NORTHWEST TRAINING AND TESTING ESSENTIAL FISH HABITAT ASSESSMENT

FINAL

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Lead Agency

Department of the Navy

Action Proponents

Commander, U.S. Pacific Fleet

Naval Sea Systems Command

Naval Air Systems Command

EXECUTIVE SUMMARY

This assessment of the effects of Navy activities in the Northwest Training and Testing (NWTT) Study Area on Essential Fish Habitat (EFH) covers regulatory issues, impacts of the Proposed Action, and mitigation measures.

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) of 1976 mandates identification and conservation of EFH. A second habitat type is also identified to focus conservation efforts: Habitat Areas of Particular Concern. These subsets of EFH are rare, sensitive, ecologically important, or located in an area that is already stressed. Federal agencies are required to consult with the National Marine Fisheries Service and to prepare an Essential Fish Habitat Assessment (EFHA) if their activities may adversely affect EFH.

The Northwest Training and Testing (NWTT) Study Area

The NWTT Study Area includes offshore air, sea, and undersea space; nearshore air, land, sea, and undersea space, and inland airspace. Offshore and nearshore operating areas contain EFH for species covered under Fishery Management Plans (FMPs), including salmonids, coastal pelagic species, Pacific Coast groundfish, and highly migratory species. The NWTT Study Area is located within the California Current System: the offshore and nearshore areas adjacent to Washington (WA), Oregon (OR), and northern California (CA) coasts; and the marine and estuarine waters of the Strait of Juan de Fuca and Puget Sound, WA; and the Western Behm Canal located in southeast Alaska (AK).

The Pacific Fishery Management Council (PFMC) has management responsibilities over the EFH in offshore waters of WA, OR, and CA and the Inland Waters portion of the Study Area. The North Pacific Fishery Management Council (NPFMC) has management responsibilities in Alaskan waters. The Navy has determined that the Proposed Action will have no effect on EFH Western Behm Canal, Alaska; therefore, discussion of Alaskan waters is not carried forward in this analysis.

Proposed Activities

The Navy proposes to continue training and testing activities in the NWTT Study Area.

Navy training activities include missile, gunnery, bombing, and electronic combat exercises; anti-submarine warfare tracking exercises; mine countermeasures training; naval special warfare training; and intelligence, surveillance, and reconnaissance 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.

Analysis Factors

The following factors were considered in the analysis of potential impacts: the duration, frequency, intensity, and spatial extent of the impact; the sensitivity or vulnerability of the habitat; and the habitat functions that might be altered by the impact. Adverse effects are defined as any impact that reduces the quality or quantity of EFH. Temporary effects are limited in duration and allow the environment to recover without measurable impact. Minimal effects do not cause large-scale changes in ecological function.

Effects on EFH could be associated with sonar and vessel noise; underwater explosives and weapons firing, launch, and impact noise; electromagnetic devices; vessel movement; in-water devices; military expended materials; seafloor devices; explosives and explosives byproducts; metals; chemicals; and other materials. Navy activities could have short-term, temporary, long-term, or permanent effects, as well as minimal, effects on individual species, substrates, biogenic habitats, or could alter water quality.

Summary of Assessment

Acoustic Stressors

Acoustic energy from sonar and vessel noise may adversely affect water column EFH. However, these effects would be minimal and temporary. Noise from explosives and weapons firing, launch, and impact may adversely affect water column EFH. However, these effects would be minimal and temporary. These actions may also adversely affect substrate and biogenic EFH and the effects would range from minimal and short term to permanent.

Energy Stressors

Electromagnetic devices may adversely affect water column EFH. However, these effects would be minimal and temporary.

Physical Disturbance and Strike Stressors

Vessel movement and in-water devices may adversely affect substrates. However, the effects would range from minimal and short term to permanent. Vessel movement and in-water devices would have no effect on biogenic EFH as mitigation measures would prevent activities occurring near sensitive nearshore habitats. Military expended materials may adversely affect water column EFH; however, these effects would be minimal and temporary. Military expended materials may adversely affect substrate and biogenic EFH. However, these effects would range from minimal and long term to permanent. Seafloor devices would have no effect on water column EFH, but may adversely affect substrate and biogenic EFH. These effects, however, would be minimal and temporary.

Contaminant Stressors

Explosives and explosives byproducts may adversely affect water column, substrate, and biogenic EFH. However, these effects would be minimal and temporary. Metals, chemicals, and other materials would have no effect on any EFH in the Study Area.

Conclusion

The assessment concludes that the potential impacts from the Proposed Action may adversely affect EFH; however, these effects would not exceed a determination of more than minimal (Table ES-1). The individual stressor effects were all either no effect or may adversely affect. However, any expected effects would be minimal and range in duration from temporary to permanent, depending on the habitat impacted.

Table ES-1: Summary of Determinations

Species	EFH				HAPC
	Water Column	Prey Species	Substrate	Biogenic	
Pacific Coast Groundfish	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and short term to permanent)	• Attached macroalgae: may adversely affect (minimal and long term based on hard substrate impacts) • Submerged rooted vegetation: may adversely affect (minimal and long term; mitigation avoids sensitive nearshore habitats) • Sedentary invertebrate beds: may adversely affect (minimal and short term to permanent [based on substrate impacts]; mitigation avoids mapped hard bottom)	May adversely affect (minimal and variable duration, habitat dependent; mitigation avoids sensitive nearshore habitats, mapped hard bottom, and surface macroalgae concentrations)
Pacific Coast Salmon Species	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and short term to permanent)	• Attached macroalgae: may adversely affect (minimal and long term based on hard substrate impacts) • Submerged rooted vegetation: may adversely affect (minimal and long term; mitigation avoids sensitive nearshore habitats) • Sedentary invertebrate beds: may adversely affect (minimal and short term to permanent [based on substrate impacts]; mitigation avoids mapped hard bottom)	May adversely affect (minimal and variable duration, habitat dependent; mitigation avoids sensitive nearshore habitats, mapped hard bottom, and surface macroalgae concentrations)
Coastal Pelagic Species	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and short term to permanent)	• Attached macroalgae: may adversely affect (minimal and long term based on hard substrate impacts) • Submerged rooted vegetation: may adversely affect (minimal and long term; mitigation avoids sensitive nearshore habitats) • Sedentary invertebrate beds: may adversely affect (minimal and short term to permanent [based on substrate impacts]; mitigation avoids mapped hard bottom)	None
Highly Migratory Species	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and short term to permanent)	• Attached macroalgae: may adversely affect (minimal and long term based on hard substrate impacts) • Submerged rooted vegetation: may adversely affect (minimal and long term; mitigation avoids sensitive nearshore habitats) • Sedentary invertebrate beds: may adversely affect (minimal and short term to permanent [based on substrate impacts]; mitigation avoids mapped hard bottom)	None

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LIST OF ACRONYMS AND ABBREVIATIONS

°	degree
>	greater than
<	less than
µg/L	micrograms per liter
µPa	micropascal
A-A	Air-to-Air
A-S	Air-to-Surface
AAW	Anti-Air Warfare
ACM	Air Combat Maneuver
ADFG	Alaska Department of Fish and Game
AK	Alaska
AMNS	Airborne Mine Neutralization System
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
ATN	Aid to Navigation
AUV	Autonomous Underwater Vehicle
$BaCrO_4$	barium chromate
BO	Biological Opinion
BOMBEX	Bombing Exercise
C	Celsius
CA	California
C.F.R.	Code of Federal Regulations
cm	centimeters
CMECS	Coastal and Marine Ecological Classification Standard
CPS	Coastal Pelagic Species
dB	decibel
dBA	decibel, A-weighted
DBRC	Dabob Bay Range Complex
DICASS	Directional Command Activated Sonobuoy
DWADS	Deep Water Active Distributed System
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFHA	Essential Fish Habitat Assessment
EIS	Environmental Impact Statement
EMATT	Expendable Mobile ASW Training Target
ENSO	El Niño Southern Oscillation
EOD	Explosive Ordnance Disposal
ESA	Endangered Species Act
EW	Electronic Warfare
fm	fathoms
FMC	Fishery Management Council
FMP	Fishery Management Plan
ft.	feet
$ft.^2$	square feet
ft./s	feet per second
G	gauss
GIS	Geographic Information System
GUNEX	Gunnery Exercise
h	depth
HAPC	Habitat Area of Particular Concern
HARM	High Speed Anti-Radiation
HDC	High Duty Cycle
HE	High Explosive
HF	High-Frequency
$Hg(CNO)_2$	Fulminate of Mercury
HMS	Highly Migratory Species
HSP	Habitat Suitability Probability
Hz	Hertz
IMPASS	Integrated Maritime Portable Acoustic Scoring
in.	inches
IEER	Improved Extended Echo Ranging
ISR	Intelligence, Surveillance Reconnaissance
kg	kilograms
kg/m^2	kilograms per square meters
kg/m^3	kilograms per cubic meter
kHz	kilohertz
km	kilometers
km^2	square kilometers
lb.	pounds
LF	Low-Frequency
LFAS	Low-Frequency Active Sonar
m	meters
m^2	square meters
m/s	meters per second
MAC	Multistatic Active Coherent
MF	Mid-Frequency
MFAS	Mid-Frequency Active Sonar
mg/L	milligrams per liter
MHHW	Mean Higher High Water
mi.	miles
MINIROV	Miniature Remotely Operated Vehicle
MISSILEX	Missile Exercise
MIW	Mine Warfare
mm	millimeters
MOA	Military Operations Area
MPA	Maritime Patrol Aircraft
MSA	Magnuson-Stevens Fishery Conservation

	and Management Act
MSL	Mean Sea Level
MSO	Maritime Security Options
MUS	Management Unit Species
N	North
NAVAIR	Naval Air Systems Command
NAVBASE	Naval Base
Navy	United States Department of the Navy
n/a	not applicable
NEPA	National Environmental Policy Act
NEPM	Non-Explosive Practice Munition
NEW	Net Explosive Weight
nm	nautical miles
nm^2	square nautical miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
NSW	Naval Special Warfare
NSWC	Naval Surface Warfare Center
NUWC	Naval Undersea Warfare Center
NWTRC	Northwest Training Range Complex
NWTT	Northwest Training and Testing Study Area
nV	nanovolts
OEIS	Overseas Environmental Impact Statement
OPAREA	Operating Area
OPS	Operations
OR	Oregon
oz.	ounces
$Pb(N_3)_2$	lead azide
PbO	lead (II) oxide
PDO	Pacific Decadal Oscillation
PFMC	Pacific Fishery Management Council
ppb	parts per billion
ppt	parts per thousand
PSA	Post Shakedown Availability
psu	Practical Salinity Unit
QRS	Quinault Range Site
R (1)	Radius
R (2)	Restricted Area
r_0	charge radius
RDX	Royal Demolition Explosive
re	referenced to
RMMV	Remote Multi-Mission Vehicle
ROV	Remotely Operated Vehicle
s	seconds
S-A	Surface-to-Air
SAS	Synthetic Aperture Sonar
SCB	Southern California Bight
SD	Swimmer Detection sonar
SEAFAC	Southeast Alaska Acoustic Measurement Facility
SOP	standard operating procedure
SPL	Sound Pressure Level
S-S	Surface-to-Surface
SSBN	Fleet Ballistic Missile Submarines
SST	Sea Surface Temperature
Study Area	NWTT Study Area
SUS	Signal, Underwater Sound
SWAG	Shock Wave Action Generator
TNT	trinitrotoluene
TORP	Torpedoes
TRACKEX	Tracking Exercise
UAS	Unmanned Aircraft System
UEWS	Underwater Emergency Warning System
UNDET	Underwater Detonation
U.S.	United States
U.S.C.	United States Code
USV	Unmanned Surface Vehicles
UUV	Unmanned Underwater Vehicle
V	volts
VHF	Very High-Frequency
W (1)	Warning Area
W (2)	West
WA	Washington
yd.	yards

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1 INTRODUCTION

1.1 PURPOSE OF THIS ESSENTIAL FISH HABITAT ASSESSMENT

In brief, an EFH is defined as those waters and substrate necessary to fish (marine, estuarine, and anadromous finfish, mollusks, and crustaceans) for spawning, breeding, feeding, or growth to maturity (Magnuson-Stevens Fishery Conservation and Management Act [MSA] § 3(10)), whereas the EFHA is an analysis of the effects of a proposed action on EFH. A detailed background and additional information can be found in the NWTT DEIS at http://www.nwtteis.com.

As required by the MSA, the purpose of this EFHA is to present the findings and analyses conducted by the United States (U.S.) Department of the Navy (Navy) which evaluated how Navy training and testing activities proposed to occur within the NWTT Study Area (Study Area) (including both the Inland Waters portion and the offshore portion of the Study Area) may affect EFH. The North Pacific Fishery Management Council (NPFMC) has management responsibilities in Alaskan waters. The Navy has determined that the Proposed Action will have no effect on EFH Western Behm Canal, Alaska; therefore, discussion of Alaskan waters is not carried forward in this analysis.

This EFHA includes a description of the Navy's Proposed Action, an overview of the EFH designated within the activity area, an analysis of the direct, indirect, and cumulative effects on EFH for the managed fish and their food resources, and proposed mitigation measures selected to minimize any potential adverse effects to EFH that could result from the Proposed Action. This EFHA also includes analyses of the Habitat Areas of Potential Concern (HAPC), which are habitat areas with extremely important ecological functions and/or areas that are especially vulnerable to human-induced degradation (e.g., estuaries, seagrass, and other areas of interest).

Additional details regarding the Navy's proposed activities in the NWTT Study Area, the affected environment, and the potential environmental effects associated with ongoing and proposed naval activities are contained in the Draft NWTT Environmental Impact Statement (EIS)/Overseas EIS (OEIS) (U.S. Department of the Navy 2014). The NWTT DEIS can be found at http://nwtteis.com/. The Marine Resources Assessments for the Pacific Northwest Operating Area (OPAREA) (U.S. Department of the Navy 2006) also contains a comprehensive description of the marine environment including climate; marine geology; physical, chemical, and biological oceanography; marine habitats; and protected species in the Study Area. These documents are available to the public and can be obtained from the Navy's Marine Resources Assessments website.[1]

This EFHA will be coordinated with the National Marine Fisheries Service (NMFS), the responsible agency for EFH regulatory enforcement and consultations. NMFS has been informed of project details described in this report and has been involved in coordination and consultation as a cooperating agency for the EIS/OEIS pursuant to the National Environmental Policy Act. NMFS has been involved at the headquarters and regional levels, reviewing the EIS/OEIS at various stages of its development. The Navy is the agency responsible for consulting on impacts to EFH for the Proposed Action. This EFHA is being developed concurrently with the NWTT EIS/OEIS.

[1] https://www.navfac.navy.mil/products_and_services/ev/products_and_services/marine_resources/marine_resource_assessments.html

1.2 Previous Essential Fish Habitat Assessments

The Navy had previously completed analyses of EFH for individual range complexes within the NWTT Study Area as described below. The NWTT Study Area is a consolidation of two range complexes described in two previous environmental documents; the 2010 Northwest Training Range Complex (NWTRC) Final EIS/OEIS, and the 2010 Naval Sea Systems Command Naval Undersea Warfare Center (NUWC) Division, Keyport Range Complex Extension Final EIS/OEIS These previous analyses and conclusions are noteworthy in that, together, they considered similar activities within the same geographical areas as are analyzed in this new NWTT EFHA.

1.2.1 Northwest Training Range Complex

The Navy previously submitted an EFHA for the NWTRC EIS/OEIS (U.S. Department of the Navy 2009). The EFHA for the NWTRC EIS/OEIS concluded that, based on the limited extent, duration, and magnitude of potential impacts from training activities between October 2010 and October 2015, there would not be adverse effects on managed species or EFH. Range activities would not contribute to large-scale cumulative impacts on present or future uses of the area. Through consultation, NMFS concluded that the NWTRC Proposed Action would adversely affect EFH for Pacific groundfish, coastal pelagic species (CPS), and Pacific salmon and included the following conservation recommendations to avoid, minimize, or offset potential adverse effects:

1. Inventory portions of the Study Area to characterize the presence, absence, and quality of sensitive habitats such as HAPCs, rockfish conservation areas, substrate important to overfished and/or rebuilding stocks such as *Seabastes* species commonly referred to as rockfishes (canary, darkblotched, Pacific ocean perch, widow, yelloweye), and petrale sole, and the habitats necessary to support deep sea corals and sponges (structure-forming benthic invertebrates) that are likely to experience training on a regular basis. In conjunction with this inventory, the Navy should develop and implement a plan that minimizes and/or avoids substrate impacts and sensitive habitats, along with deep sea corals, and sponges.

2. Develop and implement a long-term monitoring and adaptive management plan in coordination with NMFS that addresses the fate, transport and effects of expended materials on EFH resulting from implementation of the Proposed Action. This monitoring plan should be developed and implemented in coordination with the Northwest Fisheries Science Center and NMFS' Northwest Region Sustainable Fisheries Division in order to build upon the National Oceanic and Atmospheric Administration's (NOAA's) current existing data collection efforts and minimize conflicts with our on-going, at-sea research activities. The monitoring results should be reviewed along with the adaptive management plan annually in coordination with NMFS to determine the necessity to adjust training operations to avoid and/or minimize impacts to EFH.

3. Coordinate with NMFS to conduct any further analyses on the placement of any underwater training minefield proposed for placement off the coasts of Oregon and Washington State to determine, minimize, and/or avoid impacts to EFH.

The Navy responded to each conservation recommendation:

1. The Navy is unable to commit to inventorying portions of the Study Area to assist NMFS in identifying sensitive habitats as requested in this conservation recommendation. In the off-shore areas of the NWTRC, there are no specific areas that experience training at any more frequency than any other area within the NWTRC. The Navy supports working with NMFS to

improve data sharing, and as additional research information for habitat areas becomes available, the Navy will continue to incorporate results into future environmental planning and assessments of impact for the NWTRC.

2. Sufficient data does not currently exist to justify commitment to an annual review and potential adjustments to vital training, nor to the development of a long term monitoring plan based on perceived impacts to EFH. Given the quantity, wide dispersion and low potential for accumulation, the Navy stands by its determination that military expended material will not reduce the long term quality or quantity of EFH. The Navy believes that the general intent of this conservation recommendation is consistent and compatible with its goals of better understanding the environmental effects from the disposition of military expended material in the ocean. Further, the Navy agrees that regional coordination is necessary to help avoid conflicts between NMFS' ongoing, at-sea research activities and Navy training.

3. The Navy concurs with this conservation recommendation and intends to coordinate with NMFS on any further environmental analysis and planning to address the placement of the proposed underwater training minefield.

1.2.2 Naval Undersea Warfare Center Division, Keyport

The NMFS Washington State Habitat Office reviewed the U.S. Navy's Biological Opinion (BO) (National Marine Fisheries Service 2010) for the NUWC Keyport Range Complex Extension (U.S. Department of the Navy 2008b) and concluded that the proposed project may adversely affect EFH for Pacific groundfish, coastal pelagic species (CPS), and Pacific salmon. Based on this conclusion, NMFS recommended that the Navy "inventory existing eelgrass beds within the Study Area and avoid conducting project activities that may disturb or remove portions of the eelgrass beds and thus affect their productivity." Further, NMFS recommended that the Navy, "Recover all expended materials in HAPCs to avoid disturbance of sensitive habitats." However, in the NUWC Keyport Range Complex Extention BO, NMFS (2012c) concluded: "The potential for marine mammals to encounter expended material is low and does not consider this category of potential stressors further in the analyses."

The Navy responded to NMFS that it did not agree with NMFS suggestion that "any activity involving bottom contact may disturb or remove eelgrass, and must therefore be avoided or mitigated." Based on its assessment of bottom disturbing activities, the Navy concluded that impacts on EFH are either minimal or temporary, and based on the best available data would only result in inconsequential changes to habitat. Therefore, the NMFS-recommended mitigation measure of inventorying existing eelgrass beds would not be required. The Navy also concluded that the NMFS recommendation to recover all expended materials in HAPCs is not practicable either from a legal or military readiness perspective, per an April 10, 2010, letter from NUWC Keyport to NMFS.

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2 DESCRIPTION OF THE ACTION AND THE ACTION AREA

2.1 SUMMARY OF THE NORTHWEST TRAINING AND TESTING ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT PROPOSED ACTION ANALYZED IN THE ESSENTIAL FISH HABITAT ANALYSIS

The Navy prepared a Draft NWTT EIS/OEIS to assess the potential environmental impacts associated with two categories of military readiness activities: training and testing. The EIS/OEIS also assessed sonar maintenance and gunnery exercises conducted concurrently with ship transits and pierside sonar activity as part of overhaul, modernization, maintenance, and repair activities. The Action covered in this EFHA is the training and testing activities described in Alternative 1 (Preferred Alternative) in the NWTT EIS/OEIS. For the purposes of the EFHA Action Area, this analysis considers the entire Study Area as defined by the NWTT EIS/OEIS. The Action Area is described in detail below in Section 2.2 (Description of the Action Area).

The Navy routinely trains and tests in the Action Area in preparation for national defense missions. Typical training and testing activities covered in this EFHA are briefly described in Table 2-1, and in more detail within the NWTT Draft EIS/OEIS (Alternative 1) (U.S. Department of the Navy 2014). Each military training activity described meets a requirement that can be traced ultimately to requirements set forth by the National Command Authority.[2]

The Navy has been conducting military readiness activities in the Action Area for decades. 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 warfighting doctrine and procedures, and changes in force structure (organization of ships, weapons, and military personnel). Such developments influence changes in the frequency, duration, intensity, and location of required training and testing activities. The Navy categorizes most of the at-sea training activities into functional warfare areas called primary mission areas. The primary mission areas included in this EFHA are:

- Anti-Air Warfare (AAW)
- Anti-Surface Warfare (ASUW)
- Anti-Submarine Warfare (ASW)
- Electronic Warfare (EW)
- Mine Warfare (MIW)
- Naval Special Warfare (NSW)

Most activities addressed in the NWTT 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. A summary of the training and testing activities included as part of the Proposed Action is presented in Table 2-1. The activities support the same categories of activities; however, they are sorted by which organization typically conducts this type of activity. The research and acquisition community also categorizes some, but not all, of its testing activities under these primary mission areas.

[2] "National Command Authority" is a term used by the United States military and government to refer to the ultimate lawful source of military orders. The term refers collectively to the President of the United States (as Commander-in-Chief) and the United States Secretary of Defense.

Data in the tables includes the name of the activity, the number of times per year the activity occurs, annual number of ordnance used during the activity (explosive and non-explosive), and the location(s) where the activity occurs.

Table 2-1: Typical Training and Testing 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]) – Large-caliber	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.
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.
High-Speed Anti-Radiation Missile (HARM) Exercise (Non-firing)	Fixed-wing aircrews simulate firing HARM missiles, using captive air training missiles against surface targets. All missile firings are simulated; no actual missiles are fired.
Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircrews deliver bombs against surface targets.
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 (Extended Echo Ranging Sonobuoys)	Maritime patrol aircraft crews search for, detect and track submarines using explosive source sonobuoys or multistatic active coherent system.
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 as part of a mine avoidance training event.
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.

Table 2-1: Typical Training and Testing Activities (continued)

Activity Name		Activity Description
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		
Maritime Security Operations		Surface ship crews conduct a suite of Maritime Security Operations (MSO) events, including maritime security escorts for Navy vessels such as Fleet Ballistic Missile Submarines (SSBNs); Visit, Board, Search, and Seizure; Maritime Interdiction Operations; Force Protection; and Anti-Piracy Operations.
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, 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.
Naval Undersea Warfare Center, Keyport Testing Activities		
Torpedo Testing	Torpedo Non-Explosive Testing	Test of a non-explosive torpedo against a target.
Autonomous and Non-Autonomous Vehicles	Unmanned Underwater Vehicle (UUV) Testing	UUVs are autonomous or remotely operated vehicles with a variety of different payloads used for various purposes.
	Unmanned Aircraft System (UAS)	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 (USV)	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.
	ASW Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines or other training targets.

Table 2-1: Typical Training and Testing Activities (continued)

Activity Name		Activity Description
Naval Undersea Warfare Center, Keyport Testing Activities (continued)		
Maintenance and Miscellaneous	Side Scan/Multibeam Sonar	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.
	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 yards 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.

Table 2-1: Typical Training and Testing Activities (continued)

Activity Name		Activity Description
Naval Surface Warfare Center, Carderock Division, Southeast Alaska Acoustic Measurement Facility (continued)		
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.
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.
ASUW/ASW Testing	Torpedo (Explosive) 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	ASW Mission Package Testing	Air, surface, or submarine crews employ explosive torpedoes against artificial targets.
Naval Air Systems Command Testing Activities		
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.
Anti-Submarine Warfare (ASW)	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (DICASS)	All NAVAIR ASW testing activities are similar to the training event ASW TRACKEX – MPA. This test evaluates the sensors and systems used by MPA to detect and track submarines using the DICASS.
	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (MAC)	This test evaluates the sensors and systems used by MPA to detect and track submarines using the MAC sonobuoy system.
	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (SUS)	This test evaluates the sensors and systems used by MPA to communicate with submarines using any of the family of SUS systems.

Table 2-1: Typical Training and Testing Activities (continued)

Activity Name		Activity Description
Naval Air Systems Command Testing Activities (continued)		
Anti-Submarine Warfare (ASW)	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (IEER)	This test evaluates the sensors and systems used by MPA to detect and track submarines using the IEER sonobuoy system.
	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (HDC)	This test evaluates the sensors and systems used by MPA to detect and track submarines using the HDC sonobuoy system.

Notes: AUV = Autonomous Underwater Vehicle; DICASS = Directional Command Activated Sonobuoy; HDC = High Duty Cycle; IEER = Improved Extended Echo Ranging; MAC = Multistatic Active Coherent; NAVAIR = Naval Air Systems Command; PSA = Post Shakedown Availability; SUS = Signal, Underwater Sound; U.S. = United States

2.2 Description of the Action Area

The NWTT Action Area for the EFHA is composed of established maritime operating and warning areas in the eastern North Pacific Ocean region, to include the Strait of Juan de Fuca, and Puget Sound. The Action Area includes air and water space within and outside Washington state waters, and outside state waters of Alaska, Oregon, and Northern California.

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 EW systems occurs. Four range complexes and facilities are located in the Action Area: the NWTRC, NUWC Keyport Range Complex, Carr Inlet OPAREA, and Southeast Alaska Acoustic Measurement Facility (SEAFAC). 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 are also present in the Action Area. Military activities in the Study Area occur (1) on the ocean surface, (2) beneath the ocean surface, and (3) in the air.

For this EFHA, the term “at-sea” applies to the Pacific Ocean, the Strait of Juan de Fuca, the Puget Sound, , 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 (Figure 2-1).

To aid in the description of the ranges covered in the EFHA, the Area is divided into two distinct geographic areas. All of the training and testing activities proposed in this EIS/OEIS would occur in one or more of these two Action Area subdivisions:

- Offshore Area
- Inland Waters

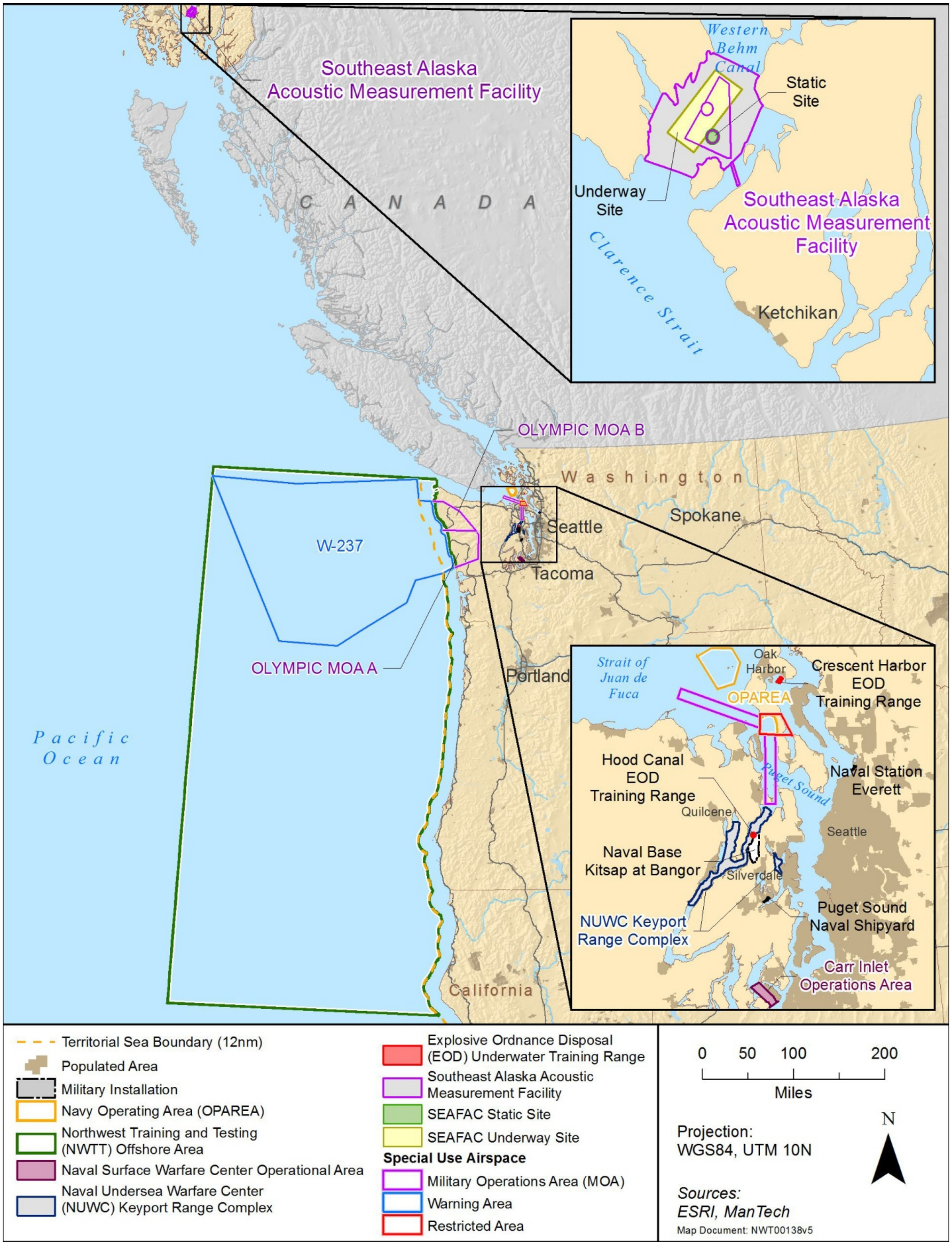

Figure 2-1: Northwest Training and Testing Study Area

2.2.1 Description of the Offshore Area

The Offshore portion of the Action Area includes surface and subsurface OPAREAs. The western boundary of the Offshore Area is approximately 250 nautical miles (nm) from the coastline of Washington, Oregon, and Northern California. The eastern boundary of the Offshore Area lies 12 nm off the coastline for most of the Study Area, including southern Washington, Oregon, and Northern California. Under the airspace of W-237 and the Olympic Military Operations Area (MOA), the eastern boundary abuts the coastline except for the Quinault Range Site. See the description of the Quinault Range Site below (Section 2.2.1.2 – Sea and Undersea Space).

2.2.1.1 Air Space

The special use airspace in the Offshore Area is comprised of Warning Area 237 (W-237), which extends westward off the coast of Northern Washington State. The eastern boundary of W-237 extends to the coastline 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]) and unlimited. W-237 can be further subdivided into smaller areas, lettered A through J (Figure 2-2).

The Olympic MOA overlays 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 coverage area of 1,614 square nautical miles (nm^2).

2.2.1.2 Sea and Undersea Space

The Offshore Area (Figure 2-2) 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 square nautical miles (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 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 provides valuable training and testing space for ships and submarines transiting between the Pacific Northwest and Southern California.

Within the boundaries of the Offshore Area lies the Quinault Range Site (Figure 2-2), a defined area of sea space where training and testing is conducted. The Quinault Range Site coincides with the boundaries of Warning Area-237A (W-237A) and also includes a surf zone component. The surf zone component extends 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.

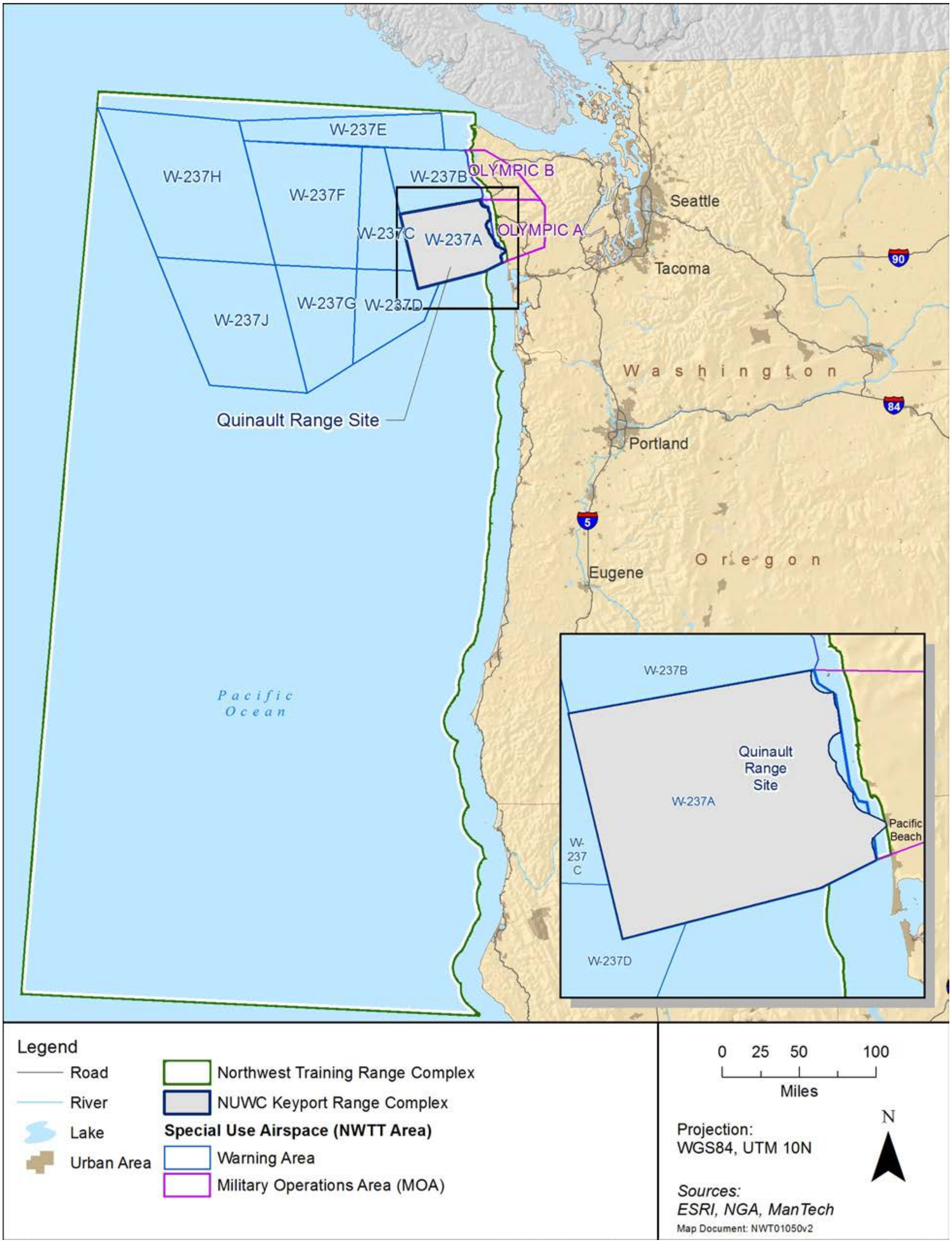

Figure 2-2: Offshore Area of the Northwest Training and Testing Study Area

2.2.2 DESCRIPTION OF THE INLAND WATERS

The Inland Waters include sea, and undersea space inland of the coastline from buoy "J" at 48° 29.6 minutes N, 125°W, eastward to the Strait of Juan de Fuca and the Puget Sound. Within the Inland Waters are specific geographic components in which training and testing occur. The Inland Waters and their component areas are described below and depicted in Figure 2-3.

2.2.2.1 Sea and Undersea Space in the Inland Waters

2.2.2.1.1 Explosive Ordnance Disposal (EOD) Ranges

Two active EOD ranges are located in the Inland Waters at the following locations, as depicted by Figure 2-3. The sites are also used for swimmer training in Mine Countermeasures.

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

2.2.2.1.2 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 NUWC 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 feet (ft.) (30.5 meters [m]). Underwater tracking of 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.

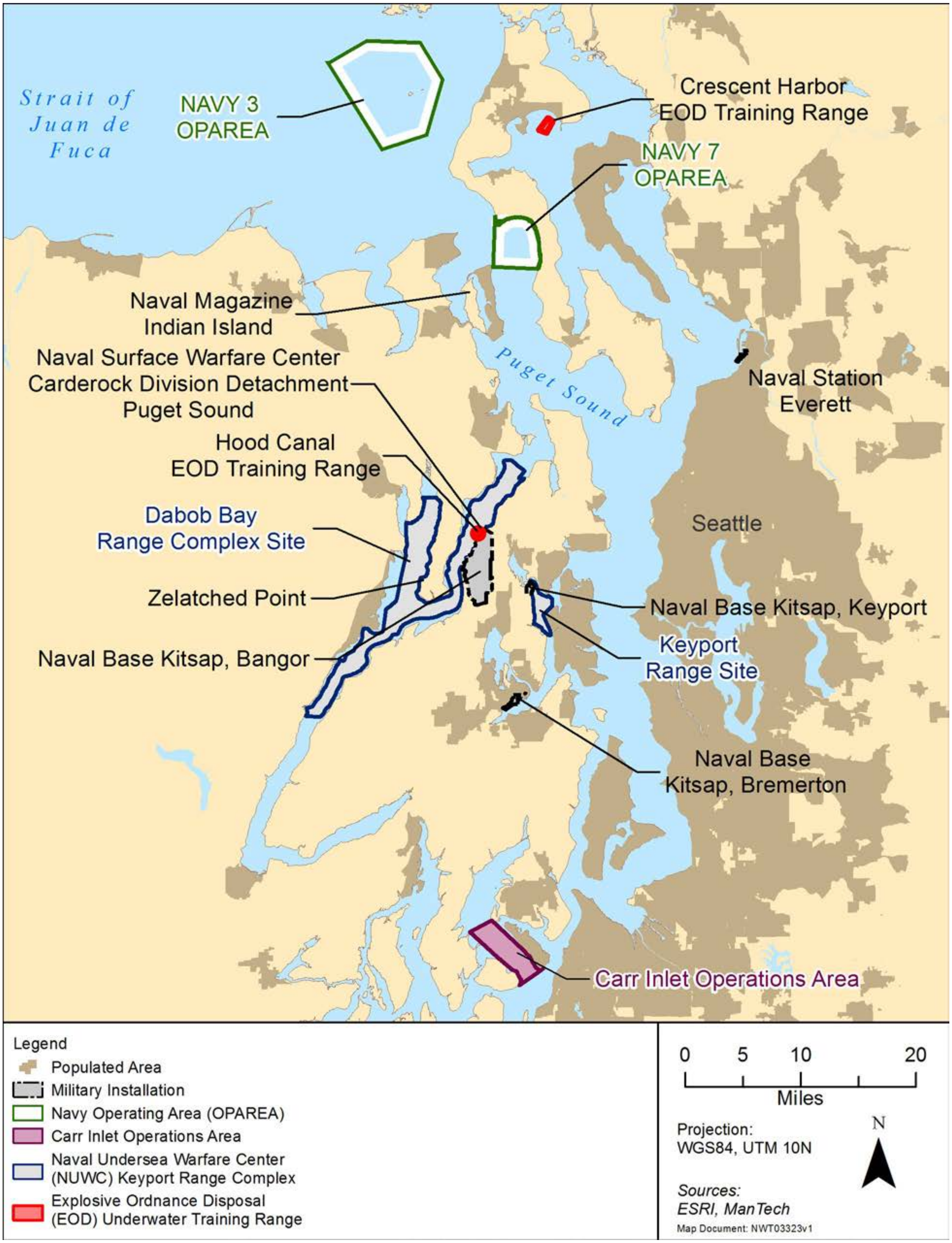

Figure 2-3: Inland Waters of the Northwest Training and Testing Study Area

The Carr Inlet OPAREA (Figure 2-3) 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 (NSWC), Carderock Division at NAVBASE Kitsap Bangor. While no permanently installed structures are present in the Carr Inlet OPAREA, the waterway remains a Naval Restricted Area (33 Code of Federal Regulations [C.F.R.] § 334.1250).

2.2.2.1.3 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 (Figure 2-3).

2.2.2.1.4 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 Restricted Area 6701 (R-6701). These areas cover a total area of 61 nm^2.

2.3 Overview of the Stressors Analyzed for Effects Determinations

For the purposes of this EFHA, the training and testing activities that encompass the Proposed Action were deconstructed to derive potential stressors that may affect EFH. The stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors potentially affecting EFH in this analysis are grouped into the following four categories:

- Acoustic
- Energy
- Physical disturbance and strike
- Contaminant

Table 2-2 describes the stressors in greater detail, including factors influencing how each stressor may affect EFH.

Table 2-2: Description of Stressors and Potential Impacts to EFH

Stressor	Description of Stressor
Acoustic (sonar and other active acoustic sources, underwater explosives, weapons firing, launch and impact noise, vessel noise)	Effects from acoustic sources are dependent on a number of factors, including the type of sound received (non-impulse or impulse), the proximity of the receiver to the sound source, and the duration, frequency, and intensity of the sound. 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. Sonar and other active acoustic sources emit sound waves into the water to detect objects, safely navigate, and communicate. Most systems operate within specific frequencies (although some harmonic frequencies may be emitted at lower sound pressure levels). Most sonar use is associated with anti-submarine warfare (ASW) activities. Sonar use associated with mine warfare (MIW) would also contribute a notable portion of overall acoustic sound. Explosives used during training and testing activities include explosive ordnance, including bombs, missiles, and naval gun shells; torpedoes; demolition charges; and explosive sonobuoys. Depending on the activity, detonations would occur in the air, near the water's surface, or underwater (some torpedoes and sonobuoys). Demolition charges could occur near the surface, in the water column, or on the seafloor. Most detonations would occur in waters greater than 200 ft. (61 m) in depth, and greater than 3 nm from shore, although MIW, demolition, and some testing detonations could occur in shallow water closer to shore. Noise associated with weapons firing and the impact of non-explosive practice munitions (NEPM) could happen at any location within the Study Area but generally would occur at locations greater than 12 nm from shore for safety reasons. These training and testing events would occur in areas designated for anti-surface warfare and similar activities. 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. Missiles and targets would also produce noise during launch. In addition, the impact of NEPM at the water surface can introduce noise into the water. Vessels (including ships, small craft, and submarines) would produce low-frequency, broadband underwater sound. Overall, naval traffic is often a minor component of total vessel traffic (Mintz and Filadelfo 2011; Mintz and Parker 2006). Commercial vessel traffic, which included cargo vessels, bulk carriers, passenger vessels, and oil tankers (all over 65 ft. [20 m] in length), was heaviest near and between the major shipping ports.

Table 2-2: Description of Stressors (continued)

Stressor	Description of Stressor
Energy (electromagnetic devices)	Electromagnetic devices are used in towed or unmanned MIW systems that mimic the electromagnetic signature of a vessel passing through the water. None of the devices include any type of electromagnetic “pulse.” The devices work by emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. 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). By comparison, magnetic field generated by a refrigerator magnet is between 150 and 200 G. The strength of an electromagnetic field decreases quickly with distance from the device. The magnetic field generated at a distance of 4 m from the source is comparable to the earth’s magnetic field, which is approximately 0.5 G.
Physical disturbance and strike (vessels, in water devices, military expended materials, and seafloor devices)	Physical disturbances may occur in association with vessel movements, the use of in-water devices, and materials expended from vessels and aircraft. Vessels used as part of the Action include ships (e.g., aircraft carriers, surface combatants), support craft, small boats, and submarines, ranging in size from 5 to over 300 m. Large 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 65 ft. [20 m] in length), which are all support craft, have variable speeds. Locations of vessel use in the Study Area varies with the type of activity taking place, but greater activity would be expected near ports than in other areas of the Study Area. In-water devices as discussed in this analysis are unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles and unmanned undersea vehicles, and towed devices. These devices are self-propelled and unmanned or towed through the water from a variety of platforms, including helicopters and surface ships. In-water devices are generally smaller than most participating vessels ranging from several inches to about 15 m. These devices can operate anywhere from the water surface to the benthic zone. Military expended materials include (1) all sizes of NEPM; (2) fragments from explosive munitions; and (3) expended materials other than munitions, such as sonobuoys and expendable targets. Activities using NEPM (e.g., small-, medium-, and large-caliber gun ammunitions, missiles, rockets, bombs, torpedoes, and neutralizers), explosive munitions (generating munitions fragments), and materials other than munitions (e.g., flares, chaff, sonobuoys, decelerators/parachutes, aircraft stores and ballast, and targets) have the potential to contribute to the physical disturbance and strike stressor.

Table 2-2: Description of Stressors (continued)

Stressor	Description of Stressor
Contaminant (explosion byproducts and unexploded ordnance, metals, chemicals other than explosives, and other materials)	Contaminant stressors include (1) explosives, (2) explosion byproducts and unexploded ordnance, (3) metals, and (4) chemicals. Explosion byproducts are not toxic to marine organisms at realistic exposure levels (Rosen and Lotufo 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Metals are introduced into seawater and sediments as a result of training and testing activities involving targets, ordnance, munitions, and other military expended materials. Several training and testing activities introduce potentially harmful chemicals into the marine environment; principally, flares and propellants for rockets, missiles, and torpedoes. Properly functioning flares, missiles, rockets, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment.

Notes: cm = centimeters, EFH = Essential Fish Habitat, ft. = feet, in. = inches, m = meters, mm = millimeters, nm = nautical miles

Table 2-3 provides a summary of the proposed training and testing activities by frequency (events per year), ordnance used (if any), and location.

Table 2-3: Proposed Action Potentially Impacting the EFH

Range Activity	Proposed Action			
	No. of events (per year)	**Ordnance (Number per year)**	**Location**	**EFH Potentially Affected**
Anti-Air Warfare (AAW)				
Air Combat Maneuver (ACM)	550	None	Offshore Area (W-237)	None
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	24	AIM-7/9/120 (15 HE warheads, 15 NEPM warheads)	Offshore Area (W-237)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Gunnery Exercise (Surface-to-Air) – Large-caliber (GUNEX [S-A]) – Large-caliber	160	Large-caliber rounds (230 HE, 80 NEPM) Medium-caliber rounds (6,320 HE, 9,680 NEPM)	Offshore Area (W-237)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	4	RIM-7/116 (8 HE warheads)	Offshore Area (W-237)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Anti-Surface Warfare (ASUW)				
High-Speed Anti-Radiation Missile (HARM) Exercise (Non-firing)	1,740	None	Offshore Area (W-237)	None
Gunnery Exercise (Surface-to-Surface) – Ship (GUNEX [S-S] – Ship)	200	Small-caliber rounds (121,200 NEPM) Medium-caliber rounds (178 HE, 33,492 NEPM) Large-caliber rounds (160 HE, 2,720 NEPM)	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	4	AGM-84 (4 HE Missiles)	Offshore Area (W-237)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	30	BDU-45, MK-84 Bombs (10 HE, 110 NEPM)	Offshore Area (W-237)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species

Table 2-3: Proposed Action Potentially Impacting the EFH (continued)

Range Training Activity	Proposed Action			
	No. of events (per year)	Ordnance (Number per year)	Location	EFH Potentially Affected
Anti-Submarine Warfare (ASW)				
Tracking Exercise – Submarine (TRACKEX – Sub)	100	None	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Tracking Exercise – Surface (TRACKEX – Surface)	65	None	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Tracking Exercise – Helicopter (TRACKEX – Helo)	4	None	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – MPA)	300	None	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Tracking Exercise – Maritime Patrol (Extended Echo Ranging Sonobuoys)	24	720 SSQ-125 sonobuoys	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Electronic Warfare (EW)				
Electronic Warfare Operations (EW OPS)	5,000 (aircraft) 275 (ship)	None	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species

Table 2-3: Proposed Action Potentially Impacting the EFH (continued)

Range Training Activity	Proposed Action			
	No. of events (per year)	**Ordnance (Number per year)**	**Location**	**EFH Potentially Affected**
Mine Warfare (MIW)				
Mine Neutralization – Explosive Ordnance Disposal (EOD)	3	Three 2.5 lb. charges	Inland Waters (Crescent Harbor EOD Training Range)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
	3	18 SWAG		
	3	Three 2.5 lb. charges	Inland Waters (Hood Canal EOD Training Range)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
	3	18 SWAG		
Submarine Mine Exercise	8	None	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Civilian Port Defense	Every other year (three in 5 years)	None	Inland Waters	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
Naval Special Warfare (NSW)				
Personnel Insertion/Extraction – Submersible	35	None	Inland Waters	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
Personnel Insertion/Extraction – Non-Submersible	10	None	Inland Waters (Crescent Harbor)	None
Other				
Maritime Security Operations	286	1,320 small caliber rounds (all blanks)	Inland Waters (NAVBASE Kitsap Bangor, Hood Canal, Dabob Bay, Puget Sound, Strait of Juan de Fuca)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
Precision Anchoring	10	None	Inland Waters (Naval Station Everett, Indian Island)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species

Table 2-3: Proposed Action Potentially Impacting the EFH (continued)

Range Testing Activity		Proposed Action			
		No. of events (per year)	Ordnance (Number per year)	Location	EFH Potentially Affected
Other (continued)					
Small Boat Attack	1	3,000 small-caliber rounds (all blanks)	Inland Waters (Naval Station Everett NAVBASE Kitsap Bangor NAVBASE Kitsap Bremerton)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species	
Intelligence, Surveillance, Reconnaissance (ISR)	200	None	Offshore Area, Inland Waters (R-6701)	None	
Search and Rescue	100	None	Inland Water (Crescent Harbor, Navy 7) Offshore(Olympic MOA)	None	
Surface Ship Sonar Maintenance	13	None	Inland Waters (NAVBASE Kitsap Bremerton, Naval Station Everett) and Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species	
Submarine Sonar Maintenance	22	None	Inland Waters (NAVBASE Kitsap Bangor, NAVBASE Kitsap Bremerton) and Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species	
Naval Undersea Warfare Center, Keyport Testing Activities					
Torpedo Testing	Torpedo Non-Explosive Testing	20	102 NEPM torpedoes	Offshore Area (QRS)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
		41	189 NEPM torpedoes	Inland Waters (DBRC Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species

Table 2-3: Proposed Action Potentially Impacting the EFH (continued)

Range Testing Activity		Proposed Action			
		No. of events (per year)	Ordnance (Number per year)	Location	EFH Potentially Affected
Naval Undersea Warfare Center, Keyport Testing Activities (continued)					
Autonomous and Non-Autonomous Vehicles	Unmanned Underwater Vehicle (UUV) Testing	151	135 NEPM torpedoes	Inland Waters (DBRC Site, Keyport Range Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
	Unmanned Aircraft System (UAS)	20	None	Offshore Area (QRS)	None
		20	None	Inland Waters (DBRC Site)	None
	Unmanned Surface Vehicle	20	None	Offshore Area (QRS)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
		20	None	Inland Waters (DBRC Site, Keyport Range Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
Fleet Training/Support	Cold Water Training	20	None	Offshore Area (QRS)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
		65	None	Inland Waters (DBRC Site, Keyport Range Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
	Post-Refit Sea Trial	32	None	Inland Waters (DBRC Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
	Anti-Submarine Warfare (ASW) Testing	5	None	Offshore Area (QRS)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species

Table 2-3: Proposed Action Potentially Impacting the EFH (continued)

Range Activity		Proposed Action			
		No. of events (per year)	Ordnance (Number per year)	Location	EFH Potentially Affected
Naval Undersea Warfare Center, Keyport Testing Activities (continued)					
Maintenance and Miscellaneous	Side Scan/Multibeam Sonar	54	None	Inland Waters (DBRC Site, Keyport Range Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
	Non-Acoustic Tests	6	None	Offshore Area (QRS)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
		74	None	Inland Waters (DBRC Site, Keyport Range Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
Acoustic Component Test	Countermeasures Testing	6	None	Offshore Area (QRS)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
		61	None	Inland Waters (DBRC Site, Keyport Range Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
	Acoustic Test Facility	176	None	Inland Waters (DBRC Site, Keyport Range Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
	Pierside Integrated Swimmer Defense	38	None	Inland Waters (DBRC Site, Keyport Range Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species

Table 2-3: Proposed Action Potentially Impacting the EFH (continued)

Range Activity		Proposed Action			
		No. of events (per year)	Ordnance (Number per year)	Location	EFH Potentially Affected
Naval Surface Warfare Center, Carderock Division Detachment Puget Sound Testing Activities					
System, Subsystem and Component Testing	Pierside Acoustic Testing	60	None	Inland Waters NAVBASE Kitsap Bangor	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
	Performance Testing At Sea	60	None	Inland Waters (DBRC Site, Carr Inlet)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
	Development Training and Testing	36	None	Inland Waters (DBRC Site, Carr Inlet)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
Proof of Concept Testing		30	None	Inland Waters (DBRC Site, Carr Inlet)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
Naval Sea Systems Command Testing Activities					
Life Cycle Activities	Pierside Sonar Testing	67	None	Inland Waters (Naval Station Everett, NAVBASE Kitsap Bangor, NAVBASE Kitsap Bremerton)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
Shipboard Protection Systems and Swimmer Defense Testing	Pierside Integrated Swimmer Defense	1	None	Inland Waters (Keyport Range Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
Unmanned Vehicle Testing	Unmanned Vehicle Development and Payload Testing	4	None	Inland Waters (DBRC Site, Keyport Range Site)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species

Table 2-3: Proposed Action Potentially Impacting the EFH (continued)

Range Activity		Proposed Action			
		No. of events (per year)	Ordnance (Number per year)	Location	EFH Potentially Affected
Naval Sea Systems Command Testing Activities (continued)					
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing	Torpedo (Explosive) Testing	3	6 HE torpedoes 6 NEPM torpedoes	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
	Torpedo (Non-explosive) Testing	3	18 NEPM torpedoes	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
	Countermeasure Testing	13	81 NEPM torpedoes	Inland Waters (DBRC Range Site, Pierside Naval Station Everett	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species
		8	123 NEPM torpedoes	Offshore Area (QRS)	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
New Ship Construction	ASW Mission Package Testing	8	None	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species

Table 2-3: Proposed Action Potentially Impacting the EFH (continued)

Range Activity		Proposed Action			
		No. of events (per year)	Ordnance (Number per year)	Location	EFH Potentially Affected
Naval Air Systems Command Testing Activities					
Electronic Warfare (EW)	Flare Test	10	600 flares	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
Anti-Submarine Warfare (ASW)	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (DICASS)	28	170 DICASS sonobuoys	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (MAC)	14	170 MAC sonobuoys	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (SUS)	5	72 Impulse SUS buoys (e.g., MK-61, MK-64, MK-82) 12 Non-impulse SUS buoys (e.g., MK-84)	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (IEER)	6	70 IEER sonobuoy detonations	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species
	Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft (HDC)	1	16 HDC sonobuoys	Offshore Area	Pacific Coast Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, Highly Migratory Species

Notes: (1) 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 = Multistatic Active Coherent; SUS = Signal, Underwater Sound (e.g., MK-61, MK-64, MK-82, and MK-84); (2) DBRC = Dabob Bay Range Complex, HE = High Explosive, lb. = pound(s), MOA = Military Operations Area, MPA = Maritime Patrol Aircraft, NAVBASE = Naval Base, NEPM = Non-explosive Practice Munition, QRS = Quinault Range Site, R-6701 = Restricted Area 6701, SWAG = Shock Wave Action Generator, U.S. = United States, W-237 = Warning Area 237

3 ESSENTIAL FISH HABITAT

In 1996, the MSA was reauthorized and amended by the Sustainable Fisheries Act (Public Law 104-297). The reauthorized MSA mandated numerous changes to the existing legislation designed to prevent overfishing, rebuild depleted fish stocks, minimize bycatch, enhance research, improve monitoring, and protect fish habitat. One of the most significant mandates in the MSA that came out of the reauthorization was the EFH provision, which provides the means to conserve fish habitat.

The EFH mandate requires that the regional Fishery Management Councils (FMCs), through federal fishery management plans (FMPs), describe and identify EFH for each federally managed species; minimize, to the extent practicable, adverse effects on such habitat caused by fishing; and identify other actions to encourage the conservation and enhancement of such habitats. Congress defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 United States Code [USC] 1802[10]). The term "fish" is defined in the MSA as "finfish, mollusks, crustaceans, and all other forms of marine animals and plant life other than marine mammals and birds." The regulations for implementing EFH clarify that "waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; while "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle (50 CFR 600.10). Habitats used at any time during a species' life cycle must be accounted for when describing and identifying EFH (NMFS 2002).

Authority to implement the MSA is given to the Secretary of Commerce and has been delegated to NMFS. The MSA requires that EFH be identified and described for each federally managed species. The MSA also requires federal agencies to consult with the NMFS on activities that may adversely affect EFH or when the NMFS independently learns of a federal activity that may adversely affect EFH. The MSA defines an adverse effect as "any impact that reduces quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions" (50 CFR 600.810).

In addition to EFH designations, areas called Habitat Areas of Particular Concern (HAPCs) are also designated by the regional FMCs. Designated HAPCs are discrete subsets of EFH that provide extremely important ecological functions or are especially vulnerable to degradation (50 C.F.R. §§ 600.805–600.815). Categorization of an area as a HAPC does not confer additional protection or restriction to the designated area. Regional FMCs may designate a specific habitat area as a HAPC based on one or more of the following reasons (National Marine Fisheries Service 2002):

1. Importance of the ecological function provided by the habitat
2. The extent to which the habitat is sensitive to human-induced environmental degradation
3. Whether, and to what extent, development activities are, or will be, stressing the habitat type
4. Rarity of the habitat type

3.1 ESSENTIAL FISH HABITAT DESIGNATIONS

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act or MSA) established eight regional FMCs. The area encompassed by the Proposed Action (Study Area) extends through the jurisdiction of two FMCs: The Pacific Fishery Management Council (PFMC) and the North Pacific Fishery Management Council (NPFMC). Only EFH within the management area of the PFMC may be adversely affected and is therefore carried forward in the analysis.

The PFMC manages the fisheries in federal waters (3-200 nm), but designates EFH in state and federal waters for all federally managed species in Washington, Idaho, Oregon, and California. The PFMC's jurisdiction overlaps with the Study Area (Inland Waters and the Offshore Area) only in the marine nearshore and tidally-submerged environments within the state territorial waters of Washington, Oregon, and California to the western boundary of the EEZ, 200 nm offshore. Figure 3-1 depicts where the PFMC's jurisdiction overlaps with the Offshore Area. There is no freshwater EFH in the Study Area.

The PFMC manages fisheries for groundfish (rockfish, flatfish, roundfish, sharks, skates, and chimeras); approximately 119 species of salmon (Chinook, coho, or pink salmon); Coastal Pelagic Species (CPS) (sardines, anchovies, and mackerel); and Highly Migratory Species (HMS) (tunas, sharks, and swordfish). The PFMC is also active in international fishery management organizations that manage fish stocks that migrate through its area of jurisdiction.

Within the Study Area, the PFMC designated EFH and HAPCs for the species listed above and manages them through the following four FMPs:

- Pacific Coast Groundfish (Pacific Fishery Management Council 2011b)
- Pacific Coast Salmon (Pacific Fishery Management Council 2012)
- Coastal Pelagic Species (Pacific Fishery Management Council 2011c)
- Highly Migratory Species (Pacific Fishery Management Council 2011a)

3.1.1 HABITAT AREAS OF PARTICULAR CONCERN

The PFMC has designated both areas and habitat types of five HAPCs: estuaries, canopy kelp, seagrass, rocky reefs, and areas of interest such as undersea features, such as banks, seamounts, and canyons (Figure 3-3: Offshore, and Figure 3-4: Inland Waters). HAPCs based on habitat type may vary in location and extent over time. For this reason, the mapped extent of these areas offers an approximation of their location. Defining criteria of habitat type for HAPCs are described below, and may be applied in specific circumstances to determine whether a given area is designated as a groundfish HAPC. HAPCs include all waters, substrates, and associated biological communities falling within the area defined by the criteria below.

Table 3-1: Essential Fish Habitat and Habitat Areas of Particular Concern Designated by Pacific Fishery Management Council

Management Unit	EFH	HAPCs
Pacific Coast Groundfish	All waters and substrate in areas less than or equal to 3,500 m (1,914 fm) to mean higher high water level or the upriver extent of saltwater intrusion. Seamounts in depths greater than 3,500 m (1,914 fm) as mapped in the EFH assessment geographic information system.	Estuaries, canopy kelp, seagrass, rocky reefs, and "areas of interest"
Pacific Coast Salmon	All waters from the ocean extent of the EEZ to the shore, and inland up to all freshwater bodies occupied or historically accessible to salmon in Alaska, Washington, Oregon, Idaho, and California.	Complex channels and floodplain habitats, thermal refugia, spawning habitat, estuaries, and marine and estuarine submerged aquatic vegetation
Coastal Pelagic Species	All marine and estuarine waters above the thermocline from the shoreline offshore to 200 nm offshore.	None
Highly Migratory Species	All marine waters from the shoreline offshore to 200 nm offshore.	None

Notes: EFH = Essential Fish Habitat, fm = fathoms, HAPC = Habitat Area of Particular Concern, m = meters, nm = nautical miles
Source: Pacific Fisheries Management Council 1998, 2011a, b

3.1.2 PACIFIC COAST GROUNDFISH ESSENTIAL FISH HABITAT

3.1.2.1 Description and Identification of Essential Fish Habitat

The Pacific Coast Groundfish FMP manages over 90 species within a large and ecologically diverse area (see Appendix A, List of Federally Managed Species). Information on the life histories and habitats of these species varies in completeness, so while some are well-studied, there is relatively little information on others. Information about the species managed by the FMP will change over time due to new studies being conducted, thus providing varying degrees of information improvement for each species. For these reasons, it is impractical to include descriptions identifying the EFH for each life stage of the species included in the FMP. Therefore, the FMP includes a description of the overall area identified as groundfish EFH and describes the assessment methodology supporting this designation. Designations of EFH for each species and their component individual life history stages are provided in Appendix B of PFMC Pacific Coast Groundfish FMP for the California, Oregon, and Washington Groundfish Fishery (Pacific Fishery Management Council 2011b).

The overall extent of groundfish EFH for all managed species is identified as all waters and substrate within the following areas:

- Depths less than or equal to 1,914 fathoms (fm) (3,500 m) to mean higher high water (MHHW) level or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 parts per thousand (ppt) during the period of average annual low flow;

- Seamounts in depths greater than 1,914 fm (3,500 m) as mapped in the EFHA geographic information system (GIS); and
- Areas designated as HAPCs not already identified by the above criteria.

This EFH identification is precautionary because it is based on the currently known maximum depth distribution of all life stages of fishery management unit species (MUS). This precautionary approach is taken because uncertainty still exists about the relative value of different habitats to individual groundfish species/life stages, and thus the actual extent of groundfish EFH. For example, there were insufficient data to derive habitat suitability probability (HSP) values for all species/life stages. Furthermore, the data used to determine HSP values are subject to continued refinement. While recognizing these limitations, the 100 percent HSP area, all of which occurs in depths less than 3,500 m, is identified as a part of groundfish EFH, recognizing that the best scientific information demonstrates this area is particularly suitable groundfish habitat. While precautionary, groundfish EFH still constitutes an area considerably smaller than the entire west coast EEZ. Figure 3-2 shows the extent of this EFH identification (Pacific Fishery Management Council 2011b).

Figures 3-3 and 3-4 offers a first approximation of the location and extent for HAPCs defined by habitat type, as opposed to discrete areas within both the Offshore and Inland Water areas, respectively. The precision of the underlying data used to create these maps, and the fact that the extent of HAPCs defined by key benthic organisms (canopy kelp, seagrass) can change along with deviations in the distribution of these organisms. Hence, at fine scales the map may not accurately represent HAPC location and extent. Defining criteria are provided in the following descriptions of HAPCs, which can be used in conjunction with the map to determine if a specific location is within one of these HAPCs. The areas of interest HAPCs are defined by discrete boundaries. The coordinates defining these boundaries are listed in Appendix B of PFMC Pacific Coast Groundfish FMP for the California, Oregon, and Washington Groundfish Fishery (Pacific Fishery Management Council 2011b).

3.1.2.1.1 Estuaries

Estuaries are protected nearshore areas such as bays, sounds, inlets, and river mouths, influenced by ocean and freshwater. Because of tidal cycles and freshwater input, salinity varies within estuaries and results in great diversity, offering freshwater, brackish, and marine habitats within close proximity (Haertel and Osterberg 1967). Estuaries tend to be shallow, protected, nutrient-rich, and are biologically productive, providing important habitat for marine organisms, including groundfish.

Defining characteristics: The inland extent of the estuary HAPC is defined as MHHW, or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow (Cowardin et al. 1979). The seaward extent is an inferred line closing the mouth of a river, bay, or sound, and to the seaward limit of wetland emergence, shrubs, or trees occurring beyond the lines closing rivers, bays, or sounds. This HAPC also includes those estuary-influenced offshore areas of continuously diluted seawater.

Figure 3-1: Overlap between the Offshore Area and the Pacific Fishery Management Council

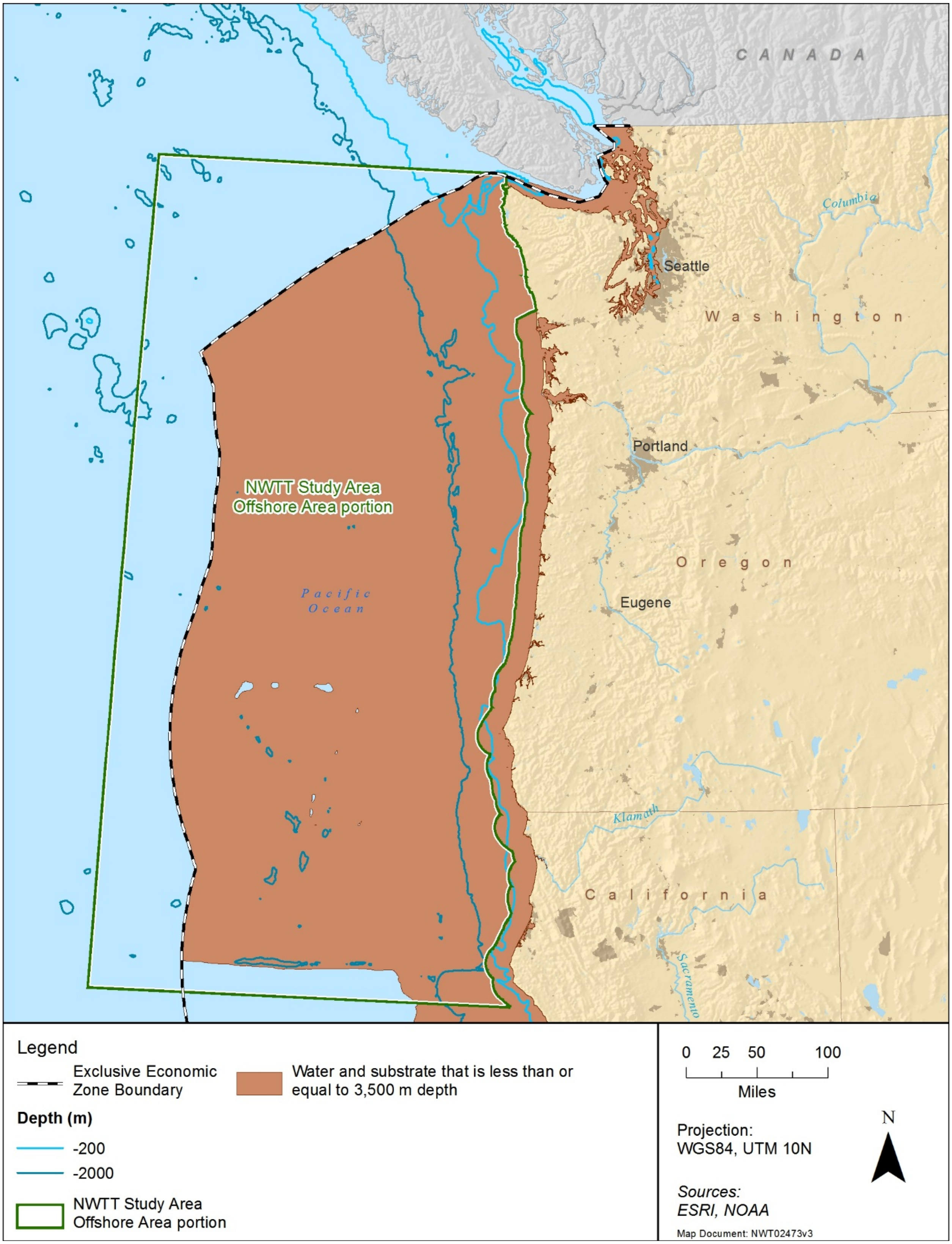

Figure 3-2: Pacific Groundfish Essential Fish Habitat in the Northwest

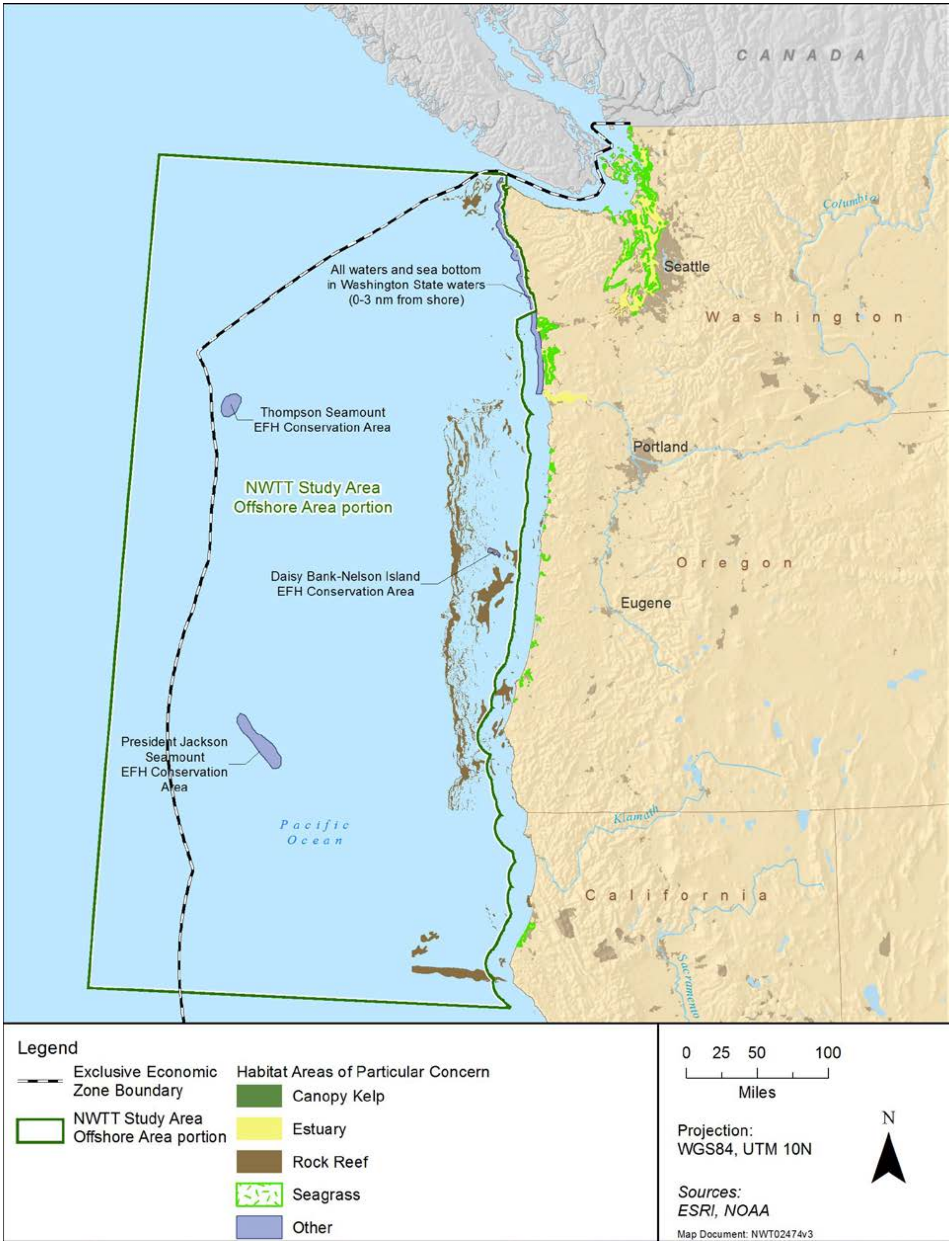

Figure 3-3: Pacific Groundfish Habitat Areas of Particular Concern in the Offshore Area

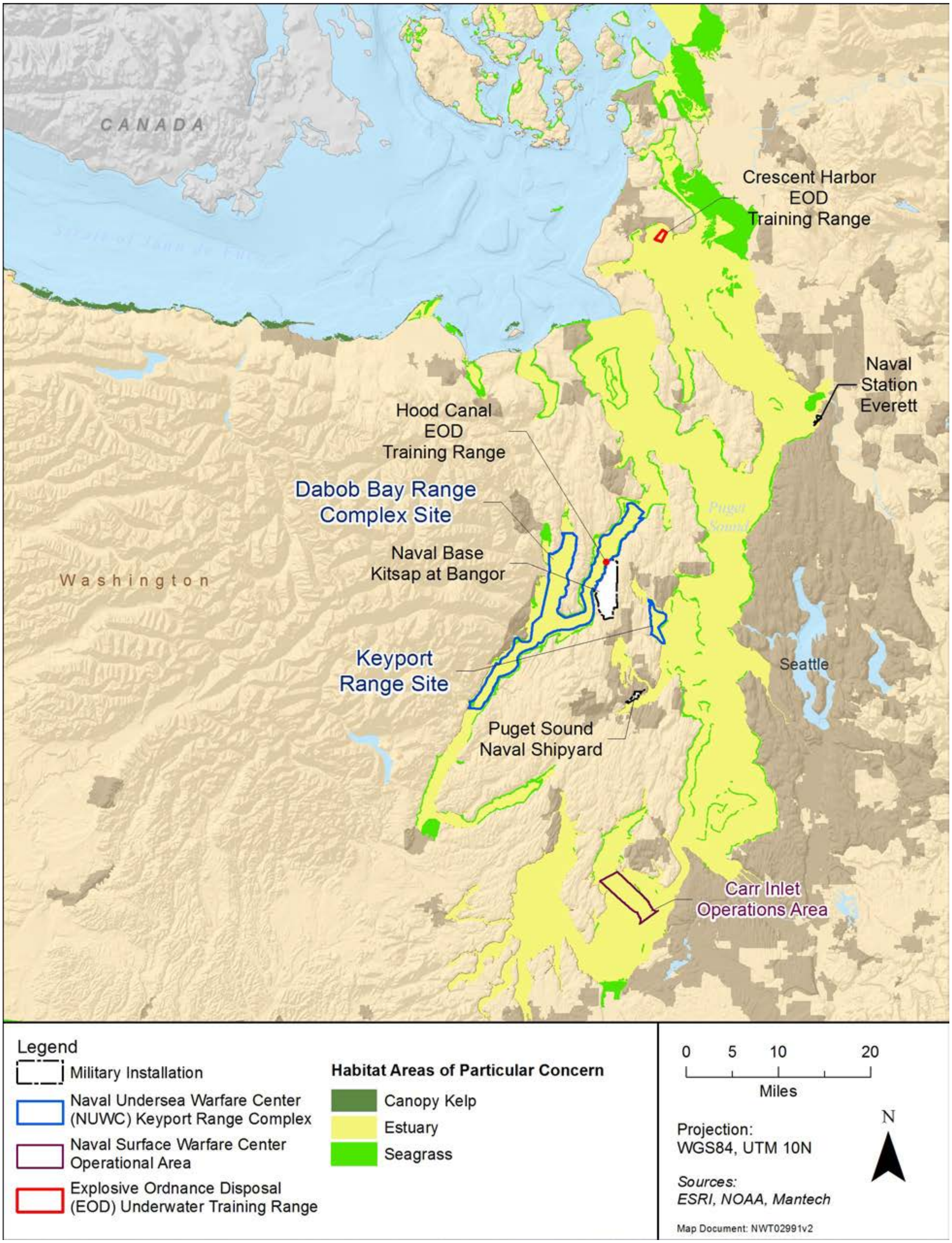

Figure 3-4: Pacific Groundfish Habitat Areas of Particular Concern in the Inland Waters

3.1.2.1.2 Canopy Kelp

Of the habitats associated with the rocky substrate on the continental shelf, kelp forests are of primary importance to the ecosystem and serve as important groundfish habitat. Kelp forest communities are found relatively close to shore along the open coast. These subtidal communities provide vertically-structured habitat throughout the water column: a canopy of tangled blades from the surface to a depth of 10 ft., a mid-water stipe region, and the holdfast region at the seafloor. Kelp stands provide nurseries, feeding grounds, and shelter to a variety of groundfish species and their prey (Ebeling et al. 1980). Kelp communities are highly productive relative to other habitats, including wetlands, shallow and deep sand bottoms, and rock-bottom artificial reefs (Bond et al. 1998). Their net primary production is an important component to the energy flow within food webs. The net primary productivity of kelp beds may be the highest of any marine community. The net primary production of seaweeds in a kelp forest is available to consumers as living tissue on attached algae, as drift in the form of whole plants or detached pieces, and as dissolved organic matter exuded by attached and drifting plants (Foster and Schiel 1985).

Data on kelp forest distribution were collected using a variety of remote sensing techniques, including aerial photos and multispectral imagery by the Washington Department of Natural Resources (1989–2004), and the Oregon (1996–1999) and California Departments of Fish and Wildlife (1989, 1999, and 2002). These data do not represent current conditions because kelp abundance and distribution is both seasonally and annually highly variable. However, kelp distribution can be estimated by compiling multiple years of data. Washington has the most comprehensive database, covering 10 years (1989–1992, 1994–2000) of annual surveys of the Straits of Juan de Fuca and the Pacific Coast. Oregon conducted a coast wide survey in 1990 and then surveyed select reefs off southern Oregon in 1996–1999. A comprehensive kelp survey in California was performed in 1989 with additional surveys of most of the coastline completed in 1999 and 2002 (ECOSCAN 1989).

<u>Defining characteristics</u>: The canopy kelp HAPC includes those waters, substrate, and other biogenic habitat associated with canopy-forming kelp species in the genus *Macrocystis* spp. and *Nereocystis*.

3.1.2.1.3 Seagrasses

Seagrasses are vascular plants forming dense beds of leafy shoots year-round in the lower intertidal and subtidal areas. Species native to the U.S. west coast include eelgrass species (*Zostera* spp.), widgeongrass (*Ruppia maritima*), and surfgrass (*Phyllospadix* spp.). Eelgrass is found on soft-bottom substrates in intertidal and shallow subtidal areas of estuaries and occasionally in other nearshore areas, and occurs extensively throughout Puget Sound (Thayer and Phillips 1977). Surfgrass is found on hard-bottom substrates along coastlines with higher wave energy. Seagrass beds are among the highest primary productivity habitats in the world (Pacific Fishery Management Council 2011b).

Despite their ecological importance to many commercial species, seagrass beds have not been as comprehensively mapped as kelp beds. Wyllie-Echeverria and Ackerman (2003) published a coastwide assessment of seagrass that identifies distribution and estimates of seagrass bed areas. GIS data for seagrass beds were located and compiled as part of the NMFS groundfish EFHA process.

Eelgrass mapping projects have been undertaken for many estuaries along the west coast. These mapping projects are generally done for a particular estuary, and many different mapping methods and mapping scales have been used. Therefore, the data that have been compiled for eelgrass beds offer an incomplete view of eelgrass distribution along the west coast.

Defining characteristics: The seagrass HAPC includes those waters, substrate, and other biogenic features associated with eelgrass species, widgeongrass, or surfgrass.

3.1.2.1.4 Rocky Reefs

Rocky habitats are generally categorized as either nearshore or offshore in reference to the proximity of the habitat to the coastline. Rocky habitat may be composed of bedrock, boulders, or smaller rocks, such as cobble and gravel. Hard substrates are one of the least abundant benthic habitats in the Study Area, yet they are among the most important habitats for groundfish and invertebrates that groundfish prey upon.

Defining characteristics: The rocky reefs HAPC includes those waters, substrates, and other biogenic features associated with hard substrate such as bedrock, boulders, cobble, and gravel to MHHW. A first approximation of its extent is provided by the substrate GIS data in the groundfish EFHA.

3.1.2.1.5 Areas of Interest within the Study Area

Areas of interest are discrete areas of special interest due to their unique geological and ecological characteristics. Applicable areas of interest are designated HAPCs:

- Washington: All waters and sea bottom in state waters from the 3 nm boundary of the territorial sea shoreward to MHHW;
- Oregon: Daisy Bank/Nelson Island, Thompson, and President Jackson Seamounts;
- California: Gumdrop, Pioneer Guide, Taney, Davidson, and San Juan Seamounts; and Mendocino Ridge

The Washington State waters HAPC encompasses a variety of habitats important to groundfish, including other HAPCs such as rocky reef habitat supporting juvenile rockfish (primarily north of Grays Harbor) and estuary areas supporting numerous economically and ecologically important species, including juvenile lingcod (*Ophiodon elongatus*) and English sole (*Parophrys vetulus*). Sandy substrates within state waters (primarily south of Grays Harbor) are important habitat for juvenile flatfishes. A large portion of this area is also contained within the Olympic Coast National Marine Sanctuary and three offshore national wildlife refuges, which provide additional levels of protection to these sensitive nearshore coastal areas.

Seamounts and canyons are prominent features in the coastal underwater landscape, and may be important in rockfish management because their distributions closely match the nearshore bathymetry (Pacific Fishery Management Council 2011b). Nearshore coastal waters are defined as water depths less than 1,914 fm (3,500 m) per Pacific Coast Groundfish FMP.

As noted in PFMC Pacific Coast Groundfish FMP for the California, Oregon, and Washington Groundfish Fishery (2011b), seamounts rise steeply to heights of over 3,300 ft. (1,000 m) from their base and are typically formed of hard volcanic substrate. They are unique in that they tend to create complex current patterns and have highly localized species distributions. Because the faunal assemblages on these features are still poorly studied, and species new to science are likely to be found, anthropogenic activities affecting these features need careful management (McClain et al. 2009).

Daisy Bank is a highly unique geological feature that occurs in federal waters due west of Newport, Oregon and appears to play a unique and potentially rare ecological role for groundfish and large sponge species.

Figure 3-5 shows the areas of interest in the Study Area that are closed to fishing to protect Pacific coast groundfish habitat.

Defining characteristics: The area-based HAPCs are defined by their mapped boundaries in the EFHA. The coordinates defining these boundaries may be found in Appendix B of PFMC Pacific Coast Groundfish FMP for the California, Oregon, and Washington Groundfish Fishery (2011b).

3.1.3 Pacific Coast Salmon Essential Fish Habitat

3.1.3.1 Description and Identification of Essential Fish Habitat

The Pacific Coast Salmon management unit includes the stocks that are harvested in the EEZ off the coasts of Washington, Oregon, and California (Pacific Fishery Management Council 2012). The main species harvested in this area are Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), and pink salmon (*O. gorbuscha*), which is significant in odd-numbered years. Sockeye (*O. nerka*), chum (*O. keta*), and steelhead (*O. mykiss*) are uncommon in the management zone. The extent of the EFH in the Study Area is depicted in Figure 3-6.

Chinook are distributed from Hokkaido Island in Japan, east to Alaska, and Central California, although their historic range extended to the Ventura River (Ventura County, CA) (National Marine Fisheries Service 2012a). Because of their large body size, Chinook spawn in greater depths using larger gravel and cobble than other anadromous salmonids. Coho are distributed from Hokkaido Island in Japan, east to Alaska, and central California; however, some populations are considered extirpated (National Marine Fisheries Service 2012b). Spawning occurs in low gradient freshwater river reaches on substrate composed of gravel ranging from 0.5 to 4.0 inches (in.) (1.3 to 10.2 centimeters [cm]) in diameter. Unlike other anadromous salmonids, coho redds commonly contain approximately 10 percent mud or silt fines due to spawning in depositional reaches (Emmett et al. 1991).

Pink salmon is distributed in small streams and rivers from northern California to around Alaska (Emmett et al. 1991), and their oceanic range extends from north of 40°N through the Bering Sea to Hokkaido Island in Japan (Pacific Fishery Management Council 2000). Spawning occurs in gravel ranging from 0.5 to 4.0 in. (1.3 to 10.2 cm in diameter, whereas fry, juveniles, and non-spawning adults do not show a preference (Emmett et al. 1991).

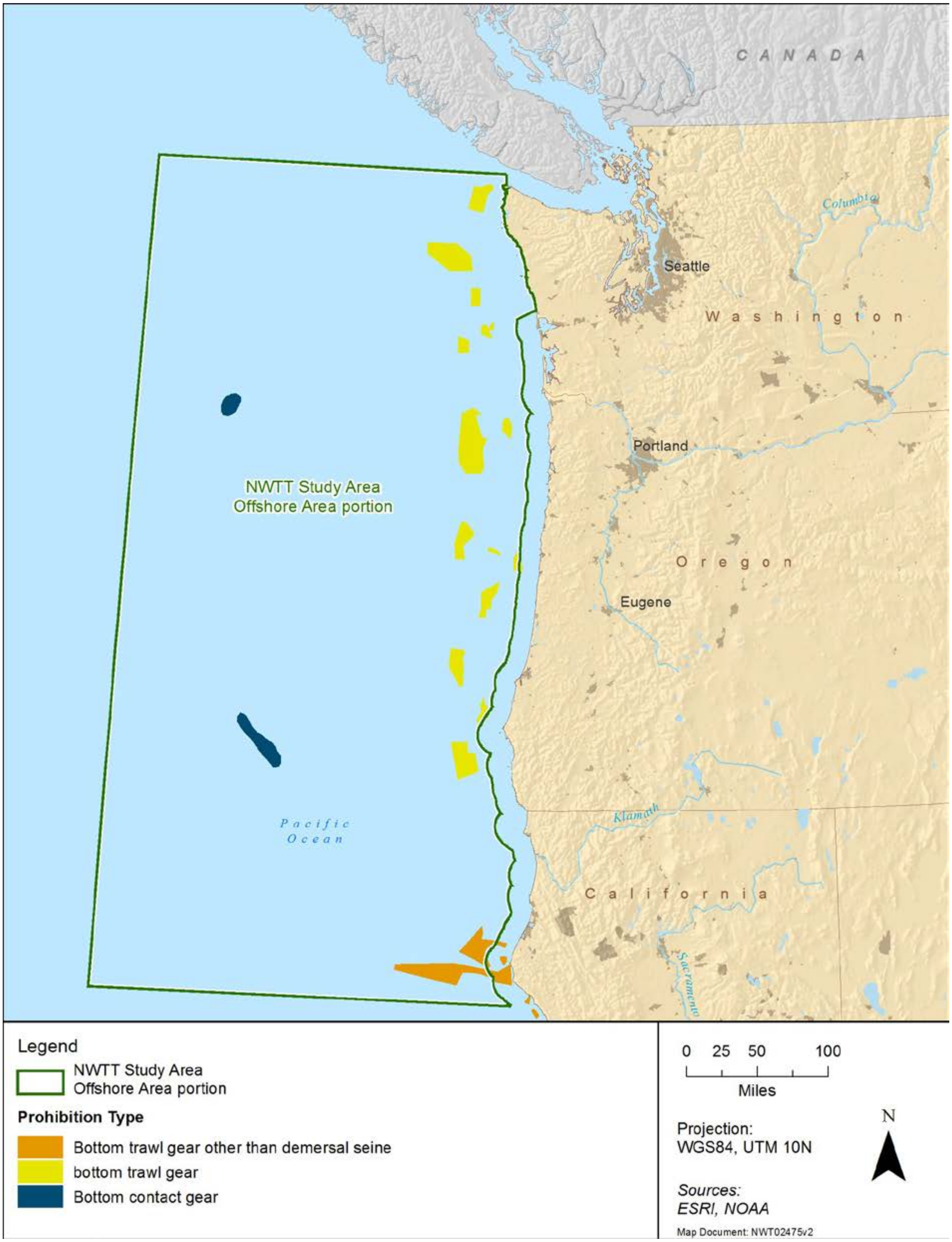

Figure 3-5: Areas of Interest Closed to Fishing to Protect Pacific Coast Groundfish Habitat

Figure 3-6: Pacific Coast Salmon Essential Fish Habitat in the Northwest

3.1.3.2 Habitat Areas of Particular Concern

3.1.3.2.1 Complex Channels and Floodplain Habitats

Complex channels consisting of meandering, island-braided, pool-riffle and forced pool-riffle channels and complex floodplain habitats consisting of wetlands, oxbows, side channels, sloughs and beaver ponds, and steeper, more constrained channels with high levels of large woody debris (LWD), provide valuable habitat for all Pacific salmon species.

Defining characteristics: An important component of these habitats is large wood, which typically occurs in the form of logjams in floodplains and larger rivers and accumulations of single or multiple logs in smaller mountain channels. The location and extent of these complex habitats can vary over space and time and have not been comprehensively mapped. Therefore, maps or spatial descriptions may not reliably identify them. As such, this HAPC relies on the detailed text that describes the general attributes of these habitats, rather than spatially explicit descriptions or maps. This HAPC includes habitats that are not found within the Study Area, and is therefore not considered further in the analysis.

3.1.3.2.2 Thermal Refugia

Thermal refugia that provide areas to escape high water temperatures are critical to salmon survival. Loss of structural elements such as large wood can also influence the formation of thermal refugia. Thermal refugia can occur at spatial scales ranging from entire tributaries (e.g., spring-fed streams), to stream reaches (e.g., alluvial reaches with high hyporheic flow), to highly localized pockets of water only a few square meters in size embedded within larger rivers.

Defining characteristics: Thermal refugia typically include coolwater tributaries, lateral seeps, side channels, tributary junctions, deep pools, areas of groundwater upwelling and other mainstem river habitats that are cooler than surrounding waters (≥2° C cooler) (Torgersen et al. 1999; Ebersole et al. 2003). The location and extent of thermal refugia are poorly understood, and maps or spatial descriptions may not reliably identify them. As such, this HAPC relies on the detailed text that describes the general attributes of these habitats, rather than spatially explicit descriptions or maps. This HAPC includes habitats that are not found within the Study Area, and is therefore not considered further in the analysis.

3.1.3.2.3 Spawning Habitat

Spawning habitat consists of the combination of gravel, depth, flow, temperature, and dissolved oxygen, among others. Impacts to any of these factors can make the difference between a successful spawning event and failure. Several anthropogenic activities are known to impact various physical, chemical, or biological features of spawning habitat, including road construction, timber harvest, agriculture, and residential development among others.

Defining characteristics: Salmon spawning habitat is typically defined as low gradient stream reaches (<3%) containing clean gravel with low levels of fine sediment and high inter gravel flow. Although there are modest differences in spawning preferences between the species, all salmon require cold, highly oxygenated, flowing water as suitable spawning habitat. The location and extent of spawning habitat can vary over space and time, and not all spawning habitat is adequately mapped. Therefore maps or spatial descriptions may not reliably identify them. As such, this HAPC relies on the detailed text that describes the general attributes of these habitats, rather than spatially explicit descriptions or maps. This HAPC includes habitats that are not found within the Study Area, and is therefore not considered further in the analysis.

3.1.3.2.4 Estuaries

Estuaries are protected nearshore areas such as bays, sounds, inlets, and river mouths, influenced by ocean and freshwater. Because of tidal cycles and freshwater input, salinity varies within estuaries and results in great diversity, offering freshwater, brackish, and marine habitats within close proximity (Haertel and Osterberg 1967). Estuaries tend to be shallow, protected, nutrient-rich, and are biologically productive, providing important habitat for marine organisms. Estuaries are complex systems that encompass a number of habitat types in a relatively small area, including sand and gravel beaches, mudflats, tidal creeks, shallow nearshore waters, pocket estuaries, and mixing zones, that are vital to the growth and survival of salmon, primarily during their juvenile phase.

Defining characteristics: The inland extent of the estuary HAPC is defined as MHHW, or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow (Cowardin et al. 1979). The seaward extent is an inferred line closing the mouth of a river, bay, or sound, and to the seaward limit of wetland emergence, shrubs, or trees occurring beyond the lines closing rivers, bays, or sounds. This HAPC also includes those estuary-influenced offshore areas of continuously diluted seawater.

3.1.3.2.5 Marine and Estuarine Submerged Aquatic Vegetation

Submerged aquatic vegetation includes the kelps and eelgrass. Kelp forest communities are found relatively close to shore along the open coast. These subtidal communities provide vertically-structured habitat throughout the water column. The net primary productivity of kelp beds may be the highest of any marine community. Data on kelp forest distribution were collected using a variety of remote sensing techniques, including aerial photos and multispectral imagery by the Washington Department of Natural Resources (1989–2004), and the Oregon (1996–1999) and California Departments of Fish and Wildlife (1989, 1999, and 2002). These data do not represent current conditions because kelp abundance and distribution is both seasonally and annually highly variable. However, kelp distribution can be estimated by compiling multiple years of data. Washington has the most comprehensive database, covering 10 years (1989–1992, 1994–2000) of annual surveys of the Straits of Juan de Fuca and the Pacific Coast. Oregon conducted a coast wide survey in 1990 and then surveyed select reefs off southern Oregon in 1996–1999. A comprehensive kelp survey in California was performed in 1989 with additional surveys of most of the coastline completed in 1999 and 2002 (ECOSCAN 1989).

Eelgrass is found on soft-bottom substrates in intertidal and shallow subtidal areas of estuaries and occasionally in other nearshore areas, and occurs extensively throughout Puget Sound (Thayer and Phillips 1977). Eelgrass mapping projects have been undertaken for many estuaries along the west coast. These mapping projects are generally done for a particular estuary, and many different mapping methods and mapping scales have been used. Therefore, the data that have been compiled for eelgrass beds offer an incomplete view of eelgrass distribution along the west coast.

Defining characteristics: The marine and estuarine submerged aquatic vegetation HAPC includes those waters, substrate, and other biogenic habitat associated with canopy-forming kelp species, eelgrass species, or other submerged aquatic vegetation..

3.1.4 Coastal Pelagic Species Essential Fish Habitat

3.1.4.1 Description and Identification of Essential Fish Habitat

The CPS inhabit pelagic habitat associated with the water column and are commonly found from surface waters to a depth of 3,281 ft. (1,000 m). For the purposes of EFHA, the CPS are treated as a complex because of the similarities in their life histories and similarities in their habitat requirements. The CPS FMP includes four finfish (northern anchovy *(Engraulis mordax),* Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*) and two invertebrates, market squid (*Loligo opalescens*) and krill (Order Euphausiacea) (Appendix A, List of Federally Managed Species). Designated EFH for CPS includes all marine and estuarine waters above the thermocline from the shoreline to 200 nm offshore (Table 3-1).

CPS are impacted directly by harvest and indirectly as bycatch since they are most commonly targeted with round-haul gear such as purse seines, drum seines, lampara nets, and dip nets. They are also taken as bycatch in midwater and pelagic trawls, gill and trammel nets, trolls, pots, hook-and-line, and jigs. Market squid are fished nocturnally using bright attractant lights pumped directly from the sea into the hold of the boat or captured with an encircling net such as a purse seine (Pacific Fishery Management Council 2011c).

Northern anchovy are small, short-lived, epipelagic schooling fish. They are distributed from British Columbia, Canada, to Baja California, Mexico. Northern anchovies are divided into northern, central, and southern sub-populations. The central sub-population was the focus of large commercial fisheries in the United States and Mexico. Most of this sub-population is located in the Southern California Bight (SCB) between Point Conception, California, and Punta Descanso, Baja California, Mexico. Northern anchovy are an important part of the food chain for other species, including predatory piscivorous fishes, seabirds, and marine mammals.

Pacific sardine are epipelagic (occurring from the surface, mean sea level [MSL] down to around 200 m [660 ft.]) schooling fish, and have been the most abundant species managed under the CPS FMP. They range from the Gulf of California-Baja California, Mexico to southeastern Alaska. Sardines can live to age 13, but usually captured in the fishery by age 5.

Pacific (chub) mackerel are found from Mexico to southeastern Alaska, but are most abundant south of Point Conception, California within 20 mi. (32 km) from shore. The northeastern Pacific stock of Pacific mackerel is harvested by fisheries in the United States and Mexico. Like sardines and anchovies, mackerel are epipelagic schooling fish, which often co-occur with other pelagic species like jack mackerel and sardines. As with other CPS, they are preyed upon by a variety of piscivorous fishes, seabirds, and marine mammals.

Jack mackerel grow to 2 ft. (60 cm) and can live to age 35. They are distributed throughout the northeastern Pacific, often well outside the EEZ. Jack mackerel up to age six are most abundant in the SCB, near the mainland coast, around islands, and over shallow rocky banks. Older, larger fish range from Cabo San Lucas, Baja California, to the Gulf of Alaska, offshore into deep water and along the coast to the north of Point Conception (Pacific Fishery Management Council 2011c).

Market squid (*Doryteuthis opalescens*) range from the southern tip of Baja California to southeastern Alaska. They are most abundant between Punta Eugenia, Baja California, and Monterey Bay, California. Usually found near the surface, market squid can occur to depths of 800 m (2,625 ft.) or more. Squid live less than a year and prefer full-salinity (35 ppt) ocean waters. They are important forage foods for fish, seabirds, and marine mammals (Pacific Fishery Management Council 2011c).

Krill are small shrimp-like crustaceans that are an important base of the marine food chain. They are eaten by many Managed Species, as well as by fishes, seabirds, and baleen whales. The PFMC is presently considering identifying EFH and possibly HAPCs for two individual krill species, *Euphausia* *pacifica* and *Thysanoessa spinifera*, and for other species of krill as a separate category. In 2006, the PFMC adopted a complete ban on commercial fishing for all species of krill in west coast federal waters (Pacific Fishery Management Council 2008).

3.1.4.2 Habitat Areas of Particular Concern Designations

No HAPCs have been designated for CPS (Table 3-1).

3.1.5 HIGHLY MIGRATORY SPECIES ESSENTIAL FISH HABITAT

3.1.5.1 Description and Identification of Essential Fish Habitat

In general, the HMS and the MUS are found in temperate waters within the Pacific Council's region (Table 3-2). Variations in the distribution and abundance of the MUS are affected by oceanic environmental conditions including water temperature, current patterns, and the food availability. Sea surface temperatures and habitat boundaries vary seasonally and annually. Abiotic environmental variability results in some HMS populations being more abundant from northern California to Washington waters during the summer and warm waters years than during winter and cold water years due to increased habitat availability within the EEZ. There are data gaps about basic life histories and habitat requirements of a few MUS. Some of the environmental drivers to migration of the stocks in the Pacific Ocean are poorly understood and difficult to categorize despite extensive tagging studies. Data are lacking on the distribution and habitat requirements of the juvenile life stages of tuna after they complete their planktonic life stage until they recruit to fisheries. Very little is known about the habitat of different life stages of most HMS which are not targeted by fisheries such as certain species of sharks. HMS are harvested by U.S. commercial and recreational anglers and by foreign fishing fleets, with only a fraction of the total harvest taken within the EEZ. (Pacific Fishery Management Council 2011a). HMS are also an important component of the recreational sport fishery. For these reasons, the Council recommends a precautionary approach in designating EFH for the (Pacific Fishery Management Council 2011a).

There are six HMS recorded to inhabit the EFH in the study area (Table 3-2). They migrate widely in the ocean, both in terms of area and depth, and are usually not associated with the features typically considered fish habitat such as estuaries, seagrass beds, or rocky bottoms. Their habitat selection appears to be less related to physical features and more correlated with ocean temperatures, salinity, oxygen, currents, and prey availability.

Table 3-2: Highly Migratory Species Management Unit With Occurrence in the Study Area

Sharks	
Blue	*Prionace glauca*
Common Thresher	*Alopias vulpinus*
Shortfin mako (bonito)	*Isurus oxyrinchus*
Tunas	
Albacore (Northern Stock)	*Thunnus alalunga*
Bigeye	*Thunnus obesus*
Pacific bluefin	*Thunnus orientalis*

Source: Pacific Fishery Management Council 2011b

3.1.5.2 Habitat Areas of Particular Concern Designations

The PFMC has currently identified no HMS HAPCs.

3.2 Description of Habitats

The NWTT Study Area covers a range of marine habitats which support a myriad of fish and shellfish communities. The intent of this section is to consolidate the EFH designations from the FMC region into larger primary habitat types so that the descriptions can be managed in a manner that is more conducive to analyzing the Navy's activities across a large area. Waters of the Study Area include shoreline habitats between the mean high and low water, bottom habitats below the mean high water, and the overlying water column.

For shore and bottom habitats, the habitat classification system described herein is a modified version of the Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979). The structure of the classification system allows it to be used at any of several hierarchical levels. The classification employs five system names, eight subsystem names, 11 class names, 28 subclass names, and an unspecified number of dominance types. The modified classification system starts at the subsystem level (e.g., intertidal shores/subtidal bottoms) and focuses analysis on a modified class level (e.g., soft shores/bottoms, hard shores/bottoms) differentiating non-living substrates from the living structures on the substrate. Living structures on the substrate are termed biogenic habitats, and include wetland plants, submerged aquatic vegetation (attached macroalgae and rooted vascular plants), sedentary invertebrate beds, and reefs. As such, these classifications may or may not overlap with the Coastal and Marine Ecological Classification Standard (CMECS) (Federal Geographic Data Committee 2012). CMECS provides a catalog of terms and a means for classifying ecological units using a simple, standard format and common terminology. Therefore, Table 3-3 aligns the habitat groupings used in this analysis with the CMECS.

The ecological functions of the substrate and biogenic habitat for managed species and their life stages are implied by their presence, extent and quality within an area. Information documenting habitat presence within broad geographic areas is widely available, whereas data on spatial extent and quality are sparse and inconsistently classified. Refer to subsequent habitat sections for details. Establishing a proper baseline for impact assessment will be primarily qualitative for habitats with sparse and inconsistent spatial data as noted in respective habitat section, and quantitative in some areas.

Table 3-3: Coastal and Marine Ecological Classification Standard Crosswalk

NWTT Habitat Type and Subtypes	Relationship between CMECS and Cowardin et al. 1979	CMECS Class/ Subclass	Confidence	Relationship Notes
Soft Shores[1]	CMECS less inclusive than Cowardin et al. 1970	Unconsolidated Substrate	Certain	CMECS Unconsolidated Substrate = Cowardin Unconsolidated Shore + Unconsolidated bottom. Shore is considered in the CMECS Geoform Component.
Rocky Shores[1]	CMECS less inclusive than Cowardin et al. 1970	Rock Substrate	Certain	CMECS Rock substrate = Cowardin Rocky Shore + Rock Bottom. Shore is considered in the CMECS Geoform Component.
Vegetated Shores[1]	CMECS synonymous with Cowardin et al. 1970	Emergent Wetland	Certain	
Aquatic Beds[1]	CMECS synonymous with Cowardin et al. 1970	Aquatic Vegetation Bed	Certain	
Soft Bottoms[1]	CMECS less inclusive than Cowardin et al. 1970	Unconsolidated Substrate	Certain	CMECS Unconsolidated Substrate = Cowardin Unconsolidated Shore + Unconsolidated Bottom.
Hard Bottoms[1]	CMECS less inclusive than Cowardin et al. 1970	Rock Substrate	Certain	CMECS Rock Substrate = Cowardin Rocky Shore + Rock Bottom.
Artificial Structures	CMECS less inclusive than Cowardin et al. 1970	Anthropogenic Substrate	Somewhat Certain	Anthropogenic Substrate = includes classes dependent on the anthropogenic material; however, materials in the Study Area vary.

[1] These habitat types were derived directly from Cowardin et al. 1979.

3.2.1 WATER COLUMN

The waters of the Study Area extend from coastal draining rivers to open ocean waters of the U.S. EEZ.

The flow and quality of water in the water column are key factors that link fish, habitat, and people. Water column properties that may affect fisheries resources include temperature, salinity, dissolved oxygen, total suspended solids, nutrients (nitrogen, phosphorus), and chlorophyll *a* (Western Pacific Regional Fishery Management Council 2009). Other factors, such as depth, pH, water velocity and movement, and turbidity can also affect the distribution of aquatic organisms. Water column habitats are somewhat independent of shore and bottom features. Flows of water, or lack thereof, are affected by large-scale watershed characteristics, global climate gradients, and earth rotation relative to north and south poles. Water column parameters referenced in the EFH and HAPCs descriptions include waters (offshore, nearshore, estuarine), vertical layers (pelagic, bottom, thermocline), and salinity zones. Any reference to waters (all estuaries) implies the inclusion of all shore and bottom habitats, unless selected habitats are implied (pelagic/demersal) (Appendix B, Primary Habitat Types Designated as Essential Fish Habitat).

Waters characterizing the Study Area vary along the continuum from coastal rivers to offshore ocean and include pelagic habitat seaward of estuarine salinities (greater than 30 practical salinity units [psu]). The offshore ocean is defined herein as the habitat seaward of the neritic zone (Figure 3-7). Overlap occurs between the neritic and estuarine systems where lower salinity plumes enter continental shelf waters. Estuarine habitat range from 0.5–30 psu and include bays, inlets, sounds, tidal creeks, and coastal rivers. Freshwater habitats have less than 0.5 psu.

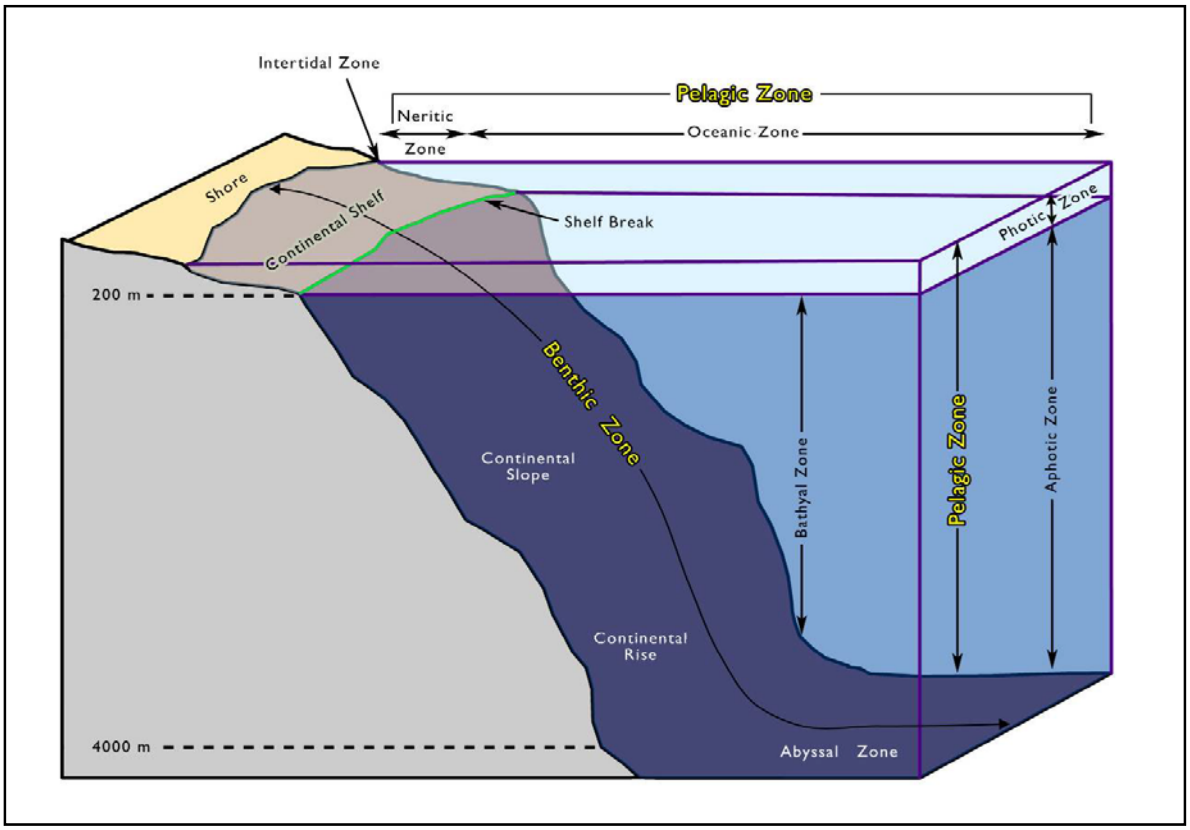

Figure 3-7: Three-Dimensional Representation of a Continental Margin and Abyssal Zone

3.2.1.1 Currents, Circulation Patterns, and Water Masses

In ocean waters, gyres and currents create physical and chemical dynamics that influence the distribution of organisms. Ocean circulation in the Study Area is dominated by the clockwise motion of the North Pacific Subtropical Gyre, which occurs between the equator and 50°N and is defined to the north by the North Pacific Current, to the east by the California Current, to the south by the North Equatorial Current, and to the west by the Kuroshio Current (Tomczak and Godfrey 2003). The North Pacific Subtropical Gyre, like all the ocean's large subtropical gyres, has extremely low rates of primary productivity (Valiela 1995) caused by a persistent thermocline that prevents the vertical mixing of water. Thermocline layers are present in the water column at varying depths throughout the world's oceans. In most areas, particularly nearshore, thermoclines dissipate seasonally, allowing nutrient-rich waters beneath the thermocline to replenish surface waters and stimulate primary production cycles.

Surface currents are horizontal wind-driven movements over the sea surface. Wind-driven circulation dominates in the upper 330 ft. (101 m) of the water column and therefore drives circulation over continental shelves (Hunter et al. 2007). Surface currents of the Pacific Ocean include equatorial, circumpolar, eastern boundary, and western boundary currents. A major surface current within the Study Area is the California Current (Figure 3-8).

Current speeds vary widely. Currents flowing along the western boundaries of oceans are typically narrow, deep, and swift and have speeds exceeding 3 feet per second (ft./s) (1 meter per second [m/s]) (Pickard and Emery 1990). Eastern boundary currents, such as the California Current, are relatively shallow, broad, and slow-moving and travel toward the equator along the eastern boundaries of ocean basins. In general, eastern boundary currents carry cold waters from higher latitudes to lower latitudes (Reverdin 2003).

The coasts of Washington and Oregon are located in an eastern boundary current system where the North Pacific Current divides into the northward flowing Alaskan Current and the southward flowing California Current (Figure 3-8) (Gramling 2000, Hickey 1998).

The California Current extends up to 620 mi. (1,000 km) offshore and varies from 370 to 620 mi. (595 to 998 km) wide. The current carries the cold, nutrient rich waters southward toward California (Hickey 1979, 1998, Miller 1996). It also has north trending undercurrents and surface countercurrents. The main surface current follows the edge of the continental shelf along the coast and is located closer to the shoreline during summer and farther off the shelf in winter (Strickland 1989). The current is strongest in summer and early fall, and weakest in winter. Flow is strongest at the surface, but the current extends through the water column to a depth of approximately 1,650 ft. (503 m) (Gramling 2000, Hickey and Banas 2003).

The California Undercurrent is a deep water current that flows northward along the entire coast of California. The strength of the Californian Undercurrent varies seasonally, with peaks during summer and early fall. The current is typically at its weakest in spring and early summer and the flow at depth may occasionally reverse and move south. The California Undercurrent flows inshore of the California Current (Gay and Chereskin 2009), and at times may surface and combine with the California Counter Current to form the Davidson Current north of Point Conception. The California Undercurrent is composed of Pacific Equatorial Water and characterized by warm water temperatures, high salinity, and nutrient-poor water (Gay and Chereskin 2009) that flows at about 328 ft. (100 m) beneath the cold, nutrient-rich waters of the California Current (Council 1990, Lynn et al. 2003).

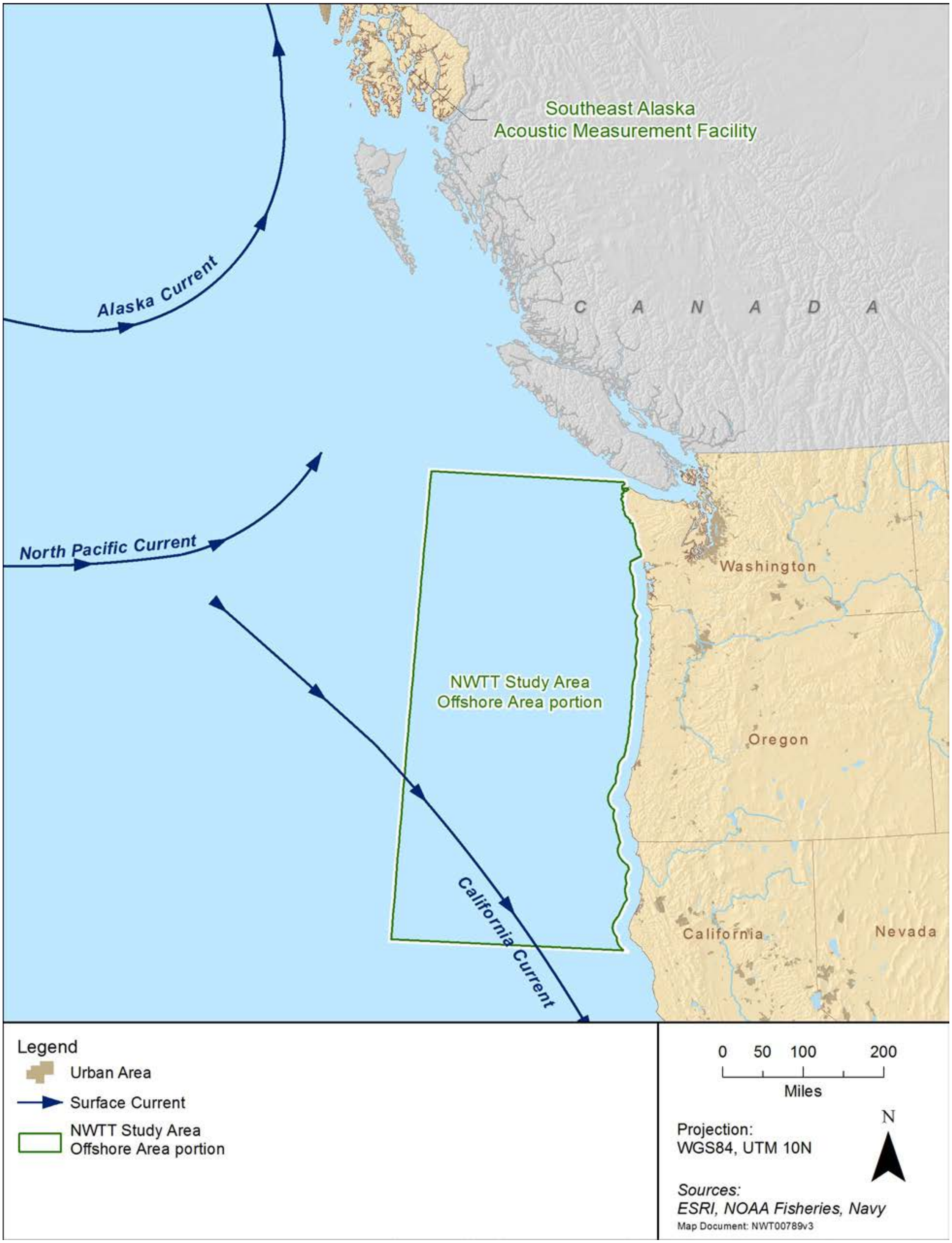

Figure 3-8: Major Currents in the Northwest Training and Testing Study Area

3.2.1.1.1 Upwelling and Water Masses of the NWTT Study Area

Ocean currents are water masses that flow from one place to another. These currents are the major forces that shape local ecosystems by creating upwelling, local climate, and indirectly through those aforementioned mechanisms, the biological productivity of coastal areas (Airamé et al. 2003). The Pacific Northwest coast supports a high density of phytoplankton (Sutor 2005). During the spring and summer, the upwelling of nutrient-rich waters into the surface layers combines with high solar radiation and increased photoperiod day length to increase phytoplankton production (Batchelder et al. 2002, Perry et al. 1989, Strub 1990). During the summer, a large standing stock of zooplankton resides 5–16 nm off the Olympic Coast (Olympic Coast National Marine Sanctuary 1993). Phyto- and zooplankton form the base of the food chain supporting invertebrates, fish, sea turtles, birds, and marine mammals.

Oceanic water masses are defined by their chemical and physical properties. Water temperature and salinity determine the density of water masses. Density differences cause stratification within the water column, which cause water masses to move both vertically and horizontally. Low-temperature, higher-salinity surface waters are dense and thus sink, whereas higher-temperature, lower-salinity waters are less dense, and hence float. Density differences are responsible for large-scale, global oceanic water circulation, which plays a major role in global climate variation and the transport of water, heat, nutrients, and larvae (Kawabe and Fujito 2010).

3.2.1.2 Oceanic Fronts

An oceanic front is the boundary between two water masses with distinct differences in density attributed by temperature and salinity. An oceanic front is characterized by rapid changes in water density over a short distance. The California Current Front separates relatively cold water temperature, low-salinity waters of the southward California Current from warmer water temperature and higher salinity inshore waters (Hickey 1998). The Subarctic Front separates the northward Subarctic Current from inshore waters. On the inshore side of the California Current, upwelling fronts develop in summer. Offshore frontal filaments, sometimes 100 km long, carry the upwelled cold, nutrient-rich water across the entire large marine ecosystem. In winter, a second and seasonal poleward current develops over the shelf and slope, giving rise to the seasonal Davidson Current Front between the warm saline subtropical waters inshore and colder, fresher temperate waters offshore. This front can be traced from off southern California (35˚N) to the northern Washington coast (48–49˚N) (Aquarone and Adams 2009).

3.2.1.3 Water Column Characteristics and Processes

Seawater is made up of a number of components including gases; nutrients; dissolved compounds; particulate matter such as solid compounds such as sand, marine organisms, and feces; and trace metals (Garrison 1998). Seawater characteristics are primarily determined by temperature and the gases and solids dissolved in it.

Chlorine, sodium, calcium, potassium, magnesium, and sulfate make up 98 percent of the solids in seawater, with chloride and sodium making up 85 percent of that total (Garrison 1998). Sea surface salinity within the Study Area ranges from 33 to 35 ppt (National Oceanic and Atmospheric Administration 2009, Organization 2009). There are typically three density layers in the water column of the ocean: a surface layer (0–655 ft. [0–200 m]), an intermediate layer (655–4,920 ft. [200–1,500 m]), and a deep layer (below 4,920 ft. [1,500 m]) (Castro and Huber 2007).

Nutrients are chemicals or elements necessary to produce organic matter. Basic nutrients include dissolved nitrogen, phosphates, and silicates. Dissolved inorganic nitrogen occurs in ocean water as nitrates, nitrites, and ammonia, with nitrates as the dominant form. The nitrate concentration of the coastal waters within the Study Area varies from 0.1 to 10.0 micrograms per liter (μg/L). The lowest concentrations typically occur in the summer. At a depth of 33 ft. (10 m) concentrations of phosphate and silicate in the California Current typically range from 0.25 to 1.25 parts per billion (ppb) (0.25 to 1.25 μg/L) and 2 to 15 ppb (2 to 15 μg/L), respectively (Barber et al. 1985).

The availability of iron affects primary production in the marine environment. Iron is introduced to the marine environment primarily by rivers and wind driven transport from continents, and from volcanic eruptions (Langmann et al. 2010). Iron is a limiting factor for growth of phytoplankton in high nutrient, low chlorophyll surface water, including surface waters of the North Pacific Ocean (Coale et al. 1998, Coale et al. 1996, Martin and Gordon 1988). Increases in iron concentrations also increase nitrogen fixation (Krishnamurthy et al. 2009).

3.2.1.3.1 Sea Surface Temperature in the Study Area

Sea surface temperature (SST) varies by season and photoperiod across the Pacific Ocean (Figure 3-9). SST are affected by atmospheric conditions, and can show seasonal variation in association with upwelling, climatic conditions, and latitude (Tomczak and Godfrey 2003). In the inland and open ocean portions of the Study Area, winter SST ranges from approximately 8° Celsius (C) in the northern regions and 10˚C in southern regions, and in summer from 17°C offshore to 11˚C along the coast (U.S. Department of the Navy 2010b). The lowest SST typically occurs in February, while the highest temperatures typically occur in August (Figure 3-9).

SST and nutrients are also influenced by long-term climatic conditions including El Niño Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), and climate change. The recurring ENSO pattern is one of the strongest in the ocean atmosphere system (Gergis and Fowler 2009). ENSO events result in significantly warmer water in the tropical Pacific. Upwelling of cold nutrient rich water along the coasts of North and South America is drastically reduced during ENSO events. La Niña is the cooler companion phase of the warmer El Niño condition. La Niña events are characterized by stronger than average easterly trade winds that push the warm surface waters of the tropical Pacific to the west and enhance upwelling along the eastern Pacific coastline (Bograd et al. 2000). The PDO is a long-term (20–30 years) climatic cycle with alternating warm and cool phases (Mantua and Hare 2002, Polovina et al. 1994). Every 20–30 years, the surface waters of the central and northern Pacific Ocean (20°N and poleward) shift several degrees from their average temperature. This oscillation affects primary production in the eastern Pacific Ocean and, consequently, affects organism abundance and distribution throughout the food chain. Analysis of satellite data indicate that the Pacific Ocean was in the warm phase of the PDO from 1977 to 1999 and is currently in the cool phase.

During an El Niño event, atmospheric temperatures increase along with corresponding increases in coastal rainfall, local sea level, sea surface temperature, the strength of the California Countercurrent, and local populations of warm water fishes. Concurrently, the trade winds weaken, upwelling and primary production decrease, and local kelp beds are severely impacted (Allen et al. 2002, Barber and Chavez 1983, Barber et al. 1985, Hayward 2000, Leet et al. 2001). During a La Niña event, opposite climactic patterns emerge. The trade winds strengthen, coastal upwelling and primary productivity increase, the California Current strengthens, and populations of cold water fishes increase. At the same time, a decrease in coastal rainfall) and a decline in local sea level and SST are observed (Bograd et al. 2000).

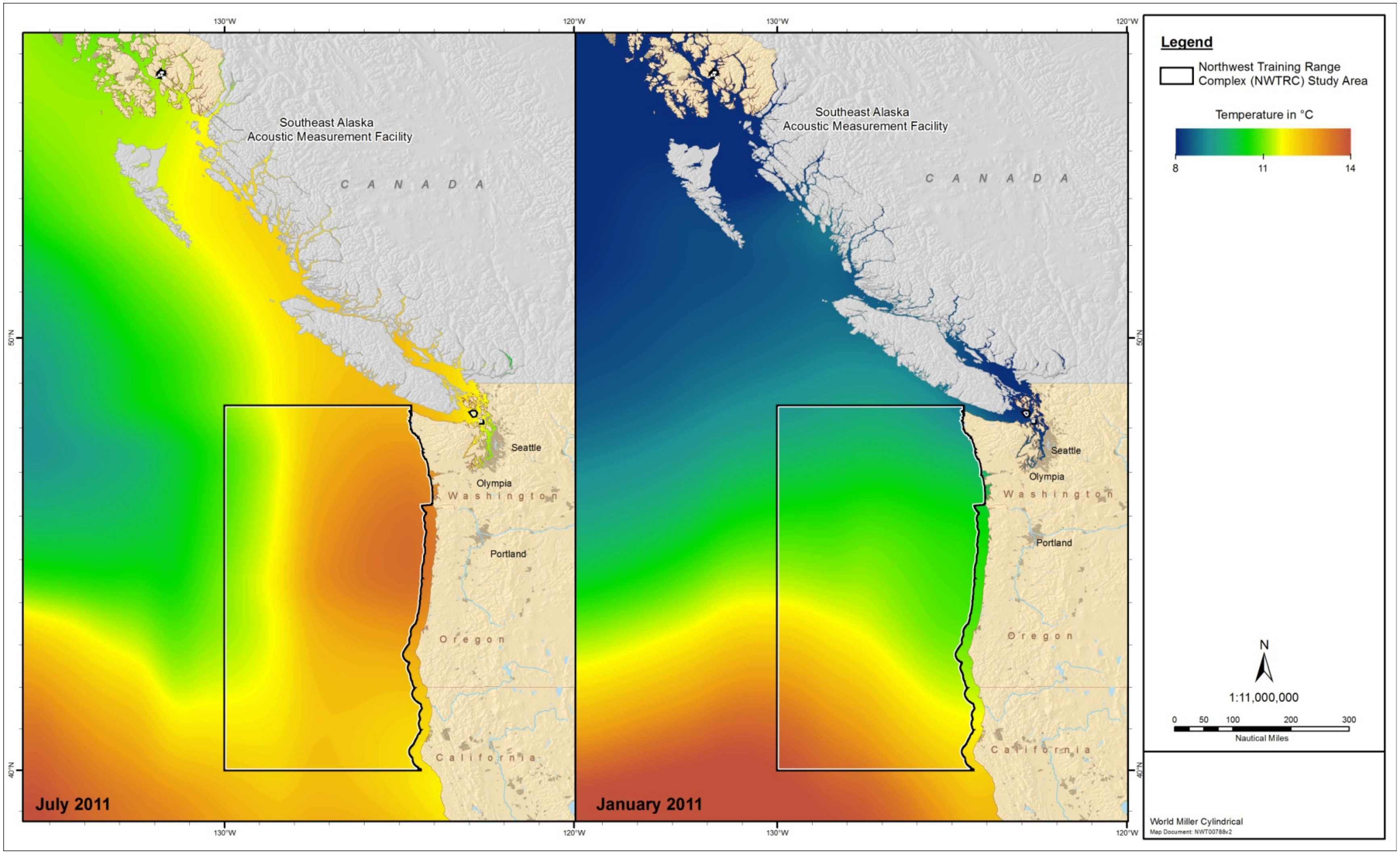

Figure 3-9: Seasonal Variation of Sea Surface Temperature in the Convergence of the Cold California Current and Warm Equatorial Waters

3.2.1.4 Bathymetry of the Study Area

The discussion of bathymetry includes a general overview of the Study Area and a description of the bathymetry of Navy training and testing areas (Table 3-4). Given that the bathymetry of an area reflects the topography of the seafloor, it is an important factor for understanding the potential impacts of proposed activities on the seafloor, the propagation of underwater sound, and species composition.

Table 3-4: Summary of Bathymetric Features within the Northwest Training and Testing 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 (Figure 2-2) 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.
Inland Waters (Puget Sound)		
Keyport Range Site	Located adjacent to the Naval Undersea Warfare Center Keyport (Figure 2-3).	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).

Range/Component	Description	General Bathymetry[1,2]

[1] U.S. Department of the Navy 2010c
[2] National Oceanic and Atmospheric Administration 2001a. 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: ° = degree(s), ft. = feet, km = kilometers, m = meters, nm = nautical miles, nm^2 = square nautical miles, OPAREA = Operating Area, W-237A = Warning Area 237A, > = greater than

3.2.1.4.1 Bathymetry of the Offshore Portion of the Study Area

Bathymetric features of the Offshore portion of the Study Area include a continental shelf, a continental slope, a rise, and a deep seafloor (Figure 3-10). The Study Area is located where the edge of the North American continental plate meets and overrides the Juan de Fuca oceanic plate. Plate tectonics, as well as periods of glaciations, erosion, and deposition, created the mountains, canyons, fjords, and coastal lowlands that are characteristic of this area (McGregor 1986, Melbourne and Webb 2003). The tectonic activity around the continental margin of the Offshore Area of the Study Area has created a fairly narrow continental shelf, only about 15–50 mi. (24.1–80.5 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 ft. (198.1 m), and the bottom is mostly flat due to sediment accumulation (Shepard 1941, Strickland 1989).

The Juan de Fuca Ridge and Gorda Ridge are located where the floor of the Pacific Ocean is spreading apart and forming new ocean crust. The Juan de Fuca Ridge is approximately 300 mi. (482 km) long and rises from 1,300 to 3,300 ft. (400 to 1,000 meters [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. Both ridges 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 1989). Submarine canyons have steep walls, winding valleys, narrow V-shaped cross-sections, steps, and considerable irregularity along the seafloor (Kennett 1982, Thurman 1997). The flooded remains of terrestrial canyons 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 that 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 and 5,532 m). The plain is blanketed by fine grained sediments, mainly clay and silt.

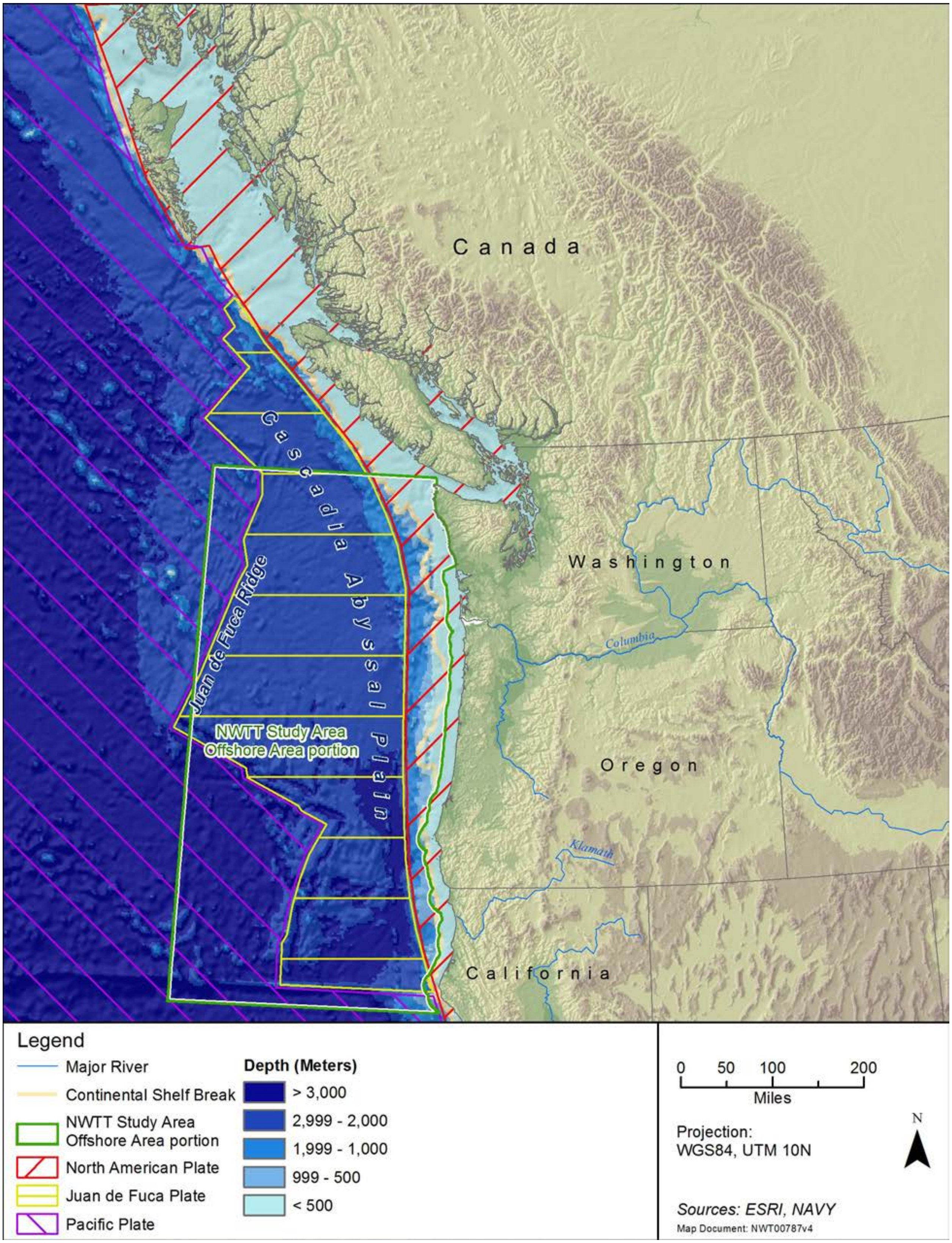

Figure 3-10: Bathymetry of the Offshore Portion of the Northwest Training and Testing Study Area

3.2.1.5 Bathymetry of the Inland Waters

The deepest basins were created in the North Puget Sound in and around the San Juan Islands, from past glaciation events (Figure 3-11). 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.

3.2.1.1 Water Column Essential Fish Habitat

The list of managed species and life-stages for which water column areas are referenced in the EFH or HAPCs descriptions are compiled in Appendix B (Primary Habitat Types Designated as Essential Fish Habitat), and a summary of water column EFH and HAPCs for the PFMC is provided in Table 3-5.

Table 3-5: Water Column Essential Fish Habitat and Habitat Areas of Particular Concern References within Fishery Management Council Areas of the Northwest Training and Testing Study Area

Water Column Parameters	Habitat Areas	Descriptor	Occurrence in the Study Area
Waters	Offshore	EFH	Offshore
	Nearshore	EFH	Inland Waters, Offshore
	Estuarine	EFH	Inland Waters,
Vertical layers	All EEZ waters	EFH	Offshore
	All EEZ waters above the thermocline	EFH	Offshore
	Less than or equal to 328 ft. (100 m)	-	-
	Less than or equal to 492 ft.(150 m)	-	-
	Less than or equal to 1312 ft. (400 m)	-	-
	Between 1804-2297 ft. (550 and 700 m)	-	-
	Less than or equal to 1969 ft. (600 m)	-	-
	Less than or equal to 3280 ft. (1,000 m)	-	-
	Less than or equal to 11,483 ft. (3,500 m)	EFH	Offshore

Notes: EFH = Essential Fish Habitat, EEZ = Exclusive Economic Zone, ft. = (feet). m = meter(s)

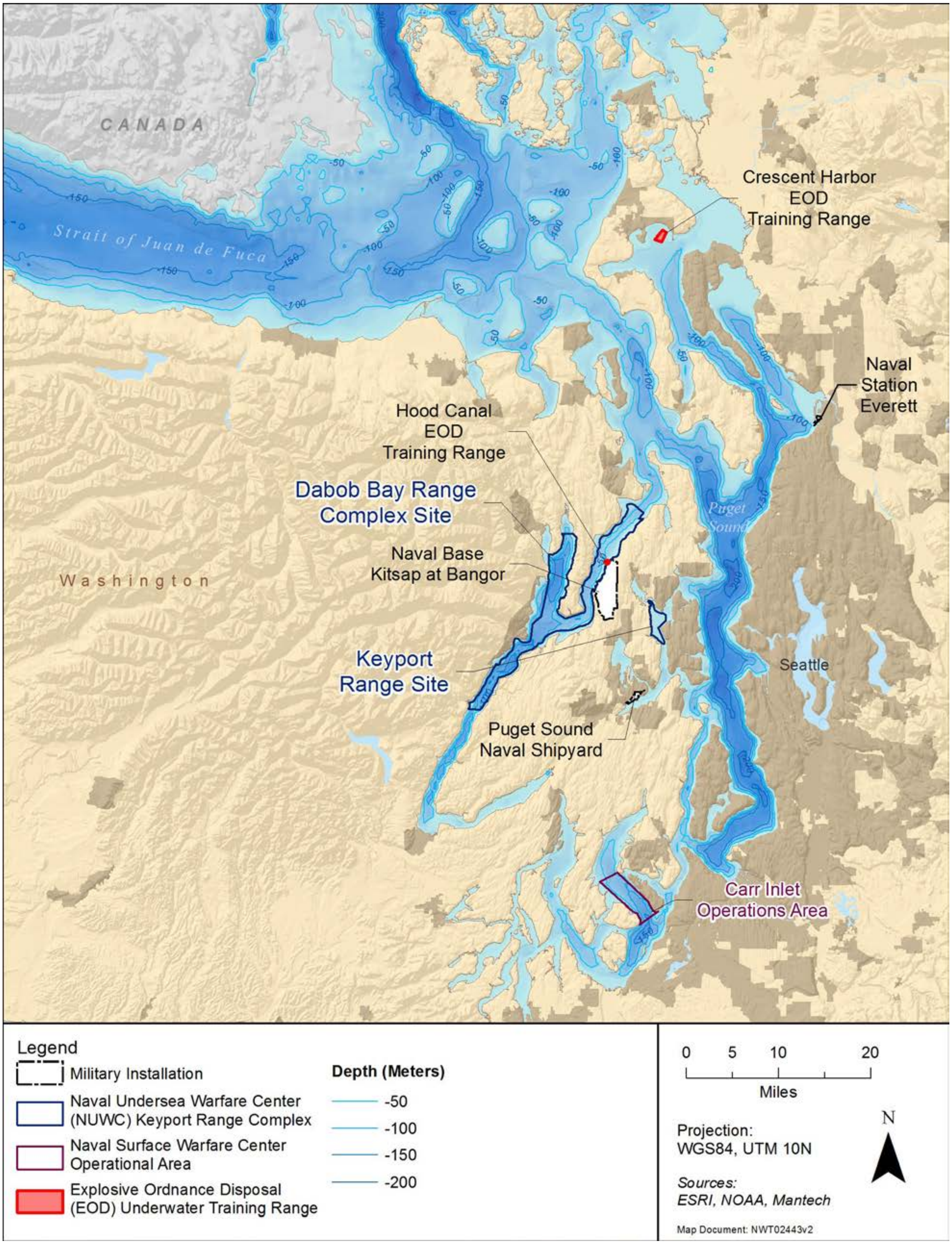

Figure 3-11: Bathymetry of the Inland Waters in the Northwest Training and Testing Study Area

3.2.2 SUBSTRATES

The fundamental descriptor of soft or hard substrate is a key factor in structuring biogenic habitats (Nybakken 1993). The difference between substrates represents a viable target for the available mapping technology (e.g., multibeam sonar) and corresponds well to characterizations of Navy impacts (e.g., explosive charges, expended materials). The substrates also correspond to the EFH or HAPC descriptors for species/life stages and are compiled in Appendix B (Primary Habitat Types Designated as Essential Fish Habitat), with a summary of substrate EFH and HAPC for the PFMC provided in Table 3-6. Seafloor features (e.g., seamounts, banks, slopes, and escarpments) are included among the types of substrate, and noted on the EFH habitat maps where spatial information is available.

Table 3-6: Substrate Essential Fish Habitat and Habitat Areas of Particular Concern References within the NWTT Study Area

Habitats	PFMC	
	Descriptor	Occurrence in the Study Area
Rocky Shelf	EFH	Offshore, Inland Waters
Non-Rocky Shelf	EFH	Offshore, Inland Waters
Canyon	EFH	Offshore
Continental Slope/Basin	EFH	Offshore
Seamounts	HAPC	Offshore, Inland Waters

Notes: EFH = Essential Fish Habitat, HAPC = Habitat Area of Particular Concern, PFMC = Pacific Fishery Management Council

3.2.2.1 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.

3.2.2.1.1 Offshore Area

Most of the Offshore Area is not located near the shoreline and is beyond the Territorial sea. The Study Area only reaches the shoreline in Washington; however, activities are proposed on the shoreline only along a 1 mi. portion of the Quinault Range Site at Pacific Beach, WA. This area in the Offshore Area is comprised of sand beaches.

3.2.2.1.2 Inland Waters

Tidal flats occur on a variety of scales in virtually all estuaries and bays in the Study Area (Figure 3-12). 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).

3.2.2.2 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 force, 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.

3.2.2.2.1 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 3-12 and Figure 3-13).

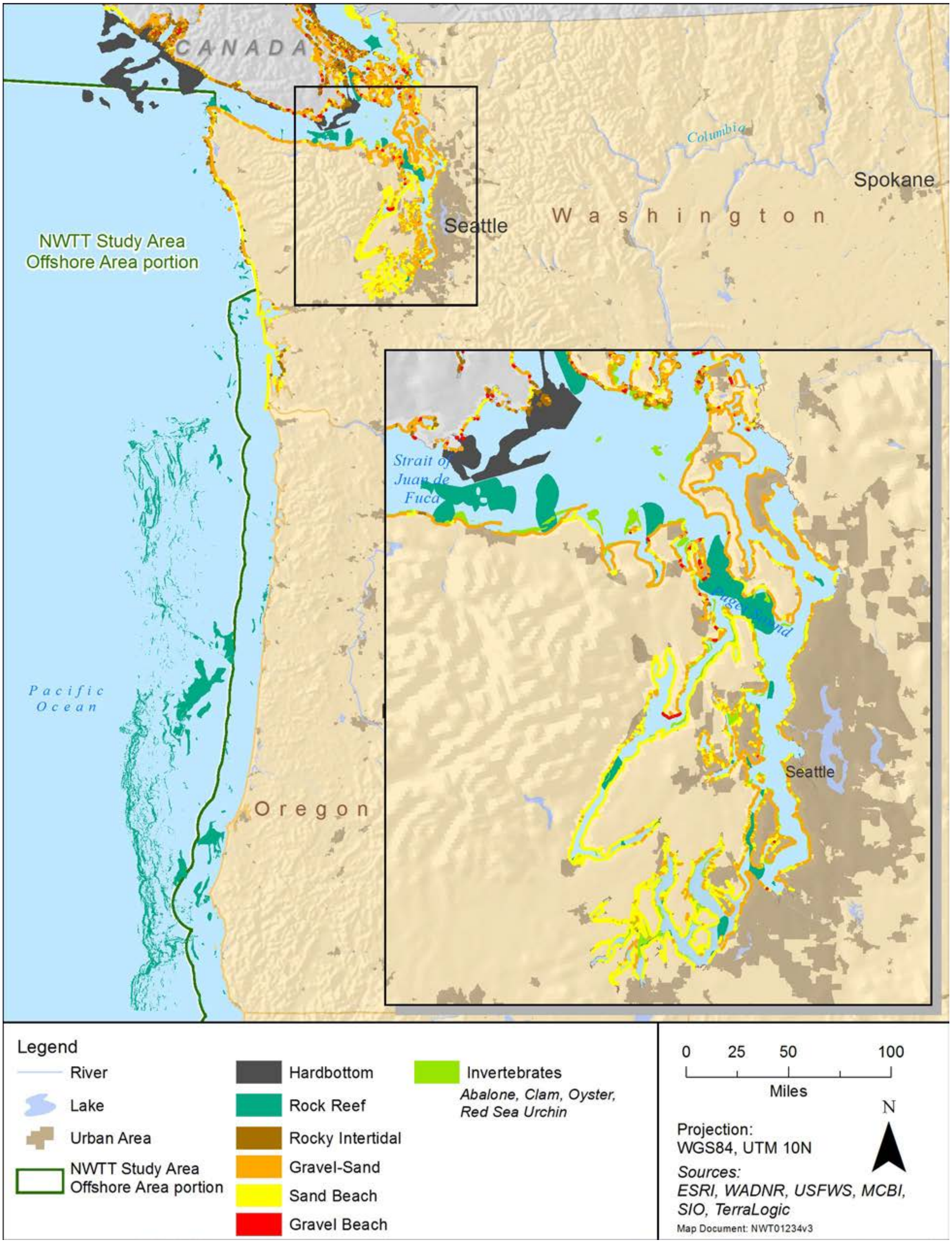

Figure 3-12: Marine Habitats in the Inland Waters of the Northwest Training and Testing Study Area

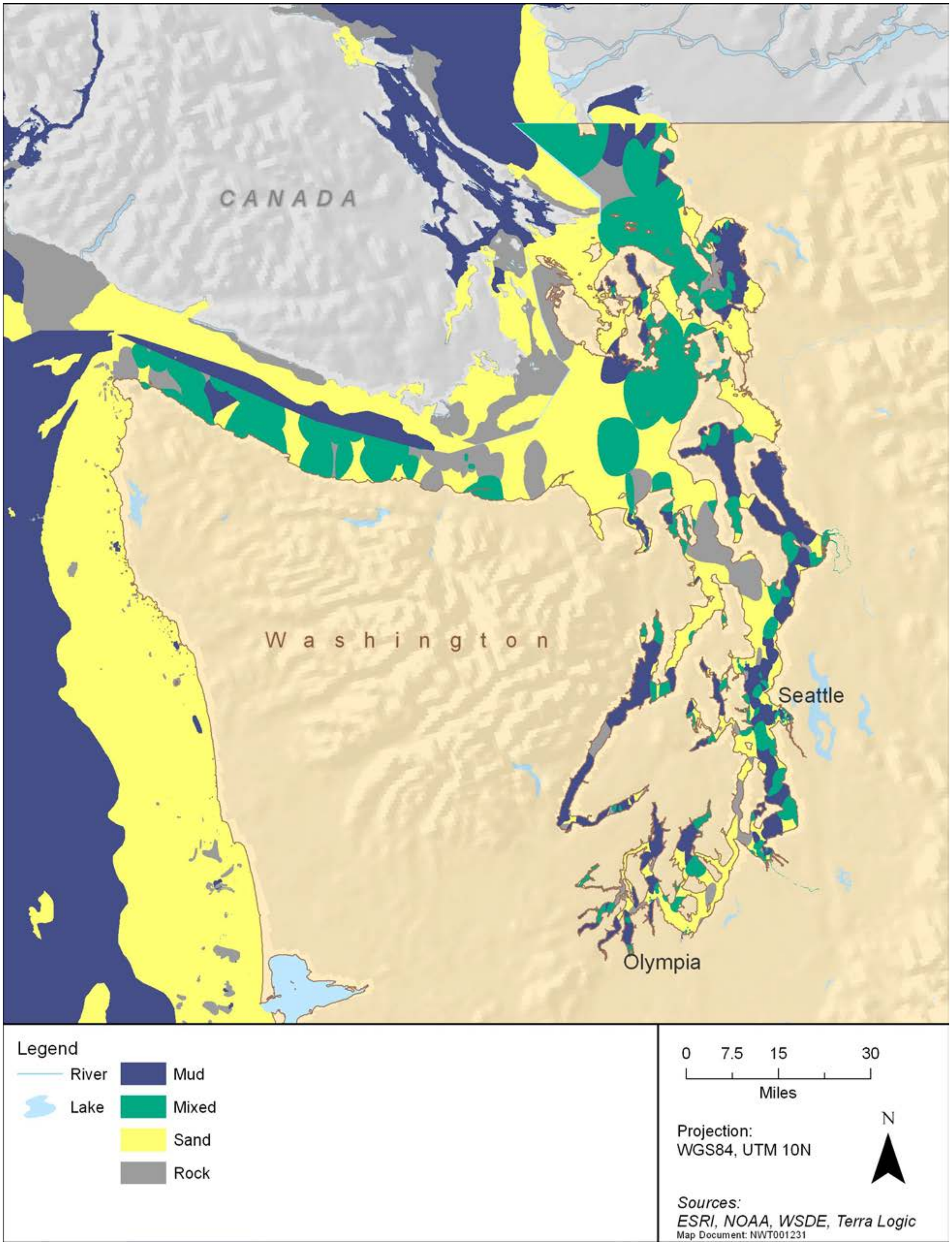

Figure 3-13: Bottom Substrate Composition of the Inland Waters of the Northwest Training and Testing Study Area

3.2.2.3 Soft Bottoms

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.

3.2.2.3.1 Offshore Area

In the Offshore Area, the soft-bottom habitat is located in the Cascadia abyssal plain (Figure 3-14). This is a nearly flat area that begins approximately 375 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).

The abyssal plain and similar deepwater areas were originally thought to be characterized by depauperate biological communities; however, recent technological advances have enabled surveys that show that these areas are host to thousands of species of invertebrates and fish (Beaulieu 2001a, b; O'Dor 2003).

3.2.2.3.2 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 (Figure 3-13). Most of these habitats are important for marine vegetation, invertebrates, fish, and avian species.

3.2.2.4 Hard Bottoms

Hard-bottom habitat includes both biogenic reefs and rocky bottoms sometimes covered by a thin veneer of living and dead sedentary invertebrates and 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. Rock Bottom habitats include all wetlands and deepwater 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.

Figure 3-14: Bottom Substrate Composition in the Offshore Area of the Northwest Training and Testing Study Area

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 ft. (20.0 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 other invertebrates and fish.

3.2.2.4.1 Offshore Area

Shallow hard-bottom habitat is relatively uncommon and patchy in the Study Area (Figure 3-14). Hard bottoms are most common offshore near rocky headlands, along steep shelf areas, and near the shelf break and submarine canyons (Figure 3-14 through Figure 3-16). 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 3-15) 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.

3.2.2.4.2 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 (Figure 3-12 and Figure 3-13).

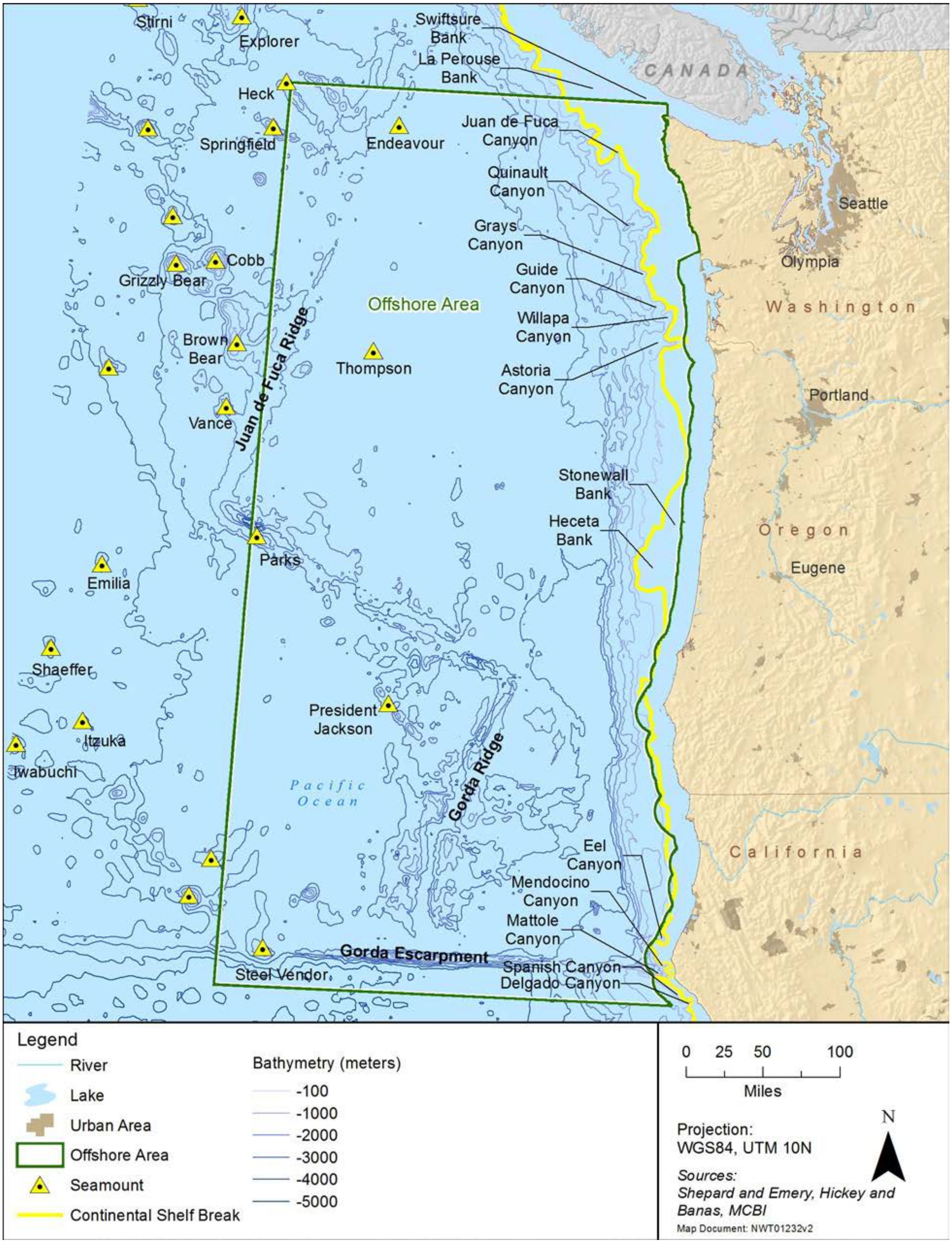

Figure 3-15: Topographic Features in the Offshore Area of the Northwest Training and Testing Study Area

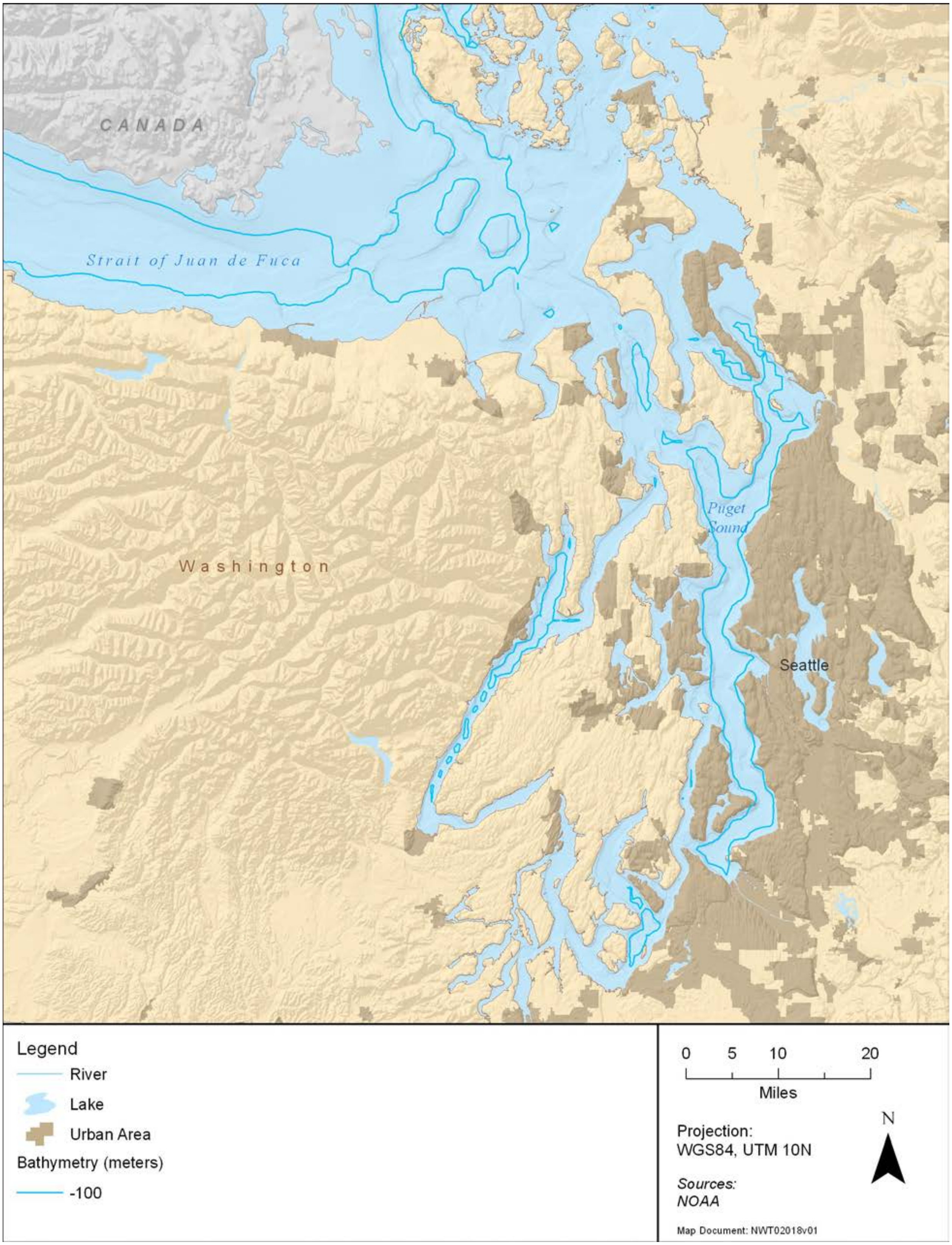

Figure 3-16: Topographic Features in the Inland Waters of the Northwest Training and Testing Study Area

3.2.2.5 Artificial Structures

Artificial habitats provide habitat for marine organisms. Artificial reefs oil and gas platforms, fish-aggregating devices, floating objects to attract pelagic fishes, and shipwrecks are examples of artificial structures. Artificial structures function as hard-bottom substrate that provide structural attachment points for algae and sessile invertebrates, which provide habitat for a diverse species community (National Oceanic and Atmospheric Administration 2007).

3.2.2.5.1 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 3-17); however, due to the destructive forces of wave and current, very few ships remain intact, particularly near the shore. Along the shorelines of the sanctuary are memorials to crews and passengers who died in nearby shipwrecks. These include the wrecks of the *Prince Arthur* in 1903, the *P.J. Pirrie* in 1920, nine ships wrecked between Quillayute Rocks and Cape Alava, five at Destruction Island, and four near Hoh Head (National Oceanic and Atmospheric Administration 1993). Oregon and Northern California shipwrecks and sinkings are not within the Offshore Area.

3.2.2.5.2 Inland Waters

Five artificial reefs are located in the Puget Sound portion of the Study Area, including one in Hood Canal. An artificial reef composed of tires is located in central Puget Sound approximately 15 mi. (24 km) north of Seattle, WA. 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). Another artificial reef, located in the Tacoma area, is the Les Davis Artificial Reef that was created from debris from the 1940 collapse of the Tacoma Narrows Bridge. There are also 97 known shipwrecks throughout the Inland Waters (Grant et al. 1996; Northern Maritime Research 2007) (Figure 3-18).

3.2.3 Biogenic Habitats

Living structures on the substrate are termed biogenic habitats, and include wetland shores, attached macroalgae beds, submerged rooted vegetation beds, and biological reefs. The differences between biogenic habitat reflect a basic continuum of resilience and recovery from disturbance; attached macroalgae recover quickly from the least disturbance (Mach et al. 2007), whereas reef structures take a very long time to recover from a relatively high level of disturbance (Fox and Caldwell 2006). The biogenic habitats also correspond to the EFH or HAPC descriptors for species/life stages (Table 3-5 and Table 3-6). The biogenic habitats are classified by water (e.g., open ocean, continental shelf, nearshore) to refine their location within a FMC region (Table 3-6).

3.2.3.1 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 species.

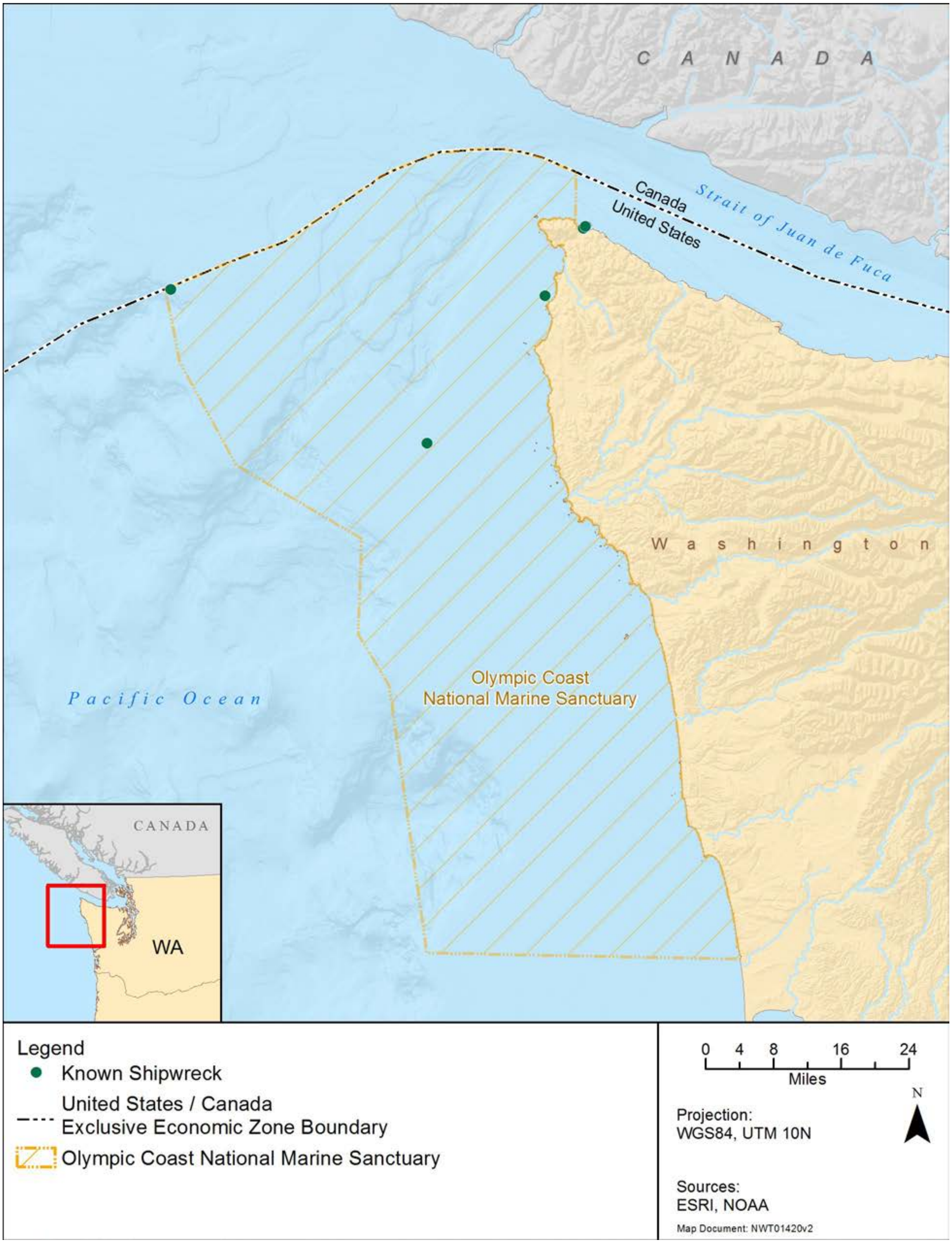

Figure 3-17: Shipwrecks in the Washington State Offshore Portion of the Study Area

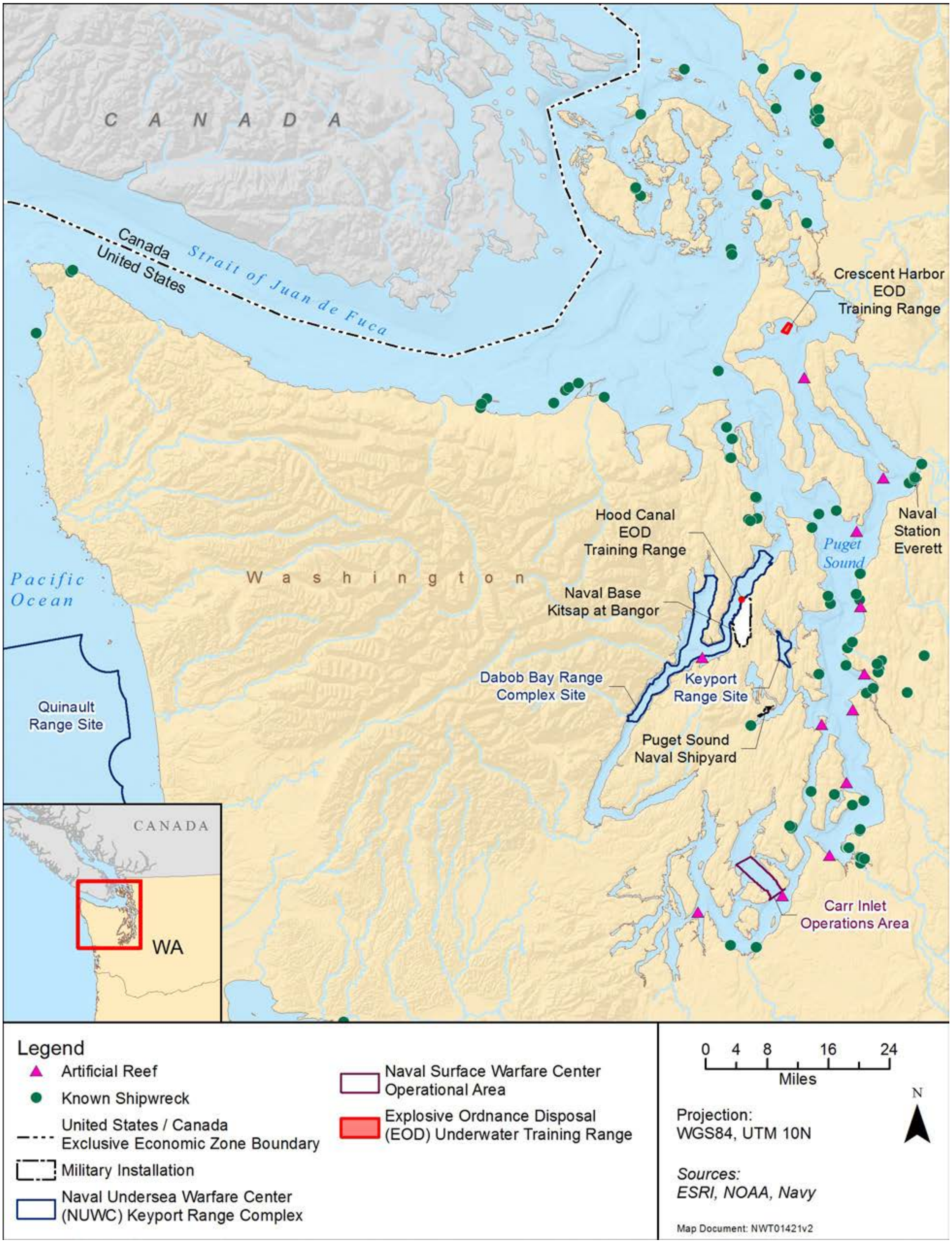

Figure 3-18: Shipwrecks and Artificial Reefs in Puget Sound, WA

3.2.3.1.1 Cordgrasses

Cordgrasses are temperate salt-tolerant land plants that inhabit salt marshes, mudflats, and other soft-bottom coastal habitats (Castro and Huber 2000). Salt marshes develop in intertidal, protected low energy environments, usually in coastal lagoons, tidal creeks, rivers, or estuaries (Mitsch et al. 2009). The structure and composition of salt marshes provide important ecosystem services. Salt marshes support commercial fisheries by providing habitat for wildlife, protecting the coastline from erosion, filtering fresh water discharges into the open ocean, taking up nutrients, and breaking down or binding pollutants before they reach the ocean (Dreyer and Niering 1995, Mitsch et al. 2009). Salt marshes also are carbon sinks (carbon reservoirs) and facilitate nutrient cycling (Bouillon 2009, Chmura 2009). Carbon sinks are important in reducing the impact of climate change (Laffoley and Grimsditch 2009), and nutrient cycling facilitates the transformation of important nutrients through the environment.

Atlantic cordgrass (*Spartina alterniflora*) is a non-native invasive species in the Study Area and produces seeds at higher rates than the native cordgrass, and quickly colonizes mudflats (Howard 2008). Atlantic cordgrass is found in the Inland Waters in mudflats in Skagit, Clallam, and Jefferson counties in WA (Puget Sound Partnership 2013).

3.2.3.2 Submerged Rooted Vegetation Beds

Submerged rooted vegetation form “meadows” or “beds” where they dominate the intertidal or shallow subtidal zone of estuarine or nearshore waters (Fonseca et al. 1998). The plants grow in soft bottom substrate receiving 15–22 percent or more of surface light intensity (Fonseca et al. 1998, Kemp et al. 2004) depending on “bio-optical” properties of the water (Biber et al. 2007).

Seagrasses are unique among flowering plants because they grow submerged in shallow marine environments. Except for some species that inhabit the rocky intertidal zone, seagrasses grow in shallow, subtidal, or intertidal sediments, and can extend over a large area to form seagrass beds (Garrison 2004, Phillips and Meñez 1988). Seagrass beds provide important ecosystem services as a structure-forming keystone species (Harborne et al. 2006). They provide suitable nursery habitat for commercially important organisms (e.g., crustaceans, fish, and shellfish) and also are a food source for numerous species (e.g., sea turtles) (Heck et al. 2003, National Oceanic and Atmospheric Administration 2001b). Seagrass beds combat coastal erosion, promote nutrient cycling through the breakdown of detritus (Dawes 1998), and improve water quality. Seagrasses also contribute a high level of primary production to the marine environment, which supports high species diversity and biomass (Spalding et al. 2003).

3.2.3.2.1 Offshore Area

In the Pacific Northwest the dominant native seagrasses are eelgrass (*Zostera marina*) and surfgrass (*Phyllospadix* spp.) (den Hartog 1970). Eelgrass grows in shallow, subtidal or intertidal unconsolidated sediments, where as surfgrass grows on wave-beaten rocky shores. The primary vegetation in the offshore portion of the Study Area is surfgrass (Figure 3-19).

3.2.3.2.2 Inland Waters

Eelgrass grows in shallow, subtidal or intertidal unconsolidated sediments, whereas surfgrass grows on wave-beaten rocky shores. Figure 3-19 shows the distribution of eelgrass and surfgrass, which are the primary species of vegetation in the intertidal areas of the Strait of Juan de Fuca and Puget Sound, which covers approximately 40 percent of the intertidal area (Bailey et al. 1998).

3.2.3.3 Attached Macroalgae Beds

Attached, non-vascular plants (i.e., macroalgae) form “meadows” or “beds” where they dominate intertidal shores or subtidal bottoms. Green, red, and brown algae represent basic taxonomic groups of macroalgae species, with some species (e.g., kelp, seaweed) growing attached to substrate. As a general rule, algae can grow down to bottom areas receiving 1 percent or more of surface light intensity (Wetzel 2001).

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

3.2.3.3.1 Offshore Area

Kelp and sargassum may occur in the sea surface of the Offshore Area of the Study Area. In turbid waters, the offshore edge of kelp beds occurs at depths of 50–60 ft. (15–18 m), which can extend to a depth of 100 ft. (30 m). The highest densities and most persistent kelp beds occur on solid rock substrate with moderately low relief and moderate sand coverage (Foster and Schiel 1985, Graham 1997). Sargassum, however, is least common along the outer coast, and offshore section of the Study Area (Shaffer 1998). Distribution of kelp and sargassum in the offshore portion of the Study Area is depicted in Figure 3-20.

3.2.3.3.2 Inland Waters

Kelp and sargassum are known to occur in the sea surface and seafloor of the Inland Waters of the Study Area. Sargassum is common along the shorelines of the Hood Canal, San Juan Archipelago, and Strait of Georgia, whereas kelp is mostly found in the Strait of Juan de Fuca (Figure 3-20).

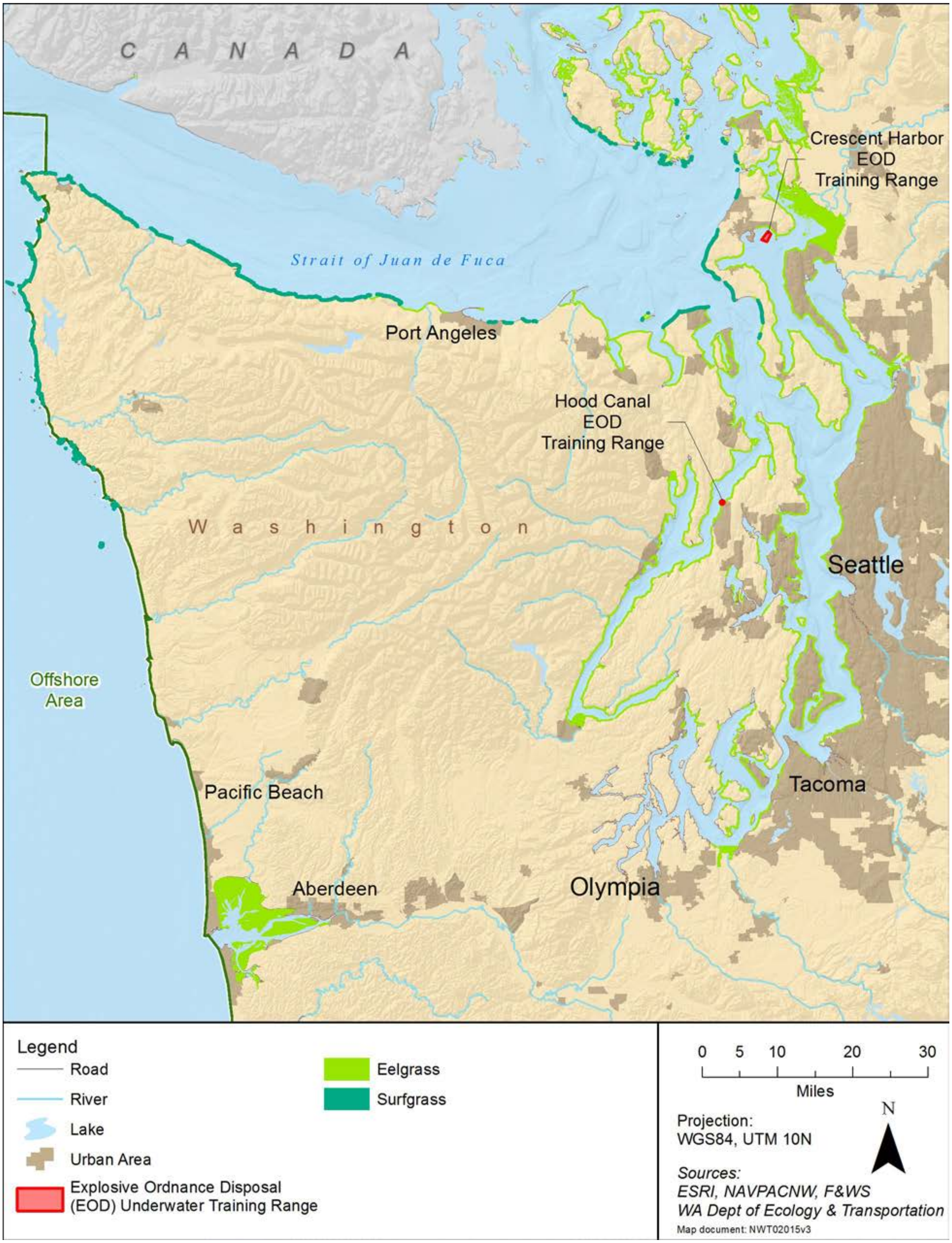

Figure 3-19: Surfgrass and Eelgrass Distribution within the Northwest Training and Testing Study Area

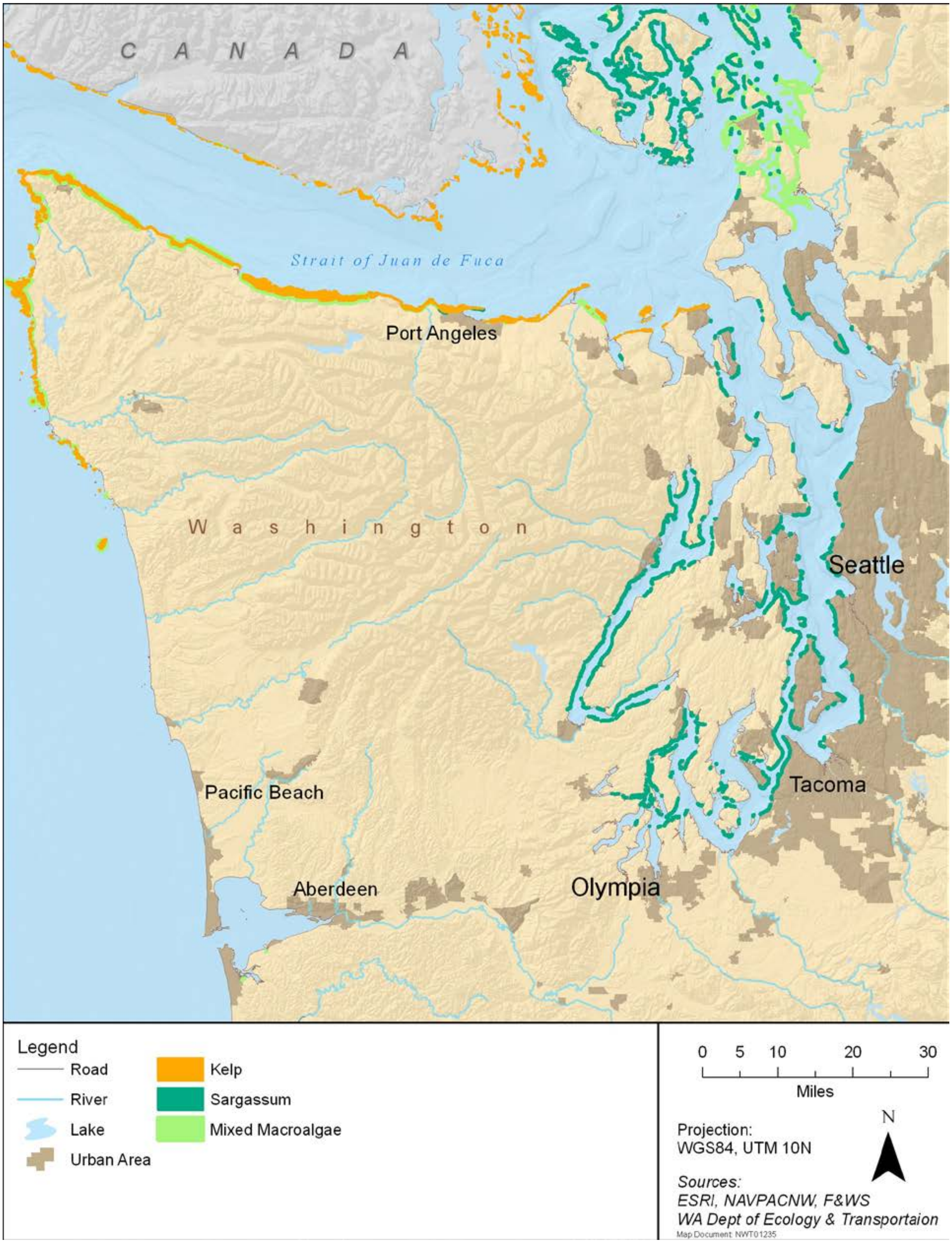

Figure 3-20: Sargassum and Mixed Macroalgae Distribution in and near the Northwest Training and Testing Study Area

4 ASSESSMENT OF IMPACTS

The overall approach to analysis in this EFHA included the following general steps:

- Identification of habitats designated as EFH and HAPCs for analysis;
- Habitat-specific impacts analysis for individual stressors;
- Habitat-specific impacts analysis for combined stressors; and
- Consideration of mitigations to reduce identified potential impacts.

Navy training and testing activities in the Proposed Action Area may produce one or more stimuli that cause stress on a habitat designated as EFH. Each proposed Navy activity was examined to determine its potential stressors (Table 4-1). Not all stressors affect every habitat, nor do all proposed Navy activities produce stressors (Table 4-2). The potential direct, indirect, and cumulative effects of the Proposed Action were analyzed based on the presence of these potential stressors within the designated habitat.

Table 4-1: List of Stressors Analyzed

Components and Stressor Categories for Physical Resources
Acoustic Stressors Sonar and other active acoustic sources Underwater explosions Weapons firing, launch, and impact noise Vessel noise
Energy Stressors Electromagnetic devices
Physical Disturbance and Strike Stressors Vessel movement In-water devices Military expended materials Seafloor devices
Contaminant Stressors Explosives, explosive byproducts Metals Chemicals Other materials

First, a preliminary analysis was conducted to determine the environmental resources potentially impacted and associated stressors. The term stressor is broadly used in this document to refer to an agent, condition, or other stimulus that causes stress to an organism or alters the abiotic habitat. Secondly, each resource was analyzed for potential impacts from individual stressors, followed by an analysis of the combined impacts of all stressors related to the Proposed Action. 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 analysis focused on relevant issues that warranted the most attention. The systematic nature of this approach allowed the Proposed Action with the associated stressors and potential impacts to be effectively tracked throughout the process. This approach provides a comprehensive analysis of applicable stressors and potential impacts. Each step is described in more detail below.

Table 4-2: Stressors by Warfare and Testing Area

Training/Testing Category	Acoustic Stressors	Energy Stressors	Physical Disturbance and Strike Stressors	Contaminant 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

4.1 Potential Impacts to Essential Fish Habitat

This section evaluates how and to what degree the training and testing activities described in Chapter 2 (Description of the Action and the Action Area) could impact EFH and HAPCs in the Study Area. A stressor is analyzed for a designated habitat if it has the potential to alter the quality or quantity of that habitat (e.g., seagrass beds, shallow reefs). The stressors applicable to one or more EFH and HAPCs in the Study Area include the following:

- Acoustic (non-impulse and impulse sources) as an impact on the quality of water column habitat for managed species;
- Energy (electromagnetic devices);
- Physical disturbance and strikes (vessels and in-water devices, military expended material, seafloor devices); and
- Contaminants (explosive byproducts, heavy metals, chemicals, and marine debris).

The stressors vary in intensity, frequency, duration, and location within the Action Area. The specific analysis of the training and testing activities considers the stressor "footprints" and their coincidence with designated EFH and HAPCs within FMC boundaries. The duration of impacts is based on either the duration of stressor or recovery of the habitat:

- Temporary – stressor duration or recovery in hours, days, or weeks;
- Short Term – stressor duration or recovery in less than 3 years;
- Long Term – stressor duration or recovery in more than 3 years but less than 20 years;
- Permanent – stressor duration or recovery in more than 20 years; and
- Minimal effects could be those that are limited in duration and that allow the affected area to recover before measurable long-term impacts to EFH occur, or those that may result in relatively small and insignificant changes to EFH and its ecological functions.

The conclusions for spatial and temporal impacts on EFH are summarized in text boxes at the end of the training and testing activities sections under each substressor. The managed species life stages that could be impacted are listed by habitat descriptors in Appendix B (Primary Habitat Types Designated as Essential Fish Habitat). The analysis will be separated by: (1) potential impacts on water column; (2) potential impacts on benthic substrate; (3) potential impacts on biogenic habitats; and (4) potential impacts on HAPCs. Table 4-3 shows which portion of EFH may be affected by the Proposed Action.

Table 4-3: Essential Fish Habitat Component and Stressors

Stressor	Water Column	Substrate	Biogenic	HAPC
Acoustic stressors (Section 4.1.1)				
Non-impulse • Sonar • Vessel noise	✓			
Explosive and other Impulse • Underwater explosions • Weapons firing, launch, and impact noise	✓	✓	✓	✓
Energy stressors (Section 4.1.2)				
Electromagnetic devices	✓			
Physical Disturbance and Strike stressors (Section 4.1.3)				
Vessel movement	✓	✓	✓	✓
In-water devices	✓	✓	✓	✓
Military expended materials	✓	✓	✓	✓
Seafloor devices		✓	✓	✓
Contaminant stressors (Section 4.1.4)				
Explosives and explosive byproducts	✓	✓	✓	✓
Metals	✓	✓	✓	✓
Chemicals	✓	✓	✓	✓
Other materials	✓	✓	✓	✓

Note: HAPC = Habitat Area of Particular Concern

4.1.1 ACOUSTIC STRESSORS

This section analyzes the potential impacts of acoustic stressors on EFH and HAPCs resulting from training and testing activities within the Action Area. For both non-impulse and impulse stressors, water column EFH and HAPC within the Action Area may be temporarily impacted through an increase in the ambient sound levels. Non-impulse acoustic stressors should have no effect on other habitat types designated as either EFH or HAPCs, as benthic and biogenic habitats are not anticipated to be affected by these activities. While the level of ambient sound in the water column will return to normal immediately following the completion of the training or testing exercise, thus resulting in only a temporary impact to water column EFH, federally managed fish and invertebrate species may be affected during this period within the vicinity of the stressor as a result of this brief alteration of the ambient noise level.

Acoustic sources were divided into two categories, impulse and non-impulse. Impulse sounds feature a very rapid increase to high pressures, followed by a rapid return to static pressure. Impulse sounds are often produced by processes involving a rapid release of energy or mechanical impacts (Hamernik and Hsueh 1991). Explosions, airgun impulses, and impact pile driving are examples of impulse sound sources. Non-impulse sounds lack the rapid rise time and can have durations longer than those of impulse sounds. Sonar pings and underwater transponders are examples of non-impulse sound sources. The terms “impulse” and “non-impulse” were selected for use because they were deemed more technically accurate and less confusing than the terms “explosive” and “acoustic” used in previous documentation.

The analysis of the potential direct effects to fish and invertebrates as a result of impacts to the water column habitats designated as EFH is limited to physical injury or mortality within the immediate vicinity of where the stressor may occur. Hearing loss, auditory masking, physiological stress, and behavioral reactions to impulse stressors beyond the range of physical impacts are assumed but not quantified, and included with the physical impacts. If there is no physical injury or mortality anticipated, the impact on water column EFH is assessed qualitatively. The qualitative assessment of hearing loss, auditory masking, physiological stress and behavioral reactions is based on the hearing and vocalization capacities of fish and invertebrates.

Fish Hearing and Vocalization

Fish have two sensory systems to detect sound in the water: the inner ear, which functions very much like the inner ear in other vertebrates, and the lateral line, which consists of a series of receptors along their body (Popper and Schilt 2008). The inner ear generally detects relatively higher-frequency sounds, while the lateral line detects water motion at low frequencies (below a few hundred Hertz [Hz]) (Hastings and Popper 2005). Although hearing capability data only exist for fewer than 100 of the 32,000 fish species, current data suggest that most species of fish detect sounds from 50 to 1,000 Hz, with few fish hearing sounds above 4 kilohertz (kHz) (Popper 2008). It is believed that most fish have their best hearing sensitivity from 100 to 400 Hz (Popper 2003). Additionally, some clupeids, such as shad in the subfamily Alosinae possess ultrasonic hearing (i.e., able to detect sounds above 100,000 Hz) (Astrup 1999).

The inner ears of fish are sensitive to acoustic particle motion rather than acoustic pressure. Although a propagating sound wave contains both pressure and particle motion components, particle motion is most significant at low frequencies (less than a few hundred Hz) and closer to the sound source. However, a fish’s gas-filled swim bladder can enhance sound detection by converting acoustic pressure into localized particle motion, which may then be detected by the inner ear. Fish with swim bladders generally have more sensitive and higher-frequency hearing than fish without swim bladders. Some fish also have specialized structures such as small gas bubbles or gas-filled projections that terminate near the inner ear. Many fish species possess a continuum of anatomical specializations that may enhance their sensitivity to pressure (versus particle motion), and thus higher frequencies and lower intensities (Popper and Fay 2010).

Past studies indicated that hearing specializations in marine fish were quite rare (Amoser and Ladich 2005). However, more recent studies show there are more fish species than originally investigated by researchers, such as deep sea fish, that may have evolved structural adaptations to enhance hearing capabilities (Buran et al. 2005, Deng et al. 2011). Marine fish families Holocentridae (squirrelfish and soldierfish), Pomacentridae (damselfish), Gadidae (cod, hakes, and grenadiers), and Sciaenidae (drums, weakfish, and croakers) have some members that can potentially hear sound up to a few kHz. There is also evidence, based on the structure of the ear and the relationship between the ear and the swim bladder, that at least some deep-sea species, including myctophids (lanternfish), may have hearing specializations and thus be able to hear higher frequencies (Deng et al. 2011, Popper 1977, 1980); however, it has not been possible to do actual measures of hearing on these fish from great depths.

Several species of reef fish tested show sensitivity to higher frequencies (i.e., over 1,000 Hz). The hearing of the shoulderbar soldierfish (*Myripristis kuntee*) has an auditory range extending toward 3 kHz (Coombs and Popper 1979), while other species tested in this family have been demonstrated to lack this higher frequency hearing ability (e.g., Hawaiian squirrelfish [*Adioryx xantherythrus*] and saber squirrelfish [*Sargocentron spiniferum*]). Some damselfish can hear frequencies of up to 2 kHz, but with best sensitivity well below 1 kHz (Egner and Mann 2005, Kenyon 1996, Wright et al. 2007, Wright et al. 2005).

Sciaenid research by Ramcharitar et al. (2006) investigated the hearing sensitivity of weakfish (*Cynoscion regalis*). Weakfish were found to detect frequencies up to 2 kHz. The sciaenid with the greatest hearing sensitivity discovered thus far is the silver perch (*Bairdiella chrysoura*), which has responded to sounds up to 4 kHz (Ramcharitar et al. 2004). Other species tested in the family Sciaenidae have been demonstrated to lack this higher frequency sensitivity.

It is possible that the Atlantic cod (*Gadus morhua*, Family: Gadidae) is also able to detect high-frequency sounds (Astrup and Mohl 1993). However, in Astrup and Mohl's (1993) study it is feasible that the cod was detecting the stimulus using touch receptors that were over driven by very intense fish-finding sonar emissions (Astrup 1999, Ladich and Popper 2004). Nevertheless, Astrup and Mohl (1993) indicated that cod have high frequency thresholds of up to 38 kHz at 185–200 decibels (dB) referenced to (re) 1 micropascal (μPa), which likely only allows for detection of odontocete's clicks at distances no greater than 33–98 ft. (10–30 m) (Astrup 1999).

Experiments on several species of the Clupeidae (e.g., herrings, shads, and menhadens) have obtained responses to frequencies between 40 and 180 kHz (Astrup 1999); however, not all clupeid species tested have demonstrated this very high-frequency hearing. Mann et al. (1998) reported that the American shad can detect sounds from 0.1 to 180 kHz with two regions of best sensitivity: one from 0.2 to 0.8 kHz, and the other from 25 to 150 kHz. This shad species has relatively high thresholds (about 145 dB re 1 μPa), which should enable the fish to detect odontocete clicks at distances up to about 656 ft. (200 m) (Mann et al. 1997). Likewise, other members of the subfamily Alosinae, including alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and Gulf menhaden (*Brevoortia patronus*), have upper hearing thresholds exceeding 100–120 kHz. In contrast, the Clupeidae bay anchovy (*Anchoa mitchilli*), scaled sardine (*Harengula jaguana*), and Spanish sardine (*Sardinella aurita*) did not respond to frequencies over 4 kHz (Gregory and Clabburn 2003, Mann et al. 2001). Mann et al. (2005) found hearing thresholds of 0.1–5 kHz for Pacific herring (*Clupea pallasii*).

Two other groups to consider are the jawless fish (Superclass: Agnatha – lamprey) and the cartilaginous fish (Class: Chondrichthyes – the sharks, rays, and chimeras). While there are some lampreys in the marine environment, virtually nothing is known about their hearing capability. They do have ears, but these are relatively primitive compared to the ears of other vertebrates, and it is unknown whether they can detect sound (Popper and Hoxter 1987). While there have been some studies on the hearing of cartilaginous fish, these have not been extensive. However, available data suggest detection of sounds from 20 to 1,000 Hz, with best sensitivity at lower ranges (Casper et al. 2003, Casper and Mann 2006, Casper and Mann 2009, Myrberg 2001). It is likely that elasmobranchs only detect low-frequency sounds because they lack a swim bladder or other pressure detector.

Most other marine species investigated to date lack higher-frequency hearing (i.e., greater than 1,000 Hz). This notably includes sturgeon species tested to date that could detect sound up to 400 or 500 Hz (Lovell et al. 2005) and Atlantic salmon that could detect sound up to about 500 Hz (Hawkins and Johnstone 1978, Kane et al. 2010).

Bony fish can produce sounds in a number of ways and use them for a number of behavioral functions (Ladich 2008). Over 30 families of fish are known to use vocalizations in aggressive interactions, whereas over 20 families known to use vocalizations in mating (Ladich 2008). Sound generated by fish as a means of communication is generally below 500 Hz (Slabbekoorn et al. 2010). The air in the swim bladder is vibrated by the sound producing structures (often muscles that are integral to the swim bladder wall) and radiates sound into the water (Zelick et al. 1999). Sprague and Luczkovich (2004) calculated that silver perch can produce drumming sounds ranging from 128 to 135 dB re 1 µPa. Female midshipman fish apparently use the auditory sense to detect and locate vocalizing males during the breeding season (Sisneros and Bass 2003).

Invertebrate Hearing and Vocalization

Very little is known about sound detection and use of sound by aquatic invertebrates (Budelmann 1992a, b, Montgomery et al. 2006, Popper et al. 2001). Organisms may detect sound by sensing either the particle motion or pressure component of sound, or both. Aquatic invertebrates probably do not detect pressure since many are generally the same density as water and few, if any, have air cavities that would function like the fish swim bladder in responding to pressure (Budelmann 1992b, Popper et al. 2001). Many aquatic invertebrates, however, have ciliated “hair” cells that may be sensitive to water movements, such as those caused by currents or water particle motion very close to a sound source (Budelmann 1992a, b, Mackie and Singla 2003). This may allow sensing of nearby prey or predators or help with local navigation.

Aquatic invertebrates that can sense local water movements with ciliated cells include cnidarians, flatworms, segmented worms, urochordates (tunicates), mollusks, and arthropods (Budelmann 1992a, b, Popper et al. 2001).The sensory capabilities of corals are largely limited to detecting water movement using receptors on their tentacles (Gochfeld 2004), and the exterior cilia of coral larvae likely help them detect nearby water movements (Vermeij et al. 2010). Some aquatic invertebrates have specialized organs called statocysts for determination of equilibrium and, in some cases, linear or angular acceleration. Statocysts allow an animal to sense movement and may enable some species, such as cephalopods and crustaceans, to be sensitive to water particle movements associated with sound (Hu et al. 2009, Kaifu et al. 2008, Montgomery et al. 2006, Popper et al. 2001). Because any acoustic sensory capabilities, if present at all, are limited to detecting water motion, and water particle motion near a sound source falls off rapidly with distance, aquatic invertebrates are probably limited to detecting nearby sound sources rather than sound caused by pressure waves from distant sources.

Both behavioral and auditory brainstem response studies suggest that crustaceans may sense sounds up to 3 kHz, but best sensitivity is likely below 200 Hz (Goodall et al. 1990, Lovell et al. 2005, Lovell et al. 2006). Most cephalopods (e.g., octopus and squid) likely sense low-frequency sound below 1,000 Hz, with best sensitivities at lower frequencies (Budelmann 1992b, Mooney et al. 2010, Packard et al. 1990). A recent study found that four cephalopod species, when exposed to low-frequency sounds, presented with massive acoustic trauma that was not compatible with life (Andre et al. 2011). A few may sense higher frequencies up to 1,500 Hz (Hu et al. 2009). Squid did not respond to toothed whale ultrasonic echolocation clicks at sound pressure levels (SPLs) ranging from 199 to 226 dB re 1 µPa, likely because these clicks were outside of squid hearing range (Wilson et al. 2007). However, squid exhibited alarm responses when exposed to broadband sound from an approaching seismic airgun with received levels exceeding 145–150 dB re 1 µPa squared second root mean square (McCauley et al. 2000).

Aquatic invertebrates may produce and use sound in territorial behavior, to deter predators, to find a mate, and to pursue courtship (Popper et al. 2001). Some crustaceans produce sound by rubbing or closing hard body parts together, such as lobsters and snapping shrimp (Au and Banks 1998, Latha et al. 2005, Patek and Caldwell 2006). The snapping shrimp chorus makes up a significant portion of the ambient noise budget in many locales (Au and Banks 1998, Cato and Bell 1992). Each click is up to 215 dB re 1 µPa, with a peak around 2–5 kHz (Au and Banks 1998, Heberholz and Schmitz 2001). Other crustaceans make low-frequency rasping or rumbling noises, perhaps used in defense or territorial display, that are often obscured by ambient noise (Patek and Caldwell 2006, Patek et al. 2009).

Reef noises, such as fish pops and grunts, sea urchin grazing (around 1.0–1.2 kHz), and snapping shrimp noises (around 5 kHz) (Radford et al. 2010), may be used as a cue by some aquatic invertebrates. Nearby reef noises were observed to affect movements and settlement behavior of coral and crab larvae (Jeffs et al. 2003, Radford et al. 2007, Stanley et al. 2010, Vermeij et al. 2010). Larvae of other crustacean species, including pelagic and nocturnally emergent species that benefit from avoiding predators associated with coral reefs, appear to avoid reef noises (Simpson et al. 2011). Detection of reef noises is likely limited to short distances (less than 330 ft. [100 m]) (Vermeij et al. 2010).

4.1.1.1 Non-Impulse Stressors

Sonar and other non-impulse sound sources (e.g., underwater communications) emit sound waves into the water to detect objects, safely navigate, and communicate. This section analyzes the potential impacts of these acoustic sources on EFH and HAPC resulting from training and testing activities within the Study Area. Unlike explosives and other impulse stressors, only water column EFH and HAPC within the Study Area may be temporarily impacted by non-impulse sound effects. The analysis of impacts on the water column environment for fish and invertebrates is limited to physical injury or mortality where those impacts may occur. Hearing loss, auditory masking, physiological stress, and behavioral reactions to impulse stressors beyond the range of physical impacts are assumed but not quantified, and are included with the physical impacts.

4.1.1.1.1 Sonar and Other Active Acoustic Sources

Most active systems operate within specific frequencies although some harmonic frequencies may be emitted at lower SPLs. Sonar use associated with ASW would emit the most non-impulse sound underwater during training and testing activities. Sonar use associated with MIW would also contribute a notable portion of overall non-impulse sound. Other sources of non-impulse noise include acoustic communications, sonar used in navigation, and other sound sources used in testing.

Underwater sound propagation is highly dependent upon environmental characteristics such as bathymetry, substrate and bottom type, 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. A very simple estimate of sonar transmission loss can be calculated using the spherical spreading law, $TL = 20 \log_{10} r$, where r is the distance from the sound source and TL is the transmission loss in decibels. While a simple example is provided here for illustration, the Navy Acoustic Effects Model takes into account the influence of multiple factors to predict acoustic propagation (U.S. Department of the Navy 2012).The simplified estimate of spreading loss for a ping from a hull-mounted tactical sonar with a representative source level of 235 dB re 1 µPa is shown in Figure 4-1. The figure shows that sound levels drop off significantly near the source, followed by a more steady reduction with distance. Most non-impulse sound sources used during training and testing have sound source levels lower than this example.

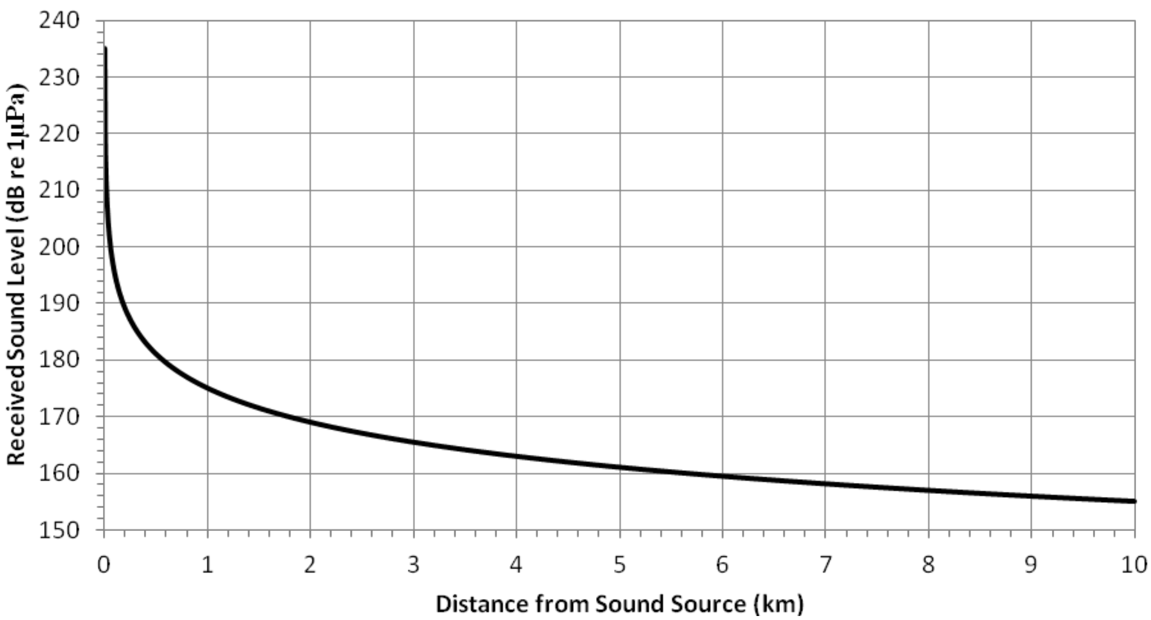

Figure 4-1: Estimate of Spreading Loss for a 235 Decibels Referenced to 1 Micropascal Sound Source Assuming Simple Spherical Spreading Loss

Most use of active acoustic sources involves a single unit or several units (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. Anti-submarine warfare activities may also use an acoustic target or an acoustic decoy.

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. While some ASW systems may be tested in the Inland Waters, ASW training activities would occur only in the offshore portion of the Study Area.

- Ship tactical hull-mounted sonar contributes a small portion of overall non-impulse sound in the Action 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; and
- 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.

Other Active Acoustic Sources

Active sound sources used for navigation and obtaining oceanographic information (e.g., depth, bathymetry, and speed) are typically directional, have high duty cycles, and cover a wide range of frequencies, from mid-frequency to very high frequency. These sources are similar to the navigation systems on standard large commercial and oceanographic vessels. Sound sources used in communications are typically high frequency or very high frequency. These sound sources could be used by vessels during most activities and while transiting throughout the Study Area.

Potential Impacts to the Water Column

Sonar and other active acoustic sources would not disturb the substrate, but they could affect the pelagic water column as a habitat for fish and invertebrates. Potential impacts on the water column habitat from active acoustic sources would mainly include impacts on species occupying the water column and their prey, including fish and invertebrates. These potential impacts could include physical injury, mortality, hearing loss, auditory masking, physiological stress, or behavioral reactions for those species.

Potential direct injuries from non-impulse sound sources, such as sonar, are unlikely because of the relatively lower peak pressures and slower rise times than potentially injurious sources such as explosives. Non-impulse sources also lack the strong shock wave such as that associated with an explosion. Therefore, direct injury is not likely to occur from exposure to non-impulse sources such as sonar, vessel noise, or subsonic aircraft noise. The theories of sonar induced acoustic resonance, bubble formation, neurotrauma, and lateral line system injury are discussed below, although these phenomena are difficult to recreate under real-world conditions and are therefore unlikely to occur.

Two reports examined impacts from mid-frequency sonar-like signals (1.5–6.5 kHz) on larval and juvenile fishes (Jørgensen et al. 2005, Kvadsheim and Sevaldsen 2005). Jørgensen et al. (2005) exposed herring (*Clupea harengus*), Atlantic cod (*Gadus morhua*), saithe (*Pollachius virens*), and spotted wolffish (*Anarhichas minor*) to various sounds to investigate the potential effects on survival, development, and behavior. Fishes of various developmental stages were placed in plastic bags 10 ft. (3 m) from the test sound source and exposed to between four and 100 pulses of 1-second duration of pure tones at 1.5, 4, and 6.5 kHz. One of the four species tested, herring, exhibited adverse effects. Two out of the 82 groups tested resulted in a post-exposure mortality of 20–30 percent, which occurred at SPLs of 189 dB re 1 µPa. and. In the remaining 80 groups tested, there were no effects on behavior, growth (length and weight), or the survival of fish observed up to 34 days post exposure. While statistically significant losses were documented in two groups, these sound levels were only tested once, so it is unknown if the increased mortality was due to the level of the test signal or other factors.

Another study looked at the impacts from mid-frequency signals (2.8–3.8 kHz) on various species of caged fish (Halvorsen et al. 2012). This study included exposing fish to a 2-second sound ranging from 2.8 to 3.8 kHz followed by a 1-second sound at 3.3 kHz. This cycle was repeated every 25 seconds for five repetitions. The overall exposure was found to have no effect on the hearing sensitive of rainbow trout. There was an observed temporary threshold shift for a group of channel catfish, but no mortality was associated with the exposure.

High SPLs may cause bubbles to form from micronuclei in the blood stream or other tissues of animals, possibly causing embolism damage (Ketten 1998). Fish have small capillaries where these bubbles could lodge, leading to rupture and internal bleeding. It has also been speculated that this phenomena could occur within the eye tissue of fish due to naturally occurring high gas saturation (Popper and Hastings 2009).

As reviewed in Popper and Hastings (2009), Hastings (1990, 1995) found acoustic stunning (loss of consciousness) in blue gouramis (*Trichogaster trichopterus*) following an 8-minute exposure to a 150 Hz pure tone with a peak SPL of 198 dB re 1 µPa. Blue gouramis have an air bubble in the mouth cavity directly adjacent to their braincase that may have contributed to or caused this injury. Hastings (1990, 1995) also recorded mortality associated with continuous wave sound in goldfish *(Carassius auratus)* exposed to 2 hours at 250 Hz with peak pressures of 204 dB re 1 µPa, and fathead minnows (*Pimephales promelas*) exposed to 0.5 hour of 150 Hz at a peak level of 198 dB re 1 µPa.

The only study on the effect of exposure of the lateral line system to continuous wave sound (conducted on one freshwater species) suggests no effect on these sensory cells by intense pure tone signals (Hastings et al. 1996).

The most familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. This phenomenon is called a noise-induced threshold shift, or simply a threshold shift (Miller 1974). A temporary threshold shift is a temporary, recoverable loss of hearing sensitivity over a small range of frequencies related to the sound source to which the fish was exposed. A temporary threshold shift may last several minutes to several weeks and the duration is related to the intensity of the sound source and the duration of the sound (including multiple exposures). A permanent threshold shift is non-recoverable, results from the destruction of tissues within the auditory system, and can occur over a small range of frequencies related to the sound exposure. As with temporary threshold shift, the animal does not become deaf but requires a louder sound stimulus (relative to the amount of permanent threshold shift) to detect a sound within the affected frequencies; however, in this case, the affect is permanent.

Permanent hearing loss or permanent threshold shift has yet to be documented in fish. The sensory hair cells of the inner ear in fish can regenerate after they are damaged, unlike in mammals where sensory hair cells loss is permanent (Lombarte and Popper 1994, Smith et al. 2006). As a consequence, any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells that were damaged or destroyed (Smith et al. 2006).

Although some species may be able to produce sound at higher frequencies (greater than 1 kHz), vocal marine fish largely communicate below the range of mid-frequency levels used by most sonar. Further, most marine fish species are not expected to be able to detect sounds in the mid-frequency range of the operational sonar. The fish species that are known to detect mid-frequencies (including most clupeids) do not have their best sensitivities in the range of the operational sonar. Thus, these fish can only hear mid-frequency sounds when sonar are operating at high energy levels or the fish are in proximity to the sonar. Considering the low-frequency detection of most marine species and the limited time of exposure due to the moving sound sources, most MFAS used in the Action Area would not have the potential to substantially mask key environmental sounds.

While not likely for MFAS, the low-frequency active sonar (LFAS) may have a greater ability to mask biologically important sounds due to their operational frequency range coinciding with range detectable and used for communication by most marine fish species. Based on the low level and short duration of potential exposure for most marine fish, it is unlikely that the use of the LFAS will cause substantial masking of biologically important sounds. Fish within a few tens of kilometers around LFAS could experience brief periods of masking while the system is used, with effects most pronounced closer to the source. However, overall effects would be localized and infrequent.

Exposure of many fish species to sonar and other acoustic sources has the potential to result in stress to the animal and may also elicit alterations in normal behavior patterns (e.g., swimming, feeding, resting, spawning, etc.). Such impacts may have the potential to affect the long-term growth and survival of an individual. However, due to the temporary and infrequent nature of sonar use in the Study Area, the resulting stress on fish is not likely to impact the health of resident populations. Likewise, although some fish in the vicinity of training and testing activities may react to sonar, the sounds are relatively temporary and infrequent in nature. Any behavioral changes are not expected to have lasting effects on the survival, growth, or reproduction of fish species.

While some marine fish may be able to detect mid-frequency sounds, most marine fish are hearing generalists and have their best hearing sensitivity below mid-frequency sonar. If they occur, behavioral responses would be brief, and unlikely to have any substantial costs. Kvadsheim and Sevaldsen (2005) reported no behavioral reaction of herrings to low- and mid-frequency sonar. Sustained auditory damage is not expected. Sensitive life stages (juvenile fish, larvae, and eggs) very close to the sonar source may experience injury or mortality, but area-wide effects would likely be minor. For these reasons, the use of mid-frequency sonar would not significantly affect fish or fish populations.

Since high-frequency sound attenuates quickly in the water, high levels of sound would be restricted to areas near the source. Most species would probably not hear these sounds and would therefore experience no disturbance, and even for fish able to hear sound at high frequencies, only short-term exposure would occur and effects would be transitory and of little biological consequence.

In summary, sonar use could affect water column habitat by affecting marine fish species by masking ecologically important sounds, inducing stress, altering behaviors, or changing hearing thresholds. Hearing specialists are more likely to be impacted than generalists due to their ability to detect both low- and mid-frequency sounds. This could be particularly relevant to the Clupeidae family (herrings), as some species can detect ultrasonic sounds in the range of mid- and high-frequency sonar. However, any such effects would be temporary and infrequent as a vessel operating mid-frequency sonar transits an area. There is no information available to suggest that exposure to non-impulse acoustic sources results in fish mortality. As such, sonar use is unlikely to impact fish species.

Training Activities

Training activities involving the use of sonar would be concentrated in the Offshore Area and the Inland Waters. The annual hours of sonar and other active acoustic sources from Navy training activities are listed in Table 4-4.

Training activities involving the use of non-impulse acoustic stressors as part of the Proposed Action may reduce the quality of water column EFH through the increase in ambient noise levels. This potential reduction would be localized to the area of the training activity and be only temporary in duration. The quality of the water column as EFH would be restored to normal levels immediately following the completion of the training activities. Therefore, non-impulse acoustic sources may adversely affect water column EFH; however, these effects would be minimal and temporary. There is no anticipated effect of non-impulse acoustic sources, including sonar, on benthic substrates and biogenic habitats designated as EFH or on HAPCs.

Testing Activities

Testing activities involving the use of sonar would occur in the Offshore Area and the Inland Waters. The annual hours of sonar and other active acoustic sources from Navy testing activities are listed in Table 4-3.

Testing events involving the use of non-impulse acoustic stressors as part of the Proposed Action may reduce the quality of water column EFH through the increase in ambient noise levels. This potential reduction would be localized to the area of the testing event and be only temporary in duration. The quality of the water column as EFH would be restored to normal levels immediately following the completion of the testing events. Therefore, non-impulse acoustic sources may adversely affect water column EFH; however, these effects would be minimal and temporary. Non-impulse acoustic sources, including sonar, would have no effect on benthic substrates and biogenic habitats designated as EFH or on HAPCs.

4.1.1.1.2 Vessel Noise

Naval vessels (including ships, small craft, and submarines) would produce low-frequency, broadband underwater sound. In the EEZ, Navy ships are estimated to contribute roughly 1 percent of the total energy due to large vessel broadband noise (Mintz and Filadelfo 2011, Mintz and Parker 2006).

Vessel movements involve transit to and from ports to various locations within the Study Area, and many ongoing and proposed training and testing activities within the Study Area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels). Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to 2 weeks. Navy traffic would be concentrated near ports or naval installations and training ranges (Mintz and Filadelfo 2011). Additionally, a variety of small boats will be operated within the Study Area. These small craft types, sizes, and speeds vary, but in general, they will emit higher frequency noise than larger ships.

There would be no effect to physical or chemical properties of the water column. However, vessel movements have the potential to expose fish and invertebrates, which are considered an element of the water column habitat, to sound and general disturbance, which could result in short-term behavioral or physiological responses (e.g., avoidance, stress, increased heart rate). While vessel movements have the potential to expose fish and invertebrates occupying the water column to sound and general disturbance, potentially resulting in short-term behavioral or physiological responses, such responses would not be expected to compromise the general health or condition of individuals.

Based on the information above, there is no effect on the water column EFH or on HAPCs due to vessel noise generated from Navy training or testing activities throughout the Study Area.

4.1.1.2 Impulse Stressors

Underwater explosions and weapons firing noise produce a rapid pressure rise and high peak pressure (see relevant section below for supporting details). This section analyzes the potential impacts of these explosive and other impulse sources on EFH and HAPC resulting from training and testing activities within the Study Area. Unlike non-impulse stressors, all habitats within the Study Area may be physically impacted by impulse sound effects. The analysis of impacts on the water column environment for biological properties of the habitat, including fish and invertebrates, is limited to physical injury or mortality. Hearing loss, auditory masking, physiological stress, and behavioral reactions to impulse stressors beyond the range of physical impacts are assumed but not quantified, and included with the physical impacts. Section 4.1.1.1 (Non-Impulse Stressors) describes the non-lethal impacts of sound on fish and invertebrates.

4.1.1.2.1 Explosives

Explosive detonations are associated with high-explosive ordnance, including bombs, missiles, torpedoes, and naval gun shells; mines and charges; explosive sonobuoys; and anti-swimmer grenades. Most explosive detonations during training and testing would be at or below the water surface, although charges associated with mine neutralization could occur near the ocean bottom. While most detonations would occur in waters greater than 33 fm (61 m) in depth, mine neutralization events would typically occur in shallower waters (less than 33 fm [61 m]). With the exception of the underwater detonations (UNDETs) conducted at the near-shore designated areas of Hood Canal and Crescent Harbor, all training and testing activities using explosives at sea would occur beyond state waters (3 nm).

In general, explosive events would consist of a single explosion or multiple explosions over a short period. During training, all large, 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, and it is estimated that 99 percent of them would explode within 5 ft. of the ocean surface (U.S. Department of the Navy 2005). Table 4-4 shows parameters of some ordnance detonated during training and testing activities.

Underwater explosions create a cavity filled with high-pressure gas, which pushes the water out against the opposing external hydrostatic pressure. At the instant of explosion, a certain amount of gas is instantaneously generated at high pressure and temperature, creating a bubble. In addition, the heat causes a certain amount of water to vaporize, adding to the volume of the bubble. This action immediately begins to force the water in contact with the blast front in an outward direction. This intense pressure wave, called a "shock wave," passes into the surrounding medium and travels faster than the speed of sound. Noise associated with the blast is also transmitted into the surrounding medium as acoustic waves. As the pressure waves generated by the explosion travel, they will interact with the surface and seafloor, lose energy, and be perceived as acoustic waves.

Table 4-4: Representative Ordnance, Net Explosive Weights, and Detonation Depths

Ordnance	Net Explosive Weight (lb.)	Detonation Depth
Shock wave action generator	0.033	Throughout the water column
76-millimeter round	2	1 foot (ft.) (0.3 meter [m])
Sonobuoy charge	5	Throughout the water column
Hellfire Air-to-Ground Missile 114 rocket	8	At or just below water's surface
5 in. Naval gunfire	8	1 ft. (0.3 m)
Maverick missile	100	At or just below water's surface
MK-20 bomb	110	2–3 ft. (0.6–0.9 m)
MK-82 bomb	192	2–3 ft. (0.6–0.9 m)
MK-83 bomb	416	2–3 ft. (0.6–0.9 m)
Explosive ordnance detonation charges	1.5, 2.5	Throughout the water column
MK-48 torpedo	650	Subsurface
MK-84 bomb	945	2–3 ft. (0.6–0.9 m)

Notes: in. = inches, lb. = pound(s)

The detonation depth of an explosive is important because of the propagation effect known as surface-image interference. For sources located near the sea surface, a distinct interference pattern arises from reflection from the water's surface. As the source depth or the source frequency decreases, these two paths increasingly, destructively interfere with each other, reaching total cancellation at the surface (barring surface reflection scattering loss). The larger explosive sources used in military activities are munitions that detonate essentially upon impact with the ocean surface. The effective source depths are quite shallow and, therefore, the surface-image interference effect can be pronounced.

Potential Impacts to the Water Column

An explosion detonated near the surface would not disturb the substrate, but the shock wave could affect the pelagic water column as a habitat for fish and invertebrates. The expanding gases can set up a pulsating bubble whose recurring pressure waves also may contribute significantly to damage. Many animals, especially smaller animals, are unlikely to survive if they are present in the region of bulk cavitation. Cavitation occurs when shock waves, which are generated by the UNDET of an explosive charge, propagate to the surface and are reflected back into the water as rarefaction (or negative pressure) waves. These rarefaction waves cause a state of tension to occur within a large region of water. Since water cannot ordinarily sustain a significant amount of tension, it cavitates and the surrounding pressure drops to the vapor pressure of water. The region in which this occurs is known as the cavitation region, and includes all water cavitating at any time after the detonation of the explosive charge. The upper and lower boundaries form what is referred to as the cavitation envelope (U.S. Department of the Navy 2008a, b). A water hammer pulse is generated when the upper and lower layers of the cavitation region rejoin (close).

Concern about potential fish mortality associated with the use of at-sea explosives led military researchers to develop mathematical and computer models that predict safe ranges for fish and other animals from explosions of various sizes (Goertner 1982, Goertner et al. 1994, Yelverton et al. 1975). Young (1991) provides equations that allow estimation of the potential effect of underwater explosions on fish possessing swim bladders using a damage prediction method developed by Goertner (1982). Young's parameters include the size of the fish and its location relative to the explosive source, but are independent of environmental conditions (e.g., depth of fish and explosive shot frequency). An example of such model predictions is shown in Table 4-5, which lists estimated explosive-effects ranges using Young's (1991) method for fish possessing swim bladders exposed to explosions. The 10 percent mortality range is the distance beyond which 90 percent of the fish present would be expected to survive. It is difficult to predict the range of more subtle effects causing injury but not mortality (Continental Shelf Associates 2004).

Table 4-5: Representative Estimated Explosive Effects Ranges for Fish with Swim Bladders

Training Operation and Type of Ordnance	NEW (lb.)	Depth of Explosion (ft.)	10% Mortality Range (ft.)		
			1 oz. Fish	1 lb. Fish	30 lb. Fish
Mine Neutralization					
SWAG Charge	0.033	10	87	61	39
1.5 lb. NEW UNDET Charge	3.24	20	366	255	164
2.5 lb. NEW UNDET Charge	20	20	609	425	273
Missile Exercise					
Hellfire	8	3.3	317	221	142
Maverick	100	3.3	643	449	288
Firing Exercise with IMPASS					
HE Naval Gun Shell, 5-inch	8	1	244	170	109
Bombing Exercise					
MK-82	192.2	3.3	772	539	346
MK-83	415.8	3.3	959	668	430
MK-84	945	3.3	1,206	841	541

Notes: AMNS = Airborne Mine Neutralization System, ft. = feet, HE = High Explosive, IMPASS = Integrated Maritime Portable Acoustic Scoring, lb. = pounds, NEW = net explosive weight, oz. = ounce, SWAG = Shock Wave Action Generator, UNDET = Underwater Detonation

Fish not killed or driven from a location by an explosion might change their behavior, feeding pattern, or distribution. Changes in behavior of fish have been observed as a result of sound produced by explosives, with effect intensified in areas of hard substrate (Wright 1982). Fish which ascend too quickly, a typical response to fear or to avoid negative stimuli, might experience an increase in the volume of gas-filled organs due to the reduction in ambient pressure. The resulting inflation might render the fish unable to immediately return to its normal habitat depth because the expanded organs make the buoyancy of the fish too great to overcome by swimming downward. Stunning from pressure waves could also temporarily immobilize fish, making them more susceptible to predation.

The few studies of marine invertebrates (crustaceans and mollusks) exposed to explosions show a range of impacts, from mortality close to the source to no observable effects. Limited studies of crustaceans have examined mortality rates at various distances from detonations in shallow water (Aplin 1947, Chesapeake Biological Laboratory 1948, Gaspin et al. 1976). Similar studies of mollusks have shown them to be more resistant than crustaceans to explosive impacts (Chesapeake Biological Laboratory 1948, Gaspin et al. 1976). Other invertebrates found in association with mollusks, such as sea anemones, polychaete worms, isopods, and amphipods, were observed to be undamaged in areas near detonations (Gaspin et al. 1976). Using data from these experiments, Young (1991) developed curves that estimate the distance from an explosion beyond which at least 90 percent of certain marine invertebrates would survive, depending on the weight of the explosive (Figure 4-2). In deeper waters where most detonations would occur near the water surface, most benthic marine invertebrates would be beyond the 90 percent survivability ranges shown above, even for larger explosives, up to 1,000 lb. net explosive weight [NEW].

The number of fish or invertebrates affected by an underwater explosion would depend on the population density in the vicinity of the blast, as well as factors discussed above such as NEW, depth of the explosion, and fish size. For example, if an explosion occurred in the middle of a dense school of menhaden, herring, or other schooling fish, a large number of fish could be killed. Individually, such explosions represent minimal mortality in terms of the total population of such fish in the Study Area. The cumulative effect of multiple explosions over a period of time could have greater than minimal impacts on fish or invertebrate populations, but this is very difficult to quantify without density and biomass estimates of fish within the impact footprint.

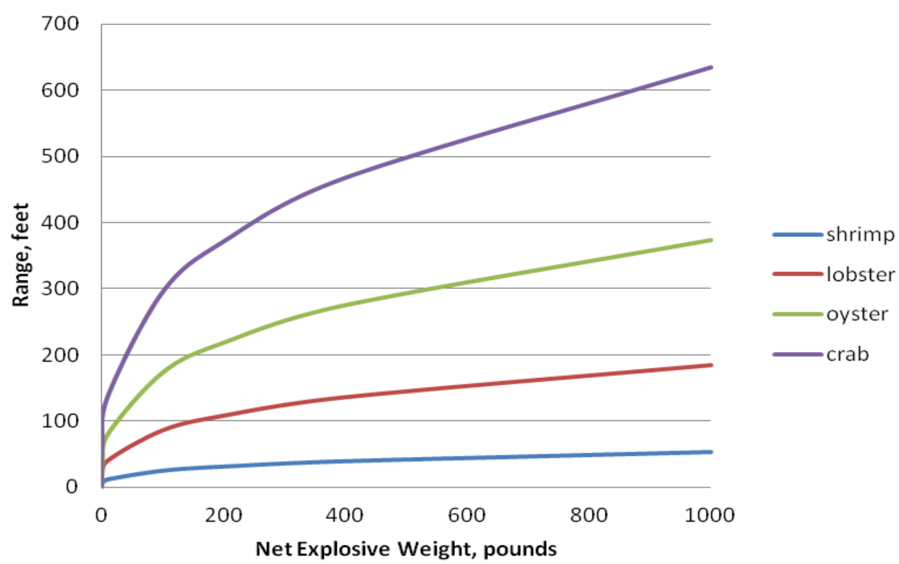

Figure 4-2: Prediction of Distance to 10 Percent Mortality of Marine Invertebrates Exposed to an Underwater Explosion (Young 1991)

The worst case scenario for explosive impacts on fish and invertebrates in the water column is based on information from Table 4-5 (representative explosive munitions), and Figure 4-2 (10 percent mortality range for crab). The range to less than 10 percent mortality is very similar for both a 30 lb. (13.6 kg) fish and a crab. The total impact area assumes no overlap in footprints, which is unlikely considering the point of targets in training and testing activities (e.g., hit the target). Such calculations provide one of the variables necessary in determining the level impact. A determination of population level impacts requires more information on the density and biomass of managed species and life-stages in the Study Area than is currently available.

Potential Impacts to Benthic Substrates and Biogenic Habitats

An explosive detonated near the seafloor could disturb the substrate and associated biogenic habitats. For a specific size of explosive charge, crater depths and widths would vary depending on depth of the charge and substrate type. There is a nonlinear relationship between crater size and depth of water, 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). Radii of the craters reportedly vary little among unconsolidated substrate types (O'Keeffe and Young 1984). On substrate types with non-adhesive particles (everything except clay), the effects should be temporary, whereas craters in clay may persist for years (O'Keeffe and Young 1984). The production of craters in soft bottom could uncover subsurface hard bottom, representing an alteration of marine substrate types (refer to training and testing activities sections for spatial analysis). On hard substrates, energy from bottom detonations is reflected to a greater degree than corresponding detonations on soft bottom (Berglind et al. 2009, Keevin and Hempen 1997). Due to lack of accurate and specific information on hard bottom types, the worst-case scenario for hard bottom impacted is equal to the area of soft bottom impacted (refer to training and testing activities sections for spatial analysis). The associated biogenic habitats are assumed to be destroyed with the bottom impact.

Table 4-6 lists training activities that include seafloor explosions, along with the location of the activity and the associated explosives charges. The only training activities with seafloor detonations would occur in the Inland Waters. No testing activities including seafloor detonations are proposed. Primarily soft-bottom habitat would be utilized for UNDETs.

Table 4-6: Training and Testing Activities that Include Seafloor Explosions

Activity	Explosive Charge (lb. NEW)	Underwater Detonations	Location
Training			
Mine Neutralization (Explosive Ordnance Disposal)	2.5	3	Crescent Harbor Explosive Ordnance Disposal Training Range
	2.5	3	Hood Canal Explosive Ordnance Disposal Training Range
	1.5	0	Hood Canal Explosive Ordnance Disposal Training Range
Shock Wave Action Generator (SWAG)	0.033	18	Crescent Harbor Explosive Ordnance Disposal Training Range
		18	Hood Canal Explosive Ordnance Disposal Training Range

Notes: lb. = pound(s), NEW = net explosive weight

Under the Proposed Action, an estimated 42 underwater explosions would occur within the Inland Waters, some of which could occur on or near the seafloor, as identified in Table 4-6.

The determination of effect for training activities on the seafloor is based on the largest net-weight charge for each training activity. 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 would 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).

In general, training activities that include seafloor detonations occur in water depths ranging from 6 ft. (1.8 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)[3]

[3] Pounds per cubic inch of trinitrotoluene (1.64 grams/cubic centimeters) x number of pounds, then solving for radius in the geometry of a spherical volume

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 lb. (27 kg) explosive charge (r_0 = 0.16 m) on a sandy bottom would produce a maximum crater size of approximately 31 ft. (10 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, yielding a crater diameter of 62 ft. (19 m) and an area of 3,060 ft.^{2} (284 m^2) of impacted substrate. The area of impacted substrate for each 15 lb. (6.8 kg) and 29 lb. (13 kg) underwater explosion on the seafloor would be approximately 1,210 ft.^{2} (112 m^2) and 1,880 ft.^{2} (174 m^2), respectively. 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 varies 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. A small potential exists for fracturing and damage to hard-bottom habitat if UNDETs occur over that type of habitat.

Training Activities

The total area of disturbed sediment per year in the Inland Waters from detonations from training activities in the Inland Waters would be approximately 579.8 ft.^{2} (68 m^2), or less than 1 percent. This total assumes all detonations would occur on or near the bottom. 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, 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 Proposed Action may result in short- to long-term impacts to soft bottom habitats and permanent impacts to hard bottom substrates.

The use of underwater explosions during training activities may adversely affect soft bottom substrate. However, these effects are determined to range from short- to long-term and individually minimal effects. Adverse effects to hard bottom substrate are unlikely, as underwater explosive training activities are performed in soft bottom habitat. The affected area covers 579.8 ft.^{2} (68 m^2), or less than 1 percent of the available substrate in the Study Area.

Training activities using explosives that could potentially affect water column EFH would be conducted throughout Offshore Area. Figure 4-2 represents the zone of greater than 10 percent mortality of crab or 30 lb. fish (refer to Section 4.1.1.2.1, Explosives, for details on methods). Table 4-7 lists training activities that include explosions in the water column of the Offshore Area.

If all the munitions listed in Table 4-7 were detonated such that their impact footprints did not overlap (very unlikely), the sum of potential temporary impacts per year on EFH waters in the Offshore Area would be 12.74 km^2, compared to approximately 416,845 km^2 of ocean surface area within the Study Area (0.00003 percent of available habitat).

Table 4-7: Explosions in the Water Column from Training Activities in the Offshore Area, and Their Impact on Water Column Essential Fish Habitat

Munitions Category	Training	
	Number of Explosions	Impact Footprint (km^2)[1]
Sonobuoys	0	0.45
Bombs	10	1.13
Missiles	27	1.85
Large-Caliber Projectiles	390	2.05
Medium-Caliber Projectiles	6,498	7.26

[1] The impact footprint (in square kilometers [km^2]) represents the zone of less than 10 percent mortality of crab or 30-pound (14-kilogram) fish.
Note: km^2 = square kilometer(s)

Given that less than 0.00003 percent of the offshore ocean waters would be affected using a very unlikely worst case scenario, the use of underwater explosives during training activities may adversely affect water column EFH; however, these effects would be temporary and individually minimal throughout the Study Area.

Testing Activities

No testing activities with seafloor detonations are proposed anywhere in the Study Area, and therefore impacts to benthic substrate EFH would not occur from this stressor.

Testing activities using explosives that could potentially affect water column EFH would be conducted in the Offshore Area only. Relevant activities include only torpedoes and sonobuoys. The impact footprints presented in Table 4-8 represents the zone of greater than 10 percent mortality of crab or 30 lb. (14 kg) fish (refer to Section 4.1.1.2.1, Explosives, for details on methods).

If all the munitions listed in Table 4-8 were detonated such that their impact footprints did not overlap (very unlikely), the sum of potential temporary impacts per year on EFH waters in the Offshore Area would be 0.9 km^2, compared to approximately 416,845 km^2 of ocean surface area within the Study Area (0.000002 percent of available habitat).

Table 4-8: Explosions in the Water Column from Testing Activities (Excluding Explosion on or near the Bottom) and Their Impact on Water Column Essential Fish Habitat

Munitions Category	Testing	
	Number of Explosions	Impact Footprint (km^2)[1]
Sonobuoys	142	0.4
Torpedoes	6	0.5

[1] The impact footprint represents the zone of less than 10 percent mortality of crab or 30 lb. (14 kg) fish.
Note: km^2 = square kilometer(s)

Given that less than 0.000002 percent of offshore ocean waters are affected using a very unlikely worst case scenario, the use of underwater explosions during testing activities may adversely affect water column EFH; however, these effects would be temporary and individually minimal throughout the Study Area.

4.1.1.2.2 Weapons Firing, Launch, and Impact Noise

Noise associated with weapons firing training and non-explosive impact could happen at any location within the Study Area but generally would occur at locations greater than 12 nm from shore. Testing activities involving weapons firing noise would be those events involved with testing weapons and launch systems. These activities would also take place throughout the Study Area.

The firing of a weapon may have several components of associated noise. Firing of guns could have acoustic effects from 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 4-9). Missiles and targets would produce noise during launch. In addition, impact of non-explosive practice munitions (NEPM) can introduce sound into the water.

Table 4-9: 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 five ft. below water surface
Airborne	
Naval Gunfire Muzzle Noise (5 in./54-caliber)	178 dB re 20 µPa directly below the gun muzzle above the water surface
Hellfire Missile Launch from Aircraft	149 dB re 20 µPa at 4.5 m
7.62 mm M-60 Machine Gun	90 dBA re 20 µPa at 50 ft.
0.50-caliber Machine Gun	98 dBA re 20 µPa at 50 ft.

Notes: dB = decibels; dBA = decibels, A-weighted; ft. = feet; µPa = micropascal; re = referenced to; in. = inches; m = meters; mm = millimeters

4.1.1.2.3 Naval Gunfire Noise

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. 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. (12.7 cm) 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. 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-seconds. 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. (12.7 cm) 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 degrees) behind the projectile in the direction of fire (Pater 1981). Measurements of a 5 in. (12.7 cm) 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 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 Impact Noise

Mines, non-explosive bombs, and intact missiles and targets could impact the water with great force and produce a large impulse and loud noise. 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. McLennan (1997) calculated the sound from large targets (over 4,400 lb. [2,000 kg]) hitting the water at speeds of over 3,280 ft./s (1,000 m/s) to have source levels in water of approximately 291 dB re 1 µPa re 1 m, although with very short pulse durations. However, the model may be an oversimplification for several stated reasons, and measurements of actual levels may yield values 10–20 dB less than theoretical predictions. Sound associated with the impact event is typically of low frequency (less than 250 Hz) and of short duration.

Weapons firing, launch, and impact noise from training and testing activities lack the strong shock wave and rapid pressure increase that would be expected from explosive detonations. Therefore, these activities may adversely affect water column EFH. However, these effects are not expected to cause direct trauma to susceptible biological properties of water column EFH such as fish or to be permanent. Other susceptible biological properties of water column EFH such as invertebrates are even less likely to experience direct trauma. Weapons firing, launch, and impact noise from training and testing activities would have no effect on abiotic substrate and associated seagrass or sedentary invertebrate beds because the pressure wave generated would not be strong enough to disrupt abiotic substrates and would only last for a very limited duration.

4.1.2 Energy Stressors

This section analyzes the potential impacts of energy stressors that can occur during training and testing activities within the Study Area, which only includes potential impacts from electromagnetic devices.

4.1.2.1 Electromagnetic Devices

The only activities that involve electromagnetic devices include the training activity Civilian Port Defense, which involves purposefully creating an electromagnetic field under water. Civilian Port Defense would occur once every other year within the Inland Waters. There are no training activities involving electromagnetic devices proposed for the Offshore Area. There are no testing activities including electromagnetic devices in any portion of the Study Area.

Electromagnetic devices are used primarily during mine detection/neutralization activities, and in most cases, the devices simply mimic the electromagnetic signature of a vessel passing through the water. None of the devices include any type of electromagnetic "pulse." The towed body used for mine sweeping is designed to simulate a ship's electromagnetic signal in the water.

Generally, voltage used to power these systems is around 30 volts (V) 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 V (capped at 55 V) 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. [10.2 cm]). 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).

Potential Impacts to the Water Column

An electromagnetic charge could affect the biological properties (which include fish and invertebrates) of the pelagic water column habitat. A comprehensive review of information regarding the sensitivity of marine organisms to electric and magnetic impulses, including fishes comprising the subclass elasmobranchii (sharks, skates, and rays; hereafter referred to as elasmobranchs), as well as other bony fishes, is presented in Normandeau et al. (2011). The synthesis of available data and information contained in this report suggests that while many fish species (particularly elasmobranchs) are sensitive to electromagnetic fields, further investigation is necessary to understand the physiological response and magnitude of the potential effects. Most examinations of electromagnetic fields on marine fishes have focused on buried undersea cables associated with offshore wind farms in European waters (Boehlert and Gill 2010, Gill 2005, Ohman et al. 2007).

Many fish groups, including elasmobranchs, salmonids, sturgeon, pacific lamprey, and others, have an acute sensitivity to electrical fields, known as electroreception (Bullock et al. 1983, Helfman et al. 2009). Extant data show that elasmobranchs are more sensitive than the other fish groups. In elasmobranchs, behavioral and physiological response to electromagnetic stimulus varies by species and age, and appears to be related to foraging behavior (Rigg et al. 2009). Many elasmobranchs respond physiologically to electric fields of 10 nanovolts (nV) per cm and behaviorally at 5 nV per cm (Collin and Whitehead 2004). Electroreceptive marine fishes identified above with ampullary (pouch) organs can detect considerably higher frequencies of 50 Hz to more than 2 kHz (Helfman et al. 2009). The distribution of electroreceptors on the head of these fishes, especially around the mouth (e.g., along the rostrum of sawfishes), suggests that these sensory organs may be used in foraging. Additionally, some researchers hypothesize that the electroreceptors aid in social communication (Collin and Whitehead 2004).

While elasmobranchs and other fishes can sense the level of the earth's electromagnetic field, the potential effects resulting from changes in the strength or orientation of the background field are not well understood. Electroreceptors are thought to aid in navigation, orientation, and migration routes of sharks and rays (Kalmijn 2000). The exact mechanism is unknown and no magnetic sensory organ has been discovered, but magnetite is incorporated into the tissues of these fishes (Helfman et al. 2009). Some species of salmon and tuna have been shown to respond to magnetic fields and may also contain magnetite in their tissues (Helfman et al. 2009). When the electromagnetic field is enhanced or altered, sensitive fishes may experience an interruption or disturbance in normal sensory perception. Research on the electrosensitivity of sharks indicates that some species respond to electrical impulses with an apparent avoidance reaction (Helfman et al. 2009, Kalmijn 2000). This avoidance response has been exploited as a shark deterrent to repel sharks from areas of overlap with human activity (Marcotte and Lowe 2008).

Both laboratory and field studies confirm that elasmobranchs and some teleost fishes are sensitive to electromagnetic fields, but the long-term impacts are not well-known. Electromagnetic sensitivity in some marine fishes (e.g., salmonids) is already well-developed at early life stages (Ohman et al. 2007), with sensitivities reported as low as 0.6 millivolt per cm in Atlantic salmon (Salmo salar) (Formicki et al. 2004); however, most of the limited research occurred on adults. Some species appear to be attracted to undersea cables, while others show avoidance (Ohman et al. 2007). Under controlled laboratory conditions, the scalloped hammerhead (*Sphyrna lewini*) and sandbar shark (*Carcharhinus plumbeus*) exhibited altered swimming and feeding behaviors in response to very weak electric fields (less than 1 nV per cm) (Kajiura and Holland 2002). A field trial in the Florida Keys demonstrated that southern stingray (*Dasyatis americana*) and nurse shark (*Ginglymostoma cirratum*) detected and avoided a fixed magnetic field producing a flux of 950 G (O'Connell et al. 2010). The maximum electromagnetic fields typically generated during Navy training and testing activities is approximately 23 G.

Little information exists regarding invertebrate susceptibility to electromagnetic fields. Most corals are thought to use water temperature, day length, and tidal fluctuations as cues for spawning. Marine invertebrates, including several commercially important species and federally managed species, have the potential to use magnetic cues (Normandeau et al. 2011). Magnetic fields are not known to control coral spawning release or larval settlement. Some arthropods such as the spiny lobster and American lobster can sense magnetic fields, and this is thought to assist the animal with navigation and orientation (Lohmann et al. 1995, Normandeau et al. 2011). These animals travel relatively long distances during their lives, and it is possible that magnetic field sensation exists for other invertebrates that travel long distances. Susceptibility experiments have focused on arthropods, but several mollusks and echinoderms are also susceptible. However, because susceptibility is variable within taxonomic groups it is not possible to make generalized predictions for groups of marine invertebrates. Sensitivity thresholds vary by species ranging from 0.3 to 30 millitesla, and responses included non-lethal physiological and behavioral changes (Normandeau et al. 2011). The primary use of magnetic cues seems to be navigation and orientation. Human-introduced electromagnetic fields have the potential to disrupt these cues and interfere with navigation, orientation, and migration. Because electromagnetic fields weaken exponentially with distance from the source, large and sustained magnetic fields present greater exposure risks than small and transient fields, even if the small field is many times stronger than the earth's magnetic field (Normandeau et al. 2011). Transient or moving electromagnetic fields may cause temporary disturbance to susceptible organisms' navigation and orientation.

The electromagnetic stressors from training and testing activities may adversely affect water column EFH in the Inland Waters due to the temporary behavioral effects on susceptible biological properties of water column EFH such as fish and invertebrates. However, these effects are expected to result in a less than minimal population-level impacts to susceptible biological properties of water column EFH.

Potential Impacts to Benthic Substrates and Biogenic Habitats

Substrate is unaffected by electromagnetic devices due to lack of a physical disturbance component. Beds of submerged rooted vegetation are unaffected because they lack a central nervous system susceptible to electromagnetic stressors. Sedentary invertebrate beds should not be impacted because their navigation and orientation is not important, though mobile larvae may be affected. Therefore, for substrate and biogenic habitat EFH, there is no adverse impact expected from electromagnetic stressors. Likewise, there are no adverse impacts expected on these habitats within HAPCs.

The use of electromagnetic stressors from training and testing activities would have no effect on benthic substrate and biogenic habitats.

4.1.3 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance and strike stressors resulting from the Navy conducting its training and testing activities within the Study Area. The water column, benthic substrates (e.g., soft and hard bottom), and biogenic habitats (e.g., mussel beds, live bottom) designated as EFH are potentially subject to physical disturbance by vessels, in-water devices, military expended material, and seafloor devices associated with Navy training and testing.

This section describes the potential characteristics of physical disturbance and strike stressors from naval training and testing activities. It also describes the relative magnitude and location of these activities to provide the basis for analysis of potential physical disturbance to designated EFH.

4.1.3.1 Vessels

Vessels are a part of nearly all training and testing exercises that occur in the NWTT Study Area. As such, Navy vessels are frequently transiting throughout the Study Area and in and out of ports. Table 4-10 provides a list of vessel types, as well as examples of each type, their typical length and speed. The potential impacts of these movements to designated EFH and HAPCs are outlined below.

Table 4-10: 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; Protection Vessels; Barge	16–250 ft. 5–80 m	Variable	20 knots
Support Craft/ Other – Specialized High Speed	Patrol Coastal Ships, Patrol Boats, Rigid Hull Inflatable Boat, High Speed Protection Vessels	33–130 ft. 10–40 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, > = greater than, + = more than

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 sites.

Potential Impacts to the Water Column

As vessels transit through an area, the water column would be temporarily disturbed. However, as the water would not be altered in any measurable or lasting manner, there would be no adverse impact to the water column itself.

Potential Impacts to Benthic Substrate

Ocean approaches would be expected to have minimal effects on soft bottom marine habitats because of the nature of high-energy surf and shifting sands. The movement of sediment by wave energy would fill in disturbed soft-bottom habitat similar to sediment recovery from a severe storm. Therefore, vessel movements in the Study Area would be expected to have a minimal effect to soft bottom marine habitats.

Physical disturbances and strikes of hard bottom substrates by vessels are undesirable due to the potential damage to the vessel, and are therefore avoided. Additionally, there are no events where contact with the seafloor is planned. Therefore, there would be no adverse impact to hard bottom substrates or artificial structures as a result of vessel movements.

Potential Impacts to Biogenic Habitats

As with hard bottom substrates, physical disturbances and strikes of benthic biogenic habitats by vessels would cause damage to the vessel and are avoided when possible. The Lookouts on Navy vessels are trained to identify benthic biogenic habitats and to avoid physical impacts where possible (see Chapter 5, Mitigation Measures). Therefore, there would be no adverse impact to benthic biogenic habitats as a result of vessel movements.

For both training and testing activities, vessel movements throughout the Study Area would may adversely affect soft bottom substrate, however these effects are expected to be minimal and temporary. Vessel movement would have no effect on the water column, hard bottom substrates, or benthic biogenic habitats designated as EFH or HAPC.

4.1.3.2 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 4-11 for a range of in-water devices used.

Table 4-11: 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, ASW = Anti-Submarine Warfare, EMATT = Expendable Mobile Anti-Submarine Warfare Training Target, m = meters, MINIROV = Miniature Remotely Operated Vehicle, RMMV = Remote Multi-Mission Vehicle, ROV = Remotely Operated Vehicle, < = less than

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 4-12 provides estimates of relative in-water device use and location under the Proposed Action. 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 4-12: Number and Location of Events Including In-Water Devices

Activity Area	Training	Testing
Offshore Area	493	154
Inland Waters	1[1]	648
Total (All Areas)	**494**	**802**

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

Potential Impacts to the Water Column

As in-water devices pass through an area, the water column would be temporarily disturbed. However, as the water would not be altered in any measurable or lasting manner, there would be no adverse impact to the water column itself.

Potential Impacts to Benthic Substrate

Physical disturbances and strikes of benthic substrates by in-water devices would cause damage to the in-water devices and are avoided when possible. The personnel operating the in-water devices are trained to identify benthic substrates using sonar and bathymetric maps and to avoid physical impacts where possible (see Chapter 5, Mitigation Measures). Hence, there would be no adverse impact to benthic substrates as a result of the use of in-water devices.

Potential Impacts to Biogenic Habitats

As with benthic substrates, physical disturbances and strikes of benthic biogenic habitats by in-water devices would cause damage to the device and are avoided when possible. The personnel operating the in-water devices vessels are trained to identify benthic biogenic habitats and to avoid physical impacts where possible (see Chapter 5, Mitigation Measures). Hence, there would be no adverse impact to benthic biogenic habitats as a result of the use of in-water devices.

For both training and testing activities, the use of in-water devices in the Offshore Area and Inland Waters would have no effect on the water column, soft or hard bottom substrates, or benthic biogenic habitats designated as EFH or HAPC.

4.1.3.3 Military Expended Materials

Many different types of military expended material remain at sea following Navy training and testing activities that occur in the Offshore Area and Inland Waters, as described in Chapter 2 (Description of the Action and the Action Area).

Military expended materials include: (1) NEPM; (2) fragments from high explosive munitions; and (3) expended materials other than ordnance, such as sonobuoys and expendable targets.

The potential for physical disturbance to habitats designated as EFH by military expended materials from Navy training and testing activities exists throughout the Study Area, although the types of military expended material vary by activity and portion of the Study Area with some locations having greater concentration of activity than others. Table 2-2 (Description of Stressors) provides a description of military expended materials that are used in Navy training and testing activities.

Potential Impacts to the Water Column

Military expended materials would either drift in the water column or pass quickly through it as they sink to the seafloor without altering the water in any measurable or lasting manner. Hence, there would be no adverse impact to the water column itself. Impacts associated with the degradation of military expended materials and their effect on water quality are discussed in Section 4.1.4 (Contaminant Stressors).

Potential Impacts to Benthic Substrate

Military expended materials have the potential to physically disturb marine substrates to the extent that they impair the substrate's ability to function as a habitat. These disturbances can result from several sources including the physical impact of the expended material contacting the substrate, the covering of the substrate by the expended material, or the alteration of the substrate from one type to another (e.g., converting soft bottom substrate into hard bottom resulting from solid expended materials overlying soft substrates). A total of 196,888 military items would be expended annually in the Offshore Area and 42 military items would be expended annually in the Inland Waters during training activities, which would result in a total impact area of approximately 19,052.92 m^2 (Table 4-13). This amount of material would be dispersed over thousands of square miles.

The likelihood of military expended materials adversely impacting substrates and biogenic habitats as they come into contact with the seafloor depends on several factors including the size, type, mass, and speed of the material; water depth; the amount of material expended; the frequency of training or testing; and the type of substrate or biogenic community, as well as the hydrodynamic regime of the area (high vs. low currents). Most of the kinetic energy of the expended material, however, is dissipated within the first few yards of the object entering the water causing it to slow considerably by the time it reaches the seafloor. Because the damage caused by a strike is proportional to the force of the strike, slower speeds generally result in lesser impacts. Countermeasures such as flares and chaff are introduced into the marine environment. These types of military expended material are not expected to impact substrates as strike stressors, given their smaller size and low velocity when deployed compared to projectiles, bombs, and missiles.

Due to the depth of water in which most training and testing events take place, a direct strike on hard bottom is unlikely to occur with sufficient force to damage the substrate. Any potential damage would be to a small portion of the structural habitat. The value of many of these substrates as habitat, however, is not dependent on the shape. An alteration in shape or structure caused by military expended materials would not necessarily reduce the habitat value of hard bottom. In softer substrates (e.g., sand, mud, silt, clay, and composites), the impact of the expended material coming into contact with the seafloor, if large enough and striking with sufficient momentum, may result in a depression and a localized redistribution of sediments as they are temporarily re-suspended into the water column.

Another potential physical disturbance military expended materials could have on substrates would be to cover them or to alter the type of substrate and, therefore, its function as habitat. The majority of military expended materials that settle on hard bottoms, while covering the substrate, would still serve the same habitat function as the substrate it is covering by providing a hard surface on which organisms can settle and attach (Figure 4-3 and Figure 4-4). Full colonization or fouling of the expended material would occur over an approximately 18-month timeframe, depending on the area (Carter and Prekel 2008). An exception would be expended materials like the parachutes that are mobile and can drift along the seafloor being deployed. Parachutes are utilized to deploy sonobuoys, lightweight torpedoes, expendable mobile ASW training targets, and other devices from aircraft that would not provide a hard surface for colonization or fouling. In these cases, the hard bottom covered by the expended material would not be physically damaged, but would have its ability to function as a habitat for colonizing or encrusting organisms impaired.

Most military expended materials that settle on soft bottom habitats, while not damaging the actual substrate, would inhibit the substrate's ability to function as a habitat by covering it with a hard surface. This would effectively alter the substrate from a soft surface to a hard structure and, therefore, would alter the ability of the substrate from one capable of supporting a soft bottom community to one that would be more appropriate as habitat for organisms more commonly found associated with hard bottom environments (Figure 4-5). Expended materials that settle in the shallower, more dynamic environments of the continental shelf would likely be eventually covered over by sediments due to currents and other coastal processes, encrusted by organisms, or remain adrift in the case of parachutes. In the deeper waters of the continental slope and beyond where currents do not play as large of a role, expended materials may remain exposed on the surface of the substrate with minimal change for extended periods (Figure 4-5). Softer expended materials, such as parachutes, would also not damage the sediments but would likely impair its ability to function as a habitat to some degree. Impacts associated with the degradation of military expended materials and their effect on sediment quality is discussed in Section 4.1.4 (Contaminant Stressors).

Potential Impacts to Biogenic Habitats

As with substrates, military expended materials have the potential to adversely impact the benthic invertebrates and vegetation that compose the biogenic habitats (e.g., sponges, macroalgae, hydroids, amphipod tubes, bryozoans) coinciding with areas where training and testing events occur. Due to their size and minimal weight, smaller items such as small-caliber projectiles may result in little to no damage to biogenic habitats while larger, heavier items such as large-caliber projectiles, bombs, or missiles may break or crush the sessile invertebrates (e.g., mussels, sponges, etc.) which may occur where military materials would be expended. Damage to these habitats would be confined to the area of impact. As observed in recent benthic surveys in the Jacksonville OPAREA, expended munitions and other hard objects that land in areas of live/hard bottom serve as colonizing structures in much the same way as the surrounding substrates (Figure 4-3 and Figure 4-4), so recovery of the area would be expected over time.

Other types of military expended materials such as parachutes, associated with certain air-dropped munitions and devices, may not adversely impact a habitat through its initial contact, but may potentially cover and/or smother the habitat over time instead. Unlike munitions and many other solid expended materials, it is unlikely that benthic invertebrates would colonize materials such as parachutes, potentially resulting in a loss of biogenic habitat in areas where parachutes settle for as long as they remain in place and intact.

Estuarine and nearshore biogenic habitats such as kelp beds, seagrass, eelgrass, and wetlands are unlikely to be impacted by military expended materials due to their close proximity to shore, well away from most areas of training and testing where military materials would be expended.

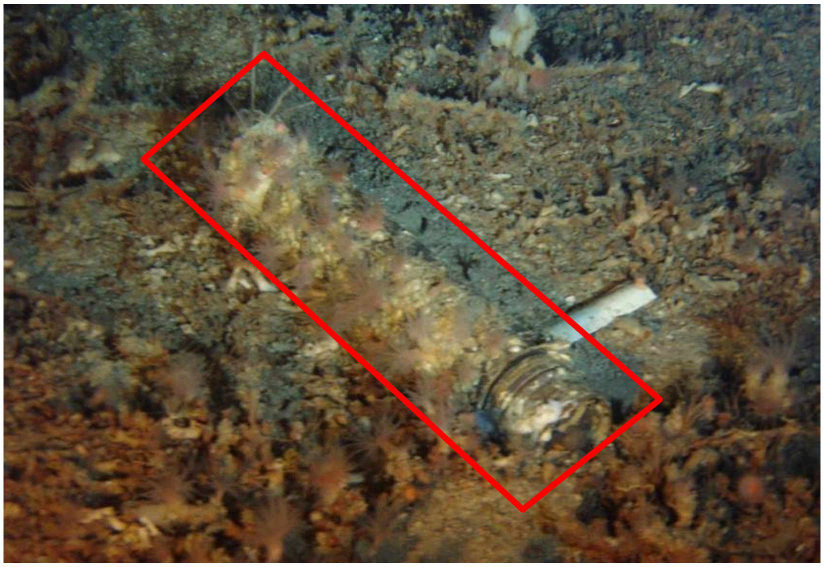

Figure 4-3: An MK-58 Smoke Float Observed in an Area Dominated by Coral Rubble on the Continental Slope

Note: Observed at approximately 191 fm (350 m) in depth and 60 nm east of Jacksonville, Florida. Of note is the use of the smoke float (outlined by red box) as a colonizing substrate for a cluster of sea anemones (U.S. Department of the Navy 2010a).

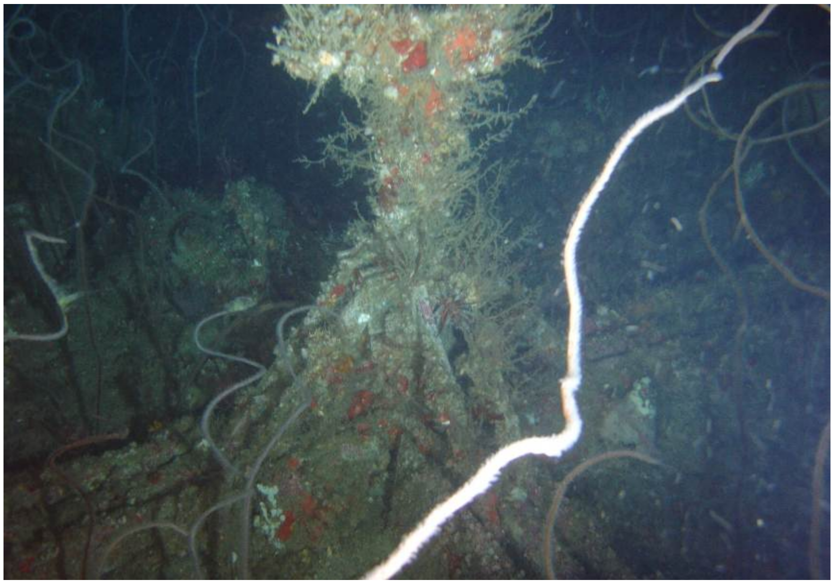

Figure 4-4: An Unidentified, Non-Military Structure Observed on the Ridge System Running Parallel to the Continental Shelf Break

Note: Observed at approximately 44 fm (80 m) in depth and 55 nm east of Jacksonville, Florida. Of note is that encrusting organisms and benthic invertebrates readily colonize the artificial structure to a similar degree as the surrounding rock outcrop (U.S. Department of the Navy 2010a).

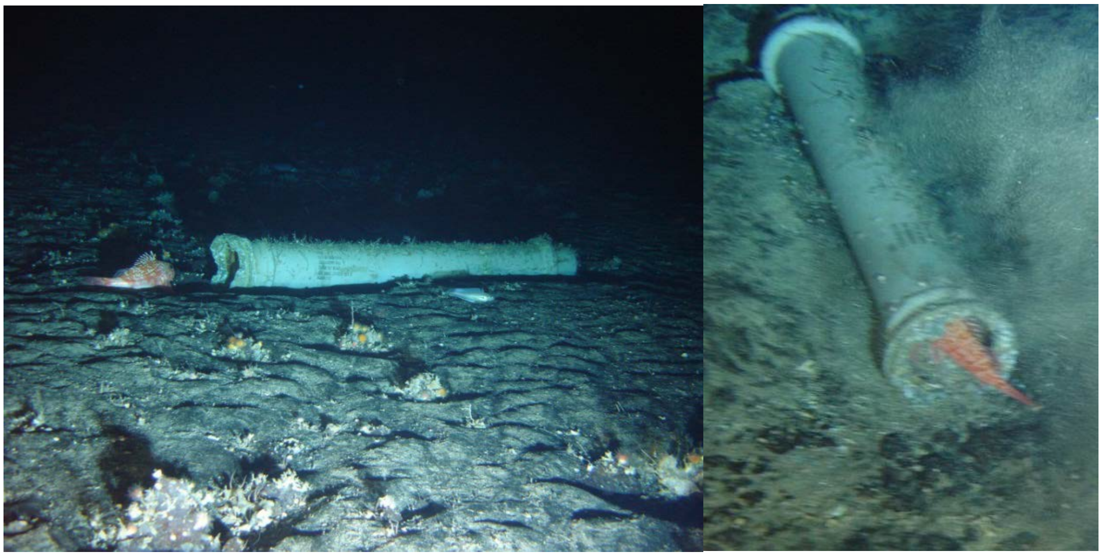

Figure 4-5: (Left) A 76-Millimeter Cartridge Casing on Soft Bottom. (Right) A Blackbelly Rosefish (*Helicolenus dactylopterus*) Using the Casing for Shelter When Disturbed

Note: The casing was observed in a sandy area on the continental slope approximately 232 fm (425 m) in depth and 70 nm east of Jacksonville, Florida. The casing has not become covered by sediments due to the depth and the relatively calm, current-free environment. When disturbed, the rosefish retreated inside the casing for protection.

4.1.3.3.1 Training Activities

Military expended materials used as part of training activities occurring in the Offshore Area and Inland Waters, have the potential to adversely affect benthic and biogenic habitats designated as EFH. In addition, designated HAPCs coinciding with areas of training activity may also be adversely affected. The portions of the water column designated as EFH would be minimally impacted by military expended materials from training events.

High-explosive military expended materials would typically fragment into small pieces. Ordnance that fails to function as designed and inert munitions would result in larger pieces of military expended materials settling to the seafloor. Once on the seafloor, these types of military expended materials would be buried by sediments, corroded from exposure to the marine environment, or colonized by benthic organisms.

Training activities involving military expended materials have the potential to impact substrates designated as EFH within the areas where training is occurring. In an attempt to quantify the potential level of disturbance of military expended materials on bottom substrates within each portion of the Study Area, an analysis of two worst case scenarios were developed. As a conservative measure for the analyses, within each category of expended items (e.g., bombs, missiles, rockets, large-caliber projectiles, etc.), the size of the largest item which would be expended was used to represent the sizes of all items in the category. For example, the footprint of missiles used during training exercises range from 1.6 to 37.4 ft.^{2} (0.15 to 3.5 m^2), respectively. For the analyses, all missiles were assumed to be equivalent to the largest in size, or 37.4 ft.^{2} (3.5 m^2). In addition, it was also assumed that the impact of the expended material on the seafloor is twice the size of its footprint. This assumption accounts for any displacement of sediments at the time of impact as well as any subsequent movement of the item on the seafloor due to currents or other forces. This should more accurately reflect the potential disturbance to soft bottom habitats, but should overestimate disturbance to hard bottom habitats since no displacement of the substrate would occur. In addition, items with casings (e.g., small, medium, and large-caliber munitions; flares; sonobuoys; etc.) have their impact footprints doubled to account for both the item and its casing. To be conservative, items and their casings were assumed to be the same size.

Potential impacts to soft bottom habitats from military expended materials would range from temporary to permanent, depending upon the nature of the environment in which the expended material settled. In areas subject to dynamic coastal processes such as tidal influx or currents, the military expended materials may be covered by sediments over time or be carried by water movement to areas outside the Study Area. In such cases, the temporal impact of the military expended materials on the environment would be temporary (recovery in days to weeks) to short term (recovery in less than 3 years). However, were the military expended materials to settle on soft bottom in areas rarely disturbed by currents or other forces, such as on many areas of the continental slope, the items may persist on the bottom indefinitely. In such cases, the items would cover the soft bottom with a hard structure (the military expended material itself), thus inhibiting the soft bottom's ability to function as a habitat within the direct vicinity of the item. In such instances, the military expended materials would function more as an artificial structure rather than as soft bottom habitat (Figure 4-5). This would result in a long-term (recovery in more than 3 years but less than 20 years were the item to decompose or break down over time), or permanent (recovery in more than 20 years) impact to the habitat. The spatial extent of the impact would be minimal, limited to the footprint of the individual military expended material. In cases where multiple military materials are expended in the same area, the same habitat may be impacted numerous times during a given training activity and the overall impact to the habitat would be cumulative of the footprints of all of the military expended materials to settle on the habitat.

Potential impacts to hard bottom substrates would primarily be temporary to short term. The military expended materials that settled on hard bottom would initially impair the substrate's ability to function as a habitat, but would ultimately serve the same function as the habitat they cover leading to only a temporary or short-term impact (Figure 4-3 and Figure 4-4). The exception would be items made of soft material, such as parachutes, that would impair the substrate or structure's ability to function as a habitat for as long as it was present. The spatial extent of the impact would be the same as noted for soft bottom substrates.

A total of 196,888 military items would be expended annually in the Offshore Area and 42 military items in the Inland Waters during training activities, which would result in a total impact area of approximately 19,052.92 m^2 (Table 4-13). This amount of material would be dispersed over thousands of square miles.

Based on the results of a worst case scenario where all military expended materials settled in areas of hard and soft bottom substrates (Table 4-13), military expended materials may adversely affect hard and soft bottom substrate EFH; however, these effects would be minimal based on the small amount of available habitat impacted. The duration of the effect however, would range from short term to permanent.

Biogenic habitats may also be potentially impacted by military expended materials. While the least common of the benthic habitat types and, therefore, the least likely to be impacted, benthic biogenic habitats have concentrated distributions throughout the Study Area, particularly occurring in the Inland Waters. The primary types of biogenic habitats that may potentially be impacted by military expended materials include mussel beds, live bottom (e.g., areas with sponges, bryozoans, hydroids, amphipod tubes), and attached macroalgae. Impacts to benthic biogenic habitats would range from short term to permanent depending on the type of organisms impacted. Most benthic organisms and macroalgae would recover from an impact over a short time period (less than 3 years). Therefore, military expended materials from training activities in the Study Area would have a minimal effect on biogenic habitats.

Deep-water corals also occur in the Offshore Area; however, given the limited spatial extent of deep-water coral within the Offshore Area and the general location where activities occur, it is highly unlikely that military expended materials would land in the vicinity of deep-water coral.

Military expended materials resulting from training activities may adversely affect biogenic and macroalgae designated as EFH in areas where these activities occur. However, due to the size of the Study Area in which activities would occur and the limited distribution of biogenic habitats, the effect to these habitats from military expended materials would be minimal. For areas that would potentially be impacted, the duration of the effect would be short term.

4.1.3.3.2 Testing Activities

Military expended materials from testing activities have the potential to adversely impact benthic substrate and biogenic habitats designated as EFH. In addition, designated HAPCs coinciding with areas of testing activities may also be adversely affected. The portions of the water column designated as EFH would not be impacted by military expended materials from testing events.

Using the same methodology as for training activities, testing activities were also analyzed to determine the potential impacts of military expended materials on benthic substrates under a worst case scenario of all military expended materials used during testing exercises within a given testing range settling to the bottom. Based on the results, military expended materials resulting from testing activities would impact less than 1 percent of the available seafloor annually, even under a worst case scenario (Table 4-13). Those impacts that do occur would be the same as characterized in the discussion in the previous section (see Section 4.1.3.3.1, Training Activities).

The potential impacts to biogenic habitats from military expended materials resulting from testing activities would be the same as described for the training exercises in Section 4.1.3.3.1 (Training Activities).

Based on the results of a worst case scenario where all military expended materials settled in areas of hard and soft bottom substrates (Table 4-13), military expended materials may adversely affect hard and soft bottom EFH; however, these effects would be minimal based on the small amount of available habitat impacted. The duration of the effect, however, would range from short term to permanent.

Military expended materials resulting from testing activities may adversely affect biogenic and macroalgae that is designated as EFH in areas where these activities occur. However, due to the size of the portions of the Study Area in which activities would occur and the limited distribution of biogenic habitats, the effect to these habitats from military expended materials would be minimal. For areas that would potentially be affected, the duration of the effect would be short term.

Table 4-13: Annual Numbers and Impacts of Military Expended Materials Proposed for Use under the Proposed Action

Military Expended Material	Size (m^2)	Impact Footprint (m^2)	Offshore Area				Inland Waters			
			Training Activities		Testing Activities		Training Activities		Testing Activities	
			Number	Impact (m^2)	Number	Impact (m^2)	Number	Impact (m^2)	Number	Impact (m^2)
Bombs (HE)	0.7544	1.5088	10	15.09	0	0	0	0	0	0
Bombs (NEPM)	0.7544	1.5088	110	165.97	0	0	0	0	0	0
Small caliber	0.0028	0.0056	121,200	678.72	0	0	0	0	0	0
Medium caliber (HE)	0.0052	0.0104	6,498	67.58	0	0	0	0	0	0
Medium caliber (NEPM)	0.0052	0.0104	43,172	448.99	0	0	0	0	0	0
Large caliber (HE)	0.0938	0.1876	390	73.16	0	0	0	0	0	0
Large caliber (NEPM)	0.0938	0.1876	2,800	525.28	0	0	0	0	0	0
Missiles (HE)	3.4715	6.9430	27	187.46	0	0	0	0	0	0
Missiles (NEPM)	2.8801	5.7602	15	86.40	0	0	0	0	0	0
Chaff (cartridges)	0.0001	0.0002	5,000	1.00	0	0	0	0	0	0
Flares	0.1133	0.2266	224	50.76	600	135.96	0	0	0	0
Airborne targets	4.3838	8.7676	28	245.49	0	0	0	0	0	0
Surface targets	0.5344	1.0688	210	224.45	0	0	0	0	9	2.04
Sub-surface targets	0.1134	0.2268	130	29.48	90	20.41	0	0	0	0
Torpedoes (HE)	3.0861	6.1721	0	0	6	37.03	0	0	0	0
Marine Markers	0.1134	0.2268	334	75.75	190	43.09	0	0	0	0
Sonobuoys (NEPM)	0.1134	0.2268	8,928	2,024.87	1,198	271.71	0	0	6	1.36
Sonobuoys (HE)	0.1134	0.2268	0	0	142	32.21	0	0	0	0
Decelerator/parachutes	0.8400	1.6800	8,952	15,039.36	1,229	2,064.72	0	0	4	6.72
Mine Shapes	2.3809	4.7619	0	0	0	0	42	200	0	0
Fiber Optic Cables	*	*	0	0	0	0	0	0	0	0
Total			**198,028**	**19,939.81**	**3,455**	**2,605.13**	**42**	**200**	**19**	**10.12**

* 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) of the NWTT EIS/OEIS. The approximate impact area is a measurement of fragments. (2) EIS/OEIS = Environmental Impact Statement/Overseas Environmental Impact Statement, HE = High Explosive, m^2 = square meters, NEPM = Non-explosive Practice Munitions, NWTT = Northwest Training and Testing,

4.1.3.4 Seafloor Devices

Seafloor devices represent any item used during training or testing activities that intentionally comes into contact with the seafloor, but are later recovered. These items include moored mine shapes, anchors, and robotic vehicles. Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile organisms. The use of seafloor devices in each of the training and testing ranges is outlined in Table 4-14.

Table 4-14: Number and Location of Events Including Seafloor Devices

Activity Area	Training	Testing
Offshore Area	0	6
Inland Waters	16	225
Total	**16**	**231**

Mine shapes are typically deployed via surface vessels or fixed-wing aircraft, and are non-explosive devices. Most moored mines deployed from surface vessels are typically secured with up to a 2,700 lb. (1,225 kg) concrete mooring block (approximately 30 in. [76.2 cm] to a side). Moored mines deployed from fixed-wing aircraft enter the water and impact the bottom, becoming semi-submerged. Upon impact, the mine casing separates and the semi-buoyant mine floats 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 usually retrieved within 7–30 days following the completion of the training or testing events.

Precision anchoring training exercises involve releasing of anchors in designated locations. The intent of these training exercises is to practice anchoring the vessel within 100 yd. of the planned anchorage location. These training activities typically occur within predetermined shallow water anchorage locations near ports with seafloors consisting of soft bottom substrate.

Crawlers are fully autonomous, battery-powered amphibious vehicles used for functions such as reconnaissance missions in territorial waters. These devices are used to classify and map underwater mines in shallow water areas. The crawler is capable of traveling 2 ft. (0.61 m) per second along the seafloor and can avoid obstacles. The crawlers are equipped with various sonar sensors and communication equipment that enable these devices to locate and classify underwater objects and mines while rejecting miscellaneous clutter that would not pose a threat. Crawlers may be used in water depths to 60 ft. (18.3 m).

Potential Impacts to the Water Column

The use of seafloor devices would not alter the water in any measurable or lasting manner. Therefore, there would be no adverse impact to the water column itself.

Potential Impacts to Benthic Substrate

As a result of their temporary nature, mine shapes would not permanently impact the substrate on which they are placed. However, their presence would temporarily impair the ability of the substrate to function as a habitat for as long as the mine shape is in place. As mine shapes are primarily deployed over soft bottom substrates, hard bottom would not be impacted. The placement of mine shapes may result in injury or mortality to invertebrates inhabiting soft bottom habitat.

The level of impact to substrates from precision anchoring training exercises would depend on the size of the anchor used, which would vary according to vessel type. Since these activities only take place in pre-designated areas consisting of soft bottom substrates, areas of hard bottom would not be affected. As most of these activities occur in areas subject to constant wave action and cycles of erosion and deposition, disturbed areas would likely be reworked by waves and tides shortly after the disturbance.

Crawlers move over the surface of the seafloor and would not harm or alter any hard substrates encountered. In soft substrates, crawlers may leave a trackline of depressed sediments approximately 24 in. (62 cm) wide (the width of the device) in their wake. However, since these crawlers operate in shallow water, any disturbed sediments would be redistributed by wave and tidal action shortly following the disturbance. Any disturbance to the soft sediments would not impair their ability to function as a habitat.

The use of seafloor devices during training and testing activities may adversely affect soft bottom EFH. However, these effects would be minimal in size and temporary (recovery in days to weeks) in duration. Seafloor devices would have no effect on hard bottom EFH as hard bottom substrates are generally avoided. There would be no effect on water column EFH from the use of seafloor devices.

Potential Impacts to Biogenic Habitats

As mine shape deployment and precision anchoring exercises are typically done only in areas of soft bottom substrates, areas of live/hard bottom would not be impacted. Mitigation zones are buffer areas between potential impacts and observed marine life on the surface or mapped on the bottom. The Navy will not conduct precision anchoring within the anchor swing diameter, or explosive mine countermeasure and neutralization activities near known or surveyed live hardbottom, artificial reefs, and shipwrecks (Chapter 5, Mitigation Measures). In addition, as a result of the distance from shore that these activities are conducted, submerged aquatic vegetation, marshes, shellfish beds, and wetlands would also not be impacted as these organisms are common in shallow, nearshore waters.

Crawlers move over the surface of the seafloor and would not harm or alter any hard substrates encountered. In soft substrates, crawlers may leave a trackline of depressed sediments approximately 24 in. (62 cm) wide (the width of the device) in their wake.

The use of seafloor devices during training and testing activities would have no effect on biogenic EFH due to the lack of their presence in the areas in which seafloor devices are used. Seafloor device usage may adversely affect soft bottom EFH; however, any effects would be minimal in size and temporary (recovery in days to weeks) in duration.

4.1.4 Contaminant Stressors

This section considers the impacts on marine sediment and water quality from explosives, explosion by-products, and chemicals or substances other than explosives associated with military expended materials (e.g., metals, chemicals, and other materials). The focus of this analysis is changes in the chemistry of substrate and water column that may adversely affect the quality of EFH for managed species. The impacts on managed species via sediment or water that do not require trophic transfer (e.g., bioaccumulation, predation) to be observed are considered here.

4.1.4.1 Explosives and Explosive Byproducts

Explosions consume most of the explosive material, creating typical combustion products. In the case of Royal Demolition Explosive (RDX), 98 percent of the products are common seawater constituents and the remainder is rapidly diluted below threshold effect level (U.S. Department of the Navy 2008b) (Table 4-15). Explosion byproducts associated with high-order detonations present no stressors to fish and invertebrates through sediment or water chemistry. Low-order detonations and unexploded ordnance present an elevated likelihood of effects on fish or invertebrates compared to high-order detonations. Deposition of undetonated explosive materials into the marine environment can be reasonably well estimated by the known failure and low-order detonation rates of high explosives (Table 4-16). Undetonated explosives associated with ordnance disposal and mine clearance are collected after training is complete; therefore, potential impacts are assumed to be inconsequential and not detectable for these training and testing activities. The fish and invertebrates inhabiting EFH may be exposed by contact with the explosive, contact with contaminants in the EFH, and ingestion of contaminated sediments.

Table 4-15: Byproducts from a Typical Underwater Detonation

Byproduct	Predicted Concentration (mg/L)	Permissible Concentration (mg/L)
Aluminum oxide	0.4340	n/a
Carbon	0.1430	n/a
Carbon monoxide	0.0293	0.552
Ethane	0.0047	120
Carbon dioxide	0.0026	1.0
Ammonia	0.0023	0.092
Propane	0.0014	120
Hydrogen cyanide	0.0003	0.001
Methane	0.0001	120
Other compounds*	< 0.0001	—

* Other compounds include methyl alcohol, formaldehyde, acetylene, and phosphine. Predicted concentrations were well below permissible concentrations.
Notes: < = less than, mg/L= milligrams per liter, n/a = not applicable

Table 4-16: Failure Rates and Low-Order Detonation Rates of Military Ordnance

Ordnance	Failure Rate (%)	Low-Order Detonation Rate (%)
Guns/artillery	4.68	0.16
Hand grenades	1.78	—
High explosive ordnance	3.37	0.09
Rockets	3.84	—
Submunitions*	8.23	—

* Submunitions are munitions contained within and distributed by another device such as a rocket.

Table 4-17 provides a list of ordnance constituents remaining after low-order detonations and with unconsumed explosives. These constituents are in addition to the high 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 (aira, Substances and Disease Registry 2007). Metals are discussed in Section 4.1.4.2.

Table 4-17: Constituents Remaining After Low-Order Detonations and from Unconsumed Explosives

Ordnance Component	Constituent
Pyrotechnics Tracers Spotting Charges	Barium chromate ($BaCrO_4$) Potassium perchlorate Chlorides Phosphorus Titanium compounds
Oxidizers	Lead (II) oxide (PbO)
Delay Elements	$BaCrO_4$ Potassium perchlorate Lead chromate
Fuses	Potassium perchlorate
Detonators	Fulminate of mercury [$Hg(CNO)_2$] Potassium perchlorate
Primers	Lead azide [$Pb(N_3)_2$]

Indirect impacts of explosive byproducts and unexploded ordnance on fish and invertebrates via sediment is possible in the immediate vicinity of the ordnance. Degradation products of RDX are not toxic to marine organisms at realistic exposure levels (Rosen and Lotufo 2010). Trinitrotoluene (TNT) and its degradation products impact developmental processes in fish and invertebrates and are acutely toxic to adults at concentrations similar to real-world exposures (Rosen and Lotufo 2007a, Rosen and Lotufo 2007b, 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6–12 in. (15–30 cm) away from degrading ordnance, the concentrations of these compounds were not statistically distinguishable from background beyond 3 and 6 ft. (1 and 2 m) from the degrading ordnance (Rosen and Lotufo 2010). Taken together, fish or invertebrates may be adversely impacted by the effects of degrading explosives within a very small radius of the explosive. This area is smaller than the crater radius for the smallest explosive footprint analyzed in Section 4.1.1.2.1 (Explosives).

The use of explosives and explosive byproducts during training and testing activities may adversely affect water column and substrate EFH; however, these effects would be temporary and minimal.

4.1.4.2 Metals

Certain metals and metal-containing compounds are harmful to fish and invertebrates at concentrations above background levels (e.g., cadmium, chromium, lead, mercury, zinc, copper, manganese, and many others) (Negri et al. 2002, Wang and Rainbow 2008). Metals are introduced into seawater and sediments as a result of training and testing activities involving vessel hulks, targets, ordnance, munitions, and other military expended materials, including batteries. In most instances, 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 more of an issue than metals in the water column. Many metals bioaccumulate and some physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals. Impacts of metals on fish and invertebrates via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Fish and invertebrates may be exposed by contact with the metal, contact with contaminants in the sediment or water, and ingestion of contaminated material.

Despite the acute toxicity of some metals (e.g., hexavalent chromium or tributyltin) (Negri et al. 2002), concentrations above safe limits are scarcely encountered even in live fire areas of the former Navy training range off Vieques, Puerto Rico, where deposition of metals from Navy activities was very high (Pait et al. 2010). Other studies found no harmful concentrations of metals associated with deposition of military metals into the marine environment (Buchman 2008). It is conceivable that fish or invertebrate eggs or larvae could be impacted by metals via sediment within a few inches of the object.

Metal contamination from training and testing activities would have no effect on water column EFH, based on studies comparing metal contamination levels and levels considered safe. It is unlikely that susceptible biological properties of the water column EFH such as fish or invertebrates will be adversely effected by the physiological effects of metals before they bioaccumulate to higher trophic levels.

4.1.4.3 Chemicals

Several Navy training and testing activities introduce potentially harmful chemicals into the marine environment, principally flares and propellants for rockets, missiles, and torpedoes.

Properly functioning flares, missiles, rockets, and torpedoes combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow release of propellants and their degradation products into the marine environment. The greatest risk to fish and invertebrates from flares, missile, and rocket propellants is perchlorate, which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals. Perchlorate contamination rapidly disperses throughout the water column and water within sediments. While it impacts terrestrial biological processes at low concentrations (e.g., less than 10 ppb), toxic concentrations are unlikely to be encountered in seawater. The principal mode of perchlorate toxicity in the environment is bioaccumulation.

In contrast to perchlorate, the principal toxic components of torpedo fuel—propylene glycol dinitrate and nitrodiphenylamine—adsorb to sediments, have relatively low toxicity, and are readily degraded by biological processes. The MK-48 torpedo weighs roughly 3,700 lb. (1,680 kg) and uses 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, carbon dioxide, hydrogen, nitrogen, methane, ammonia, and hydrogen cyanide. During normal venting of excess pressure or upon failure of the torpedo's buoyancy bag, the following are discharged: carbon dioxide, water, hydrogen, nitrogen, carbon monoxide, methane, ammonia, hydrochloric acid, hydrogen cyanide, formaldehyde, potassium chloride, ferrous oxide, potassium hydroxide, and potassium carbonate (U.S. Department of the Navy 1996a, b).

It is conceivable that marine fish and invertebrate eggs, or larvae could be impacted by propellants via sediment in the immediate vicinity of the object (e.g., within a few inches), but these potential impacts would diminish rapidly as the propellant degrades. Fish and invertebrates may be exposed by contact with the chemicals, contact with chemical contaminants in the sediment or water, and ingestion of contaminated material.

No effect on EFH from these chemicals is anticipated from training and testing activities based on the miniscule range of harmful impacts. It is unlikely that the susceptible biological properties of water column EFH, such as fish or invertebrates, will be adversely effected by the physiological effects of chemicals other than explosives and explosive byproducts before they bioaccumulate to higher trophic levels.

4.1.4.4 Other Materials

All military expended material, including targets and vessel hulks involved in sinking exercises contains materials other than metals, explosives, or chemicals. Principal components of these military expended materials include aluminized fiberglass (chaff), carbon or Kevlar fiber (missiles), and plastics (canisters, targets, sonobuoy components, parachutes). Chaff has been extensively studied, and no indirect toxic effects are known at realistic concentrations in the marine environment (Arfsten et al. 2002). Glass, carbon, and Kevlar fibers are not known to have potential toxic effects on marine invertebrates. Plastics contain chemicals that have potential effects on fish and invertebrates (Derraik 2002, Mato et al. 2001, Teuten et al. 2007).

Potentially harmful chemicals in plastics are not readily adsorbed to marine sediments; instead, fish and invertebrates are most at risk via ingestion or bioaccumulation. Because plastics retain many of their chemical properties as they physically degrade into plastic particles (Singh and Sharma 2008), the exposure risks to marine invertebrates are dispersed over time. It is conceivable that marine invertebrates could be indirectly impacted by chemicals associated with plastics, but, absent bioaccumulation, these effects would be limited to direct contact with the material.

Marine invertebrates and fish may be exposed by contact with the plastic, contact with associated plastic chemical contaminants in the sediment or water, and ingestion of contaminated material.

No effect on EFH from these other materials is anticipated from training and testing activities based on the direct contact required for harmful impacts. It is unlikely that susceptible biological properties of water column EFH, such as fish or invertebrates, will be adversely effected by the physiological effects of other materials before they bioaccumulate to higher trophic levels.

4.1.5 Study Area Combined Impact of Navy Stressors

Of all the potential stressors, only explosives on or near the bottom and military expended materials have the potential to adversely impact marine habitats as a substrate for biological communities. The impact area for underwater explosions and military expended materials were all much less than 1 percent of the total area of documented soft bottom or hard bottom in their respective training or testing areas. The percentages are even lower for substrate impacts in the Study Area as a whole. Even multiplying by 5 years, the impacts are all less than 1 percent of the benthic substrate with very unlikely worst case scenarios. Such a low percentage of bottom habitat impacted suggests less than substantial adverse effects on marine substrates and associated biogenic habitats from either individual stressors or combined stressors.

Chapter 5 (Mitigation Measures) describes standard operating procedures (SOPs) and mitigation measures proposed to help reduce the potential impacts of explosives on or near the bottom and military expended materials on marine substrates and associated biogenic habitats.

5 MITIGATION MEASURES

This section describes the Navy's SOPs and mitigation measures that are designed to help reduce or avoid potential impacts to EFH or HAPCs.

5.1 STANDARD OPERATING PROCEDURES

The Navy currently employs standard practices to provide for the safety of personnel and equipment, including ships and aircraft, as well as the success of the training and testing activities. For the purpose of this document, we will refer to standard practices as SOPs. Because of their importance for maintaining safety and mission success, SOPs have been considered as part of the Proposed Action. The only SOP that has the effect of reducing or avoiding EFH is for towed in-water devices: "Prior to deploying a towed device, there is a SOP to search the intended path of the device for any floating debris (e.g., driftwood) or other potential obstructions (e.g., animals), since they have the potential to cause damage to the device."

5.2 MITIGATION MEASURES

The Navy recognizes that the Proposed Action has the potential to impact EFH or HAPCs. Unlike SOPs, 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. The procedures discussed in this chapter, most of which are currently or were previously implemented as a result of formal or informal consultations with regulatory agencies, are being implemented by the Navy.

The mitigation measures presented in Table 5-1 will be effective at reducing potential impacts on EFH, and from the Navy's perspective, are practicable, executable, and will not impact safety and readiness. The Lookouts on Navy vessels are trained to identify marine mammals, sea turtles, and floating macroalgae and to avoid physical impacts where possible; target areas should be clear of marine mammals, sea turtles, and floating macroalgae. Mitigation zones are buffer areas between potential impacts and observed marine life on the surface or mapped on the bottom.

Table 5-1: Procedural Mitigation Measures

Activity Category or Mitigation Area	Lookout Procedural Measure	Mitigation Zone and Protection Focus
Acoustic (Non-Impulse Stressors)		
Low-Frequency and Hull-Mounted Mid-Frequency Active Sonar during Anti-Submarine Warfare and Mine Warfare	2 or 1 Lookout(s), dependent on small boats minimally manned, moored, or anchored, pierside, or shore-based	1,000 yd.
High-Frequency and Non-Hull-Mounted Mid-Frequency Active Sonar	General: 2 or 1 Lookout(s), dependent on small boats minimally manned, moored, or anchored, pierside, or shore-based	1,000 yd.

Table 5-1: Procedural Mitigation Measures (continued)

Activity Category or Mitigation Area	Lookout Procedural Measure	Mitigation Zone and Protection Focus
Acoustic (Explosive/Impulse Stressors)		
Mine Countermeasures and Mine Neutralization using Positive Control	4 Lookouts	700 yd. (640 m) for up to 2.5 lb. charge for marine mammals, turtles, and marbled murrelet. 330 yd. (300 m) for up to 1.5 lb. charge for marbled murrelet. 110 yd. (100 m) for 1-ounce charge marbled murrelet.
Improved Extended Echo Ranging Sonobuoys	1 Lookout	600 yd. (366 m) for floating vegetation and kelp paddies
Explosive Signal Underwater Sound buoys using >0.5–2.5 lb. NEW	1 Lookout	350 yd. (183 m) for floating vegetation and kelp paddies
Mine Countermeasures and Mine Neutralization using Positive Control Firing Devices	4 Lookouts	400 yd. (366 m) for up to 2.5 lb. charge for marine mammals, turtles, and marbled murrelet. 330 yd. (300 m) for up to 1.5 lb. charge for marbled murrelet. 110 yd. (100 m) for 1-ounce charge marbled murrelet
Gunnery Exercises – Small- or Medium-Caliber using a Surface Target	1 Lookout	200 yd. (183 m) for floating vegetation and kelp paddies
Gunnery Exercises – Large-Caliber Explosive Rounds using a Surface Target	1 Lookout	600 yd. (1.8 km) for floating vegetation and kelp paddies
Missile Exercises (Including Rockets) Up to 250 lb. NEW using a Surface Target	1 Lookout	900 yd. (1.8 km) for floating vegetation and kelp paddies
Missile Exercises up to 500 lb. NEW using a Surface Target	1 Lookout	2,000 yd. (1.9 km) for floating vegetation
Explosive Bombing Exercises	1 Lookout	2,500 yd. (1.9 km) for floating vegetation
Torpedo (Explosive) Testing	1 Lookout for aircraft, 2 for surface ships	2,100 yd. (1.9 km) for floating vegetation
Weapons Firing Noise During Gunnery Exercises – Large-Caliber	1 Lookout	70 yd. (60 m) within 30 degrees on either side of the gun target line on the firing side for floating vegetation.
Physical Strike and Disturbance		
Vessels	1 Lookout	500 yd. (whales); 200 yd. (other marine mammals)
Towed Devices	1 Lookout	250 yd.

Notes: km = kilometers, lb. = pounds, m = meters, NEW = net explosive weight, yd. = yards

In addition to the activities' mitigation measures described above, the Navy will avoid to the greatest extent practicable known or surveyed live hardbottom, artificial reefs, and shipwrecks for precision anchoring within the anchor swing diameter and explosive mine countermeasure and neutralization activities. To facilitate these protective measures, the Navy will include maps of known artificial reefs, shipwrecks, and live hard bottom during planning of training and testing events.

The Navy's currently implemented seafloor habitats and shipwreck mitigation zones are based off the range to effects for marine mammals or sea turtles, which are driven by hearing thresholds. Instead, the recommended measures are modified to focus on reducing potential physical impacts to seafloor habitats from explosives, and physical strike from military expended materials. The recommended 350 yd. (320 m) mitigation zone is based off the estimated maximum crater impact for explosions discussed in Section 4.1.1.2.1 (Explosives). The use of non-explosive military expended materials would result in a smaller footprint of potential impact; however, the Navy recommends applying the explosive mitigation zone to all explosive and non-explosive activities as listed above for ease of implementation. This standard mitigation zone will consequently result in an additional protection buffer during the non-explosive activities listed above. Avoiding or minimizing physical disturbance and strike of these resources will likely reduce the impact on these resources.

The Navy proposes implementing the recommended measures described above because: (1) they are likely to result in avoidance or reduction of physical disturbance and strike to sensitive habitats; and (2) they have acceptable operational impacts to the proposed activity with regard to safety, practicability, impact to readiness, and Navy policy.

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6 CONCLUSIONS

The potential impacts from the Proposed Action on EFH and HAPCs among the PFMC region did not exceed a determination of minimal. The individual stressor effects were all either no effect or minimal and ranged in duration from temporary to permanent, depending on the habitat impacted (Table 6-1).

Table 6-1: Potential Impacts on Pacific Coast Groundfish Essential Fish Habitat and Habitat Areas of Particular Concern from Each Stressor

Pacific Coast Groundfish	EFH				HAPC
	All waters and substrate in areas less than or equal to 3,500 m to mean higher high water level or the upriver extent of saltwater intrusion Seamounts in depth greater than 3,500 m as mapped in the EFPH assessment geographic information system				Estaries, canopy kelp, seagrass, rocky reefs, and "areas of interest"
	Water Column	Prey Species	Substrate	Biogenic	
Acoustic stressors					
<u>Non-impulse</u> • Sonar • Vessel Noise	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	No effect	No effect	No effect
<u>Explosive and other impulse</u> • Underwater explosions • Weapons, firing, launch, and impact noise	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and short to long term [soft bottom] to permanent [hard bottom]; mitigation avoids mapped hard bottom)	• Attached macroalgae: may adversely affect (minimal and long term based on hard substrate impacts) • Submerged rooted vegetation: may adversely affect (minimal and long term; mitigation avoids sensitive nearshore habitats) • Sedentary invertebrate beds: may adversely affect (minimal and short term to permanent [based on substrate impacts]; mitigation avoids mapped hard bottom)	May adversely affect (minimal and variable duration [habitat dependent]; mitigation avoids sensitive nearshore habitats, mapped hard bottom, and surface macroalgae concentrations)
Energy stressors					
Electromagnetic devices	May adversely affect (less than minimal and temporary)	May adversely affect (less than minimal and temporary)	No effect	No effect	No effect

Table 6-1: Potential Impacts on Pacific Coast Groundfish Essential Fish Habitat and Habitat Areas of Particular Concern from Each Stressor (continued)

Physical Disturbance and Strike stressors					
Vessel movement	No Effect	No effect	May adversely affect (minimal and temporary [soft bottom] to permanent [hard bottom]; standard operating procedures avoids mapped hard bottom)	No effect; mitigation avoids sensitive nearshore habitats	May adversely affect (minimal and temporary for offshore HAPCs; mitigation avoids mapped hard bottom and macroalgae concentrations)
In-water devices	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	No effect: standard operating procedures avoids mapped hard bottom and impacts with substrate	No effect; mitigation avoids sensitive nearshore habitats	May adversely affect (minimal and temporary for offshore HAPCs)
Military expended materials	No effect	No effect	May adversely affect (minimal and short term to permanent)	• Attached macroalgae: may adversely affect (minimal and temporary) • Submerged rooted vegetation: minimal and short term; mitigation avoids sensitive nearshore habitats • Sedentary invertebrate beds: minimal and short term to permanent (based on substrate impacts)	May adversely affect (minimal and variable duration, habitat dependent; mitigation avoids sensitive nearshore habitats and surface macroalgae concentrations)
Seafloor devices	No effect	No effect	May adversely affect (minimal and temporary [soft bottom]); no effect (hard bottom)	No effect	May adversely affect (minimal and temporary for nearshore and shallow, offshore HAPCs)
Contaminant stressors					
Explosives and explosive byproducts	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	• Sedentary invertebrate beds and reefs: may adversely affect (minimal and temporary) • Other biogenic habitats: no effect	May adversely affect (minimal and temporary)
Metals	No effect	No effect	No effect	No effect	No effect
Chemicals	No effect	No effect	No effect	No effect	No effect
Other metals	No effect	No effect	No effect	No effect	No effect

Table 6-2: Potential Impacts on Pacific Coast Salmon Essential Fish Habitat and Habitat Areas of Particular Concern from Each Stressor

Pacific Coast Salmon Species	EFH				HAPC
	All waters from the ocean extent of the EEZ to the shore, and inland up to all freshwater bodies occupied of historically accessible to salmon in Alaska, Washington, Oregon, Idaho, and California				Estuaries and Marine and Estuarine Submerged Aquatic Vegetation
	Water Column	Prey Species	Substrate	Biogenic	
Acoustic stressors					
Non-impulse • Sonar • Vessel Noise	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	No effect	No effect	No effect
Explosive and other impulse • Underwater explosions • Weapons, firing, launch, and impact noise	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and short to long term [soft bottom] to permanent [hard bottom]; mitigation avoids mapped hard bottom)	• Attached macroalgae: may adversely affect (minimal and long term based on hard substrate impacts) • Submerged rooted vegetation: may adversely affect (minimal and long term; mitigation avoids sensitive nearshore habitats) • Sedentary invertebrate beds: may adversely affect (minimal and short term to permanent [based on substrate impacts]; mitigation avoids mapped hard bottom)	May adversely affect (minimal and variable duration [habitat dependent]; mitigation avoids sensitive nearshore habitats, and surface macroalgae concentrations)
Energy stressors					
Electromagnetic devices	May adversely affect (less than minimal and temporary)	May adversely affect (less than minimal and temporary)	No effect	No effect	No effect
Physical Disturbance and Strike stressors					
Vessel movement	No effect	No effect	May adversely affect (minimal and temporary [soft bottom] to permanent [hard bottom]; standard operating procedures avoids mapped hard bottom)	No effect; mitigation avoids sensitive nearshore habitats	May adversely affect (minimal and temporary; mitigation avoids macroalgae concentrations)
In-water devices	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	No effect: standard operating procedures avoids mapped hard bottom and impacts with substrate	No effect; mitigation avoids sensitive nearshore habitats	May adversely affect (minimal and temporary)

Table 6-2: Potential Impacts on Pacific Coast Salmon Essential Fish Habitat and Habitat Areas of Particular Concern from Each Stressor (continued)

Pacific Coast Salmon Species	EFH				HAPC
	All waters from the ocean extent of the EEZ to the shore, and inland up to all freshwater bodies occupied of historically accessible to salmon in Alaska, Washington, Oregon, Idaho, and California				Estuaries and Marine and Estuarine Submerged Aquatic Vegetation
	Water Column	Prey Species	Substrate	Biogenic	
Physical Disturbance and Strike stressors (continued)					
Military expended materials	No effect	No effect	May adversely affect (minimal and short term to permanent)	• Attached macroalgae: minimal and temporary • Submerged rooted vegetation: minimal and short term; mitigation avoids sensitive nearshore habitats • Sedentary invertebrate beds: minimal and short term to permanent (based on substrate impacts)	May adversely affect (minimal and variable duration, habitat dependent; mitigation avoids sensitive nearshore habitats, mapped hard bottom, and surface macroalgae concentrations)
Seafloor devices	No effect	No effect	May adversely affect (minimal and temporary [soft bottom]); no effect (hard bottom)	No effect	May adversely affect (minimal and temporary for nearshore and shallow, offshore HAPCs)
Contaminant stressors					
Explosives and explosive byproducts	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	• Sedentary invertebrate beds and reefs: may adversely affect (minimal and temporary) • Other biogenic habitats: no effect	May adversely affect (minimal and temporary)
Metals	No effect	No effect	No effect	No effect	No effect
Chemicals	No effect	No effect	No effect	No effect	No effect
Other metals	No effect	No effect	No effect	No effect	No effect

Table 6-3: Potential Impacts on Coastal Pelagic Species Essential Fish Habitat and Habitat Areas of Particular Concern from Each Stressor

Coastal Pelagic Species	EFH				HAPC
	All marine and estuarine waters above the thermocline from the shoreline offshore to 200 nm offshore				None
	Water Column	Prey Species	Substrate	Biogenic	
Acoustic stressors					
Non-impulse • Sonar • Vessel Noise	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	No effect	No effect	N/A
Explosive and other impulse • Underwater explosions • Weapons, firing, launch, and impact noise	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and short to long term [soft bottom] to permanent [hard bottom]; mitigation avoids mapped hard bottom)	• Attached macroalgae: may adversely affect (minimal and long term based on hard substrate impacts) • Submerged rooted vegetation: may adversely affect (minimal and long term; mitigation avoids sensitive nearshore habitats) • Sedentary invertebrate beds: may adversely affect (minimal and short term to permanent [based on substrate impacts]; mitigation avoids mapped hard bottom)	N/A
Energy stressors					
Electromagnetic devices	May adversely affect (less than minimal and temporary)	May adversely affect (less than minimal and temporary)	No effect	No effect	N/A
Physical Disturbance and Strike stressors					
Vessel movement	No effect	No effect	May adversely affect (minimal and temporary [soft bottom] to permanent [hard bottom]; standard operating procedures avoids mapped hard bottom)	No effect; mitigation avoids sensitive nearshore habitats	N/A
In-water devices	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	No effect: standard operating procedures avoids mapped hard bottom and impacts with substrate	No effect; mitigation avoids sensitive nearshore habitats	N/A

Table 6-3: Potential Impacts on Coastal Pelagic Species Essential Fish Habitat and Habitat Areas of Particular Concern from Each Stressor (continued)

Coastal Pelagic Species	EFH				HAPC
	All marine and estuarine waters above the thermocline from the shoreline offshore to 200 nm offshore				None
	Water Column	Prey Species	Substrate	Biogenic	
Physical Disturbance and Strike stressors (continued)					
Military expended materials	No effect	No effect	May adversely affect (minimal and short term to permanent)	• Attached macroalgae: minimal and temporary • Submerged rooted vegetation: minimal and short term; mitigation avoids sensitive nearshore habitats • Sedentary invertebrate beds: minimal and short term to permanent (based on substrate impacts)	N/A
Seafloor devices	No effect	No effect	May adversely affect (minimal and temporary [soft bottom]); no effect (hard bottom)	No effect	N/A
Contaminant stressors					
Explosives and explosive byproducts	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	• Sedentary invertebrate beds and reefs: may adversely affect (minimal and temporary) • Other biogenic habitats: no effect	N/A
Metals	No effect	No effect	No effect	No effect	N/A
Chemicals	No effect	No effect	No effect	No effect	N/A
Other metals	No effect	No effect	No effect	No effect	N/A

Table 6-4: Potential Impacts on Highly Migratory Species Essential Fish Habitat and Habitat Areas of Particular Concern from Each Stressor

Highly Migratory Species	EFH				HAPC
	All marine waters from the shoreline offshore to 200 nm offshore				None
	Water Column	Prey Species	Substrate	Biogenic	
Acoustic stressors					
Non-impulse • Sonar • Vessel Noise	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	No effect	No effect	N/A
Explosive and other impulse • Underwater explosions • Weapons, firing, launch, and impact noise	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and short to long term [soft bottom] to permanent [hard bottom]; mitigation avoids mapped hard bottom)	• Attached macroalgae: may adversely affect (minimal and long term based on hard substrate impacts) • Submerged rooted vegetation: may adversely affect (minimal and long term; mitigation avoids sensitive nearshore habitats) • Sedentary invertebrate beds: may adversely affect (minimal and short term to permanent [based on substrate impacts]; mitigation avoids mapped hard bottom)	N/A
Energy stressors					
Electromagnetic devices	May adversely affect (less than minimal and temporary)	May adversely affect (less than minimal and temporary)	No effect	No effect	N/A
Physical Disturbance and Strike stressors					
Vessel movement	No effect	No effect	May adversely affect (minimal and temporary [soft bottom] to permanent [hard bottom]; standard operating procedures avoids mapped hard bottom)	No effect; mitigation avoids sensitive nearshore habitats	N/A
In-water devices	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	No effect: standard operating procedures avoids mapped hard bottom and impacts with substrate	No effect; mitigation avoids sensitive nearshore habitats	N/A

Table 6-4: Potential Impacts on Highly Migratory Species Essential Fish Habitat and Habitat Areas of Particular Concern from Each Stressor (continued)

Highly Migratory Species	EFH				HAPC
	All marine waters from the shoreline offshore to 200 nm offshore				None
	Water Column	Prey Species	Substrate	Biogenic	
Physical Disturbance and Strike stressors (continued)					
Military expended materials	No effect	No effect	May adversely affect (minimal and short term to permanent)	• Attached macroalgae: minimal and temporary • Submerged rooted vegetation: minimal and short term; mitigation avoids sensitive nearshore habitats • Sedentary invertebrate beds: minimal and short term to permanent (based on substrate impacts)	N/A
Seafloor devices	No effect	No effect	May adversely affect (minimal and temporary [soft bottom]); no effect (hard bottom)	No effect	N/A
Contaminant stressors					
Explosives and explosive byproducts	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	May adversely affect (minimal and temporary)	• Sedentary invertebrate beds and reefs: may adversely affect (minimal and temporary) • Other biogenic habitats: no effect	N/A
Metals	No effect	No effect	No effect	No effect	N/A
Chemicals	No effect	No effect	No effect	No effect	N/A
Other metals	No effect	No effect	No effect	No effect	N/A

Pursuant to the EFH requirements of the MSA and implementing regulations, explosives on or near the bottom and military expended materials may adversely affect EFH or HAPC at a minimal level, for variable (habitat dependent) duration (refer to Section 4.1.5, Study Area Combined Impact of Navy Stressors, for analysis). Therefore, the Proposed Action may adversely affect EFH in the Action Area; however, these effects would be minimal and temporary. There are existing mitigation measures in place that avoid sensitive nearshore habitat and hard bottom substrates. However, currently there are no other proposed mitigation measures protecting deep-water habitats from military expended materials in the Action Area.

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APPENDIX A

LIST OF FEDERALLY MANAGED SPECIES

PACIFIC FISHERY MANAGEMENT COUNCIL

GROUNDFISH MANAGEMENT UNIT

Arrowtooth flounder (*Atheresthes stomias*)
Aurora rockfish (*Sebastes aurora*)
Bank rockfish (*Sebastes rufus*)
Big skate (*Raja binoculata*)
Black-and-yellow rockfish (*Sebastes chrysomelas*)
Black rockfish (*Sebastes melanops*)
Blackgill rockfish (*Sebastes melanostomus*)
Blue rockfish (*Sebastes mystinus*)
Bocaccio (*Sebastes paucispinis*)
Bronzespotted rockfish (*Sebastes gilli*)
Brown rockfish (*Sebastes auriculatus*)
Butter sole (*Isopsetta isolepis*)
Cabezon (*Scorpaenichthys marmoratus*)
Calico rockfish (*Sebastes dallii*)
California scorpionfish (*Scorpaena gutatta*)
California skate (*Raja inornata*)
Canary rockfish (*Sebastes pinniger*)
Chameleon rockfish (*Sebastes phillipsi*)
Chilipepper (*Sebastes goodei*)
China rockfish (*Sebastes nebulosus*)
Copper rockfish (*Sebastes caurinus*)
Cowcod (*Sebastes levis*)
Curlfin sole (*Pleuronichthys decurrens*)
Darkblotched rockfish (*Sebastes crameri*)
Dover sole (*Microstomus pacificus*)
Dusky rockfish (*Sebastes ciliates*)
Dwarf-red rockfish (*Sebastes rufinanus*)
English sole (*Parophrys vetulus*)
Finescale codling (*Antimora microlepis*)
Flag rockfish (*Sebastes rubrivinctus*)
Flathead sole (*Hippoglossoides elassodon*)
Freckled rockfish (*Sebastes lentiginosus*)
Gopher rockfish (*Sebastes carnatus*)
Grass rockfish (*Sebastes rastrelliger*)
Greenblotched rockfish (*Sebastes rosenblatti*)
Greenspotted rockfish (*Sebastes chlorostictus*)
Greenstriped rockfish (*Sebastes elongates*)
Halfbanded rockfish (*Sebastes semicinctus*)
Harlequin rockfish (Sebastes variegates)
Honeycomb rockfish (*Sebastes umbrosus*)
Kelp greenling (*Hexagrammos decagrammus*)
Kelp rockfish (*Sebastes atrovirens*)
Leopard shark (*Triakis semifasciata*)
Lingcod (*Ophiodon elongates*)
Longnose skate (*Raja rhina*)
Longspine thornyhead (*Sebastolobus altivelis*)
Mexican rockfish (*Sebastes macdonaldi*)
Olive rockfish (*Sebastes serranoides*)
Pacific cod (*Gadus macrocephalus*)
Pacific hake (*Merluccius productus*)
Pacific ocean perch (*Sebastes alutus*)
Pacific rattail (*Coryphaenoides acrolepis*)
Pacific sanddab (*Citharichthys sordidus*)
Petrale sole (*Eopsetta jordani*)
Pink rockfish (*Sebastes eos*)
Pinkrose rockfish (*Sebastes simulator*)
Pygmy rockfish (*Sebastes wilsoni*)
Quillback rockfish (*Sebastes maliger*)
Ratfish (*Hydrolagus colliei*)
Redbanded rockfish (*Sebastes babcocki*)
Redstripe rockfish (*Sebastes proriger*)
Rex sole (*Glyptocephalus zachirus*)
Rock sole (*Lepidopsetta bilineata*)
Rosethorn rockfish (*Sebastes helvomaculatus*)
Rosy rockfish (*Sebastes rosaceus*)
Rougheye rockfish (*Sebastes aleutianus*)
Sablefish (*Anoplopoma fimbria*)
Sand sole (*Psettichthys melanostictus*)
Sharpchin rockfish (*Sebastes zacentrus*)
Shortbelly rockfish (*Sebastes jordani*)
Shortraker rockfish (*Sebastes borealis*)
Shortspine thornyhead (*Sebastolobus alascanus*)
Silvergray rockfish (*Sebastes brevispinis*)
Soupfin shark (*Galeorhinus zyopterus*)
Speckled rockfish (*Sebastes ovalis*)
Spiny dogfish (*Squalus acanthias*)
Splitnose rockfish (*Sebastes diploproa*)
Squarespot rockfish (*Sebastes hopkinsi*)
Starry flounder (*Platichthys stellatus*)
Starry rockfish (*Sebastes constellatus*)
Stripetail rockfish (*Sebastes saxicola*)
Swordspine rockfish (*Sebastes ensifer*)
Tiger rockfish (*Sebastes nigrocinctus*)
Treefish (*Sebastes serriceps*)
Vermilion rockfish (*Sebastes miniatus*)
Widow rockfish (*Sebastes entomelas*)
Yelloweye rockfish (*Sebastes ruberimus*)
Yellowmouth rockfish (*Sebastes reedi*)
Yellowtail rockfish (*Sebastes flavidus*)

COASTAL PELAGIC SPECIES MANAGEMENT UNIT

Jack mackerel (*Trachurus symmetricus*)
Krill (*Euphausiids*)
Market squid (*Loligo opalescens*)
Northern anchovy (*Engraulis mordax*)

Pacific mackerel (*Scomber japonicus*)
Pacific sardine (*Sardinops sagax*)

Highly Migratory Species Management Unit

Bigeye tuna (*Thunnus obesus*)
Blue shark (*Prionace glauca*)
Thresher shark (*Alopias vulpinus*)
Dorado or dolphinfish (*Coryphaena hippurus*)
Northern bluefin tuna (*Thunnus orientalis*)
North Pacific albacore (*Thunnus alalunga*)
Shortfin mako shark (*Isurus oxyrinchus*)
Skipjack tuna (*Katsuwonus pelamis*)
Striped marlin (*Tetrapturus audax*)
Swordfish (*Xiphias gladius*)
Yellowfin tuna (*Thunnus albacares*)

California Nearshore Fisheries Management Plan Species Management Unit

Black-and-yellow rockfish (*Sebastes chrysomelas*)
Black rockfish (*Sebastes melanops*)
Blue rockfish (*Sebastes mystinus*)
Brown rockfish (*Sebastes auriculatus*)
Cabezon (*Scorpaenichthys marmoratus*)
Calico rockfish (*Sebastes dallii*)
California scorpionfish (*Scorpena guttatta*)
California sheephead (*Semicossyphus pulcher*)
China rockfish (*Sebastes nebulosus*)
Copper rockfish (*Sebastes caurinus*)
Gopher rockfish (*Sebastes carnatus*)
Grass rockfish (*Sebastes rastrelliger*)
Kelp greenling (*Hexagrammos decagrammus*)
Kelp rockfish (*Sebastes atrovirens*)
Monkeyface prickleback (*Cebidichthys violaceus*)
Olive rockfish (*Sebastes serranoides*)
Quillback rockfish (*Sebastes maliger*)
Rock greenling (*Hexagrammos lagocephalus*)
Treefish (*Sebastes serriceps*)

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APPENDIX B

PRIMARY HABITAT TYPES DESIGNATED AS ESSENTIAL FISH HABITAT

B PRIMARY HABITAT TYPES DESIGNATED AS ESSENTIAL FISH HABITAT

B.1 ESSENTIAL FISH HABITAT DESIGNATIONS BY PRIMARY HABITAT TYPE FOR EACH SPECIES/MANAGEMENT UNIT AND LIFE STAGE

Table B-0-1: Pacific Fishery Management Council Groundfish Management Unit

PFMC Groundfish Management Unit							
Group/Species	**Estuarine**	**Rocky Shelf**	**Non-Rocky Shelf**	**Neritic**	**Canyon**	**Continental Slope/Basin**	**Oceanic**
Flatfish							
Curlfin Sole			A, SA	E		A, SA	E
Dover Sole			A, SA, J	L, E		A, SA, J	L, E
English Sole	A*, SA, J*, L*, E	A*, SA, J*	A*, SA, J*	L*, E		A*	
Petrale Sole			A, J	L, E		A, SA	L, E
Rex Sole	A		A, SA	E		A, SA	L, E
Rock Sole		A*, SA*, J*, E*	A*, SA*, J*, E*	L		A*, SA*, J*, E*	
Sand Sole			A, SA, J	L, E			
Pacific Sanddab	J, L, E		A*, SA, J	L, E			L, E
Rockfish							
Aurora Rockfish			A, MA, LJ			A, MA, LJ	L
Bank Rockfish		A, J	A, J		A, J	A, J	
Black Rockfish	A*, SJ*	LJ*	LJ*	A*, SJ*			A*
Black-and-yellow Rockfish		A*, MA, LJ*, SJ*, P		L*			
Blackgill Rockfish		LJ		SJ, L		A, LJ	S, LJ
Blue Rockfish		A*, MA, LJ*	LJ*	SJ*, L			
Bocaccio	SJ*, L	A*, LJ*	A*, LJ*	SJ*, L	LJ*	A*, LJ*	
Bronzespotted Rockfish						A	
Brown Rockfish	A*, MA, J*, P	A*, MA, J*, P					
Calico Rockfish	A, J	A, J	A, J				
Canary Rockfish		A, P		SJ*, L		A, P	SJ*, L
Chilipepper		A, LJ, P	A, LJ, P	SJ*, L		A, LJ, P	
China Rockfish		A, J, P		L			
Copper Rockfish	A*, LJ*, SJ*, P	A*, LJ*		SJ*, P			

Table B-1: Pacific Fishery Management Council Groundfish Management Unit (continued)

PFMC Groundfish Management Unit							
Group/Species	**Estuarine**	**Rocky Shelf**	**Non-Rocky Shelf**	**Neritic**	**Canyon**	**Continental Slope/Basin**	**Oceanic**
Rockfish (continued)							
Cowcod		A, J	J	L			
Darkblotched Rockfish		A, MA, LJ, P	A, MA, LJ, P			A, MA, P	SJ, L
Flag Rockfish		A, P					
Gopher Rockfish		A*, MA, J*, P	A*, A, J*, P				
Grass Rockfish		A*, J*, P					
Greenblotched Rockfish		A, J, P	A, J, P		A, J, P	A, P	
Greenspotted Rockfish		A, J, P	A, J, P				
Greenstriped Rockfish		A, P	A, P				
Honeycomb Rockfish		A, J, P			J		
Kelp Rockfish	SJ*	A*, LJ*, P		SJ*			
Mexican Rockfish		A	A	L			L
Olive Rockfish		A*, J*, P			A*, P		
Pacific Ocean Perch		A, LJ	A, LJ	SJ	A	A, P	SJ, L
Pink Rockfish		A	A			A	
Redbanded Rockfish			A			A	
Redstripe Rockfish		A, P				A, P	
Rosethorn Rockfish		A, P	A, P			A, P	
Rosy Rockfish		A, J, P					
Rougheye Rockfish		A	A			A	
Sharpchin Rockfish		A, P	A, P			A, P	L
Shortbelly Rockfish		A*, P	A*, P		A*, P	A*, P	
Silverygray Rockfish		A*	A*			A*	
Speckled Rockfish		A, J, P			A, P	A, P	
Splitnose Rockfish			A, J*, P			A, P	
Squarespot Rockfish		A, P			A, P		
Starry Rockfish		A, P				A, P	
Stripetail Rockfish			A, P			A, P	
Tiger Rockfish		A				A	
Treefish		A					

Table B-1: Pacific Fishery Management Council Groundfish Management Unit (continued)

PFMC Groundfish Management Unit							
Group/Species	**Estuarine**	**Rocky Shelf**	**Non-Rocky Shelf**	**Neritic**	**Canyon**	**Continental Slope/Basin**	**Oceanic**
Rockfish (continued)							
Vermilion Rockfish		A, J*	J*		A	A	
Widow Rockfish		A, MA, LJ, P	A, MA, LJ, P	SJ*, L	A, MA, LJ, P	A, MA, P	SJ*, L
Yelloweye Rockfish		A, P				A, P	
Yellowtail Rockfish		A, MA, LJ, P	A, MA, LJ, P	SJ*		A, MA, P	SJ*
Scorpionfish							
California Scorpionfish	E	A, SA, J	A, SA, J	E			
Thornyhead							
Longspine Thornyhead						A, SA, J	L, E
Shortspine Thornyhead			A			A, SA	L, E
Roundfish							
Cabezon	A, SA, LJ, SJ*, L, E	A, SA, LJ, E		SJ*, L			SJ*, L
Kelp Greenling	A*, SA, LJ*, SJ*, L, E	A*, SA, LJ*, E		SJ*, L			SJ*, L
Lingcod	A*, SA, LJ*, SJ*, L, E	A*, SA, LJ*, E	A*, LJ*	SJ*, L		A*	
Pacific Cod	A, SA, J, L, E		A, SA, J, E	A, SA, J, L		A, SA, E	A, SA, J, L
Pacific Hake (Whiting)	A, SA, J, L, E			A, SA, J, L, E			A, SA, L, E
Pacific Flatnose					A	A	
Pacific Grenadier			A, SA, J			A, SA, J	L
Sablefish	SJ	A	A, LJ	SJ, L	A, LJ	A, SA	SJ, L, E
Skates/Sharks/Chimeras							
Big Skate			A, MA, J, E			A, MA	
California Skate	A, MA, J, E		A, MA, J, E			A, MA, J, E	
Longnose Skate			A, MA, J, E			A, MA, J, E	
Leopard Shark	A, MA, J, P	A, MA, J, P	A, MA, J, P	A, MA, J, P			

Table B-1: Pacific Fishery Management Council Groundfish Management Unit (continued)

PFMC Groundfish Management Unit							
Group/Species	**Estuarine**	**Rocky Shelf**	**Non-Rocky Shelf**	**Neritic**	**Canyon**	**Continental Slope/Basin**	**Oceanic**
Skates/Sharks/Chimeras (continued)							
Soupfin Shark	A, MA, J, P	A, MA, J	A, MA, J, P	A, MA, J, P	A, MA, J		A, MA, J
Spiny Dogfish	A, LJ, SJ, P	A, MA, LJ	A, LJ, P	A, LJ, SJ	A	A, MA	A
Spotted Ratfish	A, MA, J	A, MA, J, E	A, MA, J, E			A, MA, J, E	

Notes: A = Adults; SA = Spawning Adults; MA = Mating Adults; LJ = Large Juveniles; SJ = Small Juveniles; J = Juveniles; L = Larvae; E = Eggs; P = Parturition; * = Associated with macrophytes, algae, or seagrass; PFMC = Pacific Fishery Management Council

Source: Pacific Fishery Management Council 2006

Table B-0-2: Pacific Fishery Management Council Coastal Pelagic Species Management Unit

PFMC Coastal Pelagic Species Management Unit			
Group/Species	**Coastal epipelagic**	**Coastal mesopelagic**	**Coastal benthic**
Krill	E, L, J, A		
Northern anchovy	E, L, J, A		
Mackerels	E, L, J, A		
Sardine	E, L, J, A		
Squid	L, J, A		E

Notes: A = Adults, J = Juveniles, L = Larvae, E = Eggs, PFMC = Pacific Fishery Management Council

Source: Pacific Fishery Management Council 2003, 2005

Table B-0-3: Pacific Fishery Management Council Highly Migratory Species Management Unit

PFMC Highly Migratory Species Management Unit				
Group/Species	**Coastal epipelagic**	**Coastal mesopelagic**	**Oceanic epipelagic**	**Oceanic mesopelagic**
Sharks				
Blue Shark			N, EJ, LJ, SA, A	
Thresher Sharks	LJ, SA, A	LJ, SA, A	LJ, SA, A	LJ, SA, A
Tunas				
Albacore			J, A	
Bigeye Tuna			J, A	J, A
Northern Bluefin			J	
Skipjack			A	
Yellowfin			J	

Table B-3: Pacific Fishery Management Council Highly Migratory Species Management Unit (continued)

PFMC Highly Migratory Species Management Unit				
Group/Species	**Coastal epipelagic**	**Coastal mesopelagic**	**Oceanic epipelagic**	**Oceanic mesopelagic**
Billfish				
Striped Marlin			A	
Swordfish				
Broadbill Swordfish			J, A	J, A
Dolphinfish				
Dorado			J, SA, A	

Notes: A = Adults, SA = Sub-Adults, LJ = Late Juveniles, N= Neonate, EJ = Early Juveniles, J = Juveniles, L = Larvae, E = Eggs, PFMC = Pacific Fishery Management Council

Source: Pacific Fishery Management Council 2006, 2007