/WA	0	0	0
Mesoplodon beaked whales	CA/OR/WA	0	0	0
Steller sea lion	Eastern U.S.	17	0	0
Guadalupe fur seal	Mexico	0	0	0
California sea lion	U.S.	16	0	0
Northern fur seal	Eastern Pacific	0	0	0
	California	0	0	0
Northern elephant seal	California Breeding	1	0	0
Harbor seal	SE Alaska-Clarence St.	0	0	0
	OR/WA Coastal	0	0	0
	WA Inland Waters	173	1	0
Northern sea otter	SE Alaska	0	0	0
	Washington	0	0	0

Notes: CA = California, PTS = Permanent Threshold Shift, S = South, SE = Southeast, St. = Strait, TTS = Temporary Threshold Shift, OR = Oregon, U.S. = United States, WA = Washington

Mysticetes

All mysticetes (baleen whales) are classified as low-frequency cetaceans (see Section 3.4.2.3.3, Low-Frequency Cetaceans).

North Pacific Right Whales (Endangered Species Act-Listed)

As presented in detail in Section 3.4.2.6 (North Pacific Right Whale [*Eubalaena japonica*]), North Pacific right whale are not expected to be present in the Study Area during events involving the use of sonar and other active acoustic sources. As a result, Navy events involving sonar and other active acoustic sources would have no effect on North Pacific right whale.

Humpback Whales (Endangered Species Act-Listed)

Humpback whales could be in all portions of the Study Area. Humpback whales found in the Offshore Area and the Inland Waters of Puget Sound area are recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that humpback whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in five TTS and seven behavioral reactions. The Central North Pacific stock of humpback whales would not be exposed to sound that would exceed the current impact thresholds.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's hearing of biologically relevant sounds. Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) suggest that if humpback whales are exposed to sonar and other active acoustic sources, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Overall, number of predicted behavioral reactions is low and occasional behavioral reactions are unlikely to cause long-term consequences for individual animals or populations.

Blue Whales (Endangered Species Act-Listed)

Blue whales are only present in the offshore portion of the Study Area. Blue whales may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts that blue whales of the Eastern North Pacific stock may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in two TTS and three behavioral reactions annually. Long-term consequences for individuals or populations would not be expected.

Fin Whales (Endangered Species Act-Listed)

Fin whales may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts that fin whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in 10 TTS and 14 behavioral reactions. Long-term consequences for individuals or populations would not be expected. The Northeast Pacific stock of fin whales would not be exposed to sound that would exceed the current impact thresholds.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sonar and other active acoustic sources associated with training activities throughout the year; however, these exposures would not exceed the current impact thresholds. Long-term consequences for individuals or populations would not be expected.

Gray Whales (Eastern North Pacific Stock and Endangered Species Act-Listed Western North Pacific Stock)

Gray whales may be exposed to sonar or other active acoustic stressors when their presence coincides with training activities in the Study Area. Acoustic modeling predicts that the Eastern North Pacific gray whales could be exposed to sound that may result in six TTS per year in the Inland Waters of the Study Area. The Western North Pacific stock of gray whales would not be exposed to sound that would exceed the current impact thresholds. As presented above for mysticetes in general, for both stocks and individuals within these stocks, long-term consequences would not be expected.

Minke Whales

Minke whales may be present in all portions of the Study Area. Minke whales found in the Offshore Area and the Inland Waters of Puget Sound area recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that minke whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with training activities Inland Waters of the Study Area that may result in three TTS and in the Offshore Area that may result in six TTS and nine behavioral reactions. The Alaska stock of minke whales would not be exposed to sound which would exceed the current impact thresholds. As described for humpback whales above, these predicted effects to minke whales are unlikely to cause long-term consequences for individual animals or populations.

Odontocetes

Sperm Whales (Endangered Species Act-Listed)

Sperm whales are classified as mid-frequency cetaceans (see Section 3.4.2.3.2, Mid-Frequency Cetaceans). Sperm whales are likely only in the area offshore portion of the Study Area although also possibly present but rare and in the Southeast Alaska (Western Behm Canal) portion of the Study Area. The acoustic analysis predicts that sperm whales may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in 80 behavioral reactions annually.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) suggest that if sperm whales are exposed to sonar and other active acoustic sources, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Overall, number of predicted behavioral reactions is low and occasional behavioral reactions are unlikely to cause long-term consequences for individual animals or populations.

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy sperm whales and dwarf sperm whales (*Kogia spp*.) are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Pygmy sperm whales and dwarf sperm whales are only present in the offshore portion of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities. Each species of *Kogia* in the Study Area are part of the California, Oregon, Washington stock. For purposes of this analysis and because the number of dwarf sperm whales remain unknown, the acoustic modeling was undertaken for the genus *Kogia*. The acoustic analysis predicts that *Kogia* may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in 56 TTS and 13 behavioral reactions annually. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's hearing of biologically relevant sounds. These predicted effects to *Kogia* are unlikely to cause long-term consequences for individual animals or populations.

Killer Whales – Eastern North Pacific Southern Resident (Endangered Species Act-Listed)

Killer whales from the Eastern North Pacific Southern Resident stock may be exposed to sonar and other active acoustic sources associated with training activities while they reside in the Study Area. The majority of training activities occur in the offshore portion of the Study Area. The predicted effects would occur in the Inland Waters area of Puget Sound where they could be exposed to sonar and other active acoustic sources that may result in two behavioral reactions annually. As described for sperm whales above, these predicted effects to southern resident killer whales are unlikely to cause long-term consequences for individual animals or populations. Activities involving the use of sonar and other active acoustic sources would have no effect on southern resident killer whale critical habitat.

Other Killer Whales (Alaskan Resident, Northern Resident, West Coast Transient, and Eastern North Pacific Offshore)

Killer whales (other than the Eastern North Pacific Southern Resident stock) may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The majority of these predicted effects would occur off the coast of Washington where the acoustic analysis predicts that the Eastern North Pacific Offshore stock could be exposed to sound that may result in 1 TTS and 12 behavioral reactions and the West Coast Transient stock could be exposed to sound that may result in 3 TTS and 5 behavioral reactions. As described for sperm whales above, these predicted effects to killer whales are unlikely to cause long-term consequences for individual animals or populations.

Other Dolphins and Small Whales (Delphinids)

Dolphins may be exposed to sonar or other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts that delphinids (seven species total) could be exposed to sound that may result in 431 TTS and 5,684 behavioral reactions. These predicted effects would occur in the offshore portion of the Study area. As described for sperm whales above, these predicted effects to delphinids are unlikely to cause long-term consequences for individual animals or populations.

Harbor Porpoise

Harbor porpoises may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts that harbor porpoises could be exposed to sound that may result in 1 PTS, 861 TTS and 5,919 behavioral reactions. These predicted effects in the offshore portion of the Study Area involve the Northern Oregon/Washington Coast stock (48 percent) and the Northern California/Southern Oregon stock (32 percent). For the Inland Waters (Puget Sound) portion of the Study area, the acoustic analysis predicts that harbor porpoises from the Washington Inland Waters stock could be exposed to sonar and other active acoustic sources that may result in 1 PTS, 841 TTS and 571 behavioral reactions. All but 77 of the predicted TTS and all behavioral reactions to the Washington Inland Waters stock of harbor porpoise are as a result of the Civilian Port Defense exercise. The Southeast Alaska stock of harbor porpoise would not be exposed to sound that would exceed the current impact thresholds.

Animals that do experience hearing loss (TTS) may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Long-term consequences for the population would not be expected.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) of harbor porpoises for other locations show that this small species is wary of human activity and will avoid anthropogenic sound sources in many situations at levels down to 120 dB re 1 µPa. Harbor porpoises may startle and leave the immediate area of the training event but return within a few days after the event ends. Significant behavioral reactions seem more likely than with most other odontocetes. Animals that do exhibit a significant behavioral reaction would likely recover from any incurred costs. Harbor porpoise continue to inhabit the waters of Hood Canal (including Dabob Bay), which is has for decades served as the location for training and testing events using sonar and other active acoustic sources. Based on this information, it is the use of sonar and other active acoustic sources is unlikely to result in long-term consequences for the individual or population.

Dall's Porpoise

Dall's porpoise are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Dall's porpoise may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts that Dall's porpoises could be exposed to sound that may result in 2 PTS, 2,714 TTS, and 758 behavioral reactions. These predicted effects involve the California, Oregon, and Washington stock inhabiting the Offshore Area and Inland Waters portion of the Study Area, however, except for 254 TTS and two behavioral reactions as a result of the Civilian Port Defense training in the Inland Waters, all remaining exposures are predicted to occur in the offshore portion of the Study Area. The Alaska stock of Dall's porpoise would not be exposed to sound that would exceed the current impact thresholds.

As presented previously for the training under the No Action Alternative for odontocetes, animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

For PTS, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012). Furthermore, likely avoidance of intense activity and sound coupled with mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the potential for PTS exposures to occur. Considering these factors, the predicted effects to Dall's porpoise are unlikely to cause long-term consequences for individual animals or populations.

Beaked Whales

Beaked whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. The majority of beaked whales in the Study Area are located in the Offshore Area. The acoustic analysis predicts that beaked whales in the Offshore Area (six species total) could be exposed to sound that may result in 2 TTS and 2,078 behavioral reactions. There are no beaked whales in the Inland Waters of the Study area. In the Southeast Alaska (Western Behm Canal) portion of the study area, beaked whales are rare and effects to Baird's beaked whales and Cuvier's beaked whales were not predicted by acoustic modeling.

Research and observations show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source to levels of 157 dB re 1 μPa, or below (McCarthy et al. 2011). Furthermore, in research done at the Navy's fixed tracking range in the Bahamas, animals leave the immediate area of the anti-submarine warfare training exercise but return within a few days after the event ends. Populations of beaked whales and other odontocetes on the Bahamas, and other Navy fixed ranges that have been operating for tens of years, appear to be stable (Section 3.4.4.1, Summary of Marine Mammal Monitoring during Navy Activities). Significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers (see Section 3.4.3.2.1.1, Range to Effects), especially for prolonged periods (a few hours or more) since this is one of the most sensitive marine mammal groups to anthropogenic sound of any species or group studied to date.

Costs and long-term consequences to the individual and population resulting from a marine mammal receiving a TTS are discussed in the sections above (see Sperm Whales). Population level consequences are not expected. Neither NMFS nor the Navy anticipates that marine mammal strandings or mortality would result from the operation of sonar during Navy exercises within the Study Area. Additionally, through the MMPA process (which allows for adaptive management), NMFS and the Navy will determine the appropriate way to proceed in the event that a causal relationship were to be found between Navy activities and a future stranding.

Pinnipeds

Research has demonstrated that for pinnipeds as for other mammals, recovery from a hearing threshold shift (i.e., TTS; temporary partial hearing loss; TTS or PTS) can take a few minutes to a few days depending on the severity of the initial shift. More severe shifts may not fully recover and thus would be considered PTS. Threshold shifts do not necessarily affect all hearing frequencies equally, so threshold shifts may not necessarily interfere with an animal's ability to hear biologically relevant sounds. As discussed previously, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012).

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

Otariids (Steller Sea Lions, Guadalupe Fur Seals, California Sea Lions, and Northern Fur Seals)

Steller Sea Lions

Steller sea lions are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. All Steller sea lions in the

Study Area are considered part of the Eastern U.S. stock, which is not listed under the ESA. The acoustic analysis predicts Steller sea lions may be exposed to sonar and other active acoustic sources associated with training activities that may result in 398 behavioral reactions annually; all but 16 of the predicted behavioral reactions would occur in the offshore portion of the Study Area. For Steller sea lions and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely. None of the locations designated as critical habitat for Steller sea lions are present within the Study Area.

Guadalupe Fur Seals (Endangered Species Act-Listed as Threatened)

Guadalupe fur seals are present within the offshore portion of the Study Area during the warm season (summer and early autumn) and during that portion of the year may be exposed to sonar and other active acoustic sources associated with training activities. They are considered “seasonal” migrants since they return to rookeries in Mexican waters in the cold season. The Guadalupe fur seal is considered a single Mexico stock and is listed as threatened under the ESA (Carretta et al. 2013). It is estimated that Guadalupe fur seals could be exposed to sound from sonar and other active acoustic sources that may result in 37 behavioral reactions. Significant behavioral reactions would not be expected and long-term consequences for individuals or populations are unlikely. Critical habitat has not been designated for Guadalupe fur seals.

California Sea Lions

California sea lions are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. All California sea lions in the Study Area are considered part of the U.S. stock. The acoustic analysis predicts California sea lions may be exposed to sonar and other active acoustic sources associated with training activities that may result in seven TTS and 796 behavioral reactions. One of the seven predicted TTS exposures and approximately 94 percent of the behavioral reactions are predicted to occur in the Offshore Area. For California sea lions and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Northern Fur Seals

Northern fur seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts northern fur seals from the Eastern Pacific stock may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in 1 TTS and 2,452 behavioral reactions. The California stock may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in 37 behavioral reactions. For northern fur seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Phocids (Northern Elephant Seals and Harbor Seals)

Northern Elephant Seals

Northern elephant seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. All Northern elephant seals in the Study Area are considered part of the California Breeding stock. The acoustic analysis predicts Northern elephant seals may be exposed to sonar and other active acoustic sources associated with training activities in the Offshore Area that may result in 250 TTS and 990 behavioral reactions. For Northern elephant seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Harbor Seals

Harbor seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. The acoustic analysis predicts harbor seals from the Washington Inland Waters stock during a maximum year may be exposed to sonar and other active acoustic sources associated with training activities in the Inland Waters of the Study Area that may result in 4 PTS, 373 TTS, and 174 behavioral reactions annually. During a maximum year, the biennial Civilian Port Defense exercise accounts for one TTS and 173 of the behavioral reactions predicted for the Washington Inland Waters stock. The Oregon/Washington Coastal stock and the Southeast Alaska (Clarence Strait) stock of harbor seals would not be exposed to sound that would exceed the current impact thresholds. For harbor seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Mustelid (Northern Sea Otters)

Northern sea otter inhabit very shallow water nearshore habitat that is not a location where training activities involving use of sonar and other active acoustic sources would occur. In addition, normal sea otter behavior consists of short foraging dives followed by surface behaviors when their ears are above water. As a result, effects to Northern sea otter from Navy training events involving sonar and other active acoustic sources are discountable since they are extremely unlikely to occur.

Conclusion

Training activities under Alternative 1 include the use of sonar and other active acoustic sources as described in Table 2.8-1 and Section 3.0.5.3.1 (Acoustic Stressors). These activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of sonar and other active acoustic sources for training activities as described under Alternative 1:

- *May expose marine mammals up to 24,199 times annually during a maximum year to sound levels that would be considered Level B harassment*
- *May expose harbor seals up to four times, Dall's porpoise up to two times, and harbor porpoise 1 time annually during a maximum year to sound levels that would be considered Level A harassment*

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities as described under Alternative 1:

- *May affect, and is likely to adversely affect, humpback whale, blue whale, fin whale, sperm whale, southern resident killer whale, and Guadalupe fur seal*
- *May affect, but is not likely to adversely affect, sei whale, and Western North Pacific gray whale*
- *Would have no effect on North Pacific right whale*
- *Would have no effect on southern resident killer whale critical habitat*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), testing activities under Alternative 1 include activities that produce in-water noise from the use of sonar and other active acoustic sources. Activities could occur throughout the Study Area (Offshore Area, Inland Waters-Puget Sound, and Southeast Alaska-Western Behm Canal), but would mainly occur on established testing ranges within Puget Sound. Under

Alternative 1, the majority of predicted effects to marine mammals for testing activities (approximately 58 percent) are as a result of countermeasure testing and Anti-Submarine Warfare Tracking Tests – Maritime Patrol Aircraft (Multi-Static Active Coherent) events. New activities proposed under Alternative 1 and notable changes from the No Action Alternative for sonar and other active acoustic sources are shown in Table 2.8-2 and Table 3.4-3 and summarized as follows:

- Analysis of sonar and other active acoustic source at SEAFAC in the Western Behm Canal portion of the Study Area.
- An increase in the hours analyzed for sonar and other active acoustic source hours in the Offshore Area portion of the Study Area from 24 hours to 977 hours.
- An increase in the hours analyzed for sonar and other active acoustic source hours in the Inland Waters of the Study Area from 2,354 hours to 5,448 hours.

Table 3.4-18 provides a summary of the total estimated effects from sonar and other active acoustic sources for Navy testing that would be conducted over the course of a year under the three alternatives.

Mysticetes

All mysticetes (baleen whales) are classified as low-frequency cetaceans (see Section 3.4.2.3.3, Low-Frequency Cetaceans).

North Pacific Right Whales (Endangered Species Act-Listed)

As presented in detail in Section 3.4.2.6 (North Pacific Right Whale [*Eubalaena japonica*]), North Pacific right whale are not expected to be present in the Study Area during events involving the use of sonar and other active acoustic sources. As a result, Navy events involving sonar and other active acoustic sources would have no effect on North Pacific right whale.

Humpback Whales (Endangered Species Act-Listed)

Humpback whales could be in all portions of the Study Area. Humpback whales found in the Offshore Area and the Inland Waters of Puget Sound area are recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that humpback whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 39 TTS, and 5 behavioral reactions. Humpback whales found in Southeast Alaska (Western Behm Canal) are recognized as part of the Central North Pacific stock and the acoustic analysis predicts that the Central North Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 1 behavioral reaction annually.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal’s hearing of biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability (called Presbycusis) as they age.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) suggest that if humpback whales are exposed to sonar and other active acoustic sources, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving.

Occasional behavioral reactions are unlikely to cause long-term consequences for individual animals or populations.

Blue Whales (Endangered Species Act-Listed)

Blue whales are only present in the offshore portion of the Study Area. Blue whales may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that blue whales of the Eastern North Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in six TTS annually. Long-term consequences for individuals or populations would not be expected.

Fin Whales (Endangered Species Act-Listed)

Fin whales may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that fin whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 30 TTS, and 4 behavioral reactions. Fin whales found in Southeast Alaska (Western Behm Canal) are recognized as part of the Northeast Pacific stock. The acoustic analysis predicts fin whales of the Northeast Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities that may result in two behavioral reactions annually. As described for humpback whales above, these predicted effects to fin whales are unlikely to result in long-term consequences for individuals or populations.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that fin whales of the Eastern North Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in two behavioral reactions annually. Long-term consequences for individuals or populations would not be expected.

Gray Whales (Eastern North Pacific Stock and Endangered Species Act-Listed Western North Pacific Stock)

Gray whales may be exposed to sonar or other active acoustic stressors when their presence coincides with testing activities in the Study Area. Acoustic modeling predicts that the Eastern North Pacific gray whales could be exposed to sound that may result in 11 TTS per year in the Offshore Area. The Western North Pacific stock of gray whales would not be exposed to sound that would exceed the current impact thresholds. As presented above for mysticetes in general, for both stocks and individuals within these stocks, long-term consequences would not be expected.

Minke Whales

Minke whales may be present in all portions of the Study Area. Minke whales found in the Offshore Area and the Inland Waters of Puget Sound area recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that minke whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 17 TTS and 1 behavioral reaction annually. The Alaska stock of minke whales would not be exposed to sound that would exceed the current impact thresholds. As described for humpback whales above, these predicted effects to minke whales are unlikely to cause long-term consequences for individual animals or populations.

Odontocetes

Sperm Whales (Endangered Species Act-Listed)

Sperm whales are classified as mid-frequency cetaceans (see Section 3.4.2.3.2, Mid-Frequency Cetaceans). Sperm whales are likely only in the offshore portion of the Study Area although also possibly present but rare in the Southeast Alaska (Western Behm Canal) portion of the Study Area. The acoustic analysis predicts that sperm whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 67 TTS and 11 behavioral reactions.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's hearing of biologically relevant sounds.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) suggest that if sperm whales are exposed to sonar and other active acoustic sources, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Overall, number of predicted behavioral reactions is low and occasional behavioral reactions are unlikely to cause long-term consequences for individual animals or populations.

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy sperm whales and dwarf sperm whales (*Kogia spp*.) are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Pygmy sperm whales and dwarf sperm whales are only present in the offshore portion of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities. Each species of *Kogia* in the Study Area belong to a separate stock; the California, Oregon, Washington stock of Pygmy sperm whales and the California, Oregon, Washington stock of dwarf sperm whales. For purposes of this analysis and because the number of dwarf sperm whales remain unknown, the acoustic modeling was undertaken for the genus *Kogia*. The acoustic analysis predicts that *Kogia* may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 106 TTS annually. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's hearing of biologically relevant sounds. These predicted effects to *Kogia* are unlikely to cause long-term consequences for individual animals or populations.

Killer Whales – Eastern North Pacific Southern Resident (Endangered Species Act-Listed)

Killer whales from the Eastern North Pacific Southern Resident stock may be exposed to sonar and other active acoustic sources associated with testing activities while they reside in the Study Area. The majority of testing events occur in areas such as Hood Canal, where southern resident killer whales are not believed to be present; the remaining testing activities occur offshore, where they are only present briefly during their annual migration period. The acoustic analysis predicts the Eastern North Pacific Southern Resident stock would not be exposed to sonar and other active acoustic sources associated with testing activities, which would exceed the current impact thresholds (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). Activities involving the use of sonar and other active acoustic sources would have no effect on southern resident killer whale critical habitat.

Other Killer Whales (Alaskan Resident, Northern Resident, West Coast Transient, and Eastern North Pacific Offshore)

Killer whales (other than the Eastern North Pacific Southern Resident stock) may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that the Eastern North Pacific Offshore stock could be exposed to sound that may result in 18 TTS and 4 behavioral reactions. In the Inland Waters of the Study Area, the West Coast Transient stock could be exposed to sonar and other active acoustic sources that may result in 170 TTS and 32 behavioral reactions. For Southeast Alaska (Western Behm Canal) and the Alaska Resident stock of killer whales, there are two behavioral reactions predicted by the modeling. The Northern Resident stock of killer whales would not be exposed to sound that would exceed the current impact thresholds. As described for sperm whales above, these predicted effects to killer whales are unlikely to cause long-term consequences for individual animals or populations.

Other Dolphins and Small Whales (Delphinids)

Dolphins may be exposed to sonar or other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that delphinids (seven species total) could be exposed to sonar and other active acoustic sources that may result in 8,265 TTS and 1,441 behavioral reactions. These predicted effects would occur in the offshore portion of the Study Area. In the Southeast Alaska (Western Behm Canal), acoustic analysis predicts that Pacific white-sided dolphin could be exposed to sonar and other active acoustic sources that result in three behavioral reactions annually (3 of the 1,441 delphinids total noted above). As described for sperm whales above, these predicted effects to delphinids are unlikely to cause long-term consequences for individual animals or populations.

Harbor Porpoise

Harbor porpoises may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that harbor porpoises could be exposed to sonar and other active acoustic sources that may result in 44 PTS, 18,899 TTS, and 30,394 behavioral reactions.Approximately 45 percent of these predicted effects involve the Northern Oregon/Washington Coast stock, with the remaining effects offshore predicted to the Northern California/Southern Oregon stock (30 percent). For the Inland Waters area (Puget Sound), there are 6 PTS, 4,196 TTS and 1,140 behavioral reactions predicted for the Washington Inland Waters stock of harbor porpoise. For Southeast Alaska (Western Behm Canal) and the Southeast Alaska stock of harbor porpoise, there are 400 TTS and 526 behavioral reactions predicted annually.

Animals that do experience hearing loss (PTS or TTS) may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Long-term consequences for the population would not be expected.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) of harbor porpoises for other locations show that this small species is wary of human activity and will avoid anthropogenic sound sources in many situations at levels down to 120 dB re 1 µPa. Harbor porpoises may startle and leave the immediate area of the testing event but return within a few days after the event ends. Significant behavioral reactions seem more likely than with most other odontocetes. Animals that do exhibit a significant behavioral reaction would likely recover from any incurred costs. Harbor porpoise continue to inhabit the waters of Hood Canal (including Dabob Bay), which has for decades served as the location for training and testing events using sonar and other active acoustic sources. Based on this information, it is the use of sonar and other active acoustic sources is unlikely to result in long-term consequences for the individual or population.

Dall's Porpoise

Dall's porpoise are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Dall's porpoise may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that Dall's porpoises of the California, Oregon, Washington stock inhabiting the Offshore Area and Inland Waters portion of the Study Area could be exposed to sonar and other active acoustic sources that may result in 43 PTS, 10,104 TTS, and 33 behavioral reactions. These effects are all predicted to occur in the Offshore Area except for one PTS and 351 TTS exposures in the Inland Waters of the Study Area. For the Alaska stock of Dall's porpoise inhabiting the Southeast Alaska (Western Behm Canal) portion of the Study Area, the acoustic analysis predicts 1,200 TTS. As described for sperm whales above, these predicted effects to Dall's porpoise are unlikely to cause long-term consequences for individual animals or populations.

Beaked Whales

Beaked whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. The majority of beaked whales in the Study Area are located in the Offshore Area. The acoustic analysis predicts that beaked whales in the Offshore Area (six species total) could be exposed to sound that may result in 62 TTS and 587 behavioral reactions. There are no beaked whales in the Inland Waters of the Study area. In the Southeast Alaska (Western Behm Canal) portion of the study area, beaked whales are rare and effects to beaked whales in that area are not expected.

Costs and long-term consequences to the individual and population resulting from a marine mammal receiving a TTS are discussed in the sections above (see Sperm Whales). Population level consequences are not expected. Research and observations show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source to levels of 157 dB re 1 µPa, or below (McCarthy et al. 2011). Furthermore, in research done at the Navy's fixed tracking range in the Bahamas, animals leave the immediate area of the anti-submarine warfare training exercise but return within a few days after the event ends. Populations of beaked whales and other odontocetes on the Bahamas, and other Navy fixed ranges that have been operating for tens of years, appear to be stable (Section 3.4.4.1, Summary of Marine Mammal Monitoring during Navy Activities). Significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers (see Section 3.4.3.2.1.1, Range to Effects), especially for prolonged periods (a few hours or more) since this is one of the most sensitive marine mammal groups to anthropogenic sound of any species or group studied to date.

Based on the best available science, the Navy believes that beaked whales that exhibit a significant behavioral reaction due to sonar and other active acoustic testing activities would generally not have long-term consequences for individuals or populations. Navy does not anticipate that marine mammal strandings or mortality would result from the operation of sonar during Navy testing within the Study Area.

Pinnipeds

Pinnipeds may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. Research has demonstrated that for pinnipeds, as for other mammals, recovery from a hearing threshold shift (i.e., TTS; temporary partial hearing loss; TTS or PTS) can take a few minutes to a few days depending on the severity of the initial shift. More severe shifts may not fully recover and thus would be considered PTS. Threshold shifts do not necessarily affect all hearing frequencies equally, so threshold shifts may not necessarily interfere with an animal's ability to hear biologically relevant sounds. As discussed previously, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012).

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

Otariids (Steller Sea Lions, Guadalupe Fur Seals, California Sea Lions, and Northern Fur Seals)

Steller Sea Lions

Steller sea lions are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. All Steller sea lions in the Study Area are considered part of the Eastern U.S. stock, which is not listed under the ESA. The acoustic analysis predicts Steller sea lions may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 504 behavioral reactions annually; approximately half predicted for the Offshore Area and half in the Inland Waters. For Steller sea lions and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely. None of the locations designated as critical habitat for Steller sea lions are present within the Study Area.

Guadalupe Fur Seals (Endangered Species Act-Listed as Threatened)

Guadalupe fur seals are present within the offshore portion of the Study Area during the warm season (summer and early autumn) and during that portion of the year may be exposed to sonar and other active acoustic sources associated with testing activities. They are considered "seasonal" migrants since they return to rookeries in Mexican waters in the cold season. The Guadalupe fur seal is considered a single Mexico stock and is listed as threatened under the ESA (Carretta et al. 2013). It is estimated that Guadalupe fur seals could be exposed to sound from sonar and other active acoustic sources that may result in 27 behavioral reactions in the Offshore Area. Significant behavioral reactions would not be expected and long-term consequences for individuals or populations are unlikely. Critical habitat has not been designated for Guadalupe fur seals.

California Sea Lions

California sea lions are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. All California sea lions in the Study Area are considered part of the U.S. stock. The acoustic analysis predicts California sea lions may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 153 TTS and 1,920 behavioral reactions. Of these, 152 TTS and approximately 76 percent of behavioral reaction are predicted to occur in the Inland Waters of the Study Area, with the remainder occurring in the Offshore Area. For California sea lions and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Northern Fur Seals

Northern fur seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts northern fur seals from the Eastern Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 3 TTS and 1,827 behavioral reactions; 10 of these behavioral reactions are predicted to occur in the Western Behm Canal portion of the Study Area with the remainder of the predicted effects occurring in the Offshore Area. The California stock may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 27 behavioral reactions in the offshore portion of the Study Area. For northern fur seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Phocids (Northern Elephant Seals and Harbor Seals)

Northern Elephant Seals

Northern elephant seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. All Northern elephant seals in the Study Area are considered part of the California Breeding stock. The acoustic analysis predicts Northern elephant seals may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 2 PTS, 1,082 TTS, and 243 behavioral reactions. None of the predicted exposures occur in the Inland Waters of the Study Area; there is one predicted behavioral reaction predicted for Western Behm Canal and the remaining exposures are predicted for the Offshore Area. For Northern elephant seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Harbor Seals

Harbor seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts harbor seals in the Study Area may be exposed to sonar and other active acoustic sources associated with testing activities, resulting in 29 PTS, 8,862 TTS, and 2,383 behavioral reactions. The acoustic analysis predicts harbor seals from the Oregon/Washington Coastal stock may be exposed to sonar and other active acoustic sources associated with testing activities in the offshore portion of the Study Area that may result in 4 PTS, 1,536 TTS, and 119 behavioral reactions. Acoustic analysis predicts harbor seals from the Washington Inland Waters stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Inland Waters portion of the Study Area that may result in 25 PTS, 7,324 TTS, and 2,244 behavioral reactions. For the Southeast Alaska (Clarence Strait) stock of harbor seals inhabiting the Southeast Alaska (Western Behm Canal) portion of the Study Area, the acoustic analysis predicts 2 TTS and 20 behavioral reactions. For harbor seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Mustelid (Northern Sea Otters)

Northern sea otters inhabit very shallow water nearshore habitat that is not a location where testing activities involving use of sonar and other active acoustic sources would generally occur. In addition, normal sea otter behavior consists of short foraging dives followed by surface behaviors when their ears are above water. As a result, effects to Northern sea otter from Navy testing events involving sonar and other active acoustic sources are discountable since they are extremely unlikely to occur.

Conclusion

Testing activities under Alternative 1 include the use of sonar and other active acoustic sources as described in Section 3.0.5.3.1 (Acoustic Stressors). These activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of sonar and other active acoustic sources for testing activities as described under Alternative 1:

- *May expose marine mammals up to 88,544 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 119 times annually to sound levels that would be considered Level A harassment*

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities as described under Alternative 1:

- *May affect, and is likely to adversely affect humpback whale, blue whale, fin whale, sei whale, sperm whale, and Guadalupe fur seal*
- *May affect, but is not likely to adversely affect, Western North Pacific gray whale and southern resident killer whale*
- *Would have no effect on North Pacific right whale*
- *Would have no effect on southern resident killer whale critical habitat*

3.4.3.2.1.6 Alternative 2

Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), proposed activities involving sonar and other active acoustic sources under Alternative 2 for training are identical to those proposed under Alternative 1 with the exception that the Civilian Port Defense exercise would occur annually under Alternative 2 rather than biennially as proposed in Alternative 1. Since Alternative 1 was presented and analyzed as a maximum year (an annual total that included the bi-annual event), the predicted annual impacts for Alternative 2 are identical to those described above in Section 3.4.3.2.2.5 (Alternative 1 – Training Activities), noting however that the two alternatives will have different cumulative totals over the 5-year period discussed within this EIS/OEIS. New training activities proposed under Alternative 2 and notable changes from the No Action Alternative for sonar and other active acoustic sources are shown in Table 2.8-1 and Table 3.4-3 and summarized as follows:

- Incorporation of sonar maintenance for surface ships and submarines at pierside locations and offshore
- Introduction of the Civilian Port Defense exercise occurring as an annual event
- An increase in the hours analyzed for sonar and other active acoustic source hours by approximately 52 percent

Table 3.4-17 provides a summary of the total estimated effects from sonar and other active acoustic sources for Navy training that would be conducted over the course of a year under the three alternatives.

Conclusion

Training activities under Alternative 2 include the use of sonar and other active acoustic sources as described in Table 2.8-1 and Section 3.0.5.3.1 (Acoustic Stressors). These activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of sonar and other active acoustic sources for training activities under Alternative 2:

- *May expose marine mammals up to 24,199 times annually to sound levels that would be considered Level B harassment*
- *May expose harbor seals up to four times, Dall's porpoises up to two times, and harbor porpoise 1 time annually to sound levels that would be considered Level A harassment*

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities as described under Alternative 2:

- *May affect, and is likely to adversely affect humpback whale, blue whale, fin whale, sperm whale, southern resident killer whale, and Guadalupe fur seal*
- *May affect, but is not likely to adversely affect, sei whale, and Western North Pacific gray whale Would have no effect on North Pacific right whale*
- *Would have no effect on southern resident killer whale critical habitat*

Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives) and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), testing activities under Alternative 2 include activities that produce in-water noise from the use of sonar and other active acoustic sources. Activities could occur throughout the Study Area but would be concentrated on established testing ranges within Puget Sound. Under Alternative 2, the majority of predicted effects to marine mammals for testing activities are as a result of countermeasure testing and Anti-Submarine Warfare Tracking Tests – Maritime Patrol Aircraft (Multi-Static Active Coherent) events. New activities proposed under Alternative 2 and notable changes from the No Action Alternative for sonar and other active acoustic sources are shown in Table 2.8-2 and Table 3.4-3 and summarized as follows:

- Analysis of sonar and other active acoustic source at SEAFAC in the Western Behm Canal portion of the Study Area.
- An increase in the hours analyzed for sonar and other active acoustic source hours in the Offshore Area portion of the Study Area from 24 hours to 1,073 hours
- An increase in the hours analyzed for sonar and other active acoustic source hours in the Inland Waters of the Study Area from 2,354 hours to 5,939 hours

Table 3.4-18 provides a summary of the total estimated effects from sonar and other active acoustic sources for Navy testing that would be conducted over the course of a year under the three alternatives.

Mysticetes

All mysticetes (baleen whales) are classified as low-frequency cetaceans (see Section 3.4.2.3.3, Low-Frequency Cetaceans).

North Pacific Right Whales (Endangered Species Act-Listed)

As presented in detail in Section 3.4.2.6 (North Pacific Right Whale [*Eubalaena japonica*]), North Pacific right whale are not expected to be present in the Study Area during events involving the use of sonar and other active acoustic sources. As a result, Navy events involving sonar and other active acoustic sources would have no effect on North Pacific right whale.

Humpback Whales (Endangered Species Act-Listed)

Humpback whales could be in all portions of the Study Area. Humpback whales found in the Offshore Area and the Inland Waters of Puget Sound area are recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that humpback whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 42 TTS and five behavioral reactions. Humpback whales found in Southeast Alaska (Western Behm Canal) are recognized as part of the Central North Pacific stock and the acoustic analysis predicts that the Central North Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in two behavioral reactions annually.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's hearing of biologically relevant sounds.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) suggest that if humpback whales are exposed to sonar and other active acoustic sources, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Overall, number of predicted behavioral reactions is low and occasional behavioral reactions are unlikely to cause long-term consequences for individual animals or populations.

Blue Whales (Endangered Species Act-Listed)

Blue whales are only present in the offshore portion of the Study Area. Blue whales may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that blue whales of the Eastern North Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in seven TTS and one behavioral reaction annually. Long-term consequences for individuals or populations would not be expected.

Fin Whales (Endangered Species Act-Listed)

Fin whales may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that fin whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 32 TTS and five behavioral reactions. Fin whales found in Southeast Alaska (Western Behm Canal) are recognized as part of the Northeast Pacific stock. The acoustic analysis predicts fin whales of the Northeast Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities that may result in two behavioral reactions annually. As described for humpback whales above, these predicted effects to fin whales are unlikely to result in long-term consequences for individuals or populations.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that fin whales of the Eastern North Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in three TTS annually. Long-term consequences for individuals or populations would not be expected.

Gray Whales (Eastern North Pacific Stock and Endangered Species Act-Listed Western North Pacific Stock)

Gray whales may be exposed to sonar or other active acoustic stressors when their presence coincides with testing activities in the Study Area. Acoustic modeling predicts that the Eastern North Pacific gray whales could be exposed to sound that may result in 12 TTS and one behavioral reaction per year in the Offshore Area. The Western North Pacific stock of gray whales would not be exposed to sound that would exceed the current impact thresholds. As presented above for mysticetes in general, for both stocks and individuals within these stocks, long-term consequences would not be expected.

Minke Whales

Minke whales may be present in all portions of the Study Area. Minke whales found in the Offshore Area and Inland Waters of Puget Sound are recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that minke whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 19 TTS and two behavioral reactions. The Alaska stock of minke whales would not be exposed to sound that would exceed the current impact thresholds. As described for humpback whales above, these predicted effects to minke whales are unlikely to cause long-term consequences for individual animals or populations.

Odontocetes

Sperm Whales (Endangered Species Act-Listed)

Sperm whales are classified as mid-frequency cetaceans (see Section 3.4.2.3.2, Mid-Frequency Cetaceans). Sperm whales are likely only in the area offshore portion of the Study Area although also possibly present but rare in the Southeast Alaska (Western Behm Canal) portion of the Study Area. The North Pacific stock of sperm whales would not be exposed to sound that would exceed the current impact thresholds. The acoustic analysis predicts that sperm whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 73 TTS and 12 behavioral reactions.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's hearing of biologically relevant sounds.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) suggest that if sperm whales are exposed to sonar and other active acoustic sources, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. These predicted effects to sperm whales are unlikely to cause long-term consequences for individual animals or populations.

Pygmy and Dwarf Sperm Whales (Kogia spp.)

Pygmy sperm whales and dwarf sperm whales (*Kogia spp*.) are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Pygmy sperm whales and dwarf sperm whales are only present in the offshore portion of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities. Each species of *Kogia* in the Study Area are part of the California, Oregon, Washington stock. For purposes of this analysis and because the number of pygmy sperm whales and dwarf sperm whales remain unknown, the acoustic modeling was undertaken for the genus *Kogia*. The acoustic analysis predicts that *Kogia* may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in 1 PTS and 117 TTS annually. As described for sperm whales above, these predicted effects to pygmy sperm whales are unlikely to cause long-term consequences for individual animals or populations.

Killer Whales – Eastern North Pacific Southern Resident (Endangered Species Act-Listed)

Killer whales from the Eastern North Pacific Southern Resident stock may be exposed to sonar and other active acoustic sources associated with testing activities while they reside in the Study Area. The majority of testing events occur in areas such as Hood Canal, where southern resident killer whales are not believed to be present; much of the remaining testing activities occur offshore, where they are only present briefly during their annual migration period. The acoustic analysis predicts the Eastern North Pacific Southern Resident stock would not be exposed to sonar and other active acoustic sources associated with testing activities, which would exceed the current impact thresholds (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). Activities involving the use of sonar and other active acoustic sources would have no effect on southern resident killer whale critical habitat.

Other Killer Whales (Alaskan Resident, Northern Resident, West Coast Transient, and Eastern North Pacific Offshore)

Killer whales (other than the Eastern North Pacific Southern Resident stock) may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that the Eastern North Pacific Offshore stock could be exposed to sonar and other active acoustic sources that may result in 20 TTS and 5 behavioral reactions and the West Coast Transient stock could be exposed to sonar and other active acoustic sources that may result in 197 TTS and 36 behavioral reactions. For Southeast Alaska (Western Behm Canal) and the Alaska Resident stock of killer whales, there are three behavioral reactions predicted. As described for sperm whales above, these predicted effects to killer whales are unlikely to cause long-term consequences for individual animals or populations.

Other Dolphins and Small Whales (Delphinids)

Dolphins may be exposed to sonar or other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that delphinids (seven species total) could be exposed to sonar and other active acoustic sources that may result in 9,080 TTS and 1,580 behavioral reactions. These predicted effects would occur in the offshore portion of the Study Area. In the Southeast Alaska (Western Behm Canal), acoustic analysis predicts that Pacific white-sided dolphin could be exposed to sonar and other active acoustic sources that result in five behavioral reactions annually. As described for sperm whales above, these predicted effects to delphinids are unlikely to cause long-term consequences for individual animals or populations.

Harbor Porpoise

Harbor porpoises may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that harbor porpoises could be exposed to sound that may result in 50 PTS, 20,904 TTS, and 33,434 behavioral reactions. Approximately 53 percent of these predicted effects involve the Northern Oregon/Washington Coast stock, with the remaining effects offshore predicted to the Northern California/Southern Oregon stock (36 percent of the total). This large majority (89 percent) of the predicted effects occurs in the offshore portion of the Study Area. For the Inland Waters (Puget Sound), there are 8 PTS, 4,715 TTS, and 1,286 behavioral reactions predicted for the Washington Inland Waters stock of harbor porpoise. For Southeast Alaska (Western Behm Canal) and the Alaska stock of harbor porpoise, there are 514 TTS and 656 behavioral reactions predicted annually.

Animals that do experience hearing loss (PTS or TTS) may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Long-term consequences for the population would not be expected.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) of harbor porpoises for other locations show that this small species is wary of human activity and will avoid anthropogenic sound sources in many situations at levels down to 120 dB re 1 µPa. Harbor porpoises may startle and leave the immediate area of the testing event but return within a few days after the event ends. Significant behavioral reactions seem more likely than with most other odontocetes. Animals that do exhibit a significant behavioral reaction would likely recover from any incurred costs. Harbor porpoise continue to inhabit the waters of Hood Canal (including Dabob Bay), which is has for decades served as the location for training and testing events using sonar and other active acoustic sources. Based on this information, it is the use of sonar and other active acoustic sources is unlikely to result in long-term consequences for the individual or population.

Dall's Porpoise

Dall's porpoise are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Dall's porpoise may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts that Dall's porpoises of the California, Oregon, Washington stock inhabiting the Offshore Area and Inland Waters portion of the Study Area could be exposed to sonar and other active acoustic sources that may result in 47 PTS, 11,137 TTS, and 36 behavioral reactions. Out of this total, one PTS and 443 TTS exposures are predicted for the Inland Waters and the remainder are predicted to occur in the Offshore Area. For the Alaska stock of Dall's porpoise inhabiting the Southeast Alaska (Western Behm Canal) portion of the Study Area, there are 1,571 TTS predicted. As described for sperm whales above, these predicted effects to Dall's porpoise are unlikely to cause long-term consequences for individual animals or populations.

Beaked Whales

Beaked whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. The majority of beaked whales in the Study Area are located in the Offshore Area. The acoustic analysis predicts that beaked whales in the Offshore Area (six species total) could be exposed to sound that may result in 69 TTS and 657 behavioral reactions. There are no beaked whales in the Inland Waters of the Study area. In the Southeast Alaska (Western Behm Canal) portion of the study area, beaked whales are rare and the effects to beaked whales in that area are not expected.

Costs and long-term consequences to the individual and population resulting from a marine mammal receiving a TTS are discussed in the sections above (see Sperm Whales). Population level consequences are not expected. Research and observations show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source to levels of 157 dB re 1 µPa, or below (McCarthy et al. 2011). Furthermore, in research done at the Navy's fixed tracking range in the Bahamas, animals leave the immediate area of the anti-submarine warfare training exercise but return within a few days after the event ends. Populations of beaked whales and other odontocetes on the Bahamas, and other Navy fixed ranges that have been operating for tens of years, appear to be stable (Section 3.4.4.1, Summary of Marine Mammal Monitoring) during Navy Activities). Significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers (see Section 3.4.3.2.1.1, Range to Effects), especially for prolonged periods (a few hours or more) since this is one of the most sensitive marine mammal groups to anthropogenic sound of any species or group studied to date.

Based on the best available science, the Navy believes that beaked whales that exhibit a significant behavioral reaction due to sonar and other active acoustic testing activities would generally not have long-term consequences for individuals or populations. Navy does not anticipate that marine mammal strandings or mortality would result from the operation of sonar during Navy testing within the Study Area.

Pinnipeds

Pinnipeds may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. Research has demonstrated that for pinnipeds as for other mammals, recovery from a hearing threshold shift (i.e., TTS; temporary partial hearing loss; TTS or PTS) can take a few minutes to a few days depending on the severity of the initial shift. More severe shifts may not fully recover and thus would be considered PTS. Threshold shifts do not necessarily affect all hearing frequencies equally, so threshold shifts may not necessarily interfere with an animal’s ability to hear biologically relevant sounds. As discussed previously, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012).

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

Otariids (Steller Sea Lions, Guadalupe Fur Seals, California Sea Lions, and Northern Fur Seals)

Steller Sea Lions

Steller sea lions are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. All Steller sea lions in the Study Area are considered part of the Eastern U.S. stock, which is not listed under the ESA. The acoustic analysis predicts Steller sea lions may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 564 behavioral reactions with approximately half these exposures predicted to occur in Inland Waters and half in the Offshore Area. There is one behavioral reaction predicted for Steller sea lion in the Western Behm Canal portion of the Study Area. For Steller sea lions and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely. None of the locations designated as critical habitat for Steller sea lions are present within the Study Area.

Guadalupe Fur Seals (Endangered Species Act-Listed as Threatened)

Guadalupe fur seals are present within the offshore portion of the Study Area during the warm season (summer and early autumn) and during that portion of the year may be exposed to sonar and other active acoustic sources associated with testing activities. They are considered "seasonal" migrants since they return to rookeries in Mexican waters in the cold season. The Guadalupe fur seal is considered a single Mexico stock and is listed as threatened under the ESA (Carretta et al. 2013). It is estimated that Guadalupe fur seals could be exposed to sound from sonar and other active acoustic sources that may result in 30 behavioral reactions. Significant behavioral reactions would not be expected and long-term consequences for individuals or populations are unlikely. Critical habitat has not been designated for Guadalupe fur seals.

California Sea Lions

California sea lions are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. All California sea lions in the Study Area are considered part of the U.S. stock. The acoustic analysis predicts California sea lions may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 227 TTS, and 2,137 behavioral reactions. Out of this total, one TTS and 523 behavioral reactions are predicted to occur in the Offshore Area with the remainder predicted to occur in Inland Waters. For California sea lions and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Northern Fur Seals

Northern fur seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts northern fur seals from the Eastern Pacific stock may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 3 TTS and 2,008 behavioral reactions. Out of this total, 13 behavioral reactions are predicted to occur in the Western Behm Canal portion of the Study Area with the remainder predicted to occur in the Offshore Area. The California stock may be exposed to sonar and other active acoustic sources associated with testing activities that may result in 30 behavioral reactions in the Offshore Area. For northern fur seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Phocids (Northern Elephant Seals and Harbor Seals)

Northern Elephant Seals

Northern elephant seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. All Northern elephant seals in the Study Area are considered part of the California Breeding stock. The acoustic analysis predicts Northern elephant seals may be exposed to sonar and other active acoustic sources associated with testing activities in the Offshore Area that may result in two PTS, 1,185 TTS, and 268 behavioral reactions. For Northern elephant seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Harbor Seals

Harbor seals are present in all portions of the Study Area and may be exposed to sonar and other active acoustic sources associated with testing activities throughout the year. The acoustic analysis predicts harbor seals in the Study Area may be exposed to sonar and other active acoustic sources associated with testing activities may result in 41 PTS, 10,175 TTS, and 2,529 behavioral reactions annually. The acoustic analysis predicts harbor seals from the Oregon/Washington Coastal stock may be exposed to sonar and other active acoustic sources associated with testing activities in the offshore portion of the Study Area that may result in 4 PTS, 1,689 TTS, and 130 behavioral reactions. Acoustic analysis predicts harbor seals from the Washington Inland Waters stock may be exposed to sonar and other active acoustic sources associated with testing activities in the Inland Waters portion of the Study Area that may result in 37 PTS, 8,482 TTS, and 2,371 behavioral reactions. For the Southeast Alaska (Clarence Strait) stock of harbor seals inhabiting the Southeast Alaska (Western Behm Canal) portion of the Study Area, the acoustic analysis predicts four TTS and 28 behavioral reactions. For harbor seals and as summarized above for all pinnipeds, long-term consequences for individuals or the population are unlikely.

Mustelid (Northern Sea Otters)

Northern sea otters inhabit very shallow water nearshore habitat that is not a location where testing activities involving use of sonar and other active acoustic sources would generally occur. In addition, normal sea otter behavior consists of short foraging dives followed by surface behaviors when their ears are above water. As a result, effects to Northern sea otter from Navy testing events involving sonar and other active acoustic sources are discountable since they are extremely unlikely to occur.

<u>Conclusion</u>

Testing activities under Alternative 2 include the use of sonar and other active acoustic sources as described in Section 3.0.5.3.1 (Acoustic Stressors). These activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of sonar and other active acoustic sources for testing activities as described under Alternative 2:

- *May expose marine mammals up to 98,220 times annually to sound levels that would be considered Level B harassment*
- *May expose marine mammals up to 141 times annually to sound levels that would be considered Level A harassment*

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities as described under Alternative 2:

- *May affect, and is likely to adversely affect the humpback whale, blue whale, fin whale, sei whale, Western North Pacific gray whale, sperm whale, southern resident killer whale, and Guadalupe fur seal*
- *Would have no effect on North Pacific right whale*
- *Would have no effect on southern resident killer whale critical habitat*

3.4.3.2.2 Impacts from Explosives

Marine mammals could be exposed to energy and sound from underwater explosions associated with proposed activities. The NAEMO, in conjunction with the explosive thresholds and criteria (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals) are used to predict impacts on marine mammals from underwater explosions.

Section 3.4.3.1.2.1 (Direct Injury) presents a review of observations and experiments involving marine mammals and reactions to impulse sounds and underwater detonations. Energy from explosions is capable of causing mortality, direct injury, hearing loss, or a behavioral response depending on the level of exposure. The death of an animal will, of course, eliminate future reproductive potential and cause a long-term consequence for the individual that must then be considered for potential long-term consequences for the population. Exposures that result in long-term injuries such as PTS may limit an animal’s ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual’s chance of survival or impact its ability to successfully reproduce. TTS can also impair an animal’s abilities, but the individual may recover quickly with little significant effect. Behavioral responses can include shorter surfacings, shorter dives, fewer blows (breaths) per surfacing, longer intervals between blows, ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (National Research Council of the National Academies 2005). However, it is not clear how these responses relate to long-term consequences for the individual or population (National Research Council of the National Academies 2005).

Explosions in the ocean or near the water surface can introduce loud, impulse, broadband sounds into the marine environment. These sounds are likely within the audible range of most cetaceans, but the duration of individual sounds is very short. The direct sound from explosions used during Navy training and testing activities last less than a second, and most events involve the use of only one or a few explosions. Furthermore, events are dispersed in time and throughout the Study Area. These factors reduce the likelihood of these sources causing either substantial or long-term auditory masking in marine mammals.

3.4.3.2.2.1 Range to Effects

The following section provides the range to effects from an underwater explosion to specific criteria using the Navy's explosive propagation model. Marine mammals within these ranges would be predicted to receive the associated effect. The range to effects is important information in estimating the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher-level effects, especially physiological effects such as injury and mortality.

The following section provides the range (distance) over which specific physiological or behavioral effects are expected to occur based on the explosive criteria and the explosive propagation calculations from the NAEMO (see Section 3.4.3.1.14.3). The range to effects is shown for a range of explosive bins, from E2 (up to 0.5 lb. net explosive weight) to E12 (up to 1,000 lb. net explosive weight).

Figure 3.4-8 through Figure 3.4-11 shows the range to slight lung injury and mortality for five representative animals of different masses for 0.5–1,000 lb. net explosive weight detonations. Ranges for onset slight lung injury and onset mortality are based on the smallest calf weight in each category and therefore represent a conservative estimate (i.e., longer ranges) since populations contain many animals larger than calves and are therefore less susceptible to injurious effects. Animals within these water volumes would be expected to receive minor injuries at the outer ranges, increasing to more substantial injuries, and finally mortality as an animal approaches the detonation point.

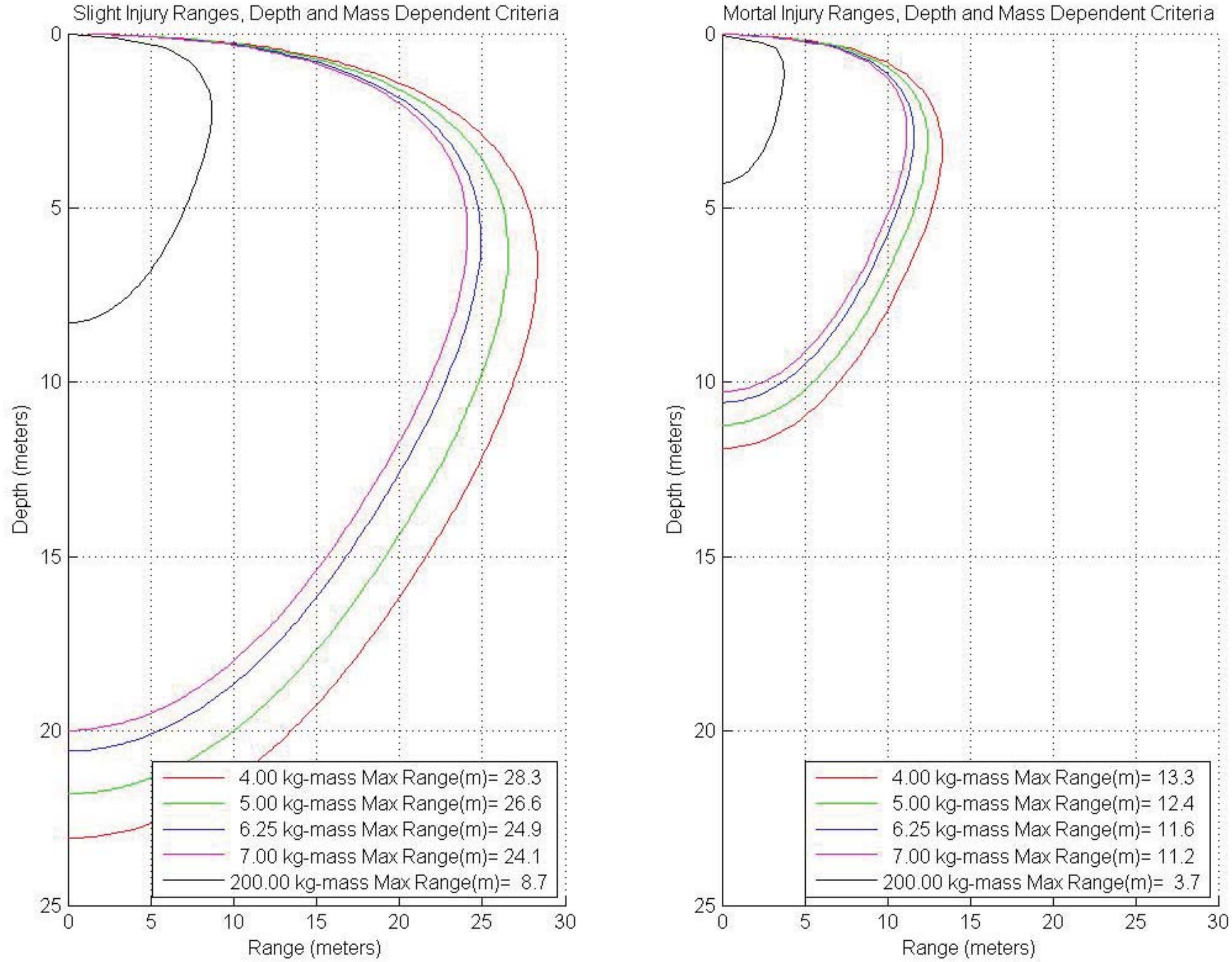

Figure 3.4-8: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 0.5-Pound Net Explosive Weight Charge (Bin E2) Detonated at 1-Meter Depth

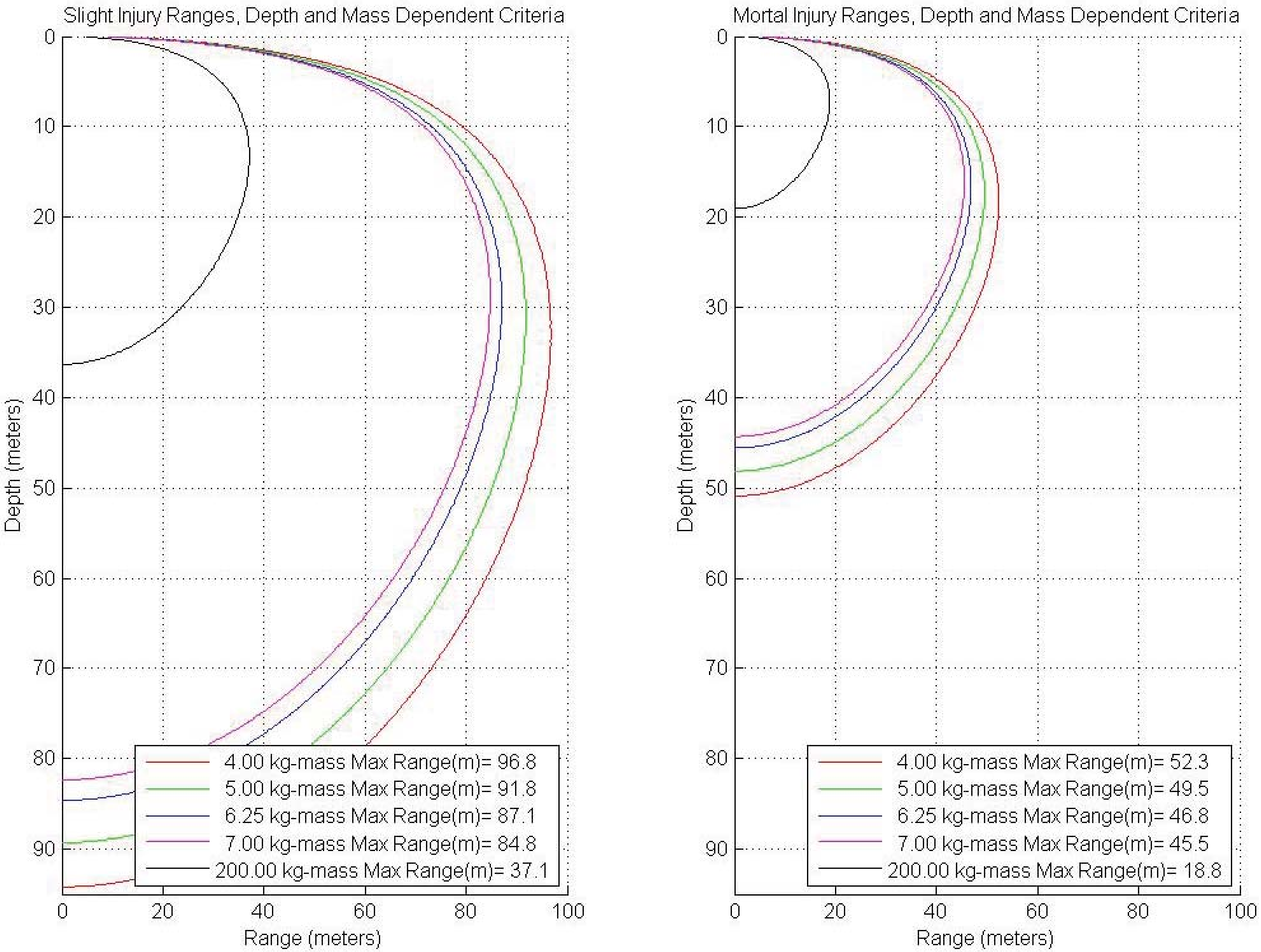

Figure 3.4-9: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 10-Pound Net Explosive Weight Charge (Bin E5) Detonated at 1-Meter Depth

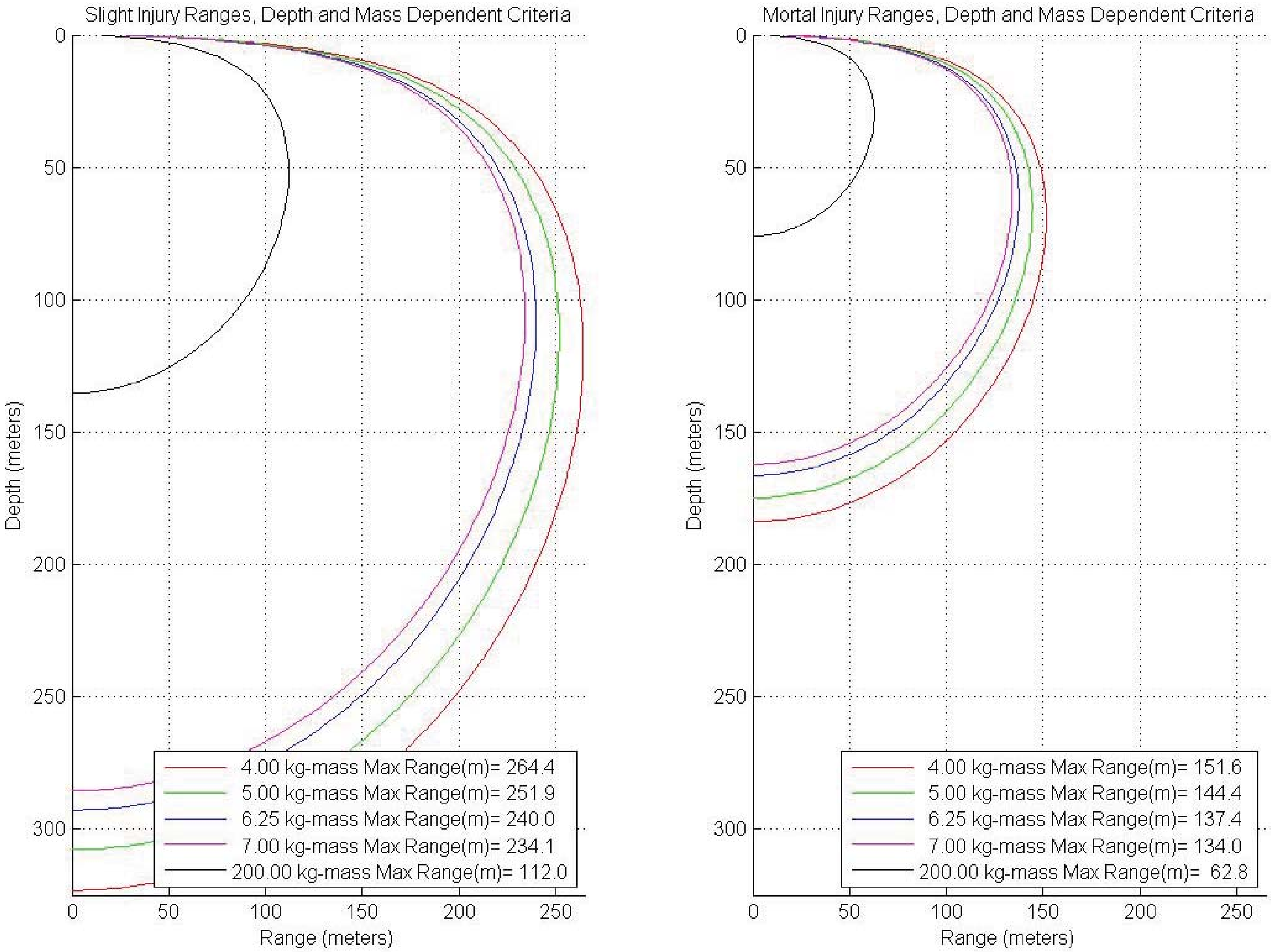

Figure 3.4-10: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 250-Pound Net Explosive Weight Charge (Bin E9) Detonated at 1-Meter Depth

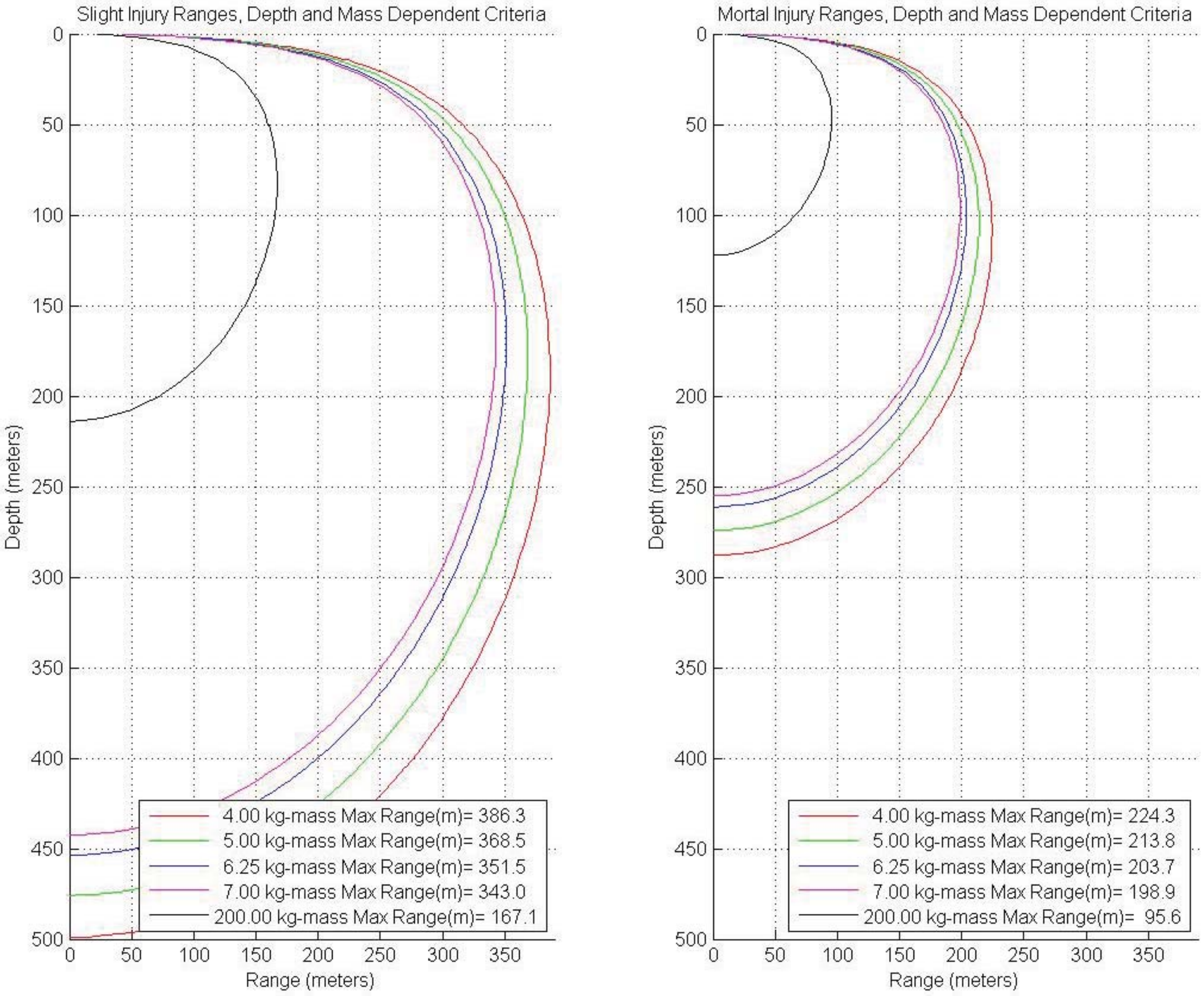

Figure 3.4-11: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 1,000-Pound Net Explosive Weight Charge (Bin E12) Detonated at 1-Meter Depth

Table 3.4-20 shows the average ranges to the potential effect based on the thresholds described in Section 3.4.3.1.10 (Thresholds and Criteria for Predicting Acoustic and Explosive Impacts to Marine Mammals). Similar to slight lung injury and mortality ranges discussed above, behavioral, TTS, and PTS ranges also represent conservative estimates (i.e., longer ranges) based on assuming all impulses are 1 second in duration. In fact, most impulses are much less than 1 second and therefore contain less energy than what is being used to produce the estimated ranges below.

Table 3.4-20: Average Approximate Range to Effects from Explosions for Marine Mammals (Nominal Values for Deep Water Offshore Areas; Not Specific to the Study Area)

Hearing Group Criteria/Predicted Impact	Average Approximate Range (meters) to Effects for Sample Explosive Bins					
	Bin E3 (0.6–2.6 lb. NEW)	Bin E5 (6–10 lb. NEW)	Bin E7 (21–60 lb. NEW)	Bin E9 (101–250 lb. NEW)	Bin E10 (251–500 lb. NEW)	Bin E12 (1,000–1,651 lb. NEW)
Low-frequency Cetaceans						
Onset Mortality	10	20	80	65	80	95
Onset Slight Lung Injury	20	40	165	110	135	165
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	85	170	370	255	305	485
TTS	215	445	860	515	690	1,760
Behavioral Response	320	525	1,290	710	905	2,655
Mid-frequency Cetaceans						
Onset Mortality	25	45	205	135	165	200
Onset Slight Lung Injury	50	85	390	235	285	345
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	35	70	160	170	205	265
TTS	100	215	480	355	435	720
Behavioral Response	135	285	640	455	555	970
High-frequency Cetaceans						
Onset Mortality	30	50	225	145	175	215
Onset Slight Lung Injury	55	90	425	250	305	370
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	140	375	710	470	570	855
TTS	500	705	4,125	810	945	2,415
Behavioral Response	570	930	5,030	2,010	4,965	5,705
Otariidae and Mustelidae						
Onset Mortality	35	65	285	175	215	260
Onset Slight Lung Injury	70	115	530	307	370	450
Onset Slight GI Tract Injury	40	8	150	145	180	250
PTS	30	50	30	50	85	150
TTS	40	85	210	220	260	400
Behavioral Response	60	145	305	300	350	530
Phocidae						
Onset Mortality	30	50	240	150	185	225
Onset Slight Lung Injury	60	100	445	265	320	385
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	95	180	410	340	445	680
TTS	235	500	1,215	665	815	1,350
Behavioral Response	345	600	1,575	815	950	1,685

Notes: GI = gastrointestinal, lb. = pound(s), NEW = net explosive weight, PTS = permanent threshold shift, TTS = temporary threshold shift

3.4.3.2.2.2 Avoidance Behavior and Mitigation Measures as Applied to Explosions

As discussed above, within the NAEMO, animats (virtual animals) do not move horizontally or react in any way to avoid sound at any level. In reality, various researchers have demonstrated that cetaceans can perceive the location and movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Castellote et al. 2012; Jansen et al. 2010; Richardson et al. 1995; Tyack et al. 2011; Watkins 1986; Wursig et al. 1998). Section 3.4.3.1.2 (Analysis Background and Framework) reviews research and observations of marine mammals' reactions to sound sources including seismic surveys and explosives. The NAEMO also does not account for the implementation of mitigation, which would prevent many of the model-predicted injurious and mortal exposures to explosives. Therefore, the model-estimated mortality and Level A effects are further analyzed and adjusted to account for animal movement (avoidance) and implementation of mitigation measures.

If explosive activities are preceded by multiple vessel traffic or hovering aircraft, beaked whales are assumed to move beyond the range to onset mortality before detonations occur, as discussed in Section 3.4.3.1.15 (Marine Mammal Avoidance of Sound Exposures). Table 3.4-20 shows the ranges to onset mortality for mid-frequency and high-frequency cetaceans for a representative range of charge sizes. The range to onset mortality for all net explosive weights is less than 284 yd. (260 m), which is conservatively based on range to onset mortality for a calf. Because the NAEMO does not include avoidance behavior, the model-estimated mortalities are based on unlikely behavior for these species—that they would tolerate staying in an area of high human activity. Therefore, beaked whales that were model-estimated to be within range of a mortality criteria exposure are assumed to avoid the activity and analyzed as being in the range of potential injury prior to the start of the explosive activity for the activities listed in Table 3.4-21.

Table 3.4-21: Activities Using Explosives Preceded by Multiple Vessel Movements or Hovering Helicopters for the Northwest Training and Testing Study Area

Training
Mine Neutralization – Explosive Ordnance Disposal
Missile Exercise (Air-to-Surface)
Sinking Exercise
Testing
Torpedo (explosive) Testing

The NAEMO does not consider mitigation, which is discussed in detail in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). As explained in Section 3.4.3.1.16 (Implementing Mitigation to Reduce Sound Exposures), to account for the implementation of mitigation measures, the acoustic analysis assumes a model-predicted mortality or injury would not occur if an animal at the water surface would likely be observed during those activities with Lookouts up to and during the use of explosives, considering the mitigation effectiveness (Table 3.4-22) and sightability of a species based on g(0) (see Table 3.4-8). The mitigation effectiveness is considered over two regions of an activity's mitigation zone: (1) the range to onset mortality closer to the explosion and (2) range to onset PTS. The model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen (Mitigation Effectiveness x Sightability, g(0)); these animals are instead assumed to be present within the range to injury and range to TTS, respectively.

Table 3.4-22: Consideration of Mitigation in Acoustic Effects Analysis for Explosives

Activity[1,2]	Factor for Adjustment of Preliminary Modeling Estimates		Mitigation Platform Used for Assessment
	Injury Zone	Mortality Zone	
Training			
Bombing Exercise (Air-to-Surface)	0.5	1	Aircraft
Gunnery Exercise (Surface-to-Surface) – Ship	0.5	0.5	Vessel
Mine Neutralization – Explosive Ordnance Disposal	1	1	Vessel
Sinking Exercise	0.5	1	Aircraft
Testing			
Torpedo (Explosive) Testing	0.5	1	Aircraft

[1] The adjustment factor for all other activities (not listed) is zero and there is no adjustment of the preliminary modeling estimates as a result of implemented mitigation for those activities.
[2] If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, mitigation is not considered in the acoustic effects analysis of that activity and the activity is not listed in this table.

During an activity with a series of explosions (not concurrent multiple explosions; see Table 3.4-23; note there are no testing activities in the Study Area for which this applies), an animal is expected to exhibit an initial startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area around the explosions is the assumed behavioral response for most cases. The ranges to PTS for each functional hearing group for a range of explosive sizes (single detonation) are shown in Table 3.4-20. Animals not observed by Lookouts within the ranges to PTS at the time of the initial couple of explosions are assumed to experience PTS; however, all animals that exhibit avoidance reactions beyond the initial range to PTS are assumed to move away from the expanding range to PTS effects with each additional explosion.

Research has demonstrated that odontocetes have directional hearing, with best hearing sensitivity facing a sound source (Kastelein et al. 2005b; Mooney et al. 2008; Popov and Supin 2009). Therefore, an odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts. Because the NAEMO does not account for avoidance behavior, the model-estimated effects are based on the unlikely behavior—that animals would remain in the vicinity of potentially injurious sound sources. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur. The remaining model-estimated PTS exposures from multiple explosives (resulting from accumulated energy) are considered to be TTS due to avoidance. Activities involving multiple non-concurrent explosive or other impulse sources are listed in Table 3.4-23.

Table 3.4-23: Activities with Multiple Non-Concurrent Impulse or Explosions

Training
Bombing Exercise (Air-to-Surface)
Gunnery Exercise (Surface-to-Surface) – Ship
Mine Neutralization – Explosive Ordnance Disposal
Sinking Exercise

Note: There are no testing activities in the Study Area for which this applies.

3.4.3.2.2.3 Predicted Impacts

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, training and testing events resulting in underwater explosions will occur in the offshore and inland portions of the Study Area; none will take place in the Western Behm Canal portion of the Study Area. Table 3.4-24 through Table 3.4-28 present the predicted impacts to marine mammals separated between training and testing activities for explosions. Annual totals presented in the tables are the summation of all annual events occurring in a 12-month period (a maximum year). There are no non-annual training or testing events involving the use of explosives under any of the alternatives.

This acoustic impact analysis uses the NAEMO (see Section 3.4.3.1.14.3) followed by post-model consideration of avoidance and implementation of mitigation to predict effects using the explosive criteria and thresholds described in Section 3.4.3.1.10 (Thresholds and Criteria for Predicting Acoustic and Explosive Impacts to Marine Mammals).

The NAEMO does not account for several factors (see Section 3.4.3.1.14.4, Model Assumptions and Limitations) that must be considered in the overall analysis of explosive (impulse) sources. When there is uncertainty in model input values, a conservative approach is often chosen to assure that potential effects are not under predicted. As a result, the NAEMO provides predictions that are conservative (over predict the likely impacts). The following is a list of several such factors that cause the model to overestimate potential effects:

- The onset mortality criterion is based on the impulse at which 1 percent of the animals receiving an injury would not recover, leading to mortality. Therefore, many animals that are predicted to suffer mortality in this analysis may actually recover from their injuries.
- Slight lung injury criteria are based on the impulse at which 1 percent of the animals exposed would incur a slight lung injury from which full recovery would be expected. Therefore, many animals that are predicted to suffer slight lung injury in this analysis may actually not incur injuries.
- The metrics used for the threshold for slight lung injury and mortality (i.e., acoustic impulse) are based on the animal’s mass. The smaller an animal, the more susceptible that individual is to these effects. In this analysis, all individuals of a given species are assigned the weight of that species newborn calf or pup weight. Since many individuals in a population are obviously larger than a newborn calf or pup of that species, this assumption causes the acoustic model to overestimate the number of animals that may suffer slight lung injury or mortality. As discussed in the explanation of onset mortality and onset slight lung injury criteria in Section 3.4.3.1.13 (Mortality and Injury from Explosions), the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.
- Many explosions from ordnances such as bombs and missiles actually occur upon impact with above-water targets. However, for this analysis, sources such as these were modeled as exploding at 1 m depth. This overestimates the amount of explosive and acoustic energy entering the water and therefore overestimates effects on marine mammals.

Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) provide additional protections, many of which are not considered in the following effect summary tables since reductions as a result of implemented mitigation were only applied to those events having a very high likelihood of detecting marine mammals.

It is important to note that acoustic impacts presented in Table 3.4-24 through Table 3.4-28 are the total number of effects and not necessarily the number of individuals impacted. As discussed in Section 3.4.3.1.12 (Behavioral Responses), an animal could be predicted to receive more than one acoustic impact over the course of a year. Most species presented in tables had species density values (i.e., theoretically present to some degree) within the areas modeled for the given alternative and activities, although modeling may still indicate no effects ("0") after summing all annual impacts. The exceptions to this, as discussed in Section 3.4.3.1.14.1 (Marine Species Density Data) are North Pacific right whale, Guadalupe fur seal, and sea otter, for which estimates of effect have been made.

As described previously for predicted impacts from sonar and other active acoustic sources, acoustic modeling for explosions indicates that under some alternatives there would be zero predicted effects to some species. In some cases the species may be absent in the season an activity is to occur, or activities under an alternative take place in locations a species does not inhabit. In other cases with zero predicted effects, marine mammals may be exposed to a stressor associated with an activity (such as the acoustic energy from an underwater detonation), but the predicted exposure is of insufficient sound pressure level or too brief to rise in energy above an established impact threshold and criteria (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). In short, because some exposures do not exceed the current impact thresholds, they are considered insignificant and quantified as zero effects.

The population of North Pacific right whale is very few in number and they are generally only found in the Bering Sea, with sightings of a single North Pacific right whale off Kodiak Island (Alaska) on three occasions over the last 15 years. As presented in detail in Section 3.4.2.6 (North Pacific Right Whale [*Eubalaena japonica*]), a single right whale was seen in 1983 at the entrance to the Strait of Juan de Fuca (Osborne et al. 1988) and in the most recent sighting within the Study Area, a single right whale was sighted over Quinault Canyon in 1992 (Green et al. 1992; Rowlett et al. 1994). Recently (June 2013), a single right whale was sighted in waters off Haida Gwaii, British Colombia (located approximately 200 nm north of the Study Area; Hume 2013) and, in October later that year, another single right whale was sighted in a group of humpbacks off the entrance to the Strait of Juan de Fuca (Pynn 2013). North Pacific right whale are not expected to be present in the Study Area during Navy events involving use of explosives, so these activities would have no effect on North Pacific right whale.

The southern resident killer whale is the only species with critical habitat located in the Study Area. The only activity involving explosions that may occur within the southern resident killer whale's designated critical habitat involves Explosive Ordnance Disposal (EOD) training events at Crescent Harbor, Whidbey Island. These EOD training events have the potential to disturb or injure fish although monitoring of these events over multiple years indicates this is a rare occurrence and has never been known to impact salmon (the prey of southern resident killer whales). Although disturbance or injury to a small number of fish is possible as a result of the training at this location, those spatially restricted and historically rare effects to fish are discountable in that they are not expected to have any meaningful impact on killer whales. The primary constituent elements of the southern resident killer whale's critical habitat have been identified as (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging (National Marine Fisheries Service 2006). The use of explosives during EOD training would not impact water quality as it supports growth and development; would not impact salmon (prey species) resulting in insufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and would not impact passage conditions. For these reasons, the primary constituent elements of the southern resident killer whale's designated critical habitat are not expected to be impacted by the proposed Navy training activity involving explosions.

3.4.3.2.2.4 No Action Alternative

Training

As described in Chapter 2 (Description of Proposed Action and Alternatives), training activities under the No Action Alternative include explosive (impulse) sources. Training activities involving explosions would mainly be conducted throughout the Offshore Area, but also at historically used locations in the Inland Waters portion of the Study Area. There are no training activities involving the use of explosions in Southeast Alaska-Western Behm Canal). Predicted effects on marine mammals from effects to explosions during annually training activities under the No Action Alternative are shown in Table 3.4-24. There are no training activities proposed that result in a majority or disproportionate number of the predicted effects. For the majority of marine mammal species, the acoustic analysis predicts they would not be exposed to explosive (impulse) sources associated with training activities, which would exceed the current impact thresholds (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). Under the No Action Alternative, only harbor porpoise, Dall's porpoise, and Northern elephant seal are predicted to have exposures that would exceed the current impact thresholds, as presented in detail in the following subsections.

Harbor Porpoise

Harbor porpoises may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that Washington Inland Waters stock harbor porpoises could be exposed to sound and energy from explosions that may result in 2 TTS.

Animals that do experience temporary partial hearing loss (TTS) may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations. Recovery from a threshold shift can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. Long-term consequences for individuals and the population would not be expected.

Dall's Porpoise

Dall's porpoise are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Dall's porpoise in the California, Oregon, Washington stock may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that Dall's porpoises could be exposed to sound or energy from explosions that may result in one PTS and four TTS annually. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's hearing of biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012). As otherwise described for harbor porpoise above, these predicted effects to Dall's porpoise are unlikely to cause long-term consequences for individual animals or populations.

Northern Elephant Seals

Northern elephant seals are present in all portions of the Study Area and may be exposed to sound and energy from explosions associated with training activities throughout the year. All Northern elephant seals in the Study Area are considered part of the California Breeding stock. The acoustic analysis predicts Northern elephant seals may be exposed to sound and energy from explosions associated with training activities that may result in one TTS annually. Research has demonstrated that for pinnipeds as for other mammals, recovery from a hearing threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so threshold shifts may not necessarily interfere with an animal's ability to hear biologically relevant sounds.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sound and energy from explosions they may react in a number of ways depending on their experience and what activity they are engaged in at the time of the acoustic exposure. Seals may not react at all until the activity is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

Conclusion

Training activities under the No Action Alternative include the use of use of explosions as detailed in Chapter 2 (Description of Proposed Action and Alternatives). These activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of explosive sources for training activities as described in the No Action Alternative:

- *May expose marine mammals up to seven times annually to sound or energy levels that would be considered Level B harassment*
- *May expose 1 Dall's porpoise annually to sound or energy levels that would be considered Level A harassment.*

Pursuant to the ESA, the use of explosive sources for training activities as described in the No Action Alternative:

- *May affect, but is not likely to adversely affect, humpback whale, blue whale, fin whale, sei whale, Western North Pacific gray whale, sperm whale, southern resident killer whale, and Guadalupe fur seal*
- *Would have no effect on North Pacific right whale*
- *Would have no effect on southern resident killer whale critical habitat.*

Table 3.4-24: No Action Alternative Annual Training Effects for Explosive (Impulse) Sources

Species	Stock	Level B		Level A			Mortality
		Behavioral	TTS	PTS	GI Injury	Lung Injury	
North Pacific right whale	Eastern North Pacific	0	0	0	0	0	0
Humpback whale	CA/OR/WA	0	0	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Blue whale	Eastern North Pacific	0	0	0	0	0	0
Fin whale	Northeast Pacific	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Sei whale	Eastern North Pacific	0	0	0	0	0	0
Minke whale	Alaska	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Gray whale	Eastern North Pacific	0	0	0	0	0	0
	Western North Pacific	0	0	0	0	0	0
Sperm whale	North Pacific	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Kogia (spp.)	CA/OR/WA	0	0	0	0	0	0
Killer whale	Alaskan Resident	0	0	0	0	0	0
	Northern Resident	0	0	0	0	0	0
	West Coast Transient	0	0	0	0	0	0
	Eastern North Pacific Offshore	0	0	0	0	0	0
	Southern Resident	0	0	0	0	0	0
Short-finned pilot whale	CA/OR/WA	0	0	0	0	0	0
Short-beaked common dolphin	CA/OR/WA	0	0	0	0	0	0
Bottlenose dolphin	CA/OR/WA	0	0	0	0	0	0
Striped dolphin	CA/OR/WA	0	0	0	0	0	0
Pacific white-sided dolphin	North Pacific	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Northern right whale dolphin	CA/OR/WA	0	0	0	0	0	0
Risso’s dolphin	CA/OR/WA	0	0	0	0	0	0

Table 3.4-24: No Action Alternative Annual Training Effects for Explosive (Impulse) Sources (continued)

Species	Stock	Level B		Level A			Mortality
		Behavioral	TTS	PTS	GI Injury	Lung Injury	
Harbor porpoise	Southeast Alaska	0	0	0	0	0	0
	Northern OR/WA Coast	0	0	0	0	0	0
	Northern California/Southern Oregon	0	0	0	0	0	0
	WA Inland Waters	0	2	0	0	0	0
Dall's porpoise	Alaska	0	0	0	0	0	0
	CA/OR/WA	0	4	1	0	0	0
Cuvier's beaked whale	Alaska	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Baird's beaked whale	Alaska	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Mesoplodon beaked whales	CA/OR/WA	0	0	0	0	0	0
Steller sea lion	Eastern U.S.	0	0	0	0	0	0
Guadalupe fur seal	Mexico	0	0	0	0	0	0
California sea lion	U.S.	0	0	0	0	0	0
Northern fur seal	Eastern Pacific	0	0	0	0	0	0
	California	0	0	0	0	0	0
Northern elephant seal	California Breeding	0	1	0	0	0	0
Harbor seal	SE Alaska-Clarence St.	0	0	0	0	0	0
	OR/WA Coastal	0	0	0	0	0	0
	WA Inland Waters	0	0	0	0	0	0
Northern sea otter	SE Alaska	0	0	0	0	0	0
	Washington	0	0	0	0	0	0

Notes: CA = California, OR = Oregon, PTS = Permanent Threshold Shift, S = South, SE = Southeast, St. = Strait, TTS = Temporary Threshold Shift, U.S. = United States, WA = Washington

Testing

As described in Chapter 2 (Description of Proposed Action and Alternatives), testing activities under the No Action Alternative do not include use of explosive (impulse) sources.

3.4.3.2.2.5 Alternative 1

Training

As described in Chapter 2 (Description of Proposed Action and Alternatives), training activities under Alternative 1 include would use underwater detonations and explosive ordnance. Training activities involving explosions would mainly be conducted throughout the Offshore Area, but also at historically used locations in the Inland Waters portion of the Study Area. There are no training activities involving the use of explosions in Southeast Alaska-Western Behm Canal. New activities proposed under Alternative 1 and notable changes from the No Action Alternative for explosives are shown in Table 2.8-1 and Table 3.4-3 and summarized as follows:

- Increase in the annual number of explosives used in the offshore portion of the Study Area by approximately 33 percent during Gunnery events.
- Increase in the number of explosives used in the Inland Waters of the Study Area from four during four annual events to 42 annually during 12 annual events.
- Introducing use of a high explosive warhead for Missile Exercise, Air-to-Surface.
- Removal of the Sinking Exercise event and its associated ordnance from the proposed action.

Predicted effects on marine mammals from exposures to explosions during annually training activities under Alternative 1 are shown in Table 3.4-25. There are no training activities proposed that result in a majority or disproportionate number of the predicted effects under Alternative 1. The acoustic analysis for Alternative 1 predicts the majority of marine mammal species in the Study Area would not be exposed to explosive (impulse) sources associated with training activities, which would exceed the current impact thresholds (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). Under Alternative 1, only harbor porpoise, Dall's porpoise, and Northern elephant seal are predicted to have exposures that would exceed the current impact thresholds, as presented in detail in the following subsections.

Harbor Porpoise

Harbor porpoises may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that Washington Inland Waters stock harbor porpoises could be exposed to sound and energy from explosions that may result in four TTS.

Animals that do experience temporary partial hearing loss (TTS) may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations. Recovery from a threshold shift can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. Long-term consequences for individuals and the population would not be expected.

Dall's Porpoise

Dall's porpoise are classified as high-frequency cetaceans (see Section 3.4.2.3.1, High-Frequency Cetaceans). Dall's porpoise in the California, Oregon, Washington stock may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that Dall's porpoises could be exposed to sound or energy from explosions that may result in two PTS and five TTS annually (one TTS predicted in the Inland Waters and the remaining effects predicted for the Offshore Area). PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's hearing of biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012). As otherwise described for harbor porpoise above, these predicted effects to Dall's porpoise are unlikely to cause long-term consequences for individual animals or populations.

Northern Elephant Seals

Northern elephant seals are present in all portions of the Study Area and may be exposed to sound and energy from explosions associated with training activities throughout the year. All Northern elephant seals in the Study Area are considered part of the California Breeding stock. The acoustic analysis predicts Northern elephant seals may be exposed to sound and energy from explosions associated with training activities in the offshore portion of Study Area that may result in one TTS annually. Research has demonstrated that for pinnipeds as for other mammals, recovery from a hearing threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so threshold shifts may not necessarily interfere with an animal's ability to hear biologically relevant sounds.

Research and observations (see Section 3.4.3.1.6, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sound and energy from explosions they may react in a number of ways depending on their experience and what activity they are engaged in at the time of the acoustic exposure. Seals may not react at all until the activity is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

Conclusion

Training activities under Alternative 1 include the use of use of explosions as detailed in Chapter 2 (Description of Proposed Action and Alternatives). These activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of explosive sources for training activities as described in Alternative 1:

- *May expose marine mammals up to 10 times annually to sound or energy levels that would be considered Level B harassment*
- *May expose Dall's porpoise 2 times annually to sound or energy levels that would be considered Level A harassment.*

Pursuant to the ESA, the use of explosive sources for training activities as described in Alternative 1:

- *May affect, but is not likely to adversely affect, humpback whale, blue whale, fin whale, sei whale, Western North Pacific gray whale, sperm whale, southern resident killer whale, and Guadalupe fur seal*
- *Would have no effect on North Pacific right whale*
- *Would have no effect on southern resident killer whale critical habitat.*

Table 3.4-25: Alternative 1 Annual Training Effects for Explosive (Impulse) Sources

Species	Stock	Level B		Level A			Mortality
		Behavioral	TTS	PTS	GI Injury	Lung Injury	
North Pacific right whale	Eastern North Pacific	0	0	0	0	0	0
Humpback whale	CA/OR/WA	0	0	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Blue whale	Eastern North Pacific	0	0	0	0	0	0
Fin whale	Northeast Pacific	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Sei whale	Eastern North Pacific	0	0	0	0	0	0
Minke whale	Alaska	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Gray whale	Eastern North Pacific	0	0	0	0	0	0
	Western North Pacific	0	0	0	0	0	0
Sperm whale	North Pacific	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Kogia (spp.)	CA/OR/WA	0	0	0	0	0	0
Killer whale	Alaskan Resident	0	0	0	0	0	0
	Northern Resident	0	0	0	0	0	0
	West Coast Transient	0	0	0	0	0	0
	Eastern North Pacific Offshore	0	0	0	0	0	0
	Southern Resident	0	0	0	0	0	0
Short-finned pilot whale	CA/OR/WA	0	0	0	0	0	0
Short-beaked common dolphin	CA/OR/WA	0	0	0	0	0	0
Bottlenose dolphin	CA/OR/WA	0	0	0	0	0	0
Striped dolphin	CA/OR/WA	0	0	0	0	0	0
Pacific white-sided dolphin	North Pacific	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Northern right whale dolphin	CA/OR/WA	0	0	0	0	0	0
Risso's dolphin	CA/OR/WA	0	0	0	0	0	0

Table 3.4-25: Alternative 1 Annual Training Effects for Explosive (Impulse) Sources (continued)

Species	Stock	Level B		Level A			Mortality
		Behavioral	TTS	PTS	GI Injury	Lung Injury	
Harbor porpoise	Southeast Alaska	0	0	0	0	0	0
	Northern OR/WA Coast	0	0	0	0	0	0
	Northern California/Southern Oregon	0	0	0	0	0	0
	WA Inland Waters	0	4	0	0	0	0
Dall's porpoise	Alaska	0	0	0	0	0	0
	CA/OR/WA	0	5	2	0	0	0
Cuvier's beaked whale	Alaska	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Baird's beaked whale	Alaska	0	0	0	0	0	0
	CA/OR/WA	0	0	0	0	0	0
Mesoplodon beaked whales	CA/OR/WA	0	0	0	0	0	0
Steller sea lion	Eastern U.S.	0	0	0	0	0	0
Guadalupe fur seal	Mexico	0	0	0	0	0	0
California sea lion	U.S.	0	0	0	0	0	0
Northern fur seal	Eastern Pacific	0	0	0	0	0	0
	California	0	0	0	0	0	0
Northern elephant seal	California Breeding	0	1	0	0	0	0
Harbor seal	SE Alaska-Clarence St.	0	0	0	0	0	0
	OR/WA Coastal	0	0	0	0	0	0
	WA Inland Waters	0	0	0	0	0	0
Northern sea otter	SE Alaska	0	0	0	0	0	0
	Washington	0	0	0	0	0	0

Notes: CA = California, OR = Oregon, PTS = Permanent Threshold Shift, S = South, SE = Southeast, St. = Strait, TTS = Temporary Threshold Shift, U.S. = United States, WA = Washington

Testing

As described in Chapter 2 (Description of Proposed Action and Alternatives), testing activities under Alternative 1 include use of underwater detonations and explosive ordnance. Testing activities involving explosions would be conducted throughout the Offshore Area. There are no testing activities involving the use of explosions in the Inland Waters of the Study Area or Southeast Alaska-Western Behm Canal. New activities proposed under Alternative 1 testing from the No Action Alternative for explosives are shown in Table 2.8-2 and Table 3.4-3 and summarized as follows:

- Introducing use of explosive SUS buoys in the offshore portion of the Study Area during Anti-Submarine Warfare Tracking Test by Maritime Patrol Aircraft.
- Introducing Torpedo Service Weapon Test events in the offshore portion of the Study Area.

Predicted effects on marine mammals from exposures to explosions during annually testing activities under Alternative 1 are shown in Table 3.4-26. The acoustic analysis for Alternative 1 predicts the majority of marine mammal species in the Study Area would not be exposed to explosive (impulse) sources associated with testing activities, which would exceed the current impact thresholds (see Section 3.4.3.1.10, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). Under Alternative 1, only Dall’s porpoise are predicted to have exposures that would exceed the current impact thresholds, as presented in detail in the following subsection. These predicted effects are as a result of Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (Improved Extended Echo Ranging [IEER]) and Torpedo (explosive) Test events, both of which would occur offshore.