Northwest Training Range Complex

Marine and Terrestrial Species

Biological Evaluation

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Commander, U.S. Pacific Fleet
c/o Pacific Fleet Environmental Office
1101 Tautog Circle
Silverdale, WA 98315

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ACRONYMS AND ABBREVIATIONS

A-	Alert Area
A-A	Air-to-Air
AAMEX	Air-to-Air Missile Exercise
AAW	Anti-Air Warfare
ac	Acre/acres
ACM	Air Combat Maneuvers
ADAR	Air Deployed Active Receiver
ADLFP	Air Deployable Low Frequency Projector
AEER	Advanced Extended Echo Ranging
AESA	Airborne Electronically Scanned Array
AGL	Above ground level
AK	Alaska
AMSP	Advanced Multi-Static Processing Program
AMW	Amphibious Warfare
ARS	Advance Ranging Source
ARTCC	Air Route Traffic Control Center
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
ATCAA	Air Traffic Control Assigned Airspace
BE	Biological Evaluation
BAMS	Broad Area Maritime Surveillance
BDA	Battle-Damage Assessment
BDU	Bomb Dummy Unit
BMP	Best Management Practices
BO	Biological Opinion
°C	Centigrade
CA	California
CAA	Clean Air Act
CCA	California Coastal Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CIWS	Close-in Weapons System
CHU	Cirtical Habitat Unit
CMP	Coastal Management Plan
cm	Centimeter/centimeters
CNO	Chief of Naval Operations
CNRNW	Commander, Navy Region Northwest
COMPTUEX	Composite Training Unit Exercise
COMSUBPAC	Commander, Submarine Forces Pacific
CPF	Commander, U.S. Pacific Fleet
CPRW	Commander, Patrol and Reconnaissance Wing
CSG	Carrier Strike Group
CVN	Aircraft Carrier, Nuclear
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DARPA	Defense Advanced Research Programs Agency
dB	Decibel/decibels
DBRC	Dabob Bay Range Complex
DESRON	Destroyer Squadron
DICASS	Directional Command Activated Sonobuoy System
DLCD	Department of Land Conservation and Development
DoD	Department of Defense
DON	Department of Navy
DPS	Distinct Population Segment
DTR	Demolition Training Range
DZ	Drop Zone
EA	Electronic Attack
EC	Electronic Combat
EER	Extended Echo Ranging
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFSEC	Energy Facility Site Evaluation Council
EIS	Environmental Impact Statement
EMATT	Expendable Mobile ASW Training Target
EO	Executive Order
EOD	Explosive Ordnance Disposal
EODMU	Explosive Ordnance Disposal Mobile Unit
EPA	Environmental Protection Agency
ES	Electronic Support
ESA	Endangered Species Act
ESG	Expeditionary Strike Group
ESU	Evolutionarily Significant Unit
ET	Electronically Timed
EW	Electronic Warfare
EX	Exercise
°F	Fahrenheit
FAST	Floating At-Sea Target
FCLP	Field Carrier Landing Practice
FDNF	Forward Deployed Naval Forces
FL	Flight Level
FONSI	Finding of No Significant Impact
FR	Federal Register
FRTP	Fleet Response Training Plan
ft	Foot/feet
GUNEX	Gunnery Exercise
HARM	High Speed Anti-radiation Missile
HE	High Explosive
HRST	Helicopter Rope Suspension Training
Hz	Hertz
ICAP	Improved Capability
IED	Improvised Explosive Device
IEER	Improved Extended Echo Ranging
IFR	Instrument Flight Rules
in	Inch/inches
IOC	Initial Operating Capability
ISR	Intelligence, Surveillance, and Reconnaissance
JLOTS	Joint Logistics over the shore
JNTC	Joint National Training Capability
JTFEX	Joint Task Force Exercise
JUCAS	Joint Unmanned Combat Air System
KE	Kinetic Energy
kg	Kilogram/kilograms
km	Kilometer/kilometers
km2	Square kilometer
kts	Knots
kHZ	KiloHetrz
LCS	Littoral Combat Ship
LMRS	Long-Term Mine Reconnaissance System
LZ	Landing Zone
MAGTF	Marine Air Ground Task Force
MBTA	Migratory Bird Treaty Act
MCM	Mine Counter Measures
m	Meter/meters
mi	Mile/miles

mm	Millimeters
METOC	Meteorological and Oceanographic Operations
MEU	Marine Expeditionary Units
MFAS	Medium-Frequency Active Sonar
MISSLEX	Air-to-Air Missle Exercise
MIW	Mine Warfare
MMA	Multi-mission Maritime Aircraft
MOA	Military Operations Area
MMPA	Marine Mammal Protection Act
MPA	Maritime Patrol Aircraft
MRUUV	Mission Reconfigurable Unmanned Undersea Vehicle
MSL	Mean Sea Level
NA	Not Applicable
NAS	Naval Air Station
NATO	North Atlantic Treaty Organization
NAVBASE	Naval Base
NAVMAG	Naval Magazine
NEPA	National Environmental Policy Act
NEW	Net Explosive Weight
NHPA	National Historic Preservation Act
nm	Nautical Mile
nm^2	Square Nautical Mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NS	Naval Station
NSCT	Naval Special Clearance Team
NSW	Naval Special Warfare
NSWG	Naval Special Warfare Group
NUWC	Naval Undersea Warfare Center
NWTRC	Northwest Training Range Complex
OCE	Officer in Charge of the Excercise
OCNMS	Olympic Coast National Marine Sanctuary
OCMP	Oregon Coastal Management Program
OEIS	Overseas Environmental Impact Statement
OLF	Outlying Landing Field
OPAREA	Operating Area
OPFOR	Opposition Forces
OPNAV	Office of the Chief of Naval Operations
OR	Oregon
ORMA	Ocean Resources Management Act
OTB	Over-the-Beach
PACFIRE	Pre-action Calibration Firing
PACNORWEST	Pacific Northwest
PCE	Primary Constituent Element
PMAR	Primary Mission Area
psi	Pounds per Square Inch
PTS	Permanent Threshold Shift
PUTR	Portable Undersea Tracking Range
R-	Restricted Area
RA	Restricted Area
RCD	Required Capabilities Document
RDT&E	Research, Development, Test and Evaluation
RHA	Rivers and Harbors Act
RHIB	Rigid Hull Inflatable Boat
ROD	Record of Decision
S-A	Surface-to-Air
SAM	Surface-to-Air Missile
SAMEX	Surface-to Air Missile Exercise
SBU	Special Boat Unit
SCORE	Southern California Off-Shore Range Extension
SD	Standard Deviation
SDV	SEAL Delivery Vehicle
SDVT	SEAL Delivery Vehicle Team
SEAD	Suppression of Enemy Air Defense
SEAL	Sea, Air, and Land Forces
SEPA	State Environmental Policy Act
SINKEX	Sinking Exercise
SMA	Shoreline Management Act
SOCAL	Southern California
SOF	Special Operations Forces
SONAR	Sound Navigation and Ranging
SOP	Standard Operating Procedure
SPIE	Special Purpose Insertion and Extraction
SSBN	Ship, Submersible, Ballistic, Nuclear (Submarine)
SSG	Surface Strike Group
SSGN	Guided Missile Submarine
SSN	Fast Attack Submarine
STW	Strike Warfare
SUA	Special Use Airspace
SUS	Signal Underwater Sound
TAP	Tactical Training Theater Assessment and Planning
TDU	Target Drone Unit
TGEX	Task Group Exercise
TORPEX	Torpedo Exercise
TRACKEX	Tracking Exercise
TS	Threshold Shift
TTS	Temporary Threshold Shift
UAS	Unmanned Aerial System
ULT	Unit Level Training
U.S.	United States
USAF	U.S. Air Force
U.S.C.	United States Code
USFF	United States Fleet Forces
USFWS	United States Fish and Wildlife Service
UTR	Underwater Training Range
UUV	Unmanned Underwater Vehicle
UXO	Unexploded Ordnance
VFR	Visual Flight Rules
VP	Fixed-Wing Patrol Squadron
VTNF	Variable Timed, Non-Fragmentation
VTUAV	Vertical Take-off and Land UAV
W-	Warning Area
WA	Washington
WDNR	Washington Department of Natural Resources
WI	Whidbey Island
yd	Yard/yards

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1 INTRODUCTION

1.1 BACKGROUND

The Department of the Navy (Navy) proposes to implement selectively focused but critical enhancements and increases in training activities and research, development, test and evaluation (RDT&E) activities that are necessary to ensure the Northwest Training Range Complex (NWTRC) supports Navy training and readiness objectives. This Biological Evaluation (BE) has been prepared to analyze the potential impacts of the Navy's proposed training and RDT&E activities within the range complex. The NWTRC consists of four primary components: ocean operating areas, the Puget Sound operating areas, special-use airspace (SUA), and training land areas. The Proposed Action does not involve extensive changes to the NWTRC facilities, activities, or training capacities as they currently exist. The range complex includes ranges and airspace that extend west to 250 nautical miles (nm) (463 kilometers [km]) beyond the coast of Northern California, Oregon, and Washington and east to Idaho (see Figures 1-1 and 1-2).

The Navy is also preparing an Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) to address environmental effects of the Proposed Action in accordance with the National Environmental Policy Act (NEPA). The Navy is the lead agency for the EIS/OEIS, and the National Marine Fisheries Service (NMFS) is a cooperating agency.

In accordance with Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended, federal agencies have the responsibility for consulting with the National Marine Fisheries Service (NMFS) on the possible effects of the current and proposed federal activities on federally-listed threatened or endangered marine species and their designated critical habitats within the NWTRC (Figure 1-1). The U.S. Fish and Wildlife Service (USFWS) is responsible for providing consultation on possible effects of the current and proposed activities on federally-listed terrestrial and other non-marine species and their designated critical habitats within the NWTRC.

This Biological Evaluation (BE) analyzes the potential effects of ongoing and future Navy training activities and research, development, test, and evaluation (RDT&E) activities in the NWTRC on federally listed threatened and endangered species and critical habitats under the jurisdiction of either the NMFS or the USFWS. Training activities include surface and subsurface ocean operating area (OPAREA) from Washington to northern California, over-ocean and overland military airspace in Washington, Oregon, northern California and Idaho, and land training areas in Washington.

1.2 DESCRIPTION OF THE NORTHWEST TRAINING RANGE COMPLEX

The NWTRC is one of many Navy Range Complexes used for training of operational forces, RDT&E of military equipment, and other military activities. As with each Navy Range Complex, the primary mission of the NWTRC is to provide a realistic training environment for naval forces to ensure they have the capabilities and readiness required to accomplish assigned missions. The NWTRC is the principle local range for surface, submarine, aviation, and explosive ordnance disposal (EOD) units located at NAS Whidbey Island, NAVSTA Everett, Puget Sound Naval Station, NBK-Bremerton and NBK-Bangor, WA, in addition to supporting other non-resident users and their training requirements to include Naval Special Warfare units.

The components of the NWTRC encompass 122,400 nm^2 (420,163 km^2) of surface/subsurface ocean operating areas (OPAREAs), 46,048 nm^2 (157,928 km^2) of SUA, and 875 acres (354 hectares) of land.

1.2.1 NWTRC Ocean OPAREAS.

The ocean areas of the Range Complex include surface and subsurface operating areas extending generally west from the coastline of Northern California, Oregon, and Washington for a distance of approximately 250 nm (463 km) into international waters (see Figure 1-1).

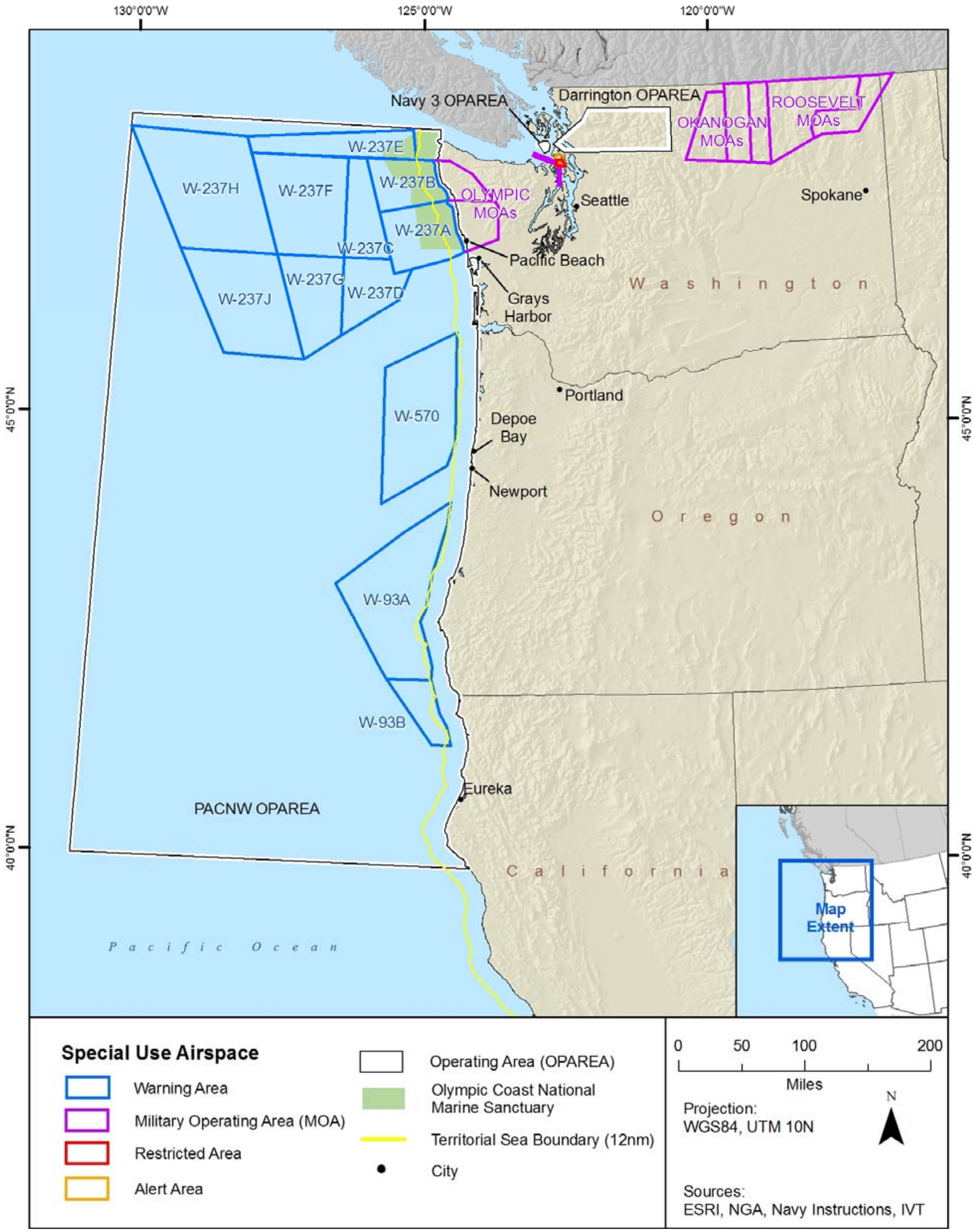


Figure 1-1. Northwest Training Range Complex

1.2.2 Puget Sound Surface/Subsurface Areas.

There are several areas within Puget Sound routinely used by the Navy for a variety of surface and underwater activities. These areas are depicted on Figure 1-2 and include:

- Navy 3. Navy 3 is a polygon of water space used by Navy ships for training. This 46 nm^2 (158 km^2) area is located 8 nm (15 km) west of Ault Field, NAS Whidbey Island, in the Strait of Juan de Fuca.
- Navy 7. Navy 7 is defined as the sea surface and subsurface area beneath R-6701.
- Crescent Harbor Underwater EOD Range. This EOD underwater range is located in Crescent Harbor off of the Seaplane Base at Whidbey Island.
- Indian Island EOD Underwater Range. This area is located offshore, just west of Naval Magazine (NAVMAG) Indian Island.
- Bangor EOD Underwater Range. This area, also known as the Floral Point EOD Underwater Range, is located within a Navy operating area in Hood Canal, near NBK-Bangor.

1.2.3 Airspace.

The NWTRC Study Area includes airspace used either exclusively by the military, or co-use with civilian and commercial aircraft. Some of this airspace is SUA, military airspace designated by the Federal Aviation Administration (FAA) as Warning Areas, Restricted Areas, and military operating areas (MOAs). The airspace included in the NWTRC Study Area is depicted in Figures 1-1 and 1-2 and includes:

- Warning Area 237. W-237 comprises 33,997 nm^2 (116,606 km^2) of airspace that generally overlays the NWTRC Ocean OPAREAS off the coast of Washington, W-237 begins approximately 3 nm (5 km) off the coast and extends westward in international waters and airspace for a distance of approximately 250 nm (463 km) from the ocean surface up to several specified altitudes depending upon which sub-area is used. The floor of W-237 airspace begins at the ocean surface, and the ceiling varies between 27,000 ft (8,230 m) and unlimited.
- Olympic MOAs. The Olympic A and B MOAs are located over the northwest coast of the Olympic Peninsula in Washington and extends out 3 nm (6 km) to join with W-237. The MOAs cover 1,641 nm^2 (5,628 km^2) of area. Olympic A and B have a floor of 6,000 ft (1,829 m) and a ceiling of 18,000 ft (5,486 m). Olympic B air traffic controlled assigned airspace (ATCAA) has a floor of 18,000 ft (5,486 m) and a ceiling of 50,000 ft (15,240 m).
- The Chinook A and B MOAs are adjacent to R-6701 over the eastern portion of the Strait of Juan de Fuca and Admiralty Inlet respectively. Both Chinook MOAs cover 56 nm^2 (192 km^2) of surface area and have a floor of 300 ft (91 m) and a ceiling of 5,000 ft (1,524 m).
- Restricted Area 6701. R-6701 is a 22 nm^2 (75 km^2) area over Admiralty bay that extends from the surface to 5,000 ft (1,524 m).
- Okanogan MOA. The Okanogan MOA is located above north central Washington and covers 4,364 nm^2 (14,968 km^2) in area. This MOA is divided into A, B, and C sections. Okanogan A is available from 9,000 ft (2,743 m) to 18,000 ft (5,486 m). Okanogan B and C have a floor of 300 ft (91 m) above the ground and a ceiling of 9,000 ft (2,743 m). The ATCAAs corresponding to the Okanogan MOA extends the airspace to 50,000 ft (15,240 m).
- Roosevelt MOA. The Roosevelt MOA is located just east of the Okanogan MOA and covers an area of 5,413 nm^2 (18,566 km^2). This MOA is divided into two sections. Roosevelt A has a floor of 9,000 ft (2,743 m) and a ceiling of 18,000 ft (5,486 m). Roosevelt B has a floor of 300 ft (91 m) above the ground and a ceiling of 9,000 ft (2,743 m). ATCAAs associated with the Roosevelt MOA extends its airspace to 50,000 ft (15,240 m).

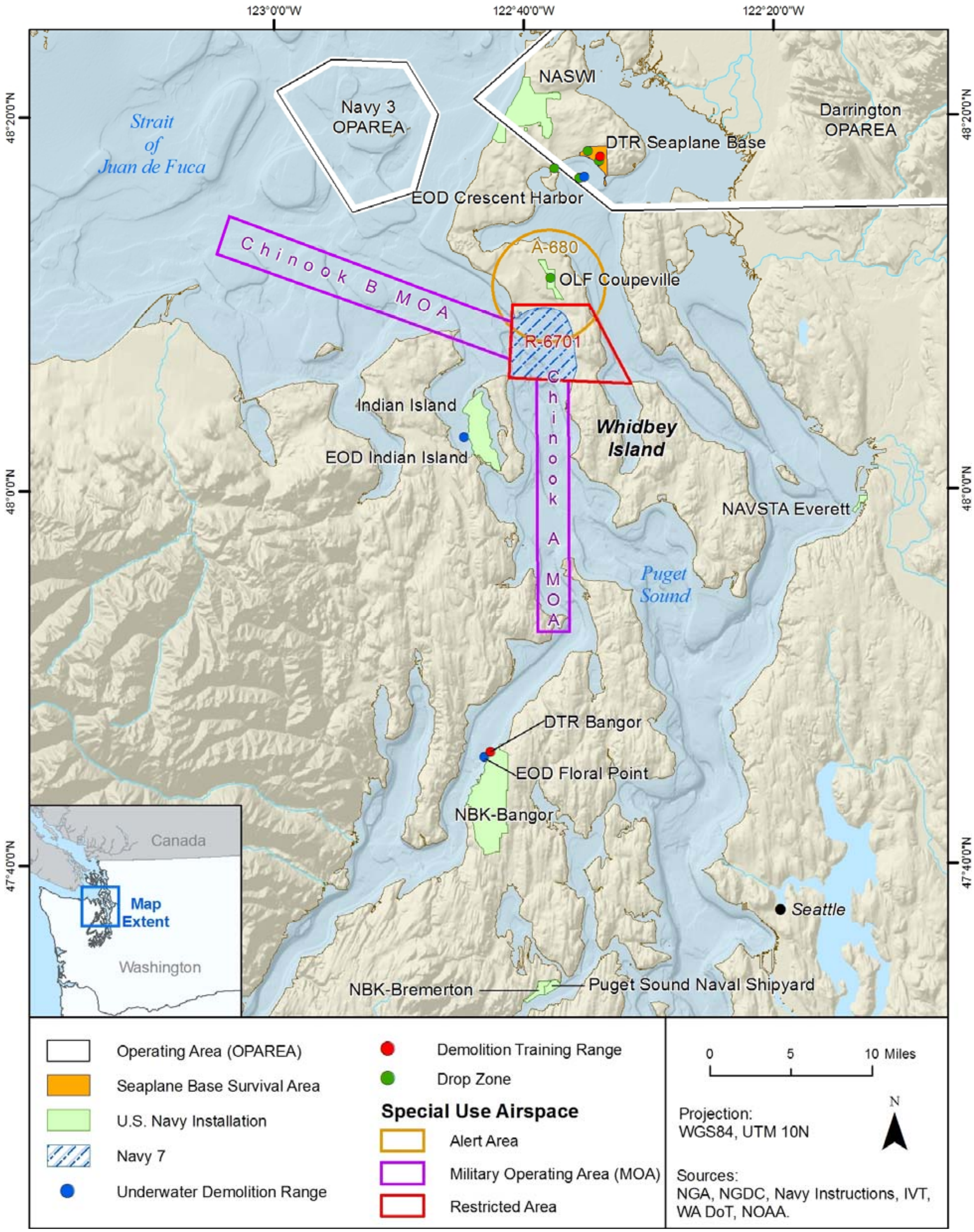


Figure 1-2. EOD Areas of the NWTRC

- W-570, located off the central coast of Oregon, is 4,470 nm^2 (15,330 km^2) in size. The airspace begins at the ocean's surface and extends to 50,000 ft (15,240 m). This area is used by P-3 aircraft for reconnaissance training.
- W-93 is located south of W-570, off the coast of Oregon and northern California. The 4,652 nm^2 (15,960 km^2) of airspace in W-570 is also used for P-3 reconnaissance training and extends from the surface to 50,000 ft (15,240 m).

1.2.4 Land Range.

The land areas of the NWTRC Study Area, all of which are on Navy property, include the Seaplane Base Survival Area, Lake Hancock Target Range, OLF Coupeville, the EOD detonation training range at NBK-Bangor, and Indian Island. Seaplane Base Survival Area comprises approximately 875 acres (354 hectares) of undeveloped Navy property, located adjacent to Crescent Harbor. It provides a robust suite of range capabilities for use in small unit amphibious and land tactical maneuvers, land navigation, and survival training. Additionally, Seaplane Base Survival Area has several unimproved helicopter landing zones, small boat landing beaches, and a parachute drop zone. Indian Island is located west of Marrowstone Island between the waters of Port Townsend and Whidbey Island. It is approximately 4.2 mi (6.7 km) long and oriented on a north-south axis. Indian Island is used by NSW to conduct insertion/extraction activities. All activities at Indian Island are covert in nature, and no live fire weapons or other ordnance are used.

1.3 PURPOSE AND NEED FOR THE PROPOSED ACTION

The purpose of the Proposed Action is to enable the NWTRC to continue fulfilling its mission of supporting naval operational readiness by providing a realistic, live-training environment for forces assigned to the Pacific Fleet and other users with the capability and capacity to support current, emerging, and future training and RDT&E requirements. The Proposed Action to support current, emerging, and future training and RDT&E training activities at the NWTRC, including implementation of range enhancements, are evaluated in this BE. These actions include:

- Increase numbers of training activities of the types currently being conducted in the NWTRC.
- Increase maximum net explosive weight (NEW) limits at Crescent Harbor EOD Range from 2.5 lb (1 kg) to 20 lbs (9 kg).
- Operate air target services for locally based aircraft, surface, and submarine combatant ships with a capability to support air-to-air missile exercise (MISSLEX), air-to-air electronic combat (EC) Opposition Force (OPFOR) requirements, surface-to-air (S-A) gunnery and missile exercises.
- Operate surface target services for locally based aircraft, surface and submarine combatant ships with a capability to support air-to-surface bombing and missile exercises, surface-to-surface gunnery and missile exercises, and submarine-to-surface missile exercises.
- Develop an additional land based EC threat signal emitter capability along the Washington coast for offshore use by aircraft, surface and subsurface combatants in W-237, the Olympic MOAs, and portions of the Pacific Northwest (PACNORWEST) Surface and Submarine Operating Area.
- Development of a small scale underwater training minefield.
- Potential use of a Portable Undersea Tracking Range (PUTR).

The types of activities and number of training operations compared to the existing or baseline conditions are summarized in Table 1-1. Proposed Action details are described in Section 2 – Proposed Action.

TABLE 1-1. BASELINE AND PROPOSED INCREASES IN TRAINING ACTIVITIES FOR PROPOSED ACTION

Navy Warfare Area	No.	Operation Type	Areas	Operations/Year	
				Baseline	Proposed Action
Anti-Air Warfare	**1**	Aircraft Combat Maneuvers	Okanogan, Olympic, and Roosevelt MOAs/ATCAAs, Darrington Area	1,353	2,000
	2	Air-to-Air Missile Exercise	W-237	0	24
	3	Surface-to-Air Gunnery Exercise	W-237, PACNORWEST OPAREA	72	160
	4	Surface-to-Air Missile Exercise	W-237, PACNORWEST OPAREA	0	4
Anti-Surface Warfare	**5**	Surface-to-Surface Gunnery Exercise	W-237, PACNORWEST OPAREA	90	180
	6	Air-to-Surface Bombing Exercise	W-237, PACNORWEST OPAREA	24	30
	7	Sink Exercise	W-237, PACNORWEST OPAREA	1	2
Anti-Submarine Warfare	**8**	Antisubmarine Warfare Tracking Exercise - MPA	W-237, PACNORWEST OPAREA	200	210
	9	Antisubmarine Warfare Tracking Exercise - Extended Echo Ranging (EER)	W-237, PACNORWEST OPAREA	10	12
	10	Antisubmarine Warfare Tracking Exercise - Surface Ship	PACNORWEST OPAREA	60	65
	11	Antisubmarine Warfare Tracking Exercise - Submarine	W-237, PACNORWEST OPAREA	96	100
Electronic Combat	**12**	Electronic Combat Exercises	W-237A, Darrington Area	2,330	5,000
Mine Warfare	**13**	Mine Countermeasures	Crescent Harbor, Indian Island	60	4
	14	Land Demolitions	Bangor DTR, Seaplane Base DTR	102	110
Naval Special Warfare	**15**	Insertion/Extraction	Seaplane Base, OLF Coupeville, Crescent Harbor	108	120
	16	NSW Training	Indian Island	35	35
Strike Warfare	**17**	HARM Exercise (Non-firing)	Okanogan, Olympic, and Roosevelt MOAs/ATCAAs	2,724	3,000
Support Operations	**18**	Intelligence, Surveillance, and Reconnaissance (ISR)	W-237, PACNORWEST OPAREA	94	100
	19	Unmanned Aerial Vehicle RDT&E and Training	R-6701 (Admiralty Bay), PACNORWEST OPAREA, W-237	12	112

1.4 LISTED AND/OR PROPOSED SPECIES OR CRITICAL HABITAT WITHIN THE ACTION AREA

Species listed under the ESA as endangered or threatened that potentially occur within the action areas include nine marine mammals, four birds species, four sea turtle species, seven fish, and one plant (Table 1-2). In addition, critical habitat is proposed for two species and critical habitat is designated for nine of the remaining species, some of which are associated with multiple sites or areas.

This BE addresses impacts of the Proposed Action on these federally listed species and critical habitat. It addresses direct disturbance impacts as well as indirect impacts to habitat. Only critical habitats that occurred in marine or estuarine areas or that were directly linked to marine or estuarine conditions were evaluated. Critical habitat locations in upland or areas removed from the coast and that were not associated with training areas within the NWTRC were excluded from the analysis. This BE also excluded five listed species and several listed critical habitats from detailed analysis because of the species' very low probability of occurring in the NWTRC or because Navy training activities would not occur in critical habitat areas. These species and the circumstances supporting their exclusion are described in Section 1.4.2.

This BE is based upon literature review, data from the Washington Department of Fish and Wildlife (WDFW), the Washington State Department of Natural Resources (WDNR), NMFS, and previous agency consultation.

Table 1-2. ESA-Listed Species and Critical Habitats Under NMFS and USFWS Jurisdiction That May Occur Within the NWTRC Proposed Action Area

Species and Critical Habitat	Status	Jurisdiction
Marine Mammals		
Blue Whale (*Balaenoptera musculus*)	Endangered	NMFS
Fin Whale (*Balaenoptera physalus*)	Endangered	NMFS
Humpback Whale (*Megaptera novaeangliae*)	Endangered	NMFS
Sei Whale (*Balaenoptera borealis*)	Endangered	NMFS
Sperm Whale (*Physeter macrocephalus*)	Endangered	NMFS
Killer Whale - southern resident DPS (*Orcinus orca*)	Endangered	NMFS
Puget Sound and Strait of Juan de Fuca areas	Critical Habitat	NMFS
North Pacific Right Whale (*Eubalaena japonica*)	Endangered	NMFS
Stellar Sea Lion - eastern DPS (*Eumetopias jubatus*)	Threatened	NMFS
Oregon and California rookeries	Critical Habitat	NMFS
Sea Otter (*Enhydra lutris)*	Threatened	USFWS
Birds		
Short-tailed Albatross (*Phoebastria albatrus*)	Endangered	USFWS
California Brown Pelican (*Pelecanus occidentalis californicus*)	Endangered	USFWS
Marbled Murrelet (*Brachyramphus marmoratus*)	Threatened	USFWS
Washington, Oregon, and California at some near-coast uplands; mostly inland	Critical Habitat	USFWS
Western Snowy Plover (*Charadrius alexandrinus nivosus*)	Threatened	USFWS
Washington, Oregon, and California at beaches, sand dunes, and mudflats	Critical Habitat	USFWS

Table 1-2. ESA-Listed Species and Critical Habitats Under NMFS and USFWS Jurisdiction That May Occur Within the NWTRC Proposed Action Area (continued)

Species and Critical Habitat	Status	Jurisdiction
Sea Turtles		
Leatherback Sea Turtle (*Dermochelys coriacea*)	Endangered	NMFS
Oregon, California Leatherback Sea Turtle Conservation Zone	Proposed Critical habitat	NMFS
Loggerhead Sea Turtle (*Caretta caretta*)	Threatened	NMFS
Olive Ridley Sea Turtle (*Lepidochelys olivacea*)	Threatened/ Endangered	NMFS
Green Sea Turtle (*Chelonia mydas*)	Threatened/ Endangered	NMFS
Fish (with critical habitats for ESUs that interface with coastal waters)		
Chinook Salmon - California Coastal ESU (*Oncorhynchus tshawytscha*)	Threatened/ Endangered	NMFS
California Coastal ESU	Critical Habitat	NMFS
Lower Columbia River, Washington/Oregon ESU	Critical Habitat	NMFS
Puget Sound, Washington ESU	Critical Habitat	NMFS
Steelhead Trout Northern California ESU (*Oncorhynchus mykiss*)	Threatened/ Endangered	NMFS
Lower Columbia River ESU	Critical Habitat	NMFS
Northern California ESU	Critical Habitat	NMFS
Central California Coastal ESU	Critical Habitat	NMFS
Steelhead Trout Puget Sound, Washington DPS (*Oncorhynchus mykiss*)	Threatened	NMFS
Chum Salmon – Hood Canal ESU (*Oncorhynchus keta)*	Threatened	NMFS
Hood Canal Washington ESU	Critical Habitat	NMFS
Columbia River ESU	Critical Habitat	NMFS
Coho Salmon – Oregon Coast ESU (*Oncorhynchu kisutch)*	Threatened/ Endangered	NMFS
Northern California-Southern Oregon Coasts, Oregon ESU	Critical Habitat	NMFS
Oregon Coast, Oregon ESU	Critical Habitat	NMFS
Bull Trout – Coastal Puget Sound ESU (*Salvelinus confluentus*)	Threatened	USFWS
Coastal Puget Sound, Washington (CHU 28) including near-shore marine waters	Critical Habitat	USFWS
Olympic Peninsula River Basins Washington (CHU 27) including near-shore marine waters	Critical Habitat	USFWS
Green Sturgeon (*Acipenser medirostris*)	Threatened	NMFS
Southern DPS	Proposed Critical Habitat	NMFS
Plants		
Golden Paintbrush *(Castilleja levisecta)*	Threatened	USFWS
Notes: DPS – Distinct Population Segment; ESU - Evolutionarily Significant Unit; CHU – Critical Habitat Unit; Status - some species designations change for different portions of their range.		
Sources: National Marine Fisheries Service 2007; NMFS FR 70(170):52488 (9/2/05); NMFS FR 70(170):52630 (9/2/05); NMFS FR 73(28):7816 (2/11/08); NMFS FR 64(86):24049 (5/5/99); USFWS FR 70(185):56212 (9/26/05); NMFS FR 72(91):26722 (5/11/07); NMFS FR 73(174):52084		

1.4.1 ESA-Listed Species in the Proposed Action Area

As of March 2008 a total of 25 species potentially occurred within the NWTRC that are listed under the ESA (see Table 1-2). Nine of these species have designated critical habitats and two species have proposed critical habitat that occur within the marine, estuarine, freshwater, or beach environments of the NWTRC. For this BE, species and critical habitats that occurred inside the PACNORWEST OPAREA (which extended to the coastal shoreline and the mouths of rivers and streams that drained into the ocean) were considered to be within the Proposed Action Area.

The NMFS has consultation responsibilities for marine mammals and anadromous fish species, while the USFWS has consultation responsibilities for terrestrial and freshwater species. For this BE, the USFWS has jurisdiction for the sea otter (*Enhydra lutris*), short-tailed albatross (*Phoebastria albatrus*), California brown pelican (*Pelecanus occidentalis californicus*), marbled murrelet (*Brachyramphus marmoratus*), western snowy plover (Charadrius *alexandrinus nivosus),* bull trout, and golden paintbrush *(Castilleja levisecta)*. The NMFS has jurisdiction for the remaining 18 species (whale [seven species], sea lion [one species], sea turtle [four species], green sturgeon [one species], trout [two species] and Pacific salmon [three species]). The population and listing status of some species (such as the Chinook salmon and coho salmon) are shown as either endangered or threatened because the species' degree of endangerment varies across its range.

The regulatory status of threatened and endangered West Coast salmon and steelhead trout is complex and currently changing, especially in the Puget Sound and northwest Washington areas. The most current status of species protected by the ESA of individual species Evolutionarily Significant Units/Distinct Population Segments (ESUs/DPSs) that occur in the consultation area is presented as Table 1-2. (source updated February 26, 2008 and derived from information posted at the National Oceanic and Atmospheric Administration (NOAA)/NMFS website at http://www.nwfsc.noaa.gov/trt/domains.cfm)

1.4.2 ESA-Listed Species and Critical Habitats Excluded from Detailed Evaluation

A total of five listed species are excluded from detailed evaluation for several reasons. These species and the factors supporting their exclusion are listed in Table 1-3. Primary factors responsible for their exclusion include the absence or very rare occurrence in the Proposed Action Consultation Area or their occurrence in fringe areas of the OPAREA that are rarely if ever used for training, therefore making these species extremely unlikely to be affected by activities associated with the Proposed Action.

Because of the absence or rarity of the species, the Proposed Action is not likely to affect the listed species. The potential for these species to be near Proposed Action activities is sufficiently small as to be discountable. Accordingly, these species will not be considered in greater detail in this BE. Thus, there would be no effect to the species listed in Table 1-3.

Training and other readiness activities associated with the Proposed Action are unlikely to result in the destruction of or adversely modify designated critical habitats. Critical habitats for these species have been designated at numerous locations within the OPAREA; however, this action does not affect the excluded areas and no destruction or adverse modification of the listed critical habitat is anticipated.

1.4.2.1 Fish

The ESA gives the Secretary of Commerce discretion to exclude areas from designation if he determines that the benefits of exclusion outweigh the benefits of designation. Considering economic factors and available information, NMFS excluded coastal waters adjacent to military areas during its 2005 critical habitat designations. Within some designated fish critical habitat, specific military areas and facilities are excluded from critical habitat because of the current national priority on military readiness, and in recognition of conservation activities covered by military integrated natural resource management plans (NMFS 2008f). The exclusion areas vary by fish species. Species-specific exclusions are as follows.

Table 1-3. ESA-Listed Species Excluded from Detailed Impact Analysis and Factors Responsible for Exclusion

Species	Basis For Exclusion
Marine Mammals	
North Pacific Right Whale	Very low abundance, scattered distribution, and rare occurrence primarily in cold waters of Gulf of Alaskan and Bering Sea north of OPAREA.
Sea Turtles	
Loggerhead Sea Turtle	Unsuitable habitat, normally associated with tropical and subtropical waters; no West Coast nesting beaches known in OPAREA (NMFS and USFWS 1998b); very irregular occurrence in southern OPAREA.
Olive Ridley Sea Turtle	Unsuitable habitat, normally associated with tropical and subtropical waters; no West Coast nesting beaches known in OPAREA (NMFS and USFWS 1998b); very irregular occurrence in southern OPAREA.
Green Sea Turtle	Unsuitable habitat, normally associated with tropical and subtropical waters; no West Coast nesting beaches known in OPAREA(NMFS and USFWS 1998b); very irregular occurrence in southern OPAREA.
Plants	
Golden Paintbrush	Closest known population on Whidbey Island located near the Seaplane Base near Forbes Point is 4 mi east of action areas. Training and other Navy activities would not occur in golden paintbrush areas. No critical habitat for this species.

1.4.2.1.1 Bull Trout

Critical habitat is designated for the bull trout in both freshwater inland streams and coastal marine waters (USFWS 2005). Inland streams are considered excluded from the BE because naval training activities would not occur in these areas. Coastal marine waters designated as critical habitat for the bull trout in the Coastal Puget Sound (CHU 28) and the Olympic Peninsula areas (CHU 27) extend from the mean high high-water (MHHW) line inland (including the tidally influenced freshwater heads of estuaries) to 33 ft (10 m) below the mean low low-water (MLLW) elevation line offshore. This zone equates to the photic zone where most bull trout activity occurs.

Department of Defense areas within this zone and within the NWTRC Study Area specifically excluded from critical marine habitat provisions include the following facilities (USFWS 2005):

1. Bayview Acoustic Research Detachment, Naval Surface Warfare Center, ID;
2. Naval Radio Station, Jim Creek, WA;
3. Naval Station, Everett, WA;
4. Naval Air Station, Whidbey Island, WA; and
5. Naval Under Sea Warfare Center Division, Newport, WA (Dabob Bay, Hood Canal, and Crescent Harbor), Keyport facilities.

Critical marine habitat outside these military facility exclusion areas and that are inside the NWTRC Study Area are included for affects analysis in this BE.

1.4.2.1.2 Chinook Salmon, Puget Sound ESU and Chum Salmon, Hood Canal Summer-Run ESU

Critical habitat is designated for the Chinook salmon, Puget Sound ESU and the chum salmon, Hood Canal summer-run evolutionarily significant unit (ESU) in the Puget Sound, Washington area in both freshwater inland streams and coastal marine waters (USFWS 2005). Inland streams are considered excluded from the BE because naval training activities would not occur in these areas. In estuarine and nearshore marine areas critical habitat includes areas contiguous with the shoreline from the line of extreme high water out to a depth no greater than 100 ft (30 m) relative to mean lower low water.

Critical habitat does not include any areas subject to an approved Integrated Natural Resource Management Plan (INRMP) or associated with Department of Defense (DoD) easements or right-of-ways. In areas within Navy security zones identified at 33 Code of Federal Regulations 334 (33 CFR 334) that are outside the areas described above, critical habitat is only designated within a narrow nearshore zone from the line of extreme high tide down to the line of mean lower low water. The specific sites addressed include the following locations (FR 70(170):52685):

1. Naval Submarine Base, Bangor;
2. Naval Undersea Warfare Center, Keyport;
3. Naval Ordnance Center, Port Hadlock (Indian Island);
4. Naval Radio Station, Jim Creek;
5. Naval Fuel Depot, Manchester;
6. Naval Air Station Whidbey Island;
7. Naval Air Station, Everett;
8. Bremerton Naval Hospital;
9. Puget Sound Naval Shipyard;
10. Naval Submarine Base Bangor security zone;
11. Strait of Juan de Fuca naval air-to-surface weapon range, restricted area;
12. Hood Canal and Dabob Bay naval non-explosive torpedo testing area;
13. Strait of Juan de Fuca and Whidbey Island naval restricted areas;
14. Admiralty Inlet naval restricted area;
15. Port Gardner Naval Base restricted area;
16. Hood Canal naval restricted areas;
17. Port Orchard Passage naval restricted area;
18. Sinclair Inlet naval restricted areas;
19. Carr Inlet naval restricted areas;
20. Dabob Bay/Whitney Point naval restricted area; and
21. Port Townsend/Indian Island/Walan Point naval restricted area.

1.5 DEFINITIONS

Under the ESA of 1973, as amended, the following definitions are used to identify potential threatened and endangered species and critical habitat for listing under the Act:

- Endangered Species: Any species which is in danger of extinction throughout all or a significant portion of its range.
- Threatened Species: Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

- Critical Habitat: "Critical Habitat" for listed species consists of (1) specific areas within the geographical area currently occupied by a species, at the time it is listed in accordance with the provisions of section 4 of the Act, on which are found those physical or biological features (i) essential to the conservation of the species, and (ii) that may require special management considerations or protection, and (2) specific areas outside the geographical area occupied by a species at the time it is listed in accordance with the provisions of section 4 of the Act, upon a determination by the Secretary that such areas are essential for the conservation of the species (50 CFR §424.02(d)). In evaluating project effects on critical habitat, the Services (that is the USFWS and NMFS) must be satisfied that the constituent elements of the critical habitat likely will not be altered or destroyed by proposed activities to the extent that the survival and recovery of affected species would be appreciably reduced.

The ESA requires federal agencies to conserve listed species and consult with the USFWS and/or NMFS to ensure that Proposed Actions that may affect listed species or critical habitat are consistent with the requirements of the ESA. The ESA specifically requires agencies not to "take" or "jeopardize" the continued existence of any endangered or threatened species, or to destroy or adversely modify habitat critical to any endangered or threatened species.

- Take: Under Section 9 of the ESA, "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect.

- Jeopardize: Under Section 7 of the ESA, "jeopardize" means to engage in any action that would be expected to reduce appreciably the likelihood of the survival and recovery of a listed species by reducing its reproduction, numbers, or distribution.

2 PROPOSED ACTION

2.1 OVERVIEW OF THE PROPOSED ACTION

The Proposed Action does not involve extensive changes to the NWTRC facilities, activities, or training capacities as they currently exist. Rather, the Proposed Action would result in selectively focused but critical enhancements and increases in training that are necessary to ensure the NWTRC supports Navy training and readiness objectives.

Actions to support current, emerging, and future training and research, development, test and evaluation (RDT&E) activities at the NWTRC, including implementation of range enhancements, will be evaluated in this Biological Evaluation (BE). These actions include:

- Potential increase in the number of training activities of the types currently being conducted in the NWTRC.
- Operate air target services for locally based aircraft, surface, and submarine combatant ships with a capability to support air-to-air (A-A) MISSILEX, electronic combat (EC) Opposition Force (OPFOR) requirements, surface-to-air (S-A) gunnery and missile exercises.
- Operate surface target services for locally based aircraft, surface combatant ships and submarines with a capability to support air-to-surface (A-S) bombing and missile exercises, surface-to-surface (S-S) gunnery and missile exercises, and EC OPFOR.
- Develop an additional land based EC threat signal emitter capability along the Washington coast for offshore use by aircraft, surface and subsurface combatants in W-237, the Olympic Military Operating Areas (MOAs), and portions of the Pacific Northwest (PACNORWEST) Surface and Submarine Operating Areas (OPAREA).
- Development of a small scale underwater training minefield.
- Potential use of a PUTR.

This section is divided into the following major subsections: Section 2.1.1 provides a detailed description of the NWTRC. Sections 2.1.2 describes the major elements of the Proposed Action.

2.1.1 Description of the NWTRC Study Area

Military activities in the NWTRC Study Area occur (1) on the ocean surface, (2) under the ocean surface, (3) in the air, and (4) on land. A summary of the land, air, sea, undersea space addressed in this BE is provided in Table 2-1. To aid in the description of the ranges covered in this BE, the ranges are divided into three major geographic and functional subdivisions. Each of the individual ranges falls into one of these three major range subdivisions:

- The Offshore Area. This area consists of all air, sea, and undersea ranges, OPAREAs, and military training activities in international airspace and waters out to approximately 250 nautical miles west of the coastline.
- The Inshore Area includes all air, land, sea, and undersea ranges and OPAREAs inland of the coastline and including Puget Sound, but excluding water ranges that are used exclusively by Explosive Ordnance Disposal (EOD)/Naval Special Warfare (NSW) forces.
- The EOD ranges and OPAREAs primarily are land, sea, and undersea ranges used by NSW and EOD forces.

Figures 2-1 through 2-3 depict the range complex, and Table 2-1 provides an overview of the size of each range within these areas. Table 2-2 summarizes the major component areas of the NWTRC Offshore Areas.

Table 2-1. Summary of Air, Sea, Undersea, and Land Space of the NWTRC

Area Name	Airspace (nm^2)			Sea Space (nm^2)	Undersea Space (nm^2)	Land Range (acres)
	International Airspace	Restricted Airspace	MOA / Other			
Offshore Area	122,400*	NA	NA	122,400	122,400	NA
Inshore Area	NA	367	11,684	61	61	875
EOD/NSW Ranges	NA	NA	NA	.4	.4	**
TOTAL	**33,997**	**367**	**11,684**	**122,421**	**122,400**	**875**

* International Airspace is over-water in the PACNORWEST OPAREA and includes 33,997 nm^2 of Warning Area airspace
** EOD acreage is included in the Inshore Areas total
Source: 366 Report to Congress

Table 2-2. NWTRC Offshore Areas

Area Designation	Description
Pacific Northwest Ocean Surface/Subsurface Operating Area (PACNORWEST OPAREA)	The Pacific Northwest Ocean Surface/Subsurface Operating Area (PACNORWEST OPAREA) extends from the northern coast of California to the Strait of Juan de Fuca, from the coast line westward to 130° West longitude.
Warning Area 237 (W-237 [A-H, J])	W-237 airspace extends westward starting 3 nm (5.5 kilometers [km]) offshore from the coast of Washington State and is divided into nine (9) areas (A-H, and J) of designated SUA (Special Use Airspace).
Warning Area 570 (W-570)	W-570 is a smaller warning area that begins approximately 12 nm (22.2 km)off the central coast of Oregon.
Warning Area 93 (W-93 [A/B])	Warning Area 93 is located approximately 12 nm (22.2 km) off the coast of Oregon, approximately 10 nm (18.5 km) south of and similar in size to W-570.

* EOD acreage is included in the Inshore Areas total
Source: 366 Report to Congress

2.1.1.1 NWTRC Offshore Area Overview

The PACNORWEST OPAREA serves as maneuver water space for ships and submarines to conduct training and to use as transit lanes. It extends from the Strait of Juan de Fuca in the north, to approximately 50 nm (92.6 km) south of Eureka, California in the south, and from the coast line of Washington, Oregon, and California westward to 130^{o} West longitude.

2.1.1.1.1 Air Space

The Special Use Airspace (SUA) in the Offshore Area is comprised of three Warning Areas that overlay portions of the PACNORWEST OPAREA. W-237 extends westward off the coast of Northern Washington State and is divided into nine (9) sub-areas (A-H, and J). U.S. and Allied ships, submarines, and aircraft conduct training in W-237 in Anti-Submarine Warfare (ASW), Anti-Surface Warfare (ASUW), Anti-Air Warfare (AAW), and Electronic Combat (EC).

W-570 is a smaller warning area located 12 nm (22.2 km) off the central coast of Oregon. W-570 is primarily used by the United States Air Force (USAF) Western Air Defense Sector aircraft from McChord AFB. P-3 aircraft from Commander, Patrol and Reconnaissance Wing TEN (CPRW-10) at Naval Air Station Whidbey Island (NASWI) occasionally use W-570 for reconnaissance training activities. Additionally, occasional training activities occur in international airspace outside of Warning Areas in accordance with international agreements on "Operations and Firings Over the High Seas."

W-93 is located 12 nm (22.2 km) off the coast of Oregon and northern California, approximately 10 nm(18.5 km) south of and similar in size to W-570. It is primarily used by Oregon Air National Guard aircraft; however, W-93 is also used occasionally by CPRW-10 P-3 aircraft for reconnaissance training. USAF and Air National Guard aircraft activities conducted in W-570 and W-93 are not part of the Proposed Action and are not considered in this BE.

2.1.1.1.2 Sea Space

The PACNORWEST OPAREA is approximately 510 nm (945 km) in length from the northern boundary to the southern boundary, and 250 nm (463 km) from the coastline to the western boundary at 130^{o} W longitude. Total surface area of the PACNORWEST OPAREA is 122,400 nm^2 (420,163 km^2). Commander Submarine Force, U.S. Pacific Fleet (COMSUBPAC) Pearl Harbor manages this water space as transit lanes for U.S. submarines. While the sea space is ample for all levels of Navy training, no infrastructure is in place to support training. There are no dedicated training frequencies, no permanent instrumentation, no meteorological and oceanographic operations (METOC) system, and no OPFOR or EC target systems. In this region of the Pacific Ocean, storms and high sea states can create challenges to surface ship training between October and April. In addition, strong undersea currents in the Pacific Northwest make it difficult to place bottom-mounted instrumentation such as hydrophones.

2.1.1.1.3 Undersea Space

The Offshore Area undersea space lies beneath the PACNORWEST OPAREA as described above. The bathymetry chart depicts a 100 fathom curve parallel to the coastline approximately 12 nm (22.2 km) to sea, and in places 20 nm (37 km) out to sea. The area of deeper water of more than 100 fathoms (600 ft) is calculated to be approximately 115,800 nm^2, while the shallow water area of less than 100 fathoms (600 ft) is all near shore and amounts to approximately 6,600 nm^2 (22,637 km^2). Figure 2-1 depicts the 100 fathom curve.

2.1.1.2 NWTRC Inshore Area Overview

Inshore Areas (see Figures 2-2 and 2-3) include military operating areas (MOAs) and associated Air Traffic Control Assigned Airspace (ATCAA) which superimposes the MOAs, air and surface/subsurface Restricted Areas, the Darrington Area, and Outlying Landing Field (OLF) Coupeville.

MOAs are special use airspace of defined vertical and lateral dimensions established outside Class A airspace to separate/segregate certain non-hazardous military activities from instrument flight rules (IFR) traffic in controlled airspace and to identify for visual flight rules (VFR) traffic where these activities are conducted. Four MOAs provide military aircraft maneuver space for training. They are the Olympic, Chinook, Okanogan, and Roosevelt MOAs. The ATCAAs associated with the MOAs include the Olympic, Okanogan/Molson, and Roosevelt/Republic ATCAA. There is no ATCAA associated with the Chinook MOAs.

The Darrington Area, while not a designated MOA, is a block of airspace established by Letter of Agreement with Seattle Air Route Traffic Control Center for EC training and other non-warfare related missions. R-6701 is airspace located over central Whidbey Island, restricted for military use. Navy 7 is a sea surface and subsurface area beneath R-6701. Navy 3 is a surface and subsurface restricted area off the west coast of northern Whidbey Island. Restricted airspace, such as that in R-6701, is special use airspace designated under 14 CFR Part 73 within which the flight of aircraft, while not wholly prohibited, is subject to restriction. The specific limits and regulations of restricted surface areas such as Navy 3 and Navy 7 are included in the appropriate U.S. Coast Pilot.

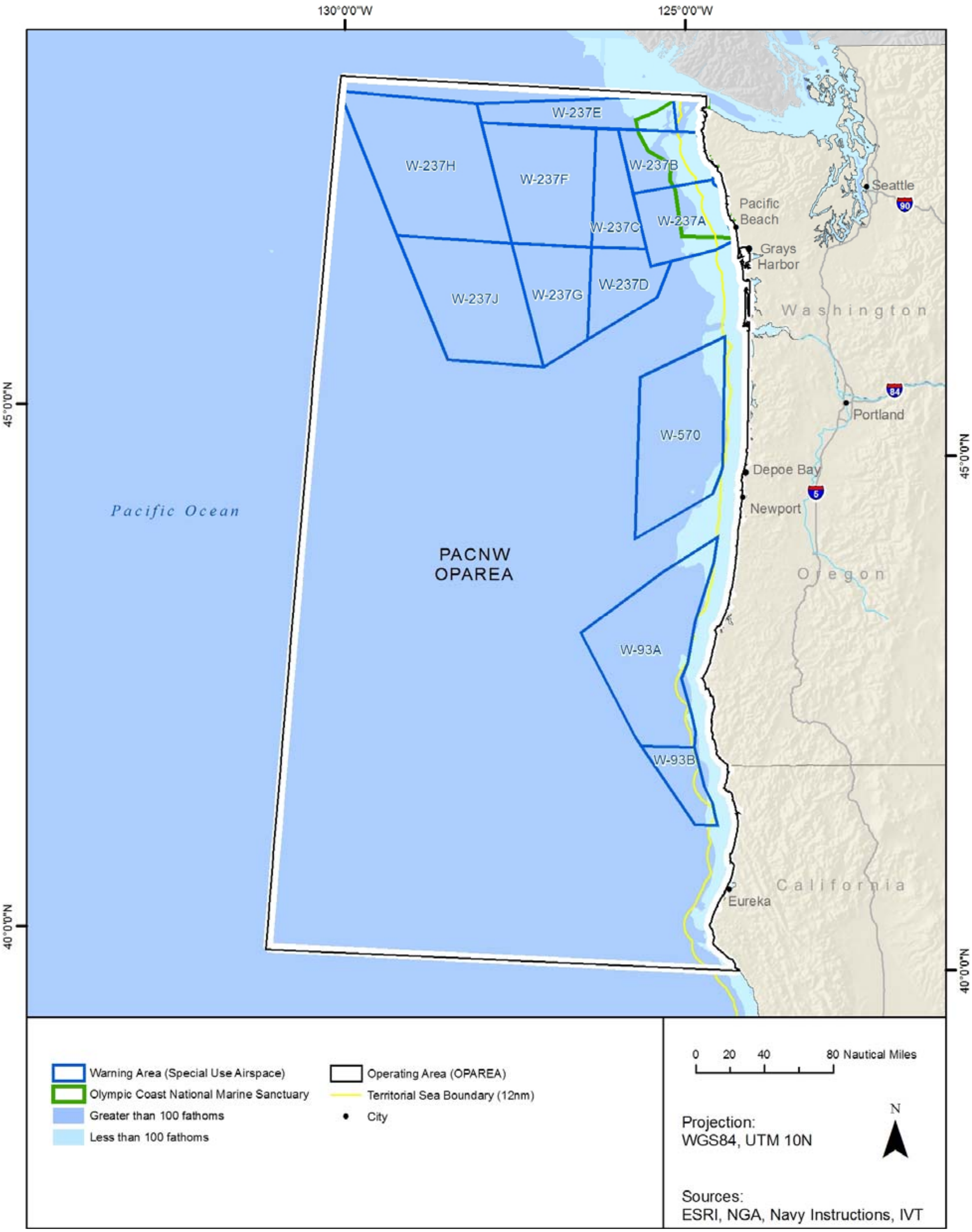


Figure 2-1: NWTRC Offshore Area

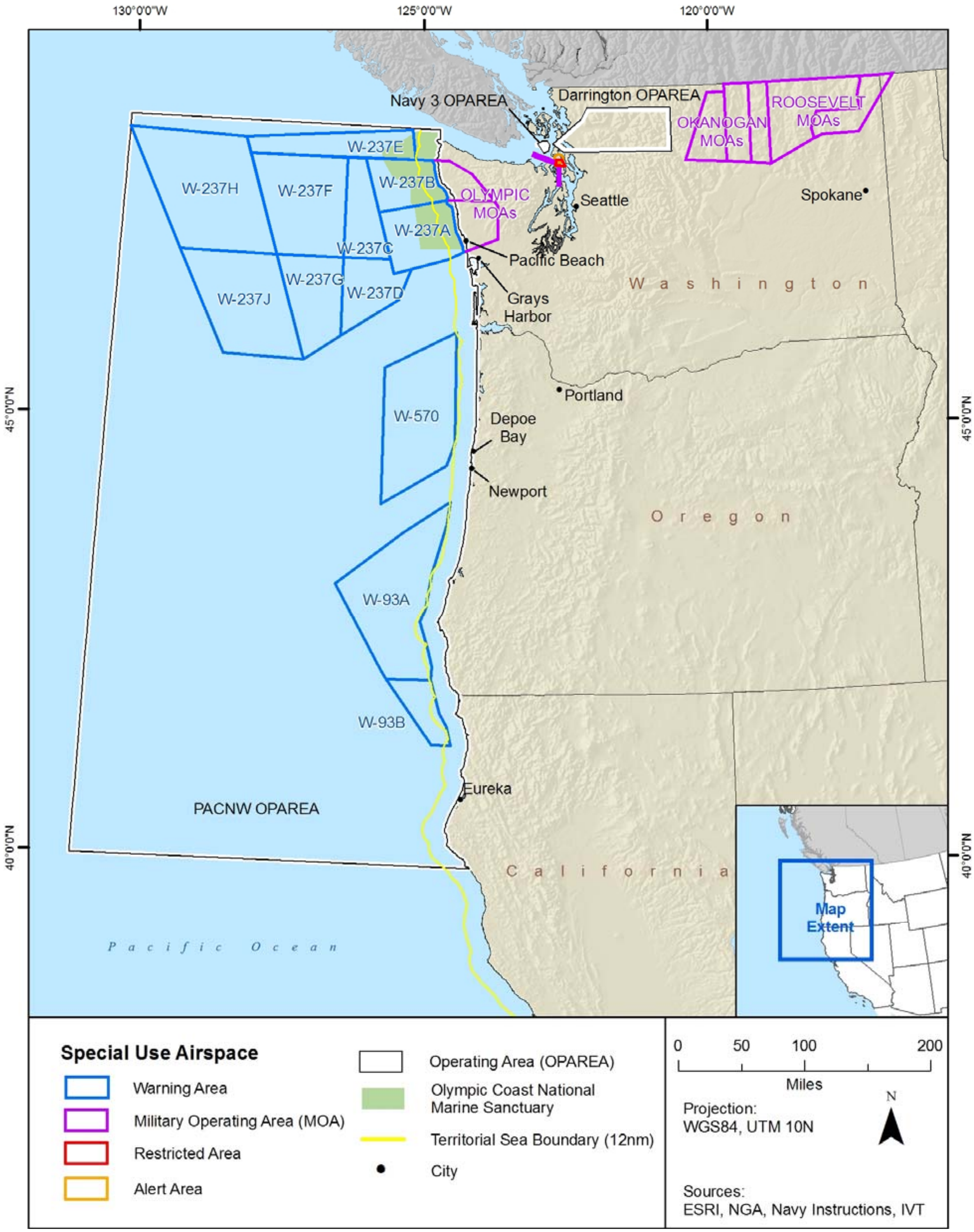


Figure 2-2. Northwest Training Range Complex Study Area, Including Inshore Area

OLF Coupeville is used primarily for Field Carrier Landing Practice (FCLP) for EA-6Bs from NASWI, but is also used as a Drop Zone (DZ) for parachute training, Landing Zone (LZ) for helicopter training, and for small unit ground training events as well. An alert area (A-680) establishes a 3-nm (5.5 km) radius alert area around the OLF. An alert area is special use airspace wherein a high volume of pilot training activities or an unusual type of aerial activity is conducted, neither of which is hazardous to aircraft. Nonparticipating pilots are advised to be particularly alert when flying in these areas. Table 2-3 summarizes the NWTRC Inshore Areas.

Table 2-3. NWTRC Inshore Areas

Area Designation	Description
Olympic MOA (A/B) Olympic ATCAA (A/B)	Olympic MOA is located over the Olympic Peninsula, along the Washington State coast. The MOA lower limit is 6,000 ft above mean sea level (MSL) but not below 1200 feet above ground level (AGL), and the upper limit is flight level (FL) 180, with a total area coverage of 1,614 nm^2 (5,536 km^2). The ATCAA starts at FL180 with an upper limit of FL500. (See Figure 2-2)
Chinook MOA (A/B)	The Chinook MOAs are both located over water west of Whidbey Island. The two small air corridors, A and B, are each 2 nm (3.7 km)wide and extend from 300 feet above the surface to 5,000 feet MSL. They are used for aircraft ingress and egress for R-6701/Navy 7. (See Figure 2-3)
Okanogan MOA (A/B/C) Okanogan/Molson ATCAA	Okanogan MOA is located in north-central Washington near the U.S.-Canadian border. MOA parts B &C have lower limits of 300 feet AGL and an upper limit of 9,000 feet MSL. MOA part A has a lower limit of 9,000 feet MSL up to but not including FL180. The Okanogan and Molson ATCAAs start at FL180 and the upper limit is FL500; with a total area coverage of 4,339 nm2 (14,882 km2) (See Figure 2-2)
Roosevelt MOA (A/B) Roosevelt/Republic ATCAA	Roosevelt MOA is located in north-central Washington near the U.S.-Canadian border. The lower limit of segment A is 9,000 ft MSL and the lower limit of segment B is 300 ft AGL. The upper limit of segment A is FL 180 and the upper limit of segment B is 9,000 ft MSL. The Roosevelt and Republic ATCAAs start at FL180 with an upper limit of FL500. The total area coverage is 5,319 nm2 (18,244 km2) (See Figure 2-2)
Darrington Area	Darrington Area is a block of airspace used for electronic countermeasures training and functional check flight missions. This area is not a designated MOA (although it is used like a MOA) and is used by NASWI based units only (EA6, EP3, and P3). The lower limit is 10,000 ft MSL and the upper limit is FL 230 (higher altitude is available upon request) with a total area of 2,131 nm² (7,309 km2)(See Figure 2-2 and 2-3)
R-6701 (Admiralty Bay) Navy 7	R-6701 is a Restricted Area over Admiralty Bay, WA with a lower limit at the ocean surface and an upper limit of 5,000 ft MSL. Navy 7 is the surface and subsurface restricted area that underlays R-6701. They cover a total area of 56 nm² (192 km2) (See Figure 2-3)
Navy 3	Navy 3 OPAREA is a surface and subsurface restricted area off the west coast of northern Whidbey Island. (See Figure 2-3)
A-680 (OLF Coupeville)	A-680 is a 3 nm (5.5 km) circle centered on OLF Coupeville located 15 nm (27.8 km) south of NASWI. (See Figure 2-3)
Seaplane Base Survival Area	The Seaplane Base Survival Area includes forest, grassland, and beach area at Navy Seaplane Base/Crescent Harbor, NASWI. (See Figure 2-3).

2.1.1.3 Airspace

Table 2-4 summarizes the airspace attributes of the Inshore Areas. Figures 2-2 and 2-3 depict the airspace of the Inshore Area.

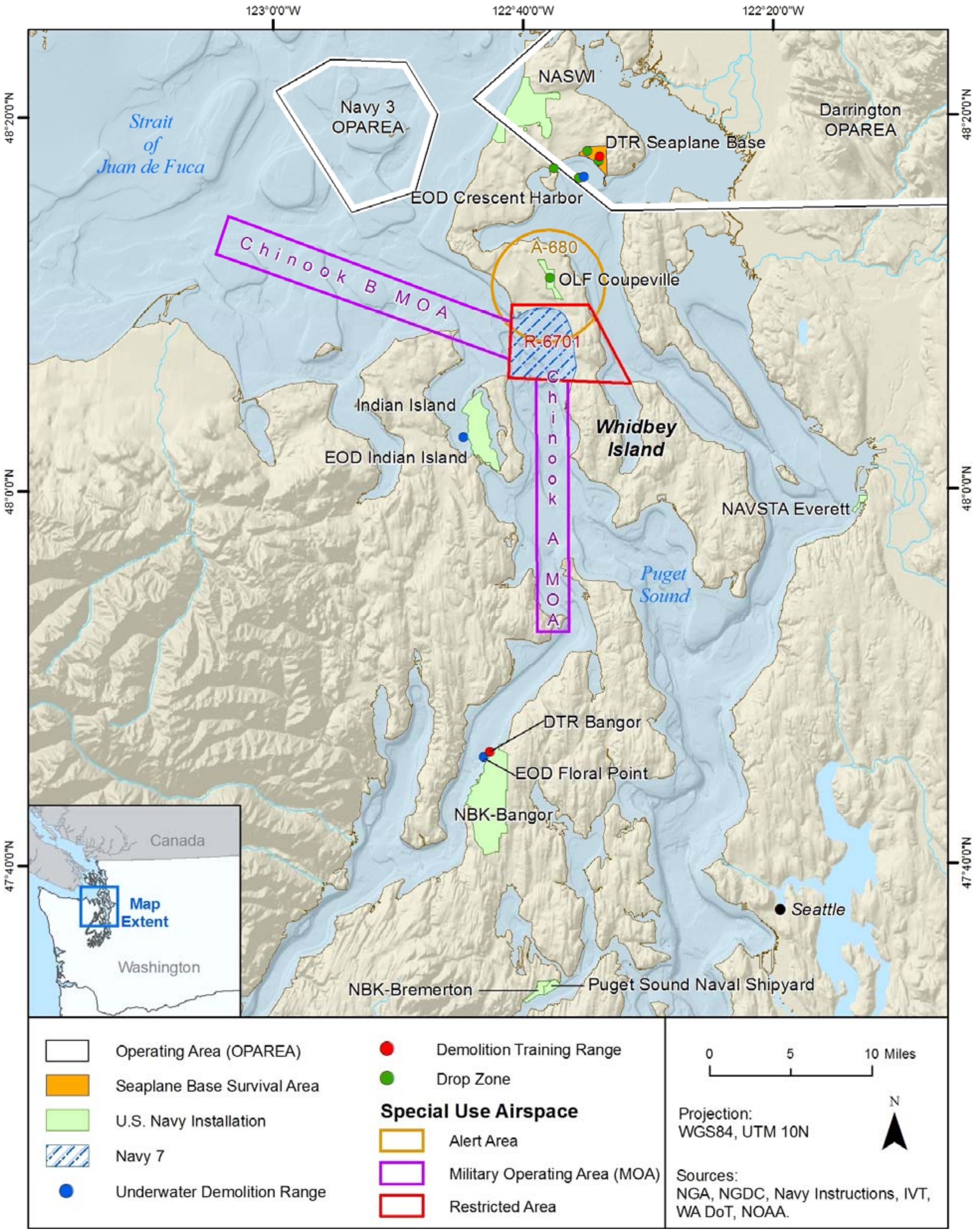


Figure 2-3. Northwest Training Range Complex Inshore Area (Puget Sound)

Table 2-4. Inshore Area Airspace Summary

Airspace	nm²	Lower Limit	Upper Limit	Over Land?	Controlling/ Scheduling Authority
Inshore					
A-680 (OLF Coupeville)	28	Surface	3,000 ft MSL	Yes	NASWI
R-6701	22	Surface	5,000 ft MSL	No	NASWI
Chinook MOA (A,B) SUA corridors for R-6701	56	300 ft MSL			
Olympic MOA (A,B)	1,614	6 000 ft MSL	FL180	Yes	NASWI
Olympic ATCAA		FL180	FL500		
Darrington Area	2,131	10,000 ft MSL	FL230, higher alt avail on request	Yes	NASWI
Okanogan MOA (A,B,C)	4,339	A: 9000 ft MSL B: 300 ft AGL C: 300 ft AGL	A: FL180 B: 9,000 ft MSL C: 9,000 ft MSL	Yes	NASWI
Okanogan ATCAA		FL180	Up to but not including FL240		
Molson ATCAA		FL240	FL500		
Roosevelt MOA (A,B)	5,319	A: 9,000 ft MSL B: 300 ft AGL	A: FL180 B: 9,000 ft MSL	Yes	NASWI
Roosevelt ATCAA		FL180	Up to but not including FL240		
Republic ATCAA		FL240	FL500		
TOTAL	**13,509**				

Source: 366 Report to Congress, AP-1A Flight Information Publication

2.1.1.4 Explosive Ordnance Disposal (EOD) Ranges

Three EOD units are currently located in the NWTRC: Headquarters element, EOD Mobile Unit Eleven (HQ EODMU-11), EODMU-11 Detachment (Det.) Naval Base Kitsap-Bangor (NBK-Bangor) and EODMU-11 Det. Whidbey Island. EODMU-11 Det. Whidbey Island is based at the Seaplane Base, NASWI and conducts most of their underwater detonations in adjacent Crescent Harbor Underwater EOD Range. Most of their ground training events are conducted in the Survival Area and the upland Detonation Training Range (DTR) located there. EOD units also conduct parachute training at a drop zone at OLF Coupeville, at a drop zone in Crescent Harbor, and occasionally at other drop zones in the area. EODMU 11 Det. NBK-Bangor conducts much of their non-explosive training in Hood Canal, Dabob Bay and other nearby waters. Although still open as training sites, the underwater detonation training areas at Floral Point Underwater EOD Range, located in Hood Canal near NBK-Bangor and Indian Island Underwater EOD Range, adjacent to Indian Island, are seldom used for underwater detonations. Figure 2-3 depicts the EOD Ranges and Table 2-5 provides an overview of each range within these areas.

Explosive Ordnance Disposal Mobile Unit Eleven is scheduled to relocate in 2009. The relocation will move a large number of EOD forces out of the Pacific Northwest region to their new home base in San Diego, California, which is outside of the NWTRC. As a result of this move, underwater detonation training conducted for mine warfare will decrease significantly. From a yearly average of 60 underwater detonations as analyzed in the No Action Alternative (the baseline), future EOD activities will result in no more than four annual underwater detonations in the NWTRC.

2.1.1.5 Naval Special Warfare (NSW) Ranges

Naval Special Warfare (NSW) forces have no dedicated ranges in the NWTRC, but train in Puget Sound waters and conduct on-land training at several Navy-owned locations. NSW land training typically occurs at Indian Island, and occasionally at the Seaplane Base survival area and OLF Coupeville.

Table 2-5. NWTRC EOD/NSW Ranges

Area Designation	Description
DTR Seaplane Base, NASWI and Seaplane Base Survival Area	EODMU-11 is based at Seaplane Base, NASWI and utilizes the Survival Area and an upland DTR at the Seaplane Base.
Crescent Harbor Underwater EOD Range	EODMU-11 conducts most underwater detonations and water landing parachute training in Crescent Harbor.
OLF Coupeville	EOD units conduct parachute operations training at OLF Coupeville.
DTR Bangor	The DTR at Bangor is used for small detonations on land at NAVBASE Kitsap-Bangor.
Floral Point Underwater EOD Range	Floral Point Underwater EOD Range, located in Hood Canal, near NBK-Bangor, is active but seldom used.
EOD Indian Island	Indian Island Underwater EOD Range, located adjacent to Indian Island, is active but seldom used.

2.1.2 Navy Sonar Systems

Navy sonar training is a significant piece of overall Navy training. Recently, sonar and its potential impacts to the marine environment have become a controversial issue. This section is designed to better inform the reader about a) What is sonar; b) Why the Navy trains with Sonar; and c) What sonar is used in the NWTRC? The analysis of impacts of sonar to the marine environment is conducted in Chapter 3 of this EIS/OEIS.

2.1.2.1 What is Sonar?

Sonar, which stands for "SOund Navigation And Ranging," is a tool that uses underwater acoustics to navigate, communicate, or detect other underwater objects. There are two basic types of sonar; active and passive.

- **Active sonar** emits pulses of sound waves that travel through the water, reflect off objects, and return to the receiver on the ship. By knowing the speed of sound in water and the time for the sound wave to travel to the target and back, we can quickly calculate distance between the ship and the underwater object. As examples, active sonar systems can be used to track targets and realign internal navigation systems by identifying known ocean floor features. Whales, dolphins and bats use the same technique, echolocation, for identifying their surroundings and locating prey.
- **Passive sonar** is a listening device that uses hydrophones (underwater microphones) that receive, amplify, and process underwater sounds. It is used primarily to detect the presence of submarines. The advantage of passive sonar is that is places no sound in the water, and thus does not reveal the location of the listening vessel. Passive sonar can indicate the presence, character, and direction of submarines.

Underwater sounds in general, and sonar specifically can be categorized by their frequency. For the analysis in this EIS/OEIS, sonar falls into one of three frequency ranges; low-frequency, mid-frequency, and high-frequency.

- **Low-frequency** sonar is sonar that emits sounds in the lower frequency range, less than 1 kilohertz (kHz). Low-frequency sonar is useful for detecting objects at great distances, as low-frequency sound does not dissipate as rapidly as higher frequency sounds. However, lower frequency sonar provides less accuracy than other sonars.
- **Mid-frequency** sonar uses sound in the frequency spectrum between 1 and 10 kHz. With a typical range of up to 10 nm, mid-frequency sonar is the Navy's primary tool for detecting and

identifying submarines. Sonar in this frequency range provides a valuable combination of range and target resolution (accuracy).

- **High-frequency** sonar uses frequencies greater than 10 kHz. Although high-frequency sonar dissipates rapidly, giving it a shorter effective range, it provides higher resolution and is useful at detecting and identifying smaller objects such as sea mines.

Modern sonar technology includes a multitude of sonar sensor and processing systems. In concept, the simplest active sonar emits sound waves, or "pings," sent out in multiple directions (i.e., is omnidirectional). Sound waves reflect off the target object and move in multiple directions (Figure 2-4). The time it takes for some of these sound waves to return to the sonar source is calculated to provide a variety of information, including the distance to the target object. More sophisticated active sonars emit an omnidirectional ping and then rapidly scan a steered receiving beam to provide directional as well as range information. Even more advanced sonars use multiple pre-formed beams to listen to echoes from several directions simultaneously and provide efficient detection of both direction and range. For more information about sonar or sound in the sea, go to dosits.org.

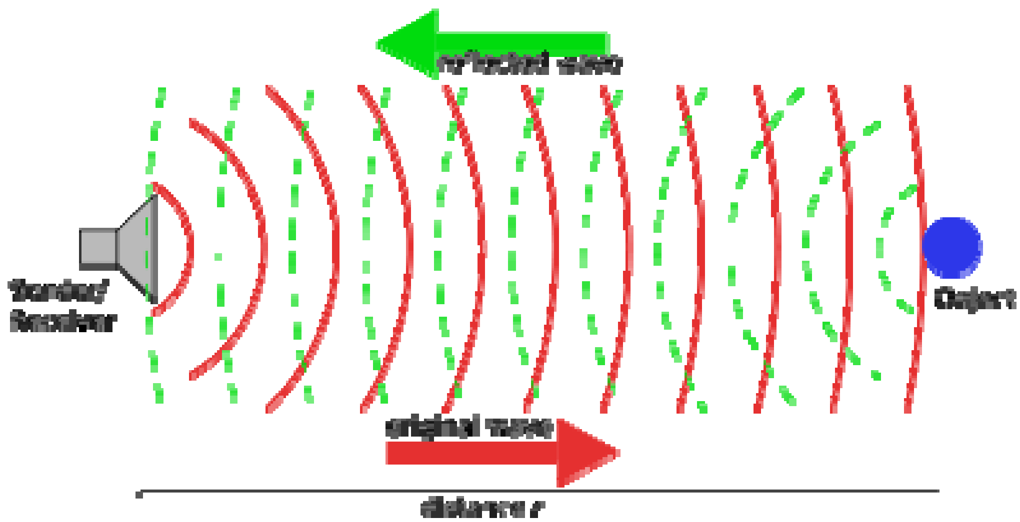


Figure 2-4: Principle of an Active Sonar

2.1.2.2 Why the Navy Trains with Sonar

Sea control is the foundation for the United States' global power projection. If the United States cannot command the seas and airspace above them, we cannot project power to command or influence events ashore and we cannot shape the security environment. For the last century, submarines have been the weapon of choice for weaker naval powers intending on contesting a dominant power's control of the seas. Today, there are more than 300 modern, quiet diesel submarines around the world, operated by more than 40 nations, including Iran and North Korea. The United States cannot in good conscience ask its young Sailors and Marines to serve on ships at sea without the ability to defend themselves against this threat. The key to maintaining the Navy's ability to defend against adversary submarines is a comprehensive "at-sea" training regime to prepare our Sailors for this contingency. This training requires the use of active sonar. The skills developed during this training are perishable and require periodic refreshing, which can't be regenerated easily. If training is not as realistic as possible, the Navy will quickly lose its edge in this critical dimension of the battlefield.

Submarines have been and are likely to remain the weapon system with the highest leverage in the maritime domain. The ability to locate and track a submarine is a mission skill that must be possessed by every ASW-capable ship, submarine, and aircraft. There are three fundamental truths about ASW. First, it is critically important to our strategies of sea control, power projection, and direct support to land campaigns.

Second, ASW requires a highly competent team of air, surface and sub-surface platforms to be effective in a complex and a highly variable three-dimensional environment. Each asset brings different strengths to the fight. The Navy will need this full spectrum of undersea, surface, airborne, and space-based systems to ensure full exploitation of the operating area. The undersea environment – ranging from the shallows of the littoral to the vast deeps of the great ocean basins and polar regions under ice – demand a multi-disciplinary approach: reliable intelligence; oceanography; and surveillance and cueing of multiple sensors, platforms and undersea weapons. Most importantly, it takes highly skilled and motivated people.

Finally, ASW is extremely difficult. As an example, during the 1982 Falklands conflict, the Argentine submarine SAN LUIS operated in the vicinity of the British task force for more than a month and was a constant concern to Royal Navy commanders. Despite the deployment of five nuclear attack submarines, 24-hour per day airborne ASW operations, and expenditures of precious time, energy, and ordinance, the British never once detected the Argentine submarine. Today, this complex and challenging mission taxes naval forces to their very limits. The U.S. Navy must continue to improve or its performance compared to other world powers will most certainly decline.

As modern submarines have become significantly quieter, passive sonar is not effective enough in tracking and prosecuting all enemy submarines. Mid-frequency active sonar has become a necessary piece of the Navy's ASW program. Without mid-frequency active sonar, the U.S. Navy would be severely limited in its ability to counter the threat posed by modern, quiet submarines. Training with mid-frequency active sonar is, therefore, critical to national security.

ASW remains the linchpin of sea control. With the proliferation of modern, quiet submarines and the expansion of the Navy mission to both littoral and deep waters, the ASW challenge has become more severe. To counter the adversarial submarine challenges, the Navy's best course of action is to conduct extensive training including the use of active sonar that mirrors the intricate operating environment that would be present in hostile waters.

2.1.3 Sonars Used in the NWTRC

Table 2-6 lists typical U.S. Navy acoustic systems and identifies those used during training activities conducted in the NWTRC. The acoustic systems presented in Table 2-6 have been separated out into systems that were analyzed and systems that were not analyzed in the effects analysis. The systems that were not analyzed included systems that are typically operated at frequencies greater than 200 kHz.

It is important to note that, as a group, marine mammals have functional hearing ranging from 10 hertz (Hz) to 200 kHz; however, their best hearing sensitivities are well below that level. Since active sonar sources operating at 200 kHz or higher dissipate rapidly and are at or outside the upper frequency limit of even the ultrasonic species of marine mammals, further consideration and modeling of these higher frequency acoustic sources are not warranted. As such, high-frequency active sonar systems in excess of 200 kHz are not analyzed in this EIS/OEIS.

Table 2-6. Acoustic Systems Analyzed and not Analyzed

Systems Analyzed				
System	**Frequency**	**Associated Platform**	**System Use/Description**	**Used in NWTRC?**
AN/SQS-53C	MF	Surface ship sonar (CG, DDG)	Utilized 70% in search mode and 30% in track mode	Yes
AN/SQS-56C	MF	Surface ship sonar (FFG)	Utilized 70% in search mode and 30% in track mode	Yes
AN/SSQ-62 DICASS Sonobuoy	MF	Helicopter and MPA deployed	12 pings, 30 seconds between pings	Yes
AN/SSQ-110A Explosive source sonobuoy	Impulsive	MPA deployed	Contains two 4.1 lb charges	Yes
MK-48 Torpedo	HF	Submarine fired torpedo	Active for 15 min per torpedo run	Yes
Systems Not Analyzed				
System	**Frequency**	**Reason Not Analyzed**	**System Use/Description**	**Used in NWTRC?**
AN/BQS-15	HF	Minimal use, limited impact of HF source	Submarine mine detection sonar	Yes
AN/AQS-13 or AN/AQS-22	MF	Not used in NWTRC	Helicopter dipping sonar	No
AN/SQQ-32	HF	Not used in NWTRC	MCM over the side system	No
MK-46 Torpedo	HF	Not used in NWTRC	Surface ship and aircraft fired exercise torpedo	No
AN/SLQ-25 (NIXIE)	MF	Not used in NWTRC	DDG, CG, and FFG towed array	No
AN/SQS-53 and AN/SQS-56 (Kingfisher)	MF	Not used in NWTRC	DDG, CG, and FFG hull-mounted sonar (small object detection)	No
AN/BQQ-10	MF	Not used in NWTRC	Submarine hull-mounted sonar	No
ADC MK-3 and MK-2	MF	Not used in NWTRC	Submarine fired countermeasure	No
Surface Ship and Submarine Fathometer	12 kHz	System is not unique to military and operates identically to commercially available bottom sounder	Depth finder on surface ships and submarines	Yes
SQR-19	Passive	System is a passive towed array emitting no active sonar	A listening device towed behind a surface ship	Yes
TB-16/23/29/33	Passive	System is a passive towed array emitting no active sonar	A listening device towed behind a submarine	Yes
AN/SSQ-53 DIFAR Sonobuoy	Passive	Sonobuoy is passive and emits no active sonar	Passive listening buoys deployed from helicopter or MPA	Yes
AN/AQS-14/20/24	>200 kHz	System frequency outside the upper limit for marine mammals	Helicopter towed array used in MIW for the detection of mines	No

ADC – Acoustic Device Countermeasure; CG – Guided Missile Cruiser; DDG – Guided Missile Destroyer; DICASS – Directional Command-Activated Sonobuoy System; DIFAR – Directional Frequency Analysis and Recording; FFG – Fast Frigate; HF – High-Frequency; IEER – Improved Extended Echo Ranging; kHz – Kilohertz; MCM Mine Countermeasures; MF – Mid-Frequency; MIW – Mine Warfare; MPA – Maritime Patrol Aircraft

2.2 PROPOSED ACTION

The Proposed Action would meet Navy current and near-term training activity requirements. It would accommodate current training activities and would support an increase in training activities to include force structure changes associated with the introduction of new weapon systems, vessels, and aircraft into the Fleet. Baseline-training operations would be increased. In addition, training associated with force structure changes would be implemented for the EA-18G Growler, Guided Missile Submarine (SSGN), P-8 Multimission Maritime Aircraft (MMA), and Unmanned Aerial Vehicles (UAVs). Force structure changes associated with new weapons systems would include new air-to-air missiles, and new sonobuoys. Range enhancements would be implemented, to include new electronic combat threat simulators/targets, development of a small scale underwater training minefield, development of a PUTR, and development of air and surface target services.

The number of training activities to be conducted with the Proposed Action compared to existing conditions (baseline) is presented in Table 2-7. Although most activities will increase over current conditions under the Proposed Action, mine countermeasure activities will decrease. Under the Proposed Action, no more than two underwater detonations per year will take place at Crescent Harbor, and no more than one detonation per year at Indian Island and Floral Point for a maximum of four detonations per year.

2.2.1 Force Structure Changes

The NWTRC is required to accommodate and support training with new ships, aircraft, and vehicles as they become operational in the Fleet. In addition, the NWTRC is required to support training with new weapons/sensor systems. The Navy has identified several future platforms and weapons/sensor systems that are in development and likely to be incorporated into Navy training requirements within the 10-year planning horizon. Several of these new technologies are in early stages of development, and thus specific concepts of operations, operating parameters, or training requirements have not yet been developed and thus are not available.

Specific force structure changes within the NWTRC are based on the Navy's knowledge of future requirements for the use of new platforms and weapons systems and based on the level of information available to evaluate potential environmental impacts. Therefore, this BE, to the extent feasible, will evaluate potential environmental impacts associated with the introduction of the following platforms and weapons/sensor systems.

2.2.1.1 New Vessels, Submarines, and Aircraft/Vehicles

2.2.1.1.1 EA-18G Growler

The EA-18G Growler is an electronic combat version of the FA-18 E/F that will replace the EA-6B Prowler. The Growler will have an integrated suite of EC systems that will allow it to perform the same missions as the EA-6b. In addition to the EA-6b missions, the EA-18G will have a limited self-protection capability requiring aircrews to train for offensive air-to-air missile engagements and conduct missile exercises. The advanced capabilities of the Growler weapons systems will require greater standoff ranges and broader frequency spectrum access than current systems.

2.2.1.1.2 P-8 Multimission Maritime Aircraft (MMA)

The P-8A MMA is the Navy's replacement for the aging P-3 Orion aircraft. It is a modified Boeing 737-800ERX which brings together a highly reliable airframe and high-bypass turbo fan jet engine with a fully connected, state-of-the-art open architecture mission system. This combination, coupled with next-generation sensors, will dramatically improve ASW and ASUW capabilities.

The MMA will ensure the Navy's future capability in long-range maritime patrol. It will be equipped with modern ASW, ASUW, and ISR sensors. In short, MMA is a long-range ASW, ASUW, ISR aircraft that is capable of broad-area, maritime and littoral operations. NASWI is being analyzed as a potential homebasing location for this aircraft in the ongoing MMA Homebasing EIS. Currently, the P-8/MMA preferred alternative in the Homebasing EIS is 4 P-8 squadrons to replace 4 P-3 squadrons at NASWI. As P-8 live training is expected to be supplemented with virtual training to a greater degree than P-3 training, P-8 training activities in the NWTRC are likely to be less than those currently conducted by P-3's. IOC is expected in 2013.

2.2.1.1.3 Unmanned Aerial Systems (UAS)

Broad Area Maritime Surveillance (BAMS) UAS. The BAMS UAS is being designed to support persistent, worldwide access through multi-sensor, maritime ISR providing unmatched awareness of the battlespace. It will support a spectrum of Fleet missions serving as a distributed ISR node in the overall naval environment. These missions include maritime surveillance, Battle-Damage Assessment (BDA), port surveillance and homeland security support, MIW, maritime interdiction, surface warfare, counter drug operations, and battlespace management. The BAMS will operate at altitudes above 40,000 feet, above the weather and most air traffic to conduct continuous open-ocean and littoral surveillance of targets as small as exposed submarine periscopes. Operation of these systems could produce new requirements for range complexes in terms of airspace and frequency management. Because current FAA airspace structure does not allow unmanned aircraft in MOAs, UAS activities are limited to Restricted Areas or offshore Warning Areas. Due to the size of NWTRC Restricted Areas and the airspace size requirements of the BAMS mission, the operations can only take place in W-237. IOC is anticipated for 2009.

Navy Unmanned Combat Air System (N-UCAS). The N-UCAS (Grumman X-47B) program is a Navy effort to demonstrate the technical feasibility, military utility, and operational value of an aircraft carrier based, networked system of high performance, weaponized UASs to effectively and affordably execute 21st century combat missions, including SEAD, surveillance, and precision strike within the emerging global command and control architecture. Operation of these systems could produce new requirements for range complexes in terms of airspace, frequency management, and target sets. IOC of these systems has not yet been established.

2.2.1.2 New Weapons Systems

Under the Proposed Action, several weapons systems are being introduced that warrant evaluation in this BE.

2.2.1.2.1 AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM)

The Advanced Medium-Range Air-to-Air Missile (AMRAAM) is a supersonic, air launched, aerial intercept, guided missile employing active radar target tracking, proportional navigation guidance, and active Radio Frequency (RF) target detection. It employs active, semi-active, and inertial navigational methods of guidance to provide an autonomous launch and leave capability against single and multiple targets in all environments. The EA-18G Growler, the replacement aircraft for the EA-6B Prowler, will have an air-to-air missile capability. The NWTRC will be required to support training for this new capability. Air-to-air missile training, including use of live AMRAAM missiles, will occur in W-237.

2.2.1.2.2 Improved Extended Echo Ranging (IEER) Sonobuoy

The Improved Extended Echo Ranging (IEER) system is an improved multi-static active acoustic sensor, which employs a new sonobuoy coupled with improved processing algorithms to extend the EER deep-water search capability into the shallow waters of the littoral zone. The IEER system was developed by the Navy in response to the fleet need for a large-area search capability against diesel submarines operating in littoral waters. The system uses the same source buoy as used in the EER system, the AN/SSQ-110A sonobuoy. It operates on one of 31 selectable radio frequency channels and has two sections. The upper section is called the control buoy and is similar to the upper electronics package of the AN/SSQ-62 Directional Command Activited Sonobuoy System (DICASS) sonobuoy. The lower section consists of two Signal Underwater Sound (SUS) explosive payloads of Class A explosive weighing 4.2 pounds each. When commanded by the aircrew, the SUS charges explode, creating a loud acoustic signal. The echoes from the explosive charge are then analyzed on the aircraft to determine a submarine's position. Since IEER has become operationally capable, the Navy has implemented mitigation measures through a coordinated process with NMFS under the national defense exemption of the MMPA. Those measures will be discussed in more detail in Section 6 of this document.

2.2.1.2.3 Advanced Extended Echo Ranging (AEER)

The Advance Extended Echo Ranging (AEER) program examines improvements in both long-range shallow and deep water ASW search using active sources (Air Deployable Low Frequency Projector [ADLFP], Advance Ranging Source [ARS]) and passive sonobuoy receivers (ADAR). The signal processing is provided by research conducted under Advanced Multi-static Processing Program (AMSP).

The proposed AEER system is operationally similar to the IEER system. The AEER system will use the same ADAR sonobuoy as the acoustic receiver and will be used for a large area ASW search capability in both shallow and deep water. However, instead of using an explosive AN/SQA-110A as an impulsive source for the active acoustic wave, the AEER system will use a battery powered (electronic) source for the AN/SSQ-125 sonobuoy. The output and operational parameters for the AN/SSQ-125 sonobuoy (source levels, frequency, wave forms, etc.) are classified, however, this sonobuoy is intended to replace the EER/IEER's use of explosives and is scheduled to be deployed in 2009. Acoustic impact analysis for the AN/SSQ-125 in this document assumes a similar per-buoy effect as that modeled for the DICASS sonobuoy. IOC for the AEER system is unknown.

2.2.1.3 New Instrumentation Technology

The NWTRC will acquire improved technology and capabilities to score, track, and provide feedback. Technology is also permitting the fielding of non-fixed site, mobile tracking ranges.

2.2.2 NWTRC Enhancements

The Navy has identified specific enhancements and recommendations to optimize range capabilities required to adequately support training for all missions and roles assigned to the NWTRC. Enhancement recommendations were based on capability shortfalls (or gaps) and were assessed using the Navy range required capabilities as defined by the required capabilities document (RCD) of September, 2005. Proposed enhancements for the NWTRC are discussed below and will be analyzed in this BE.

Table 2-6 identifies the baseline and proposed increases in operations in the NWTRC.

2.2.2.1 New Electronic Combat (EC) Threat Simulators/Targets

Electronic Combat (EC) is one of the principal elements of an OPFOR. Every warfare type supported by the NWTRC (except basic NSW/EOD) requires an OPFOR with the capability to produce RF signatures characteristic of the employment of EC threats by an OPFOR. For Basic level training, EC Threat Level 1 is required (a limited number [1-2] of threat weapons systems emitters used primarily for signal recognition). For Intermediate level training, EC Threat Level 2 is required (sufficient EC emitters to provide multiple coordinated threats with accurate threat replication). Additionally, EC is the primary mission of the EA-6B, EA-18G, and EP-3, and a secondary mission of the P-3 - all aircraft based at NASWI. These aircrews require multi-axis threat training currently unattainable at the NWTRC. Similarly, ships and submarines require EC training. Due to their antenna height limitations and the curvature of the earth, effective EC training could only be conducted if the emitter is located on or very near the coastline. Pacific Beach, Washington is one potential location for a fixed land based electronic warfare (EW) emitter. This location, or a similar site on the Washington coast, would allow EC training at sea for ships, submarines, and aircraft, and provide the possibility of multi-axis training for aircraft when combined with the existing EW emitter at OLF Coupeville or EC threat simulation requirements of contract air-target and/or surface-target services. This location would also allow for EC training of aircrews to take place in the Olympic MOAs.

The overall number of sorties or training events will not increase as a result of these enhancements. Instead, training flights or ship training events that historically did not include EC training as part of the event, will now conduct that training. For example, a ship operating in the PACNORWEST for the purposes of navigation training will simultaneously conduct EC training if a coastal threat simulator is functional. This is a new mission area for ships training in the NWTRC since no coastal threat simulator existed previously. For aircraft that had conducted this training only when within range of the NASWI threat simulator, they can now include this mission in their W-237 training flights.

2.2.2.2 Development of the Portable Undersea Tracking Range

The PUTR is a self-contained, portable, undersea tracking capability that employs modern technologies to support coordinated undersea warfare training for Forward Deployed Naval Forces (FDNF). PUTR will be available in two variants to support both shallow and deep water remote operations in keeping with Navy requirements to exercise and evaluate weapons systems and crews in the environments that replicate the potential combat area. The system will be capable of tracking submarines, surface ships, weapons, targets, and Unmanned Underwater Vehicles (UUVs) and distribute the data to a data processing and display system, either aboard ship, or at a shore site.

The PUTR would be developed to support ASW training in areas where the ocean depth is between 300 ft and 12,000 ft and at least 3 nm from land. This proposed project would temporarily instrument 25-square-mile or smaller areas on the seafloor, and would provide high fidelity crew feedback and scoring of crew performance during ASW training activities. When training is complete, the PUTR equipment would be recovered. All of the potential PUTR areas have been used for ASW training for decades.

No on-shore construction would take place. Seven electronics packages, each approximately 3 ft long by 2 ft in diameter, would be temporarily installed on the seafloor by a range boat, in water depths greater than 600 ft. The anchors used to keep the electronics packages on the seafloor would be either concrete or sand bags, which would be approximately 1.5 ft-by-1.5 ft and would weigh approximately 300 pounds. Operation of this range requires that underwater participants transmit their locations via pingers (see "Range Tracking Pingers" below). Each package consists of a hydrophone that receives pinger signals, and a transducer that sends an acoustic "uplink" of locating data to the range boat. The uplink signal is transmitted at 8.8 kilohertz (kHz), 17 kHz, or 40 kHz, at a source level of 190 decibels (dB). The Portable Undersea Tracking Range system also incorporates an underwater voice capability that transmits at 8-11 kHz and a source level of 190 dB. Each of these packages is powered by a D cell alkaline battery. After the end of the battery life, the electronic packages would be recovered and the anchors would remain on the seafloor. The Navy proposes to deploy this system for 3 months of the year (approximately June – August), and to conduct TRACKEX activities for 10 days per month in an area beyond 3 nm from shore. During each of the 30 days of annual operation, the PUTR would be in use for 5 hours each day. No additional ASW activity is proposed as a result of PUTR use.

If fishermen, boaters, or whales are observed in the area, training involving weapons training would be stopped or moved to another area.

MK-84 range tracking pingers would be used on ships, submarines, and ASW targets when ASW TRACKEX training is conducted on the PUTR. The MK-84 pinger generates a 12.93 kHz sine wave in pulses with a maximum duty cycle of 30 milliseconds (3% duty cycle) and has a design power of 194 dB re 1 micro-Pascal at 1 meter. Although the specific exercise, and number and type of participants will determine the number of pingers in use at any time, a maximum of three pingers and a minimum of one pinger would be used for each ASW training activity. On average, two pingers would be in use for 3 hours each during PUTR operational days.

Effect on Training

No increase in tactical MFA sonar use in the NWTRC is anticipated as a result of PUTR use. Instead, the PUTR will improve the effectiveness of existing ASW training, through high fidelity exercise replay and scenario debriefing capability. There will be no increases in ship or aircraft training events. As mentioned, there will be new sound sources introduced into the ocean environment during the times PUTR is operating.

2.2.2.3 Development of Air Target Services

Navy training requires air targets for Basic and Intermediate AAW, A-A, and S-A GUNEX and MISSLEX. Live rotary and/or fixed wing OPFOR aircraft are required for Basic and Intermediate AAW, ASUW, and Intermediate level ASW, STW, and EC. Additionally, EC Threat Level 1 and 2 are required for almost all training types and levels supported in the NWTRC. Air Target Services can be used to generate EC threats as well as the visual and spectral signatures of real threats. Additionally, local air and surface units, and potentially submarine units in the future, require air target and EC Threat Level 1 capability to complete AAW missile and gunnery training and exercises at the Basic level. Additionally, the EA-18G will have an offensive AAW capability and as such, require air targets. Currently, no air target services exist for the NWTRC. All surface combatant ships must complete this training in the Southern California Range Complex. The target system needs to have the capability to support both air-to-air (A-A) and surface-to-air (S-A) missile exercises, and include subsonic and supersonic aircraft or drones that can operate from surface to 50,000 feet for Intermediate level training. The aircraft or drones in the target system should be capable of active EC jamming and simulated cruise missile launch capabilities. For Basic level AAW training, towed targets are required. Air Target services are traditionally used to provide OPFOR targets.

Due to lack of capability in the NWTRC, surface combatants stationed in the Puget Sound must complete parts of their Basic and Intermediate AAW training elsewhere. This results in increased travel costs; ship/aircraft fuel costs, increased maintenance costs due to increased flying and steaming times to go to other training venues to achieve the training as well as time away from homeport and families which negatively impacts retention and quality of service. To meet Chief of Naval Operations mandated time-in-homeport requirements it is important that the NWTRC meet minimum required capabilities to conduct AAW.

Three current training activities will be positively affected by the introduction of new air target services in the NWTRC. The activities and impacts follow:

- A-A MISSILEX. Aircraft have previously conducted this training activity in the NWTRC, but on a somewhat limited scale. With the introduction of the EA-18G and its air-to-air missile capability, the requirement will increase. The new air services will allow these aircrews to train locally, and with a broader range of targets. See Table 2-6 for specific increases.

- S-A GUNEX. Similar to the A-A MISSILEX for aircraft above, ships will conduct S-A GUNEX at an increased level with the increased targets and opportunities.

- S-A MISSILEX. Aircraft carriers conduct S-A MISSILEX as a training requirement. No other locally based ships are required to complete this live fire training. Previously, locally based aircraft carriers traveled to other training ranges to complete this requirement. If the BQM-74E or similar target is included in the increased air target services, this new mission will be conducted in the NWTRC.

2.2.2.4 Development of Surface Target Services

The Proposed Action includes the development of surface targets services. The Navy requires surface targets for ship, submarine, and aircraft crews to complete ASUW training. Surface Target Services can be used to generate EC threats as well as the visual and spectral signatures of real threats. The NWTRC does not have ASUW targets or target services in the complex. Surface ships have the ability to launch a Floating At-Sea Target (FAST) which meets the stationary requirement but these do not replicate the visual or spectral signature of threat platforms. Aircraft and submarines do not have the capability to launch a FAST, although aircraft can launch a marine floating marker (flare), which also does not replicate the visual or spectral signature of real threats.

Due to lack of capability in the NWTRC, surface combatants stationed in the Puget Sound must complete parts of their Basic and Intermediate ASUW training in other training venues. This results in increased travel costs; ship/aircraft fuel costs, increased maintenance costs due to increased flying and steaming times to go to other training venues to achieve the training as well as time away from homeport and families which negatively impacts retention and quality of service. To meet Chief of Naval Operations mandated time-in-homeport requirements it is important that the NWTRC meet minimum required capabilities to conduct ASUW.

Surface-to-surface gunnery exercises will increase as a result of the development of surface target services. Currently, training is limited to the type of targets available for surface ships. New moving targets will greatly enhance the training available in the NWTRC. See Table 2-6 for actual increases in training activities.

2.2.2.5 Small Scale Underwater Training Minefield

The addition of a small scale underwater training minefield in the NWTRC will allow submarines to conduct mine avoidance training in the range complex. Mine avoidance exercises train ship and submarine crews to detect and avoid underwater mines. The underwater minefield will consist of approximately 15 mine-like shapes tethered to the ocean floor, in depths of 500 to 600 ft (150 to 185 m) and rising to within 400 to 500 ft (120 to 150 m) of the ocean surface.

Until this underwater training minefield is installed, no mine avoidance training is possible in the NWTRC. When the minefield is installed, submarine crews will use the AN/BQS-15 high frequency active sonar to locate and avoid the mine shapes. Each mine avoidance exercise involves one submarine operating the AN/BQS-15 sonar for six hours to navigate through the training minefield. A total of seven mine avoidance exercises will occur in the NWTRC annually.

2.2.2.6 Range Activity Summary Tables

Tables 2-7 through 2-10 summarize the activities in the NWTRC. Table 2-6 summarizes the resulting impact to training from each of the NWTRC enhancements. Table 2-7 provides detailed information on the Proposed Action activities. Table 2-8 lists the annual expenditure of ordnance and other related training materials in the NWTRC. Table 2-9 lists the active sonar sources in use or proposed for use in the NWTRC.

Table 2-7. Impact of Range Enhancements on Annual Level of Activities in the NWTRC

Range Activity	Platform	Before Range Enhancement	After Range Enhancement	Percent Increase
New Electronic Combat (EC) Threat Simulators/Targets				
Electronic Combat (EC) Exercises	EA-6B/EA-18G	2,290 sorties	4,580 sorties	100
	P-3	14 sorties	28 sorties	100
	EP-3	195 sorties	390 sorties	100
	CVN	0 events	50 events	N/A
	DDG	0 events	50 events	N/A
	FFG	0 events	100 events	N/A
	AOE	0 events	25 events	N/A
	SSGN	0 events	25 events	N/A
	SSBN	0 events	25 events	N/A
New Portable Undersea Tracking Range (PUTR)				
No new training or training level increases. PUTR allows more effective training of existing events. PUTR will introduce new MFA and HFA sound sources into the ocean as part of the tracking instrumentation.				
New Air Target Services				
Air-to-Air (A-A)Missile Exercise	EA-18G	12 events 15 missiles	24 events 30 missiles	100
Surface-to-Air (S-A) Gunnery Exercise	DDG	19	38	100
	FFG	57	113	98
	AOE	4	9	125
S-A Missile Exercise	CVN	0	4	N/A
New Surface Target Services				
Surface-to-Surface (S-S) Gunnery Exercise	CVN	4 events	8 events	100
	DDG	23 events	42 events	83
	FFG	70 events	126 event	80
	AOE	2 events	4 events	100
Small Scale Underwater Training Minefield				
Mine Avoidance	SSGN	0 events	4 events 24 sonar hours	N/A
	SSBN	0 events	3 events 18 sonar hours	N/A

Table 2-8. Current and Proposed Annual Level of Activities in the NWTRC Study Area

Range Activity	Platform	System or Ordnance	Baseline (Current Activity)	Proposed Action	Location
Anti-Air Warfare (AAW)					
Aircraft Combat Maneuvers	EA-6B	None	1,353 sorties	2,000 sorties	Offshore Area Inshore Area
	EA-18G*				
	FA-18				
	F-16				
Air-to-Air (A-A)Missile Exercise*	EA-18G	AIM-7 Sparrow	0 events 0 missiles	24 events 30 missiles	Offshore Area
		AIM-9 Sidewinder			
		AIM-120 AMRAAM			
Surface-to-Air (S-A) Gunnery Exercise	DDG	5"/54 BLP, 20mm CIWS	72 events	160 events	Offshore Area
	FFG	76mm, 20mm CIWS			
	AOE	20mm CIWS			
S-A Missile Exercise**	CVN	Sea Sparrow Missile or RAM	0 events	4 events	Offshore Area
Anti-Surface Warfare (ASUW)					
Surface-to-Surface (S-S) Gunnery Exercise	CVN	20mm CIWS, 7.62mm, .50 cal	4 events	8 events	Offshore Area
	DDG	5"/54 BLP, 20mm, 7.62mm, .50 cal	21 events	42 events	
	FFG	76mm, 20mm, 7.62mm, .50 cal	63 events	126 event	
	AOE	20mm, 7.62mm, .50 cal	2 events	4 events	
Air-to-Surface (A-S) Bombing Exercise	P-3C	MK-82 (live), BDU-45 (inert)	24 sorties	30 sorties	Offshore Area
	P-8*	MK-82 (live), BDU-45 (inert)			
HARM Exercise	EA-6B	CATM-88C (not released)	See STW	See STW	Offshore Area Inshore Area
	EA-18G*	CATM-88C (not released)			
Sink Exercise	E-2	None	1 event	2 events	Offshore Area
	P-3	MK-82, AGM-65 Maverick			
	FA-18	MK-82, MK-83, MK-84, SLAM-ER			
	EA-6B	AGM-88C HARM			
	EA-18G*	AGM-88C HARM			
	SH-60	AGM-114 HELLFIRE			
	DDG	5"/54			
	FFG	76mm			
	SSN	MK-48 ADCAP			

Table 2-8. Current and Proposed Annual Level of Activities in the NWTRC Study Area (cont'd)

Range Activity	Platform	System or Ordnance	Baseline (Current Activity)	Proposed Action	Location
Anti-Submarine Warfare (ASW)					
Anti-Submarine Warfare (ASW) Tracking Exercise - MPA	P-3C P-8 MMA*	Targets: SSN, MK-39 EMATT Sonobuoys: SSQ-53 DIFAR (passive) SSQ-62 DICASS (active) SSQ-77 VLAD, SSQ-36 BT	200 sorties	210 sorties	Offshore Area
ASW Tracking Exercise - Extended Echo Ranging (EER)	P-3C P-8 MMA*	SSQ-110A source sonobuoy SSQ-77 VLAD	10 sorties	12 sorties	Offshore Area
ASW Tracking Exercise - Surface Ship	DDG	SQS-53C MFA sonar	24 events 36 sonar hours	26 events 39 sonar hours	Offshore Area
	FFG	SQS-56 MFA sonar	36 events 54 sonar hours	39 events 59 sonar hours	
ASW Tracking Exercise - Submarine	SSBN SSGN	BQQ-5 (passive only) BQQ-5 (passive only)	96 events	100 events	Offshore Area
Electronic Combat (EC)					
Electronic Combat (EC) Exercises	EA-6B/EA-18G	None	2,135 sorties	4,580 sorties	Offshore Area Inshore Area
	P-3		13 sorties	28 sorties	
	EP-3		182 sorties	390 sorties	
	CVN*		0 events	50 events	
	DDG*		0 events	50 events	
	FFG*		0 events	100 events	
	AOE*		0 events	25 events	
	SSGN*		0 events	25 events	
	SSBN*		0 events	25 events	
Mine Warfare (MIW)					
Mine Countermeasures	EOD Pers. H-60, RHIB	2.5 lb C-4	60 events 60 detonations 878 pers.	4 events 4 detonations 102 pers.	EOD Ranges
Land Demolitions	EOD Pers. Truck	C-4, various igniters, fuses, smoke grenades	102 detonations	110 detonations	EOD Ranges
Mine Avoidance**	SSGN (1 per event)	AN/BQS-15 HFA Sonar	0 events	4 events 24 sonar hours	Offshore Area
	SSBN (1 per event)	AN/BQS-15 HFA Sonar	0 events	3 events 18 sonar hours	

Table 2-8. Current and Proposed Annual Level of Activities in the NWTRC Study Area (cont'd)

Range Activity	Platform	System or Ordnance	Baseline (Current Activity)	Proposed Action	Location
Naval Special Warfare (NSW)					
Insertion/Extraction	C-130 (1 sortie per event)	None	24 sorties	27 sorties	Inshore Area EOD Ranges
	H-60 (1 sortie per event)		84 sorties	93 sorties	
	Personnel		1,064 pers.	1,160 pers.	
NSW Training	SDV (1 per event)	None	35 events	35 events	Indian Island
	RHIB (2 per event)		35 events	35 events	
	NSW Pers.		245 pers.	245 pers.	
STRIKE WARFARE (STW)					
HARM Exercise (Non-firing)	EA-6B, EA-18G*	CATM-88C (not released)	2,724 sorties	3,000 sorties	Offshore Area Inshore Area
Intelligence, Surveillance, and Reconnaissance (ISR)	P-3, EP-3, EA-6B, EA-18G*	None	94 sorties	100 sorties	Offshore Area
Unmanned Aerial System(UAS) Research, Development, Test and Evaluation (RDT&E) and Training	Scan Eagle, Global Hawk*, BAMS*	None	12 sorties	112 sorties	Offshore Area Inshore Area

Notes: * This activity, ordnance, or location is only applicable under the Proposed Action.

Table 2-9. Annual Ordnance and Expendables Use in the NWTRC

Training Area and Ordnance/Expendable Type	Number of Rounds/Expendables Per Year	
	Baseline (Current Activity)	Proposed Action
Pacific Northwest Ocean Surface/Subsurface Operating Area (PACNW OPAREA)		
BOMBS		
BDU-45 (Inert)	88	110
MK-82 (HE)	12	18
MK-83 (HE)	4	8
MK-84 (HE)	4	8
MISSILES		
AIM-7 Sparrow	0	13
AIM-9 Sidewinder	0	9
AIM-120 AMRAAM	0	7
AGM-65 Maverick	3	6
AGM-84 Harpoon	3	6
AGM-88 HARM	2	4
AGM-114 HELLFIRE	1	2
NATO Sea Sparrow Missile	0	8
SLAM ER	1	2
NAVAL GUNSHELLS		
20 mm	7,200	16,000
25 mm	15,750	31,500
57mm	630	1,260
76mm	560	1,120
5-inch	1,716	3,463
SMALL ARMS ROUNDS		
7.62mm Projectile	1,224	2,720
.50-cal machine gun	58,500	117,000
TORPEDOES		
MK-48 ADCAP	1	2
PYROTECHNICS		
LUU-2B/B Flare	0	11
MK-58 Marine Marker (Day/Night smoke/flare)	208	220
TARGETS		
MK-39 Expendable Mobile ASW Training Target (EMATT)	121	126
Tactical Air Launched Decoy (TALD)	0	22
TDU-34 Towed Target (Retained, not expended)	72	160
BQM-74E	0	16
HSMST (Recovered)	0	9

Table 2-9. Annual Ordnance and Expendables Use in the NWTRC (continued)

Training Area and Ordnance Type	Number of Rounds Per Year	
	Baseline (Current Activity)	Proposed Action
Pacific Northwest Ocean Surface/Subsurface Operating Area (PACNW OPAREA) (continued)		
TARGETS (continued)		
Trimaran (Recovered)	0	20
SPAR (Recovered)	0	31
Killer Tomato	60	120
SONOBUOYS		
SSQ-36 BT	288	302
SSQ-53 DIFAR Passive	7,283	7,661
SSQ-62 DICASS Active	844	886
SSQ-77 VLAD	593	653
SSQ-110A Source	124	149
Indian Island Underwater EOD Range		
EXPLOSIVES		
2.5 lb Net Explosive Weight (NEW) charges	3	1
20 lb NEW charges	1	0
Crescent Harbor Underwater EOD Range		
EXPLOSIVES		
< 2.5 lb NEW charges	3	0
2.5 lb NEW charges	45	2
5 lb NEW charges	1	0
20 lb NEW charges	4	0
Floral Point Underwater EOD Range		
EXPLOSIVES		
2.5 lb NEW charges	3	1
Seaplane Base Demolition Training Range		
EXPLOSIVES		
Detasheet C-2 (0.083 in)	800	862
C-4 1.25 lb block	1,476	1,591
C-4 2.0 lb block	240	259
Igniters	160	172
MK142 Firing Device	91	98
Hand Grenades	160	172
MK174 Ctg Cal .50 Impulse	847	913
DetaSheet 2.0 lb (M024)	240	259
Blasting Cap, Electric (M130)	1,758	1,896
Det Cord (ft) (M456)	31,960	34,467
Fuse, Blasting,Time (ft) (M670)	16,300	17,578

Table 2-9. Annual Ordnance and Expendables Use in the NWTRC (continued)

Training Area and Ordnance Type	Number of Rounds Per Year	
	Baseline (Current Activity)	Proposed Action
Seaplane Base Demolition Training Range (continued)		
EXPLOSIVES (continued		
Igniter, Time, Blasting Fuse (M766)	320	345
Blasting Cap, Non-Electric (M131)	959	1,034
PYROTECHNICS		
Red Smoke, G950	224	241
Green Smoke, G940	91	98
Violet Smoke, G955	192	207
Bangor Demolition Training Range		
EXPLOSIVES		
Detasheet C-2 (0.083 in)	50	55
C-4 1.25 lb block	94	102
C-4 2.0 lb block	15	16
Igniters	10	11
MK142 Firing Device	6	6
Hand Grenades	10	11
MK174 Ctg Cal .50 Impulse	54	58
DetaSheet 2.0 lb (M024)	15	17
Blasting Cap, Electric (M130)	112	121
Det Cord (ft) (M456)	2,040	2,200
Fuse, Blasting,Time (ft) (M670)	1,040	1,122
Igniter, Time, Blasting Fuse (M766)	20	22
Blasting Cap, Non-Electric (M131)	61	66
PYROTECHNICS		
Red Smoke, G950	14	15
Green Smoke, G940	6	6
Violet Smoke, G955	12	13

Table 2-10. Active Sonars Employed in the NWTRC

Sonar	Description	Frequency Class	Proposed Action Annual Use
MK-48	Torpedo sonar	High frequency	2 Torpedoes
AN/SQS-53C	Surface ship sonar	Mid-frequency	39 hours
AN/SQS-56C	Surface ship sonar	Mid-frequency	59 hours
AN/SSQ-62	Sonobuoy sonar	Mid-frequency	886 sonobuoys
AN/BQS-15	Submarine mine sonar	High frequency	42 hours

2.3 MEASURES IDENTIFIED IN PREVIOUS CONSULTATIONS

This section summarizes conservation recommendations identified during previous consultations between the Navy and NMFS about proposed activities within the NWTRC that may be pertinent to the Proposed Action. Measures are summarized for the following consultations:

Minimization measures included in the NMFS BO for the Navy Explosive Ordnance Disposal Operations (EOD) at Whidbey Island, Port Townsend, and Bangor sites (NMFS 2008f):

- Pre-explosion surveys (via boat) will be conducted within a 2,083-ft radius of the detonation site to determine presence of absence or marine mammals and sea birds. The explosive will not be detonated if marine mammals or sea birds are within the 2,083-ft survey distance. The explosive will be detonated only when the sea birds and mammals are not observed in the survey area.
- At the Crescent Harbor and Port Townsend Bay sites, during the juvenile salmonid migration season (July 1 through September 30 for salmon), charges larger than 2.5 pounds will not be used. If it is necessary to use charges larger than 2.5 pounds, and up to 20 pounds, these charges will be detonated at least 3,280 ft from the nearest shoreline.
- At the Bangor site, charges larger than one pound should not be used during the juvenile salmonid migration season (March 15 through July 1).
- The Navy will initiate the following restoration action to enhance salmonid and forage fish production around Crescent Harbor, Whidbey Island.
    - Restoration of the former salt marsh at Crescent Harbor marsh on the Navy's Seaplane Base.
    - Restoration of intertidal beach habitat at Maylor Point in Oak Harbor at the Seaplane Base.
- A monitoring plan will be implemented to provide estimates of fish mortalities related to EOD operation and training. Reports will be submitted annually to NMFS.

Deviation from these conservation measures may result in effects not considered in this consultation and will not be exempted from the prohibition against take as described in the incidental take statement. Further consultation will be required to determine what effect the modified action may have on listed species or designated critical habitat.

2.3.1 Conservation Recommendations

ESA, Section 7(a)(1) directs federal agencies to use their authority to further the purpose of the Act by carrying out conservation programs for the benefit of threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a Proposed Action on listed species or critical habitat, to help implement recovery plans, or to develop information. The following conservation recommendations would provide information for future consultations involving the issuance of marine mammal permits that may affect endangered species, as well as reduce harassment related to research activities:

It is recommended the same conservation measures identified in the previous section (section 2.3) be applied to the Proposed Action.

3 ENVIRONMENTAL BASELINE

3.1 INTRODUCTION

The environmental baseline includes the past and present impacts of federal, state, and private actions and other human activities in the Proposed Action Area. It also includes the anticipated actions of proposed federal projects in the Proposed Action Area that have already undergone formal or early ESA Section 7 consultation, and the impacts of state and private actions that are contemporaneous with the consultation in process (50 Code of Federal Regulations [CFR] 402.02). The environmental baseline includes the effects of several activities that affect the survival and recovery of federal threatened and endangered species in the Proposed Action Area.

The geographic layout and size of the NWTRC, the Proposed Action Area, are described in Section 1.2. The NWTRC consists mostly of open ocean.

Several human activities have contributed to the current status of populations of the ESA-listed threatened and endangered species found in the NWTRC. Some of these activities, most notably commercial whaling, occurred extensively in the past, but ended and no longer appear to affect the populations directly, although the long-term effects of these population reductions persist today. Other human activities continue to affect listed species, either directly or indirectly. The following discussion summarizes the principal activities and conditions that are known to affect the likelihood that these protected species will survive and recover in the wild.

3.2 MARINE MAMMALS

3.2.1 Whales

This group includes the blue, fin, humpback, sei, sperm, and southern resident killer whales, which is under the jurisdictional review of the NMFS.

3.2.1.1 Natural Mortality

Natural mortality rates in cetaceans, especially large whales, are largely unknown. Although factors contributing to natural mortality cannot be quantified at this time, there are a number of suspected causes, including parasites, predation, red tide toxins, and ice entrapment. For example, the giant spirurid nematode (*Crassicauda boopis*) is thought to be responsible for congestive kidney failure and death in some large whale species (Lambertson et al. 1987). A well-documented observation of killer whales attacking a blue whale off Baja California indicates that whales are, at least occasionally, vulnerable to these predators (Tarpy 1979). Evidence of ice entrapment and predation by killer whales has been documented in most populations of bowhead whales (Tomilin 1957; Mitchell and Reeves 1982; Nerini 1984; Philo et al. 1993). Stochastic events, such as fluctuations in weather and ocean temperature affecting prey availability, may also contribute to natural mortality.

Maldini et al. (2005) identified 202 toothed cetaceans that had stranded between 1950 and 2002, of which sperm whales constituted 10 percent. These studies did not identify the causes of the strandings or the causes of death.

3.2.1.1.1 Diseases and Parasites

Marine mammals frequently suffer from a variety of diseases resulting from viral, bacterial, and parasitic infections (NOAA 2006). Microparasites such as bacteria, viruses, and yeasts are small, and can reproduce with their hosts (Geraci et al. 1999). These types of organisms flourish in marine mammal habitats, and usually pose little threat to a healthy animal (Geraci et al. 1999).

Viruses have been associated with marine mammal die-offs. The first mass mortality attributed to a virus (Influenza A) occurred between December 1979 and October 1980 along the New England coast. Since

1980, viruses have been implicated in almost all marine mammal mass mortalities attributed to infectious diseases (Geraci et al. 1999).

Opportunistic viruses and parasites can invade and overwhelm those animals already weakened for other reasons, such as malnutrition or infection. It is difficult to determine whether a microparasite is the primary pathogen, or if it is a secondary infection in an animal already weakened from other causes (Geraci et al. 1999).

3.2.1.1.2 Predation

Marine mammals may fall prey to sharks or killer whales. The young, the old, and the weak, especially, are at risk. Bite marks are occasionally observed on the hides of marine mammals.

3.2.1.1.3 Natural Toxins

Several species of diatoms can produce a toxin called domoic acid. These diatoms are widespread, and can be found on the western coast of the United States. Domoic acid is known to have serious effects on a variety of marine species. Since 1987, domoic acid has been identified as the cause of mass mortalities of marine mammals off the coast of California, and whale deaths off Georges Bank. "Red tides" created by a dinoflagellate (*Karenia brevis*) are responsible for annual mass mortalities of fish, and in some years for mass mortalities of marine mammals and sea turtles (NMFS 2007a).

3.2.1.2 Induced Mortality

Induced mortality rates in cetaceans, especially large whale populations, have been affected by a variety of human activities. The following discussion summarizes the principal activities that are known to affect these protected species.

3.2.1.2.1 Commercial Harvesting

Large whale populations in the Proposed Action Areas have historically been affected by commercial exploitation. Prior to the International Whaling Commission's (IWC's) 1966 moratorium on whaling, most large whale species had been so severely depleted that they were listed as endangered under the ESA of 1966.

From 1900 to 1965, for example, nearly 30,000 humpback whales were taken in the Pacific Ocean, with an unknown number of additional animals taken prior to 1900 (Perry et al. 1999). In addition, 9,500 blue whales were reportedly killed by commercial whalers between 1947 and 1987 (Rice 1984), along with 25,800 sperm whales (Barlow et al. 1997). Large-scale commercial whaling no longer exists, but past whaling likely altered the age and social structures of these whale populations in ways that continue to influence them.

3.2.1.2.2 Subsistence Harvesting

Subsistence hunters are typically indigenous peoples that hunt and fish as part of their culture and to supply food for their families. Communities of indigenous hunters on the western coast of North America take small numbers of whales each year.

3.2.1.2.3 Entrapment and Entanglement

Entrapment and entanglement in commercial fishing gear is one of the most frequently documented sources of induced mortality in large whale species. For example, an estimated 78 rorquals were killed annually in the offshore southern California drift gillnet fishery during the 1980s (Heyning and Lewis 1990). From 1996 to 2000, 22 humpback whales in the central north Pacific population were found entangled in fishing gear (Angliss et al. 2002). Entanglement that does not immediately result in mortality still puts whales at increased risk of starvation, physical trauma, infection, and ship strikes.

In 1996, a vessel from Pacific Missile Range Facility on Kauai rescued an entangled humpback whale, removing two crab-pot floats. The gear was traced to a recreational fisherman in southeastern Alaska.

Sperm whale interactions with the longline fisheries in the Gulf of Alaska are increasing in frequency, with the first documented entanglement reported in June of 1997 (Hill and Mitchell 1998). The percentage of humpback whales entangled in fishing gear in southeastern Alaska between 1997 and 2004 is estimated at between 52 and 78 percent (Neilson et al. 2007).

The offshore drift gillnet fishery interacts with fin whales. In 1999, one fin whale was killed by gear that was used in the Bering Sea/Aleutian Island groundfish trawl fishery. The size of the fin whale population is unknown, so the effect of that loss on the fin whale population is unknown.

3.2.1.2.4 Ship Strikes

Collisions with commercial ships are an increasing threat to many large whale species, particularly because shipping lanes cross important large whale breeding and feeding habitats or migratory routes. On the Pacific Coast, a humpback whale is probably killed about every other year by ship strikes (Barlow et al. 1997). From 1996 to 2002, eight humpback whales were reportedly struck by vessels in Alaskan waters.

Despite these reports, the magnitude of the risks commercial ship traffic poses to large whales in the region of influence is difficult to estimate. Very little information is available on ship strikes in the U.S. Exclusive Economic Zone. Virtually no information exists on interactions between whales and commercial vessels outside of U.S. waters in the north Pacific Ocean. These interactions clearly occur, but their significance to the different species of whales present in the region of influence cannot be reliably estimated.

3.2.1.2.5 Strandings

A stranded marine mammal is defined as "any dead marine mammal on a beach or floating nearshore; any live cetacean on a beach or in water so shallow that it is unable to free itself and resume normal activity; or any live pinniped which is unable or unwilling to leave the shore because of injury or poor heath" (Wilkinson 1991). Marine mammals have stranded throughout human history; therefore, many strandings can be attributed to natural and environmental causes. Marine mammals are known to strand for a variety of reasons, but the cause or causes of most strandings are largely unknown (Geraci and Smith 1976; Eaton 1979; Odell et al. 1980; Best 1982; NMFS 2006a). Current science suggests that multiple factors, including both natural and man-made factors, may act alone or in combination to result in a stranding. Because most stranded marine mammals are either weak or dead when they come ashore, the original cause of death or weakness is believed to occur at sea, and the animal is then driven ashore by currents, tides, or wind.

Several studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause marine mammals to strand or might pre-dispose them to strand when exposed to another phenomenon. For example, several studies of stranded marine mammals suggest a link between unusual mortality events and body burdens of toxic chemicals in the stranded animals (Kajiwara et al. 2002; Kuehl and Haebler 1995; Magnucci-Giannoni et al. 2000). These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Fair and Becker 2000; Foley et al. 2001; Moberg 2000; Relyea 2005; Romero 2004; Sih et al. 2004).

Offshore species such melon-headed whales or beaked whales may follow prey that moves close to shore, and then may have trouble with orientation in shallow waters with sandy bottoms that absorb cetacean echolocation signals (Woodings 1995). Between 1990 and 2000, cetaceans stranded 800 to 1,500 times a year, with increases during periods of El Niño events (NMFS 2006a). The main cause of human-related strandings was fisheries interactions (NMFS 2006a).

Appendix A includes a detailed review and analysis of reported marine mammal strandings with a focus on the potential for sonar to be a factor in the strandings. Although few of these events involve threatened or endangered species, they were considered to determine if listed species were likely to strand following exposure to mid-frequency active sonar.

3.2.1.2.6 Habitat Loss and Degradation

Human activities, such as wastewater discharges, dredging, ocean disposal, aquaculture, and coastal development, are known to affect marine mammals and their habitat. In the north Pacific, undersea exploitation and development of mineral deposits, and dredging of ship channels, pose a continuing threat to the coastal habitat of right whales. Point-source pollutants from coastal runoff, offshore mineral and gravel mining, at-sea disposal of dredged materials and sewage effluent, oil spills, commercial vessel traffic, and discarded trawling and fishing gear are continuing threats to marine mammals and their habitat.

The impacts of these activities are difficult to measure. Some researchers have correlated contaminant exposure with possible health effects in marine mammals. Studies of captive harbor seals have demonstrated a link between exposure to organochlorines (e.g., dichlorodiphenyltrichloroethane [DDT], polychlorinated biphenyls [PCBs], and polycyclic aromatic hydrocarbons [PAHs]) and immunosuppression (Ross et al. 1995; de Swart et al. 1996). Organochlorines tend to bioaccumulate through the food chain, increasing the potential for indirect exposure to marine mammals through their food sources. Organochlorines accumulate in fish and fish-eating animals. Thus, contaminant concentrations in plankton-feeding mysticetes are reported to be up to two orders of magnitude less than in fish-eating odontocetes (Borell 1993; O'Shea and Brownell 1994; O'Hara and Rice 1996; O'Hara et al. 1999).

Climate change, indirectly linked to human activities, is also degrading the marine environment, and may result in large-scale loss of viable habitat in the future. According to the World Wildlife Fund (2007), climate change is expected to reduce food sources, such as krill, in the polar seas; lower seawater concentrations; shrink the extent of icy polar habitats; encourage human activities in and exploitation of previously inaccessible polar areas; increase susceptibility to disease; alter the chemistry of seawater; and reduce reproductive success for several species of cetaceans. Climate change also may affect the viability of current migration routes and calving grounds, displacing cetacean populations and reducing the effectiveness of existing sanctuaries, refuges, and reserves.

3.2.1.2.7 Anthropogenic Noise

Marine mammals in the region of influence are regularly exposed to natural and anthropogenic sounds. Sources of anthropogenic noise include transportation; dredging; construction; oil, gas, and mineral exploration; seismic surveys; sonar; detonations; and ocean research activities (Richardson et al. 1995). For example, source intensities are in the range of 180 to 190 dB, referenced to 1 micropascal at 1 meter (re 1 µPa @1 m), for supertankers and container ships; about 185 dB for dredging, about 216 to 259 dB for oil exploration air guns, and about 267 to 279 dB for underwater trinitrotoluene (TNT) detonations (DON 1998).

Several investigators argue that anthropogenic sources of noise have increased ambient noise levels over the last 50 years (Jasny et al. 2005; National Research Council (NRC) 1994; 1996; 2000; 2003; and 2005; Richardson et al. 1995). Much of this increase is from increased shipping, as ships become more numerous and of larger tonnage (NRC 2003; McDonald et al. 2006). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters, and recreational boats all generate low-frequency (under 1,000 Hz) underwater noise.

Noise is generated by oil and gas drilling and production platforms; tankers, vessel and aircraft support; seismic surveys; and the explosive removal of platforms (NRC 2003). Many researchers have described behavioral responses of marine mammals to sound from helicopters, fixed-wing aircraft, vessels, dredging, construction, and geologic exploration (Richardson et al. 1995). Most observations have been of short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker et al. 1993; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984), but the long-term effects, if any, are unclear. Increasing levels of anthropogenic noise are a habitat concern for whales and other cetaceans because of their potential effect on these species' ability to communicate (Carretta et al. 2001).

Surface shipping is the most widespread source of anthropogenic, low-frequency noise in the oceans (Simmonds and Hutchison 1996). The Navy estimates that the 60,000 vessels of the world's merchant fleet annually emit low-frequency sound into the world's oceans for the equivalent of 21.9 million days, assuming that 80 percent of the merchant ships are at sea at any one time (DoN 2001c). The noise spectrum of merchant ships ranges from 20 to 500 Hz, and peaks at about 60 Hz. Between 1950 and 1975, shipping caused a rise in ambient noise levels estimated at about 10 dB (Ross 1976). The background ocean noise level at 100 Hz has been increasing by an estimated 1.5 dB per decade since the introduction of propeller-driven ships (NMFS 2006d).

An association may exist between long-term exposure to low-frequency sounds from shipping and an increased incidence of marine mammal mortality from ship collisions. At lower frequencies, the dominant source of noise is the cumulative effects of ships that are too far away to be heard individually but which, because of their great numbers, contribute substantially to the background noise level.

3.2.1.2.7.1 Deep Water Ambient Noise

Shipping, weather, and seismic activity are the primary sources of deep-water ambient noise. Noise levels between 20 and 500 Hz appear to be dominated by distant shipping vessel noise that usually exceeds wind-generated noise. Above 300 Hz, the level of wind-related noise may exceed shipping vessel noise. Wind, wave, and precipitation noise sources close to the point of measurement dominate frequencies between 500 Hz and 50 kHz. The ambient noise frequency spectrum and intensity can be predicted fairly accurately for most deep-water areas, based primarily on known shipping traffic density and wind state (Urick 1983). For frequencies between 100 and 500 Hz, the average deep-water ambient noise spectra is estimated to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas.

3.2.1.2.7.2 Shallow Water Ambient Noise

In contrast to deep water, ambient noise levels in shallow waters are subject to wide variations in level and frequency, depending upon time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, and marine animals (Urick 1983). Sound propagation is affected by the variable shallow water conditions, including depth, bottom slope, and bottom type. Where the bottom is reflective, the sound levels tend to be higher than where the bottom is absorptive.

3.2.1.2.8 Tourism

Vessels engaged in marine mammal watching could affect whales in the Proposed Action Area. The business of viewing whales and dolphins in their natural habitat has grown rapidly over the last decade into a billion-dollar industry (Hoyt 2001). Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational, and scientific benefits, marine mammal watching is not without potential negative effects. One concern is that animals may become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995). Another concern is that preferred habitats may be abandoned if disturbance levels are too high. Whale watch vessel operators seek out areas where whales concentrate, which has led to several vessels congregating around groups of whales, increasing the potential for harassment, injury, or death of the animals.

Several investigators have studied the effects of whale watch vessels on marine mammals (Amaral and Carlson 2005; Au and Green 2000; Erbe 2002; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Watkins 1986; Williams et al. 2002). The whale's behavioral responses to whale-watching vessels depended upon the distance of the vessel from the whale, the vessel speed, vessel direction, vessel noise, and the number of vessels. The whales' responses included changes in vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions.

NMFS has promulgated regulations (50 CFR 224.103) that specifically prohibit:

- negligent or intentional operation of an aircraft or vessel, or any other negligent or intentional act that disturbs or molests a marine mammal,
- feeding or attempting to feed a marine mammal in the wild,
- approaching humpback whales in Hawaiian or Alaskan waters closer than 100 yds (91 m).

In addition, NMFS started an education and outreach program to provide commercial operators and the public with responsible marine mammal viewing guidelines. In January 2002, NMFS published an official policy on human interactions with wild marine mammals which states that, "NOAA Fisheries cannot support, condone, approve or authorize activities that involve closely approaching, interacting or attempting to interact with whales, dolphins, porpoises, seals or sea lions in the wild. This includes attempting to swim with, pet, touch or elicit a reaction from the animals."

3.2.1.2.9 Scientific Research

Marine mammals have been the subject of field studies for decades. The primary objective of most of these studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued many permits for various non-lethal forms of "take" of marine mammals in the Proposed Action Area from a variety of activities, including aerial and vessel surveys, photo-identification, remote biopsy sampling, and attachment of scientific instruments. Example incidental take permits authorized by the NMFS for various non-lethal activities associated with four whale species are summarized in Table 3-1. Current authorizations can be reviewed online at http://www.nmfs.noaa.gov/pr/permits/incidental.htm.

Table 3-1. Take Permits for four Whale Species Authorized by NMFS

ACTIVITY	PERMIT BY SPECIES				
	Blue	Fin	Right	Sperm	Total
Audiometric / sonocular on stranded individuals	15	15	15	15	60
Photo-Identification, behavior, aerial photogrammetry, underwater observation	6,740	13,680	400	20,020	40,840
Biopsy	985	2,385	60	1,325	4,755
Tagging	155	150	10	135	450
Incidental harassment	1,220	1,220	20	1,220	3,680
TOTAL	**9,115**	**17,450**	**505**	**22,715**	**49,785**

Source: USFWS/NMFS

Existing permits authorize investigators to make thousands of close approaches of other endangered whales for photo-identification, behavioral observations, acoustic recording, aerial photogrammetry, biopsies, and underwater observation. The actual number of close approaches does not appear to have approached the number authorized in existing permits. Nevertheless, nothing prevents high levels of close approaches of several endangered whale species by different investigators each year. After decades of such research activities, the consequences of these harassment activities are unknown (Moore and Clarke

2002). This situation is particularly problematic because much of this research occurs in areas that are critical to the population ecology of whales. Activities that disrupt the behavior of whales in these critical areas could have substantial, long-term consequences for their ecology.

3.2.1.2.10 Competition for Resources

Cetaceans are important components of marine ecosystems (Katona and Whitehead 1988). Recent information indicates that whales probably consume at least as much fish as is harvested by humans (Kenney et al. 1985; Winn et al. 1987). People and whales may be competing for prey if either takes a large fraction of a fishery stock, even if those takes occur at different times.

Humpback whales, for example, are known to feed on several species of fish that are harvested directly by humans. They also feed on species that are the prey of harvestable fishes. The magnitude and details of potential resource competition between humans and whales is not known, but expanding human and whale populations and the increased demand for fish products may create new problems. The issue could become especially severe if new or expanding fisheries target species consumed extensively by whales.

3.2.1.3 Critical Habitat

The southern resident killer whale is the only whale species that currently has designated critical habitat in the NWTRC Study Area. Critical habitat includes those physical, chemical, and biological features essential to the conservation of listed species that may require special management considerations or protection. These physical, chemical, and biological features include:

- Space for individual and population growth and for normal behavior;
- Food, water supply, water quality, air, light, minerals, or other nutritional or physiological requirements;
- Cover or shelter;
- Sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal;
- Habitats protected from disturbance or representative of the historic geographical and ecological distributions of a species.

Critical habitat designations are species-specific areas that possess physical, chemical, and biological features considered essential to the ultimate survival and recovery of the listed species. These features are called primary constituent elements (PCEs). Substantial alteration or destruction of one or more PCEs may change habitat suitability and the conservation status of the listed species. Alteration or loss of critical habitat is deemed especially detrimental to the listed species because these areas are generally the last remaining areas considered suitable for the continued survival and welfare of the species. For critical habitats that predate the use of PCEs, evaluating potential implications of habitat changes or uses is more qualitative, but still combines the best scientific and commercial data with professional judgment.

The PCEs essential for conservation of the southern resident killer whale are:

- Water quality to support growth and development;
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and
- Passage conditions to allow for migration, resting, and foraging.

3.2.2 Pinnipeds

This group includes the Steller sea lion which is under the jurisdictional review of the NMFS.

3.2.2.1 Natural Mortality

Natural mortality is thought to result primarily from predation, diseases and parasites, food shortages, and habitat loss.

3.2.2.2 Induced Mortality

Major sources of induced (anthropogenic) mortality include conflicts between seals and various fisheries and environmental contamination.

3.2.2.2.1 Harvesting

Fur seals were hunted first by Native Americans, and later by European colonists. Fur seals were hunted commercially in southern California until about 1825, by which time they had been extirpated north of the U.S. / Mexico border. Hunting continued in Mexico until about 1894, with the Mexican harvest from 1806 to 1890 estimated at about 52,000 seals. (NMFS 2007a)

3.2.2.2.2 Entanglement and Fisheries Interactions

No reports exist of fur seals being taken as bycatch by fisheries in southern California. Incidental mortality from drift and set gillnet fisheries may occur in Mexico. Several fur seals have stranded on the Channel Islands; most appear to have resulted from natural causes, but some strandings appear to have resulted from interactions with fisheries or marine debris. Evidence includes abrasions around the neck, embedded fish hooks, and entanglement in fishing line. (NMFS 2007a).

3.2.2.3 Critical Habitat

Critical habitat is designated in the NWTRC for the Steller sea lion at some rookeries and haul-out areas. PCEs are not specifically addressed by the Federal Register critical habitat announcement (NMFS 1993). These areas provide the physical and biological habitat features that support reproduction, foraging, resting, and refuge features considered essential to the conservation of the Steller sea lion (NMFS 1993).

3.2.3 Sea Otter

This species is under the federal jurisdictional review of the USFWS.

3.2.3.1 Natural Mortality

Natural mortality is thought to result primarily from predation, diseases and parasites, food shortages, and habitat loss.

3.2.3.2 Induced Mortality

Major sources of induced (anthropogenic) mortality include conflicts between seals and various fisheries and environmental contamination.

3.2.3.2.1 Harvesting

The northern sea otter historically ranged throughout the Aleutian Islands, as far north as the Pribilof Islands and in the eastern Pacific Ocean from the Alaskan Peninsula south along the coast to Oregon (Wilson el al. 1991). This subspecies was extirpated from most of its range (including the Washington and Oregon coasts) during the 1700s and 1800s as the species was exploited for its fur. In 1969 and 1970, a total of 59 sea otters captured at Amchitka Island, Alaska were released along the Washington coast. After a decade of questionable status, the Washington sea otter population began to increase steadily. From 1989 to 2004, the population grew at an average annual rate of about 8.2 percent. The most recent survey, in 2004, found 743 individuals. There are currently no legal hunting or trapping seasons for the sea otter in Washington (Lance et al. 2004).

3.2.3.2.2 Contaminant, Entanglement, and Fisheries Interactions

The sea otter populations are susceptible to the adverse effects of oil spills resulting from vessel sinkings, collisions, and groundings, as well as unlawful discharges of oily bilge waste. Oil's effects on otters may be acute (immediate) or chronic (long-term). The most pronounced effect is the fouling of an otter's insulative pelage. Because sea otters rely on clean and well-groomed fur to remain warm, even partial contamination (as little as 30 percent of the total body surface) easily results in death from hypothermia or pneumonia. When otters attempt to clean their pelage, they ingest hydrocarbons that can be acutely toxic. Sea otters also can inhale volatile components of freshly-spilled oil, injuring their lungs and other organs (Lance et al. 2004).

Incidental drowning of sea otters can occur when they are entangled in gill or trammel nets. Set-nets have entangled sea otters in Alaska and California. Net entanglement is believed to have killed an average of 80 sea otters per year in California between the mid 1970s (or earlier) and the early 1980s. Restrictions on the use of gill and trammel nets were followed by a resurgence of the sea otter population. California State law prohibits the use of gill or trammel nets (essentially, nets with a mesh >3.5 in) in waters shallower than 30 fathoms at mean low water through much of the southern sea otter range (USFWS 1996).

In Washington, non-treaty gill nets are prohibited throughout the current sea otter range. Sea otters can drown in trap or pot gear used for crabs or cod. Seventeen otters are known to have been taken in various traps and pots used in Alaska and California. No sea otter deaths have been attributed to pot gear in Washington. Crab pots may be the most likely to capture otters, as many are used near shore. Black cod and shrimp pots are not likely to capture otters because they are generally used in deeper waters, which are beyond the typical dive depths (less than 100 ft [30 m]) of sea otters (Lance et al. 2004).

3.2.3.3 Critical Habitat

There is no federally-designated critical habitat for the sea otter in the NWTRC. Habitat features considered important for the conservation of the species by Lance et al. (2004) include kelp forests and occupied marine areas protected from oil spills.

3.3 BIRDS

3.3.1 California Brown Pelican

3.3.1.1 Natural Mortality

Weather is directly and indirectly the most significant cause of natural mortality for the brown pelican. Losses of individual pelicans or localized populations occur from hurricanes and other severe storms, and from associated wave action or surge erosion. El Niño conditions can reduce food availability and cause mortality in pelican chicks. Mortality also is caused by freeze events, which can cause direct deaths, particularly among chicks, or can decrease food supplies. Predation of eggs and chicks by other seabirds or mammals is more likely when weather reduces available food and parents must spend extended periods foraging away from the nest (USFWS 2008).

3.3.1.2 Induced Mortality

3.3.1.2.1 Contaminants

By the early 1970s, it was recognized that organochlorine pesticides were the major threat to the brown pelican. DDT and its metabolites acted by direct toxicity on all age classes, and by impairing reproduction, primarily through eggshell thinning. Endrin produced significant direct-toxicity die-offs of brown pelicans, while dieldrin caused reduced egg hatching and post-hatching survival. Severe restrictions or the elimination of use of these pesticides has led to substantial recovery of the brown pelican throughout its range (USFWS 2008).

3.3.1.2.2 Fisheries Interactions

Oil spills and chronic oil pollution continue to represent a potential source of injury and mortality to pelicans. Sources include tankers and other vessels, offshore oil platforms, and natural oil seeps (USFWS 2008).

Commercial fishing can have a direct effect on individual pelicans through physical injury, such as wing damage, caused by trawling gear. The most susceptible individuals appear to be young, inexperienced birds that collide with shrimp net lines. Damage to the mouth or pouch by hooks used in commercial or recreational fishing can hinder feeding and cause death from starvation. Brown pelicans can become ensnared in monofilament fishing line, which can result in drowning or serious injury, infections from cuts, impaired movement and flight, or inability to feed. In recent data from a large seabird rehabilitation organization, fishing-related injuries represented about 35 percent of all observed pelican mortality (USFWS 2008).

3.3.1.3 Critical Habitat

There is no designated critical habitat for the California brown pelican in the NWTRC Study Area.

3.3.2 Marbled Murrelet

3.3.2.1 Natural Mortality

Marbled murrelets are highly vulnerable to predation on the nesting grounds. Potential nest predators include jays and crows, owls, hawks, raccoons, martens, chipmunks, and squirrels. Nests near forest edges are most susceptible to predation. Prey abundance is another critical determinant of marbled murrelet populations, because the birds must balance the energy costs of foraging trips from inland nest sites to the ocean with the benefits for themselves and their young. Marbled murrelets probably are affected by the fluctuations in marine environmental conditions, such as El Niño events, that depress food supplies, increase mortality of adults, and decrease reproductive success for many seabird species (USFWS 1996).

3.3.2.2 Induced Mortality

3.3.2.2.1 Habitat Loss

Marbled murrelets nest inland in Washington, Oregon, and California, typically in large-diameter, old-growth trees in low-elevation forests with multi-layered canopies. The trees must occur within about 35 mi (57 km) of the coast to enable murrelets to fly back and forth. Marbled murrelet reproductive success has been adversely affected by the forest fragmentation that has resulted from timber harvest and development in the coastal forests. In western Washington and Oregon, old-growth forests have been reduced by an estimated 82 percent from pre-logging levels, and much of the remaining forest does not occur in the large blocks that are required to protect murrelet nests from predation (USFWS 1996).

3.3.2.2.2 Contaminant, Entanglement, and Fisheries Interactions

Marbled murrelets commonly experience direct mortality from human activities such as oil spills and gillnet fisheries.

Marbled murrelets have a high vulnerability to oiling, and large oil spills in the vicinity of murrelet concentrations have had catastrophic effects. For example, the Tenyo Maru spill in 1991 at the mouth of the Strait of Juan de Fuca in Washington resulted in the greatest number of murrelets recovered in any oil spill except the Exxon Valdez oil spill, and represented a significant portion of the local population. Oil spills may also affect forage fish populations, reduce reproductive success, and disrupt breeding activity. Chronic oil pollution can cause mortality through oiling and ingestion of oil (USFWS 1996).

Mortality of marbled murrelets from entanglement and drowning in fishing nets is a concern, particularly in Washington where gillnet are most widely used. As a result of this mortality closures of some areas, specifically to protect marbled murrelets, were implemented in the 1995 season. Reductions in fishing efforts in coastal waters because of depressed salmon populations has had the coincidental benefit of reducing marbled murrelet entanglement and mortality (USFWS 1996).

3.3.2.3 Critical Habitat

To stem population declines, critical habitat was designated by the USFWS in 1996. It includes about 6,000 mi^2 (15,540 km^2) of mature and old-growth forest nesting habitat in Washington, Oregon, and California. All critical habitat is located onshore.

3.3.3 Short-tailed Albatross

3.3.3.1 Natural Mortality

Severe storms, loss of nesting habitat to volcanic eruptions, and competition with black-footed albatrosses for nesting habitat are among the most important natural threats to short-tailed albatrosses. In the 1930s, nesting habitat on Torishima Island was damaged by volcanic eruptions, leaving fewer than 50 birds. Only two breeding colonies remain active today: Torishima Island and Minami-kojima Island in Japan (USFWS 2001b).

3.3.3.2 Induced Mortality

3.3.3.2.1 Harvesting

During the late 1800s and early 1900s, the world population of short-tailed albatrosses was nearly wiped out for the birds' plumage. Feather hunters clubbed to death an estimated five million short-tailed albatross at the Torishima Island (Japan) colony alone. By 1932, when the Japanese government declared this island a bird refuge, the short-tailed albatross had been extirpated from most nesting locations throughout its range (USFWS 2000b). After an extensive investigation of the historical breeding sites, Austin (1949) declared the species extinct.

Despite this finding, breeding was again reported at Torishima Island in 1950, presumably by birds that were wandering juveniles during the final years of harvesting (Tickell 2000). This colony has grown steadily at a rate of 6.5 to 8 percent over the past 20 years. A second colony established itself at a former breeding site at Minami-kojima in the Senkaku Islands in 1971 and has recently been growing at an annual rate of 11 percent (USFWS 2005b).

3.3.3.2.2 Contaminant, Entanglement, and Fisheries Interactions

Human-induced threats include hooking and drowning on commercial long-line gear, entanglement in derelict fishing gear, ingestion of plastic debris, contamination from oil spills, and potential predation by introduced mammals on breeding islands (USFWS 2001b). Plastics, which may be mistaken for food items or may have food such as flying-fish eggs or invertebrates attached, are commonly ingested and contribute to chick mortality (BLI 2001; Suryan 2006). Invasive species at colonies, including cats, rats, and plants, also can be a significant source of mortality (USFWS 2005b).

3.3.3.3 Critical Habitat

There is no designated critical habitat for the short-tailed albatross in the NWTRC Study Area.

3.3.4 Western Snowy Plover

3.3.4.1 Natural Mortality

The Pacific coast population of the western snowy plover breeds primarily on coastal beaches. This habitat is unstable because of unconsolidated soils, high winds, storms, and wave action. As a result, mortality of eggs and chicks can be produced by moderate to severe weather events (USFWS 1999). Predation by gulls, ravens, foxes, skunks, raccoons, or coyotes can result in a high rate of clutch loss in some areas or in some years (The Nature Conservancy 1998).

3.3.4.2 Induced Mortality

3.3.4.2.1 Habitat Loss

A leading factor in the decline of the western snowy plover has been human-caused alteration of coastal habitat by construction of residential, commercial, and recreational facilities, harbors, roads, and campgrounds. This loss of habitat, along with increased human disturbance and expanding predator populations involving animals that are associated with the presence of humans, has resulted in poor reproductive success.

Loss of nesting habitat has also resulted from the encroachment of introduced European beachgrass (*Ammophila arenaria*). This plant reduces the amount of unvegetated area above the surf line, the area where snowy plovers prefer to nest.

3.3.4.3 Critical Habitat

In 2005, the USFWS (2005e) designated 32 units in Washington, Oregon, and California as critical habitat for the Pacific coast western snowy plover. Most are in central and southern California, but they also include three locations in Grays Harbor and Pacific Counties in Washington; seven locations in Coos, Curry, Douglas, Lane, and Tillamook Counties in Oregon; and seven locations in Humboldt County (six sites) and Del Norte County (one site) in northern California.

3.4 SEA TURTLES

The existing environmental conditions for sea turtles are very challenging. General threats to sea turtles include deliberate take, increased human presence, loss or degradation of nesting habitat from coastal development and beach armoring, excessive nest predation by native and non-native predators, disorientation of hatchlings by beachfront lighting, degradation of foraging habitat, marine pollution and debris, watercraft strikes, and incidental take from dredging and commercial fishing operations. Sea turtles typically forage far from their natal beaches and travel immense distances to return to their home beach for nesting, exposing them to risks at each stage in their life. ESA-listed sea turtles are not known to nest within the area of potential effect for the Proposed Action, so the discussion below will be limited to threats to sea turtles during other portions of their life cycle.

3.4.1 Leatherback Turtle

3.4.1.1 Natural Mortality

Excessive nest predation of eggs and new hatchlings by native and non-native predators and degradation of foraging habitats are primary natural mortality factors. Predators of eggs and hatchlings include several species of mammals, birds, invertebrates, and fish. Eggs and hatchlings have high mortality rates, but as the survivors grow natural mortality declines markedly.

3.4.1.2 Induced Mortality

3.4.1.2.1 Harvesting and Coastal Development

The crash of the Pacific leatherback population, once the world’s largest population, is believed primarily to be the result of exploitation by humans for the eggs and meat, as well as incidental take in numerous commercial fisheries of the Pacific. Other factors threatening leatherbacks globally include loss or degradation of nesting habitat from coastal development; disorientation of hatchlings by beachfront lighting; marine pollution and debris; and watercraft strikes. Investigation of clutch hatching success suggest that the leatherback turtle has lower hatching success levels than other sea turtles. Reasons for this condition are unknown.

3.4.1.2.2 Fisheries Interactions and Contaminants

Leatherbacks are seriously declining at all major Pacific basin rookeries, including those in Indonesia, Malaysia, and southwestern Mexico (NMFS and USFWS 1998d). Lewison et al. (2004) estimated that, worldwide, more than 50,000 leatherbacks were taken as pelagic longline bycatch in 2000, and that thousands of these turtles die each year from longline gear interactions in the Pacific Ocean alone. Incidental capture of leatherbacks by the north Pacific high seas driftnet fleet, which targets squid and tuna, was also a source of mortality during the 1980s and early 1990s (Eckert 1993). They have been known to ingest longline hooks used to catch tuna and swordfish (Davenport and Balazs 1991; Skillman and Balazs 1992; Grant 1994; Work and Balazs 2002).

Environmental contamination from coastal runoff, marina and dock construction, dredging, aquaculture, oil and gas exploration and extraction, increased under water noise and boat traffic can degrade marine habitats used by marine turtles. The development of marinas and docks in inshore waters can negatively impact nearshore habitats. Fueling facilities at marinas can sometimes discharge oil, gas, and sewage into sensitive estuarine and coastal habitats. An increase in the number of docks built may also increase boat and vessel traffic. Turtles swimming or feeding at or just beneath the surface of the water are particularly vulnerable to boat and vessel strikes, which can result in serious propeller injuries and death.

Marine debris is a continuing contaminant problem for marine turtles. Marine turtles living in the open ocean commonly ingest or become entangled in marine debris (e.g., tar balls, plastic bags, plastic pellets, balloons, and ghost fishing gear) as they feed along oceanographic fronts, where debris and their natural food items converge. This is especially problematic for turtles that spend all or significant portions of their life cycle in the open ocean (e.g., leatherbacks, juvenile loggerheads, and juvenile green turtles).

3.4.1.3 Critical Habitat

There is no designated critical habitat in the NWTRC Study Area for the leatherback turtle. In December 2007, the NMFS issued a 90-day finding concluding sufficient evidence had been provide by petitioners (Center for Biological Diversity et al. 2007) to warrant revising critical habitat for the leatherback turtle to include the Conservation Zone (NMFS 2007c).

3.5 FISH

3.5.1 Green Sturgeon

Green sturgeon have few known predators other than humans and some marine mammals (Fitch and Lavenburg, 1971; Emmet et al., 1991). Larval and young green sturgeon are likely preyed upon by other species present in spawning areas. Adults have relatively few direct threats from natural predators, which is due to a life history design based on achieving large size and possibly using freshwater as refugia from predators (Committee on the Status of Endangered Wildlife in Canada [COSEWIC], 2004). Sturgeon exhibit a combination of morphology, life history and habitat requirements that make them highly susceptible to negative impacts from human activities (Boreman, 1997). Anthropogenic activities known to impact sturgeon include: exploitation, blockage of available freshwater spawning habitat, and exposure to bioaccumulating industrial and municipal pollution (Boreman, 1997).

3.5.2 Pacific Northwest Salmonids

Over the past several decades, populations of wild salmon and steelhead throughout the West Coast have declined to dangerously low levels. There is no single factor responsible for this decline, and it is even difficult to quantify the relative contributions of different factors. Salmon population declines are the result of numerous forces, such as habitat loss due to development, resource extraction, dam construction and other land uses, and commercial and recreational harvest. Human activities that diminish salmon populations also cause them to be more susceptible to natural environmental fluctuations, such as poor ocean conditions and drought. Relationships between salmon species, life-stage requirements, subpopulations, watershed conditions, human activities, and time and their effects on salmon conditions are consequently complex and beyond the scope of this document to address in detail.

However, because Pacific Northwest salmon species share the similar general life history characteristics, the following sections describe these shared characteristics and identify the environmental and human factors affecting salmon, steelhead, and bull trout. These factors and their relative relationships based on literature reviews are summarized in Table 3-2.

Pacific salmon (genus *Oncorhynchus*) range from San Francisco Bay, California, northward around the Pacific Rim (Eggers 2004). There are seven species of Pacific salmon, five of which reproduce in North America waters – sockeye (*O. nerka*), pink (*O. gorbuscha*), chum (*O. keta*), Chinook (*O. tshawytscha*), and coho (*O. kisutch*) (Groot and Margolis 1991).

The life history of Pacific salmon includes incubation, hatching and emergence in freshwater, migration to the ocean, and subsequent initiation of maturation and return to freshwater for completion of maturation and spawning (Myers et al. 1998). Salmon are anadromous, meaning that they migrate up rivers and streams from the sea to spawn in freshwater. Pacific salmon spawn in gravel beds in rivers, streams and along lake-shores where females lay their eggs in nests or "redd" (Groot and Margolis 1991; DFO 2002). Depending on the species, they spend between one to seven years at sea, with most making extensive and complicated migrations (Groot and Margolis 1991; Eggers 2004). Pacific salmon return to their natal rivers to spawn and, with few exceptions, die soon after (Augerot and Foley 2005). The strong fidelity of homing to their natal streams have resulted in the development of many reproductively isolated subpopulations such that little inbreeding occurs between salmon from one river and another (Quinn 2005, Groot and Margolis 1991). These subpopulations are exposed to different physical and biotic factors such as temperature, flow, gravel size, predators, prey, competitors, and pathogens (Quinn 2005). These variations between streams have lead to the evolution of specializations to help the salmon survive in their home rivers (Quinn 2005). These distinct habitat dynamics require these subpopulations be managed individually rather than as a species (Quinn 2005).

Anadromous salmon depend on the ecological integrity and connectivity of a suite of habitats extending from the natal freshwater spawning or rearing streams to estuaries and then to coastal, shelf, and offshore waters for their growth (Duffy et al. 2005). The relative importance of estuarine and coastal marine environments differs within and among the various salmon species due to differences in residence times and utilization of these environments (Duffy et al. 2005). Juvenile salmon reside mainly in nearshore intertidal waters that provide five key functions: migration corridors, food, physiological refuge, refuge from predators, and refuge from high-energy environments, such as those with strong currents and wave action (Thorpe 1994; Anchor Environmental L.L.C. and People for Puget Sound 2002). After achieving a size threshold or after a specific residence time, salmon reportedly move from shallow nearshore to offshore surface waters in estuarine and marine waters (Duffy et al. 2005).

3.5.2.1 Natural Mortality

As shown in Table 3-2, natural mortality results from marine mammal and bird predation and is considered a minor factor in the overall abundance and distribution of salmonids in the Pacific Northwest.

3.5.2.2 Induced Mortality

As shown in Table 3-2, five of six major factors responsible for salmonid abundance and distribution are linked to human activities. These activities include agriculture, dams, fishing, forestry practices, and urbanization. Five of six additionally important factors are also consequences of human activities, which include gravel harvesting, irrigation, bycatch mortality, hatchery fish interference, and illegal fishing.

Table 3-2. Factors Responsible for the Decline in Salmon Abundance and Distribution in the Pacific Northwest

FACTORS RESPONSIBLE FOR THE DECLINE IN SALMON ABUNDANCE AND DISTRIBUTION IN THE PACIFIC NORTHWEST	
MAJOR FACTORS	
Agriculture: 1, 2, 4, 5, 6, 8, 9, 10, 18, 21, 22	**Fishing:** 16, 19
Dams: 9, 11, 18	**Forestry:** 1, 2, 4, 6, 7, 10, 21, 22
Drought: 9, 10	**Urbanization:** 1, 3, 5, 6, 7, 8, 9, 10, 11, 21, 22
POTENTIALLY IMPORTANT FACTORS *	
Gravel Harvest: 6	**Hatchery Fish Interference:** 19, 20
Irrigation: 9, 12	**Poor Ocean Conditions:** 13, 14, 15, 16
Bycatch Mortality: 16, 19 (salmon killed during fishing for other species)	**Illegal Fishing:** 16, 19
MINOR FACTORS	
Bird Predation: 17	**Marine Mammal Predation:** 16, 17
Components Of The Factors Causing Salmon Decline	
1. Loss of Streamside Vegetation and Functions	12. Lack of Fish Screens at Water Diversion Canals
2. Pesticide Exposure	13. Reduced Upwelling
3. Industrial Pollutants Exposure	14. Altered Ocean Currents and Flow
4. Increased Amount of Sediment Entering Streams	15. Decreased Food Abundance
5. Stream Straightening and Channelizing	16. Reduced Numbers of Adults Reaching Spawning Grounds
6. Habitat Destruction	17. Reduced Numbers of Young Fish Making It To The Sea
7. Decreased Amount of Large Logs In Streams And Loss of Deep Pools and Channel Form	18. Barriers Preventing Salmon From Migrating Upstream or Downstream
8. Filling of The Side Channels of Streams	19. Loss of Genetic Integrity and Diversity
9. Reduced Fresh Water Flow In Rivers and Streams	20. Competition Between Hatchery and Wild Fish
10. Exposure to Abnormal Temperatures	21. Forest Fragmentation
11. Habitat Area Loss	22. Estuary Degradation

* Insufficient data exists for an appropriate assessment of magnitude.

Table based on studies of rivers in Western Oregon and Northern California. Adapted with permission by Pacific States Marine Fisheries Commission from Status and Future of Salmon of Western Oregon and Northern California: Overview of Findings and Options by Botkin, Cummins, Dunne, Regier, Simpson, Sobel, and Talbot.

3.5.2.2.1 Harvesting and Coastal Development

Legal and illegal fishing and bycatch mortality are considered major or important factors responsible for the decline in salmon abundance and distribution (Table 3-2).

3.5.2.2.2 Fisheries Interactions and Contaminants

Water quality degradation associated with agricultural activities and urbanization are considered major factors in the decline in salmon abundance and distribution (Table 3-2). Water contaminants of primary concern include pesticides, industrial pollutants, sediments, and abnormal water temperature exposures.

3.5.2.3 Critical Habitats

Critical habitats and the PCEs that define critical habitat for each salmonid species are described in Table 5-9.

4 LIST OF SPECIES

The following narratives summarize the biology and ecology of the threatened and endangered species in the action area that are relevant to the effects analysis in this BE. Summaries of the global status and trends of each species are presented to provide a foundation for the analysis. The narratives are organized by major taxonomic group (that is, marine mammals, birds, sea turtles, and fish).

4.1 MARINE MAMMALS

The marine mammals present in Washington, Oregon, and northern California coastal waters, and potentially present in the NWTRC, are listed below in Table 4-1, along with their estimated abundance, regulatory status, and seasonal occurrence. Detailed discussions of each species follow.

Table 4-1. Abundance, Status, and Seasonal Occurrence of ESA-Listed Marine Mammals

Common Name (*Scientific Name*)	Abundance (CV) [a/]	Stock	ESA /MMPA Status [b/]	Occurrence	Season	
					May - Oct	Nov - Apr
Blue whale (*Balaenoptera musculus*)	1,186 (0.19)	Eastern North Pacific	E, D, S	Rare, all year	Yes	No
Fin whale (*Balaenoptera physalus*)	3,454 (0.27)	California, Oregon, and Washington	E, D, S	Rare, all year	Yes	Yes
Humpback whale (*Megaptera novaeangliae*)	1,391 (0.22)	Eastern North Pacific	E, D, S	Rare, warm season	Yes	No
Sei whale (*Balaenoptera borealis*)	43 (0.61)	Eastern North Pacific	E, D, S	Very rare, all year	Yes	No
Sperm whale (*Physeter macrocephalus*)	1,233 (0.41)	California, Oregon, and Washington	E, D, S	Uncommon	Yes	Yes
Southern resident killer whale (*Orcinus orca*)	89	Eastern North Pacific Southern Resident	E, D	Rare	Yes	Yes
Steller sea lion (*Eumetopias jubatus*)	48,519	Eastern North Pacific	T, D	Uncommon	Yes	Yes
Sea Otter (*Enhydra lutris kenyoni*)	360 to 2,359	California Washington	T, D	Common, all year	Yes	Yes

a/ CV = Correlation of Variance from Carretta et al. 2007a, 2007b; Angliss and Outlaw 2008;
b/ ESA = Endangered Species Act. MMPA = Marine Mammal Protection Act. E = endangered. D = depleted. S = strategic stock under the MMPA. T = threatened.

4.1.1 Blue Whale (*Balaenoptera musculus*)

4.1.1.1 Regulatory Status

In the north Pacific, the International Whaling Commission (IWC) began management of commercial whaling for blue whales in 1969; blue whales were fully protected from commercial whaling in 1976 (Allen 1980). Blue whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna. The blue whale is listed as endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for blue whales. The Eastern North Pacific stock is considered a depleted and strategic stock under the MMPA. A final species recovery plan has been prepared (National Marine Fisheries Service 1998).

4.1.1.2 Habitat Preferences

Blue whales inhabit both coastal and oceanic waters in temperate and tropical areas (Yochem and Leatherwood 1985). Important foraging areas include the edges of continental shelves and upwelling regions (Reilly and Thayer 1990; Schoenherr 1991). Feeding grounds have been identified in coastal upwelling zones off the coast of California (Croll et al. 1998; Fiedler et al. 1998; Burtenshaw et al. 2004) and Baja California, Mexico (Reilly and Thayer 1990). Blue whales off the coast of southern California appear to feed exclusively on dense euphausiid schools between 328 to 656 ft (100 to 200 m) (Croll et al. 1998; Fiedler et al. 1998). These concentrations form downstream from upwelling centers in close proximity to regions of steep topographic relief off the continental shelf break (Croll et al. 1999). Migratory movements of the blue whale in California probably reflect seasonal patterns and productivity (Croll et al. 2005). Blue whales also feed in cool, offshore, upwelling-modified waters in the eastern tropical and equatorial Pacific (Reilly and Thayer 1990; Palacios 1999). Moore et al. (2002) determined that blue whale call locations in the western north Pacific were associated with relatively cold, productive waters and fronts.

4.1.1.3 Population Size and Trends

The blue whale population was severely depleted by commercial whaling in the twentieth century (NMFS 1998). In the north Pacific, pre-exploitation population size is speculated to be approximately 4,900 blue whales and the current population estimate is a minimum of 3,300 blue whales (Wade and Gerrodette 1993, NMFS 2006e). Blue whale population structure in the north Pacific remains uncertain, but two stocks are recognized within U.S. waters: the Hawaiian and the eastern north Pacific (NMFS 2006e). There is no clear information on the population trend of blue whales in the north Pacific. Population estimate for this stock of blue whales is about 1,744 (Carretta et al. 2007).

A clear population trend for blue whales is difficult to detect under current survey methods. An increasing trend between 1979/80 and 1991 and between 1991 and 1996 was suggested by available survey data, but it was not statistically significant (Carretta et al. 2006). The abundance of blue whales along the California coast has clearly been increasing during the past two decades (Calambokidis et al. 1990; Barlow 1994; Calambokidis 1995). The magnitude of this increase is considered too large to be explained by population growth alone, so a shift in distribution may have occurred (NMFS 1998). However, the scarcity of blue whales in areas of former abundance (e.g., Gulf of Alaska near the Aleutian Islands) suggests that the increasing trend does not apply to the species' entire range in the eastern north Pacific (Calambokidis et al. 1990). Although the population in the north Pacific is expected to have grown since being given protected status in 1966, the possibility of continued unauthorized takes by Soviet whaling vessels after blue whales were protected in 1966 (Yablokov 1994) and the existence of incidental ship strikes and gillnet mortality makes this uncertain.

4.1.1.4 Distribution

Blue whales are distributed from the ice edges to the tropics in both hemispheres (Jefferson et al. 1993). Blue whales as a species are thought to summer in high latitudes and move into the subtropics and tropics during the winter (Yochem and Leatherwood 1985). Data from both the Pacific and Indian Oceans, however, indicate that some individuals may remain year-round in low latitudes, such as over the Costa Rican Dome (Wade and Friedrichsen 1979; Reilly and Thayer 1990). The productivity of the Costa Rican Dome may allow blue whales to feed during their winter calving/breeding season and not fast, like humpback whales (Mate et al. 1999). A discovery tag shot into a blue whale by whalers off Vancouver Island in May 1963 was recovered a year later in June 1964 just south of Kodiak Island, supporting the idea that blue whales taken off British Columbia were en route to and from feeding areas in the Gulf of Alaska (COSEWIC 2002).

The range of the blue whale is known to encompass much of the north Pacific Ocean, from Kamchatka (Russia) to southern Japan in the west, and from the Gulf of Alaska south to at least Costa Rica in the east

(NMFS 1998b). Blue whale vocalizations have been detected in many portions of the north Pacific (e.g., McDonald et al. 1995; Watkins et al. 2000a; 2000b; Stafford et al. 2001; Stafford 2003), even those areas where sighting reports are rare (e.g., central north Pacific; Northrop et al. 1971; Thompson and Friedl 1982; McDonald and Fox 1999).

In the north Pacific, blue whales may be found as far north as the Gulf of Alaska, Aleutian Islands, Kuril Islands, and the Kamchatka Peninsula during the spring and summer months (Yochem and Leatherwood 1985) and as far south as approximately 702 nm (1,300 km) off the coast of Guatemala in the fall and winter months. Photographic identification effort has revealed extensive movements from the Gulf of California and the west side of Baja California in late winter and spring to California in summer and fall (Calambokidis et al. 1990). Off the coast of southern California, blue whales tend to be more common at the western end of the Santa Barbara Channel (Fiedler et al. 1998). Some blue whales are found year-round off the coast of California and Baja California (Reilly and Thayer 1990). One individual blue whale was photo-identified off the Queen Charlotte Islands in British Columbia and resighted off the Santa Barbara Channel in California, representing the first match between California and waters further north (COSEWIC 2002). A blue whale photographed south of Prince William Sound in the Gulf of Alaska and determined to be an individual that was identified five previous times in 1995 and 1998 off southern California (Calambokidis 2005).

Areas of primary occurrence (areas and habitats where a species is primarily found) for the blue whale in the PACNORWEST OPAREA and Puget Sound area is south of 44°N, from the shore to seaward of the OPAREA boundary. This takes into consideration both sighting and acoustic data, as well as the fact that blue whales are known to feed in the southern part of the PACNORWEST OPAREA. There is an area of secondary occurrence (areas and habitats where a species may be found, especially during anomalous environmental conditions [e.g., El Niño events] or seasonal migrations) between 44°N and 48°N. The dividing line of 44°N is based on the available sighting data. There is an additional area of primary occurrence north of 48°N based on whaling records off British Columbia. This area is presumably a known feeding area. The Puget Sound Study Area is an area of rare occurrence for the blue whale.

The coast of the PACNORWEST OPAREA is an area of primary occurrence for the blue whale. October is still a time of year during which blue whales are feeding. Less individuals are seen during the end of this season since the majority of the population migrates south at this time. Analyses of acoustic data collected by SOSUS hydrophones reveal that males are calling at this time of the year in this area (Stafford et al. 2001). The Puget Sound Study Area is an area of rare occurrence for the blue whale.

4.1.1.5 Diving Behavior

Blue whales spend more than 94 percent of their time below the water's surface (Lagerquist et al. 2000). Croll et al. (2001) determined that blue whales dived to an average of 462 ft and for 7.8 minutes (min) when foraging and to 222 ft and for 4.9 min when not foraging. Calambokidis et al. (2003) deployed tags on blue whales and collected data on dives as deep as about 984 ft (300 m).

4.1.1.6 Acoustics

Blue and fin whales produce calls with the lowest frequency and highest source levels of all cetaceans. Blue whale vocalizations are long, patterned low-frequency sounds with durations up to 36 seconds (Richardson et al. 1995) repeated every 1 to 2 min (Mellinger and Clark 2003). Their frequency range is 12 to 400 Hz, with dominant energy in the infrasonic range at 12 to 25 Hz (Ketten 1998; Mellinger and Clark 2003). Source levels are up to 188 dB re 1 µPa-m (Ketten 1998; McDonald et al. 2001). During the Magellan II Sea Test (at-sea operations designed to test systems for antisubmarine warfare), off the coast of California in 1994, blue whale vocalization source levels at 17 Hz were estimated in the range of 195 dB re 1 µPa-m (Aburto et al. 1997).

Vocalizations of blue whales appear to vary among geographic areas (Rivers 1997), with clear differences in call structure suggestive of separate populations for the western and eastern regions of the north Pacific (Stafford et al. 2001). Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

4.1.1.7 Impacts of Human Activity

4.1.1.7.1 Historic Whaling

Blue whales were occasionally hunted by the sailing-vessel whalers of the 19th century (Scammon 1874). The introduction of steam power in the second half of that century made it possible for boats to overtake large, fast-swimming blue whales and other rorquals. From the turn of the century until the mid-1960s, blue whales from various stocks were intensely hunted in all the world's oceans. Blue whales were protected in portions of the Southern Hemisphere beginning in 1939, but were not fully protected in the Antarctic until 1965. In 1955, they were given complete protection in the North Atlantic under the International Convention for the Regulation of Whaling; this protection was extended to the Antarctic in 1965 and the north Pacific in 1966 (Gambell 1979; Best 1993). The protected status of North Atlantic blue whales was not recognized by Iceland until 1960 (Sigurjonsson 1988). Only a few illegal kills of blue whales have been documented in the Northern Hemisphere, including three at Canadian east-coast whaling stations during 1966-69 (Mitchell 1974), some at shore stations in Spain during the late 1950s to early 1970s (Aguilar and Lens 1981; Sanpera and Aguilar 1992), and at least two by "pirate" whalers in the eastern North Atlantic in 1978 (Best 1992). Some illegal whaling by the Union of Soviet Socialist Republics also occurred in the north Pacific (Yablokov 1994); it is likely that blue whales were among the species taken by these operations, but the extent of the catches is not known. Since gaining complete legal protection from commercial whaling in 1966, some populations have shown signs of recovery, while others have not been adequately monitored to determine their status (NMFS 1998). Removal of this threat has allowed increased recruitment in the population, and therefore, the blue whale population in the eastern north Pacific is expected to have grown.

4.1.1.7.2 Fisheries Interactions

Because little evidence of entanglement in fishing gear exists, and large whales such as the blue whale may often die later and drift far enough not to strand on land after such incidents, it is difficult to estimate the numbers of blue whales killed and injured by gear entanglements. In addition, the injury or mortality of large whales due to interactions or entanglements in fisheries may go unobserved because large whales swim away with a portion of the net or gear. Fishermen have reported that large whales tend to swim through their nets without entangling and causing little damage to nets (Barlow et al. 1997).

4.1.1.7.3 Ship Strikes

Because little evidence of ship strikes exists, and large whales such as the blue whale may often die later and drift far enough not to strand on land after such incidents, it is difficult to estimate the numbers of blue whales killed and injured by ship strikes. In addition, a boat owner may be unaware of the strike when it happens. Ship strikes were implicated in the deaths of blue whales in 1980, 1986, 1987, 1993, and 2002 (Carretta et al. 2006). Additional mortality from ship strikes probably goes unreported because the whales do not strand, or if they do, they do not always have obvious signs of trauma (Carretta et al. 2006). However, several blue whales have been photographed in California with large gashes in their dorsum that appear to be from ship strikes (Carretta et al. 2006). According to the California Marine Mammal Stranding Network Database (2006), six blue whales were struck by vessels off of California from 1982-2005. The average number of blue whale mortalities in California attributed to ship strikes was 0.2 whales per year for 1998-2002 (Carretta et al. 2006). In addition, there were 9 unidentified whales and one unidentified balaenopterid struck by ships in California from 1982-2005 (California Marine Mammal

Stranding Network Database 2006). Of these 10 animals, 5 were reported by the Navy as being struck offshore of the Channel Islands (e.g., San Nicholas and San Clemente Islands).

4.1.2 Fin Whale (*Balaenoptera physalus*)

4.1.2.1 Regulatory Status

In the north Pacific, the IWC began management of commercial whaling for fin whales in 1969; fin whales were fully protected from commercial whaling in 1976 (Allen 1980). Fin whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna. Fin whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for the fin whale. A draft species recovery plan has been prepared (National Marine Fisheries Service 2006).

4.1.2.2 Habitat Preference

The fin whale is found in continental shelf, slope, and oceanic waters (Gregr and Trites 2001; Reeves et al. 2002). Globally, this species tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, although those locations may shift seasonally or annually (Payne et al. 1986; 1990; Kenney et al. 1997; Notarbartolo-di-Sciara et al. 2003). Fin whales in the north Pacific spend the summer feeding along the cold eastern boundary currents (Perry et al. 1999). Littaye et al. (2004) determined that fin whale distribution in the Mediterranean Sea was linked to frontal areas and upwelling within large zooplankton patches.

In the north Pacific, fin whales appear to prefer krill and large copepods, but also eat schooling fish such as Pacific herring *(Clupea harengus pallasi)*, walleye pollock *(Theragra chalcogramma)*, and capelin (*Mallotus villosus*) (Nemoto and Kawamura 1977). Single fin whales are most common, but they gather in groups, especially when good sources of prey are aggregated. Female fin whales in the north Pacific mature at 8 to 12 years of age (Boyd et al. 1999) and calve once every two to three years (Agler et al. 1993). Peak calving is in October through January (Hain et al. 1992).

4.1.2.3 Population Size and Trends

In the north Pacific, the total pre-exploitation population size of fin whales is estimated at 42,000 to 45,000 whales (Ohsumi and Wada 1974). The most recent abundance estimate (early 1970s) for fin whales in the entire north Pacific basin is between 14,620 and 18,630 whales (NMFS 2006e). Fin whales have a worldwide distribution, with two distinct stocks recognized in the north Pacific: the east China Sea Stock and “the rest of the North Pacific Stock” (Donovan 1991). Currently, there are considered to be three stocks in the north Pacific for management purposes: an Alaska Stock, a Hawaii Stock, and a California/Oregon/Washington Stock (Barlow et al. 1997). Currently, the best estimate for the California/Oregon/Washington Stock is 2,099 (CV = 0.18) individuals (Barlow and Forney 2007).

The population trend for this species is thought to be potentially increasing. They are broadly distributed throughout the world’s oceans, usually in temperate to polar latitudes and less commonly in the tropics (Reeves et al. 2002).

4.1.2.4 Distribution

The fin whale is found in continental shelf and oceanic waters (Gregr and Trites 2001; Reeves et al. 2002). Globally, it tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, although those locations may shift seasonally or annually (Payne et al. 1986, 1990; Kenney et al. 1997; Notarbartolo-di-Sciara et al. 2003).

The north Pacific population summers from the Chukchi Sea to California, and winters from California southward (Gambell 1985). Aggregations of fin whales are found year-round off southern and central California (Dohl et al. 1983; Forney et al. 1995; Barlow 1997). Observations in the mid to late 1990s show aggregations of fin whales year-round in southern/central California (Dohl et al. 1983; Barlow 1997; Forney et al. 1995), year-round in the Gulf of California (Tershy et al. 1993), in summer in Oregon (Green et al. 1992; McDonald 1994), and in summer/autumn in the Shelikof Strait/Gulf of Alaska (Brueggeman et al. 1990). Acoustic signals from fin whale are detected year-round off northern Washington, Oregon, and California, with a concentration of vocal activity between September and February (Moore et al. 1998). During the winter, fin whales are sparsely distributed from 60° N, south to the northern edge of the tropics, near which it is assumed that they mate and calve (Mizroch et al. 1999). However, some fin whales have been sighted as far north as 60°N all winter (Mizroch et al. 1999). Because fin whale abundance appears lower in winter/spring in California (Dohl et al. 1983; Forney et al. 1995) and in Oregon (Green et al. 1992), it is likely that the distribution of this stock extends seasonally outside these coastal waters.

In the OPAREA the area of primary occurrence for the fin whale is the entire OPAREA during both the upwelling and relaxed seasons. This is based on the distribution of sighting records, acoustic detections, and the high number of British Columbia whaling catch records to the north. Occurrence of fin whales is rare within the Puget Sound Study Area; fin whales are extremely rare here (Wade 2005). Prior to commercial whaling off British Columbia, fin whales were occasional visitors to the inland waters (Osborne et al. 1988). Of note, strandings reported within Puget Sound have all been individuals struck by vessels and presumably carried on the bow into the Sound (Norman et al. 2004).

4.1.2.5 Diving Behavior

Fin whales typically dive for 5 to 15 min, separated by sequences of four to five blows at 10- to 20-sec intervals (Cetacean and Turtle Assessment Program [CETAP] 1982; Stone et al. 1992; Lafortuna et al. 2003). Kopelman and Sadove (1995) found significant differences in blow intervals, dive times, and blows per hour between surface feeding and non-surface-feeding fin whales. Croll et al. (2001) determined that fin whales dived to 321 ft (98 m) (standard deviation [S.D.] = ± 107 ft [33 m]) with a duration of 6.3 min (SD = ± 1.53 min) when foraging and to 194 ft (59 m) (SD = ± 97 ft [30 m]) with a duration of 4.2 min (SD = ± 1.67 min) when not foraging. Goldbogen et al. (2006) reported that fin whales in California made foraging dives to a maximum of 748 to 889 ft (228 to 271 m) and dive durations of 6.2 to7.0 min. Fin whale dives to 492 ft (150 m), coinciding with the diel migration of krill, were reported by Panigada et al. (1999).

4.1.2.6 Acoustics

Fin and blue whales produce calls with the lowest frequency and highest source levels of all cetaceans. Infrasonic pattern sounds have been documented for fin whales (Watkins et al. 1987; Clark and Fristrup 1997; McDonald and Fox 1999). Fin whales produce a variety of sounds with a frequency range up to 750 Hz. The long-patterned 15- to 30-Hz vocal sequence is most typically recorded; only males are known to produce these (Croll et al. 2002). The most typical fin whale sound is a 20-Hz infrasonic pulse (actually an FM sweep from about 23 to 18 Hz) of about 1 sec duration and source levels of 184 to 186 dB re 1 µPa-m (maximum up to 200) (Richardson et al. 1995; Charif et al. 2002). Croll et al. (2002) suggested that these long, patterned vocalizations might function as male breeding displays, much like those that male humpback whales sing. The source depth, or depth of calling fin whales, has been reported to be about 164 ft (50 m) (Watkins et al. 1987). While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

4.1.2.7 Impacts of Human Activity

As early as the mid-17th century, the Japanese were capturing fin, blue, and other large whales using a fairly primitive open-water netting technique (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. The north Pacific and Antarctic whaling operations soon added this "modern" equipment to their arsenal. After blue whales were depleted in most areas, the smaller fin whale became the focus of whaling operations, and more than 700,000 fin whales were landed in the 20th century. The incidental take of fin whales in fisheries is extremely rare. In the California/Oregon drift gillnet fishery, observers recorded the entanglement and mortality of one fin whale, in 1999, off southern California (NMFS 2000). Based on a worst-case scenario, NMFS estimates that a maximum of six fin whales (based on calculations that adjusted the fin whale observed entangled and killed in 1999 by the number of sets per year) could be captured and killed in a given year by the California-Oregon drift gillnet fleet (NMFS 2000). Anecdotal observations from fishermen suggest that large whales swim through their nets rather than get caught in them (NMFS 2000). Because of their size and strength, fin whales probably swim through fishing nets, which might explain why these whales are rarely reported as having become entangled in fishing gear.

4.1.3 Humpback Whale (*Megaptera novaeangliae*)

4.1.3.1 Regulatory Status

The humpback whale is listed as endangered under the ESA. There is no designated critical habitat for this species in the North Pacific. The humpback whale is listed as vulnerable on the IUCN Red List of Threatened Animals based on the fact that, although most monitored stocks had shown evidence of fast recovery and may have increased to more than 50 percent of their levels three generations ago (1930s, assuming a 20-year generation time), they had not yet attained 80 percent of those levels (Baillie and Groombridge 1996). A final species recovery plan has been prepared (National Marine Fisheries Service 1991).

4.1.3.2 Habitat Preferences

Although humpback whales typically travel over deep, oceanic waters during migration, their feeding and breeding habitats are mostly in shallow, coastal waters over continental shelves (Clapham and Mead 1999). Shallow banks or ledges with high sea-floor relief characterize feeding grounds (Payne et al. 1990; Hamazaki 2002). The habitat requirements of wintering humpbacks appear to be determined by the conditions necessary for calving. Breeding grounds are in tropical or subtropical waters, generally with shelter created by islands or reefs. Optimal calving conditions are warm water (75° to 82°F [24° to 28°C]) and relatively shallow, low-relief ocean bottom in protected areas (behind reefs), apparently to take advantage of calm seas, to minimize the possibility of predation by sharks, or to avoid harassment by males (Smultea 1994; Clapham 2000; Craig and Herman 2000). Females with calves occur in significantly shallower waters than other groups of humpback whales, and breeding adults use deeper, more offshore waters (Smultea 1994; Ersts and Rosenbaum 2003).

4.1.3.3 Population Size and Trends

The population trend for this species is thought to be increasing. The most recent estimate of population size for the California/Washington Stock is 943 (Carretta et al. 2005). The most recent estimate of population size for the Eastern North Pacific Stock is 1,391 individuals (CV = 0.22; Carretta et al. 2007).

Humpback whales live in all major ocean basins from equatorial to sub-polar latitudes, migrating from tropical breeding areas to polar or sub-polar feeding areas (Jefferson et al. 1993, NMFS 2006e). Three Pacific stocks of humpback whales are recognized in the Pacific Ocean: the Western North Pacific stock, Central North Pacific stock, and Eastern North Pacific stock Calambokidis et al. 1997; Baker et al. 1998). In the entire north Pacific Ocean basin prior to 1905, it is estimated that there were 15,000 humpback whales (Rice 1978). In 1966, after heavy commercial exploitation, humpback abundance was estimated at 1,000 to 1,200 whales (Rice 1978), although it is unclear if estimates were for the entire north Pacific or just the eastern north Pacific. There are no reliable estimates for current humpback whale abundance in the entire north Pacific (NMFS 2006e).

4.1.3.4 Distribution

Humpback whales are globally distributed in all major oceans and most seas. They are generally found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep water during migration (Clapham and Mattila 1990; Calambokidis et al. 2001).

North Pacific humpback whales are distributed primarily in four more-or-less distinct wintering areas: the Ryukyu and Ogasawara (Bonin) Islands (south of Japan), the Hawaiian Islands, the Revillagigedo Islands off Mexico, and along the coast of mainland Mexico (Calambokidis et al. 2001). There is known to be some interchange of whales among different wintering grounds, and matches between Hawai'i and Japan and Hawai'i and Mexico have been found (Salden et al. 1999; Calambokidis et al. 2000b). However, it appears that the overlap is relatively small between the western north Pacific humpback whale population and central and eastern north Pacific populations (Darling and Mori 1993; Calambokidis et al. 2001).

There is also some trans-oceanic interchange between the north Pacific and south Pacific breeding populations (Medrano-González et al. 2001). Baker et al. (1993) hypothesized that the most likely route for such interbreeding of northern and southern humpback whales is the equatorial waters of the eastern Pacific Ocean (EPO). This apparently occurs through geographic overlap of some individuals from both ocean basins off the Central American coast (Acevedo and Smultea 1995). However, this is probably a relatively rare occurrence.

During summer months, north Pacific humpback whales feed in a nearly continuous band from southern California to the Aleutian Islands, Kamchatka Peninsula, and the Bering and Chukchi seas (Calambokidis et al. 2001). There is much interchange of whales among different feeding grounds, although some site fidelity is the rule. The U.S./Canada border is an approximate geographic boundary between the California and Alaska feeding groups (Carretta et al. 2006). Humpback whales off Washington, Oregon, and California form a discrete feeding aggregation. Their feeding ground ranges between 32°N and 48°N, and there is limited interchange with areas north of Washington (Calambokidis et al. 1996; 2004a). Individuals of the Eastern North Pacific stock migrate along the west coast of the continental U.S., between the Mexican breeding ground and feeding grounds in southern British Columbia, using a corridor along the coast of Baja California. Some humpback whales remain in some higher latitude feeding grounds through the breeding season, or perhaps individual variability in the timing of migrations results in the presence of some individuals in high latitude areas during all months of the year (Straley 1990).

The humpback whale has one of the longest migrations known for any mammal; individuals can travel nearly 4,320 nm (8,000 km) between feeding and breeding areas (Clapham and Mead 1999). Migratory transits between the Hawaiian Islands and southeastern Alaska have been documented to take as little as 36 to 39 days (Gabriele et al. 1996; Calambokidis et al. 2001).

Humpback whales feed in the PACNORWEST OPAREA during the non-breeding season. They are present in northern California between April and December and may be found off Oregon and Washington from May through November (Dohl et al. 1983; Green et al. 1992; Forney and Barlow 1998). Humpback whales were common in inland Washington waters in the early 1900s; however, there have only been a few sightings in this area since the whales were heavily hunted in the eastern north Pacific (Scheffer and Slipp 1948; Calambokidis and Steiger 1990; Pinnell and Sandilands 2004). Today, humpback whales occasionally occur in the Puget Sound Study Area but do not remain there for long periods (Everitt et al. 1980; Osborne and Ransom 1988). Calambokidis and Steiger (1990) recorded the movements of at least two humpback whales in southern Puget Sound in June and July 1988.

Humpback whales primarily feed along the shelf break and continental slope (Green et al. 1992; Tynan et al. 2005). Off Washington, they are known to concentrate between Juan de Fuca Canyon and the outer edge of the shelf break in a region called "the Prairie," near Barkley and Nitnat Canyons, and near

Swiftsure Bank (Calambokidis et al. 2004b). Humpback whales also tend to congregate near Heceta Bank off the coast of Oregon (Green et al. 1992). These locations represent important feeding areas for humpback whales in the OPAREA.

During the upwelling season the area of primary occurrence is a band along the outer coast from the shore to about the 9,842 ft (3,000 m) isobath. Primary occurrence branches off somewhat near the Strait of Juan de Fuca to account for feeding aggregations near this area. The area of secondary occurrence is an additional 100 nm (185 km) buffer that accounts for the possibility of encountering some individuals that might migrate further offshore from the main migratory corridor. There is a rare occurrence seaward of this secondary buffer. There is an area of secondary occurrence in the Strait of Juan de Fuca and in the central part of the Puget Sound Study Area (to around the San Juan and west side of the Whidbey islands) and near Nanaimo (west coast of the Strait of Georgia) based on historical whaling records. There is a rare occurrence in the southern part of Puget Sound, east of the Whidbey islands, and north of Nanaimo.

During the relaxed season, whale occurrence along the outer coast is similar to that of the upwelling season. Occurrence throughout the Puget Sound Study Area is expected to be rare. Humpback whales are expected to be in the OPAREA during the beginning of the relaxed season. Between January and March, most whales are further south on their breeding grounds and not in the OPAREA.

4.1.3.5 Diving Behavior

Humpback whale diving behavior depends on the time of year (Clapham and Mead 1999). In summer, most dives last less than 5 min; those exceeding 10 min are atypical. In winter (December through March), dives average 10 to 15 min; dives of greater than 30 min have been recorded (Clapham and Mead 1999). Although humpback whales have been recorded to dive as deep as about 1,638 ft (500 m) (Dietz et al. 2002), on the feeding grounds they spend the majority of their time in the upper 400 ft (120 m) of the water column (Dolphin 1987; Dietz et al. 2002). Humpback whales on the wintering grounds do dive deeply; Baird et al. (2000) recorded dives to 577 ft (176 m).

4.1.3.6 Acoustics

Humpback whales produce three classes of vocalizations: (1) “songs” in the late fall, winter, and spring by solitary males; (2) sounds made within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995). The best-known types of sounds produced by humpback whales are songs, which are thought to be breeding displays used only by adult males (Helweg et al. 1992). Singing is most common on breeding grounds during the winter and spring, but is occasionally heard outside breeding areas and out of season (Matilla et al. 1987; Clark and Clapham 2004). There is geographical variation in humpback whale song, with different populations singing different songs, and all members of a population using the same basic song. The song evolves over the course of a breeding season, but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). Recent information on the songs of humpback whales suggests that their hearing may extend to frequencies of at least 24 kilohertz (kHz) and source levels of 151-173 dB re 1 µPa (Au et al 2006).

Female vocalizations appear to be simple; Simão and Moreira (2005) noted little complexity. The male song, however, is complex and changes between seasons. Components of the song range from under 20 Hz to 4 kHz and occasionally 8 kHz, at source levels of 144 to 174 dB re 1 µPa-m, with a mean of 155 dB re 1 µPa-m. The main energy lies between 0.2 and 3.0 kHz, with frequency peaks at 4.7 kHz. Au et al. (2001) recorded high-frequency harmonics (out to 13.5 kHz) and source levels (between 171 and 189 dB re 1 µPa-m) of humpback whale songs. Songs have also been recorded on feeding grounds (Mattila et al. 1987; Clark and Clapham 2004).

Social calls are from 50 Hz to over 10 kHz, with the highest energy below 3 kHz (Silber 1986). Social calls are from 20 Hz to over 10 kHz, with the highest energy below 3 kHz (D'Vicente et al. 1985, Silber 1986, Simao and Moreira 2005).

Feeding calls, unlike song and social sounds, are highly stereotyped series of narrow-band trumpeting calls. They are 20 Hz to 2 kHz, less than 1 sec in duration, and have source levels of 175 to 192 dB re 1 μPa-m. The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al. 1985).

No tests of humpback whale hearing have been made. Houser et al. (2001) constructed a humpback audiogram using a mathematical model based on the internal structure of the ear. The predicted audiogram indicates sensitivity to frequencies from 700 Hz to 10 kHz, with maximum relative sensitivity between two and six kHz.

4.1.3.7 Impacts of Human Activity

4.1.3.7.1 Historic Whaling

Commercial whaling, the single most significant impact on humpback whales, ceased in the North Atlantic in 1955 and in all other oceans in 1966. The humpback whale was the whale most heavily exploited by Soviet whaling fleets after World War II.

4.1.3.7.2 Fisheries Interactions

Entanglement in fishing gear poses a threat to individual humpback whales throughout the Pacific. Entangled humpback whales found swimming, floating, or stranded with fishing gear attached, have been reported in the north Pacific. A number of fisheries based out of West Coast ports may incidentally take the Eastern North Pacific (ENP) stock of humpback whale, and documented interactions are summarized in the U.S. Pacific Marine Mammal Stock Assessments: 2006 (Carretta et al. 2007). The estimated impact of fisheries on the ENP humpback whale stock is probably underestimated; the serious injury or mortality of large whales from entanglement in gear may go unobserved because whales swim away with a portion of the net, line, buoys, or pots. According to Carretta et al. (2007) and the California Marine Mammal Stranding Network Database (U.S. Department of Commerce 2006), 12 humpback whales and two unidentified whales have been reported to be entangled in fishing gear (all crab pot gear, except for one of the unidentified whales) since 1997.

4.1.3.7.3 Ship Strikes

Humpback whales, especially calves and juveniles, are highly vulnerable to ship strikes and other interactions with non-fishing vessels. Younger whales spend more time at the surface, are less visible, and are found closer to shore (Herman et al. 1980; Mobley et al. 1999), thereby making them more susceptible to collisions. Humpback whale distribution overlaps substantially with the transit routes of large commercial vessels, including cruise vessels, large tug and barge transport vessels, and oil tankers.

Ship strikes were implicated in the deaths of at least two humpback whales in 1993, one in 1995, and one in 2000 (Carretta et al. 2006). During 1999-2003, an additional five injuries and two mortalities of unidentified whales were attributed to ship strikes. Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not have obvious signs of trauma. Several humpback whales have been photographed in California with large gashes in their dorsum that appear to be from ship strikes (Carretta et al. 2006). According to the California Marine Mammal Stranding Network Database (U.S. Department of Commerce 2006), one humpback whale was struck by a ship off of California between 1982 and 2005. The average number of humpback whale deaths from ship strikes between 1999 and 2003 is at least 0.2 per year (Carretta et al. 2006).

Whale-watching boats and scientific research vessels specifically direct their activities toward whales, and may have direct or indirect impacts on humpback whales. The growth of the whale-watching industry has not increased as rapidly for the ENP stock of humpback whales as it has for the Central North Pacific stock (wintering grounds in Hawaii and summering grounds in Alaska), but whale-watching activities do occur throughout the ENP stock's range. There is concern regarding the impacts of close vessel approaches to large whales because harassment may occur, preferred habitats may be abandoned, and fitness and survivability may be compromised if disturbance levels are too high. While a 1996 study in

Hawaii measured the acoustic noise of different whale-watching boats (Au and Green 2000) and determined that the sound levels were unlikely to produce grave effects on the humpback whale auditory system, the potential direct and indirect effects of harassment due to vessels cannot be discounted. Several investigators have suggested that shipping noise may have caused humpback whales to avoid or leave feeding or nursery areas (Jurasz and Jurasz 1979; Dean et al. 1985), while others have suggested that humpback whales may become habituated to vessel traffic and its associated noise. Still other researchers suggest that humpback whales may become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995).

4.1.3.7.4 Other Threats

Humpback whales are potentially affected by a resumption of commercial whaling, loss of habitat, loss of prey (for a variety of reasons including climate variability), underwater noise, and pollutants. Very little is known about the effects of organochlorine pesticides, heavy metals, polychlorinated biphenyls, and other toxins on baleen whales, although the impacts may be less than higher trophic level odontocetes due to baleen whales' lower levels of bioaccumulation from prey.

Anthropogenic noise may also affect humpback whales, because humpback whales seem to respond to moving sound sources, such as whale-watching, fishing, and recreational vessels and low-flying aircraft (Beach and Weinrich 1989; Clapham and Matilla 1993; Atkins and Swartz 1989). Their responses to noise are variable, and have been correlated with the size, composition, and behavior of the whales when the noises occurred (Herman et al. 1980; Watkins 1981; Krieger and Wing 1986).

4.1.4 Sei Whale (*Balaenoptera borealis*)

4.1.4.1 Regulatory Status

The sei whale was given complete protection from commercial whaling in the north Pacific in 1976. The sei whale is listed as endangered under the ESA. It is also classified as endangered by the IUCN (Baillie and Groombridge 1996), and is listed in CITES Appendix I. Critical habitat has not been designated for the Eastern North Pacific stock. A species recovery plan has not been prepared. The Eastern North Pacific stock is considered a "depleted" and "strategic" stock under the MMPA.

4.1.4.2 Population Size and Trends

The IWC groups all sei whales in the north Pacific Ocean into one stock (Donovan 1991). Mark-recapture, catch distribution, and morphological research, however, indicated that more than one stock exists; one between 175°W and 155°W longitude, and another to the east of 155°W longitude (Masaki 1976; Masaki 1977). In the U.S. Pacific Exclusive Economic Zone (EEZ), only the ENP Stock is recognized. Worldwide, sei whales were severely depleted by commercial whaling activities. In the north Pacific, the pre-exploitation population estimate for sei whales is 42,000 whales, and the most current population estimate for sei whales in the entire north Pacific (from 1977) is 9,110 (NMFS 2006e).

Application of various models to whaling catch and effort data suggests that the total population of adult sei whales in the north Pacific declined from about 42,000 to 8,600 between 1963 and 1974 (Tillman 1977). Since 500-600 sei whales per year were killed off Japan from 1910 to the late 1950s, the stock size presumably was already, by 1963, below its carrying capacity level (Tillman 1977). The current population estimate for sei whales in the entire north Pacific (from 1977) is 9,110 (NMFS 2006). The current estimate for sei whales in the Eastern North Pacific stock is 56 (CV = 0.61) individuals (Carretta et al. 2007).

4.1.4.3 Habitat Preferences

Sei whales are most often found in deep, oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges (Kenney and Winn 1987; Schilling et al. 1992; Gregr and Trites 2001; Best and

Lockyer 2002). These areas are often the location of persistent hydrographic features, which may be important factors in concentrating zooplankton, especially copepods. On the feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood 1987). In the north Pacific, sei whales are found feeding particularly along the cold eastern currents (Perry et al. 1999). Characteristics of preferred breeding grounds are unknown. In the north Pacific, sei whales particularly feed along the cold eastern currents (Perry et al. 1999). In the north Pacific, prey includes calanoid copepods, krill, fish, and squid (Nemoto and Kawamura 1977). The dominant food for sei whales off California during June through August is the northern anchovy (*Engraulis mordax*), while in September and October they eat mainly krill (Rice 1977).

4.1.4.4 Distribution

Sei whales have a worldwide distribution but are found primarily in cold temperate to subpolar latitudes, rather than in the tropics or near the poles (Horwood 1987). Sei whales are also known for occasional irruptive occurrences in areas followed by disappearances for sometimes decades (Horwood 1987; Schilling et al. 1992; Clapham et al. 1997; Gregr et al. 2005). Sei whales spend the summer months feeding in the subpolar higher latitudes and return to the lower latitudes to calve in the winter. There is some evidence from whaling catch data of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood 1987; Perry et al. 1999; Gregr et al. 2000). For the most part, the location of winter breeding areas remains a mystery (Rice 1998; Perry et al. 1999).

In the north Pacific, sei whales are thought to occur mainly south of the Aleutian Islands. They are present all across the temperate north Pacific north of 40°N (NMFS 1998a) and are seen at least as far south as 20°N (Horwood 1987). Whaling data suggest that the northern limit for this species is about 55°N (Gregr et al. 2000). In the east, they range as far south as Baja California, Mexico, and in the west, to at least Japan and Korea (NMFS 1998a).

In the PACNORWEST OPAREA and Puget Sound area sei whales are known for occasional irruptive occurrences in areas followed by disappearances for sometimes decades. There is a secondary occurrence in the PACNORWEST OPAREA to reflect the current situation with sei whales seldom being found here. Due to the many British Columbia whaling catches in the early to mid 1900s, sei whales have clearly utilized this area in the past (Pike and MacAskie 1969; Gregr et al. 2000). There is a rare occurrence in the Puget Sound Study Area since sei whales are not expected to occur there. A sei whale washed ashore west of Port Angeles during September 2003 (Preston 2003).

4.1.4.5 Acoustics

Sei whale vocalizations have been recorded on a few occasions. They consist of paired sequences (0.5 to 0.8 sec, separated by 0.4 to 1.0 sec) of 7 to 20 short (4 milliseconds [msec]) frequency-modulated sweeps between 1.5 and 3.5 kHz; source level is not known (Richardson et al. 1995). While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing. Sei whales in the Antarctic produced broadband "growls" and "whooshes" at a frequency of 433 + 192 kHz and source level of 156 + 3.6 dB re 1 µPa@ 1 m (McDonald et al. 2005).

4.1.4.6 Impact of Human Activity

4.1.4.6.1 Historic Whaling

Several hundred sei whales were taken each year between 1910 and the start of World War II in the north Pacific by whalers based at shore stations in Japan and Korea (Committee for Whaling Statistics 1942). From 1910 to 1975, approximately 74,215 sei whales were caught in the entire north Pacific Ocean (Perry et al. 1999). The species was taken less regularly and in much smaller numbers by pelagic whalers elsewhere in the north Pacific during this period (Committee for Whaling Statistics 1942). Small numbers were taken sporadically at shore stations in British Columbia from the early 1900s until the 1950s, when their importance began to increase (Pike and MacAskie 1969). More than 2,000 were killed in British Columbia waters between 1962 and 1967, when the last whaling station in western Canada closed (Pike and MacAskie 1969). Small numbers were taken by shore whalers in Washington (Scheffer and Slipp 1948) and California (Clapham et al. 1997) in the early twentieth century, and California shore whalers took 386 from 1957 to 1971 (Rice 1977). Heavy exploitation by pelagic whalers began in the early 1960s, with total catches throughout the north Pacific averaging 3,643 per year from 1963 to 1974 (total 43,719; annual range 1,280-6,053; Tillman 1977). The total reported kill of sei whales in the north Pacific by commercial whalers was 61,500 between 1947 and 1987 (Barlow et al. 1997).

A major area of discussion in recent years has been IWC member nations issuing permits to kill whales for scientific purposes. Since the moratorium on commercial whaling came into effect, Japan, Norway, and Iceland have issued scientific permits as part of their research programs. For the last five years, only Japan has issued permits to harvest sei whales, although Iceland asked for a proposal to be reviewed by the IWC SC in 2003. Japan has captured minke (*Balaenoptera acutorostrata*), Bryde's (*Balaenoptera edeni),* and sperm (*Physeter macrocephalus*) whales in the north Pacific (JARPN II). Japan extended the captures to include 50 sei whales from pelagic areas of the western north Pacific. Twelve sei whales were taken between 1988 and 1995 in the North Atlantic off Iceland and West Greenland, although the IWC set a catch limit of 0 for all stocks in 1985.

4.1.4.6.2 Fisheries Interactions

Sei whales, because of their offshore distribution and relative scarcity in U.S. Atlantic and Pacific waters, probably have a lower incidence of entrapment and entanglement than fin whales. Data on entanglement and entrapment in non-US. waters are not reported systematically. Heyning and Lewis (1990) made a crude estimate of about 73 rorquals killed/year in the southern California offshore drift gillnet fishery during the 1980's. Some of these may have been fin whales instead of sei whales. Some balaenopterids, particularly fin whales, may also be taken in the drift gillnet fisheries for sharks and swordfish along the Pacific coast of Baja California, Mexico (Barlow et al. 1997). Heyning and Lewis (1990) suggested that most whales killed by offshore fishing gear do not drift far enough to strand on beaches or to be detected floating in the nearshore corridor where most whale-watching and other types of boat traffic occur. Thus, the small amount of documentation may not mean that entanglement in fishing gear is an insignificant cause of mortality. Observer coverage in the Pacific offshore fisheries has been too low for any confident assessment of species-specific entanglement rates (Barlow et al. 1997). Sei whales, like other large whales, may break through or carry away fishing gear. Whales carrying gear may die later, become debilitated or seriously injured, or have normal functions impaired, but with no evidence recorded.

4.1.4.6.3 Ship Strikes

The decomposing carcass of a sei whale was found on the bow of a container ship in Boston harbor, suggesting that sei whales, like fin whales, are killed at least occasionally by ship strikes (Waring et al. 1997). Sei whales are observed from whale-watching vessels in eastern North America only occasionally (Edds et al. 1984) or in years when exceptional foraging conditions arise (Weinrich et al. 1986; Schilling et al. 1992). No comparable evidence is available for evaluating the possibility that sei whales experience significant disturbance from vessel traffic.

4.1.4.6.4 Other Threats

No major habitat concerns have been identified for sei whales in either the North Atlantic or the north Pacific. However, fishery-caused reductions in prey resources could have influenced sei whale abundance. The sei whale has a strong preference for copepods and euphausiids (i.e., low trophic level organisms), at least in the North Atlantic, so it may be less susceptible to the bioaccumulation of organochlorine and metal contaminants than, fin, humpback, and minke whales, all of which seem to feed more regularly on fish and euphausiids (O'Shea and Brownell 1995). Sei whales off California often feed on pelagic fish as well as invertebrates (Rice 1977), so they might accumulate contaminants to a greater degree than do sei whales in the North Atlantic. There is no evidence that levels of organochlorines, organotins, or heavy metals in baleen whales generally (including fin and sei whales) are high enough to cause toxic or other damaging effects (O'Shea and Brownell 1995). However, very little is known about the possible long-term and trans-generational effects of exposure to pollutants.

4.1.5 Sperm Whale (*Physeter macrocephalus*)

4.1.5.1 Regulatory Status

The sperm whale is listed as endangered under the ESA. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna. The sperm whale is listed as vulnerable on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for sperm whales. A draft species recovery plan has been prepared (National Marine Fisheries Service 2006). The Washington to California stock is considered as a "depleted" and "strategic" stock under the MMPA.

4.1.5.2 Habitat Preferences

Sperm whales show a strong preference for deep waters (Rice 1989), especially in areas with high sea floor relief. Globally, sperm whale distribution is associated with waters over the continental shelf break, over the continental slope, and into deeper waters (Hain et al. 1985). However, in some areas, such as off New England, on the southwestern and eastern Scotian Shelf, or the northern Gulf of California, adult males are reported to quite consistently use waters with bottom depths less than 328 ft (100 m) and as shallow as 131 ft (40 m) (Whitehead et al. 1992; Scott and Sadove 1997; Croll et al. 1999; Garrigue and Greaves 2001; Waring et al. 2002). Worldwide, females rarely enter the shallow waters over the continental shelf (Whitehead 2003).

Sperm whales have a highly diverse diet. Prey includes large mesopelagic squid and other cephalopods, fish, and occasionally benthic invertebrates (Fiscus and Rice 1974; Rice 1989; Clarke 1996).

Sperm whales forage during deep dives that routinely exceed 1,312 ft (400 m) and 30 min (Watkins et al. 2002). They are capable of diving to depths of over 6,562 ft (2,000 m) with durations of over 60 min (Watkins et al. 1993). Males spend little time at the surface (Jaquet et al. 2000), but, females spend one to five hours daily at the surface without foraging (Whitehead and Weilgart 1991; Amano and Yoshioka 2003).

4.1.5.3 Population Size and Trends

Current estimates of population abundance, status, and trends for the Alaska stock of sperm whales are not available (Hill and DeMaster 1999). Approximately 258,000 sperm whales in the north Pacific were harvested by commercial whalers between 1947 and 1987 (Hill and DeMaster 1999). However, this number may be negatively biased by as much as 60 percent because of under-reporting by Soviet whalers (Brownell et al. 1998). In particular, the Bering Sea population of sperm whales (consisting mostly of males) was severely depleted (Perry et al. 1999). Catches in the north Pacific continued to climb until 1968, when 16,357 sperm whales were harvested. Catches declined after 1968, in part through limits imposed by the IWC (Rice 1989). Reliable estimates of current and historical sperm whale abundance across each ocean basin are not available (NMFS 2006e).

Five stocks of sperm whales are recognized in U.S. waters: the north Atlantic, the northern Gulf of Mexico, the Hawaiian, the California /Oregon /Washington, and the North Pacific stocks (NMFS 2006e). Sperm whales are widely distributed across the north Pacific Ocean and into the southern Bering Sea in summer, but the majority are thought to occur south of 40°N latitude in winter. Estimates of pre-whaling abundance in the north Pacific are considered somewhat unreliable, but sperm whales may have totaled 1,260,000 individuals. Whaling harvests between 1800 and the 1980s took at least 436,000 sperm whales from the north Pacific Ocean (NMFS 2006e).

The available data suggest that sperm whale abundance has been relatively stable in California waters since 1979 (Barlow 1994), but there is uncertainty about both the population size and the annual mortality rates. The California/Oregon/Washington stock population is estimated to be 1,233 individuals (CV = 0.41) (Carretta et al. 2007). Sperm whale abundance in the eastern temperate north Pacific Ocean is estimated to be 32,100 and 26,300 individuals by acoustic and visual detection methods, respectively (Barlow and Taylor 2005).

The NOAA stock assessment report divides sperm whales within the U.S. Pacific EEZ into three discrete, noncontiguous areas: (1) water around the Hawaiian Islands, (2) Washington, Oregon, and California waters, and (3) Alaskan waters (Carretta et al. 2007). Preliminary genetic analyses reveal significant differences between sperm whales off the coast of Washington, Oregon, and California and those sampled offshore to the Hawaiian Islands (Mesnick et al. 1999; Carretta et al. 2007).

4.1.5.4 Distribution

Male sperm whales are found from tropical to polar waters in all oceans of the world, between approximately 70°N and 70°S (Rice 1998). The female distribution is more limited and corresponds approximately to the 40° parallels but extends to 50° in the north Pacific (Whitehead 2003). Based on known habitat preferences, the primary area of occurrence for the sperm whale is seaward of the 3,281-ft (1,000-m)-isobath in the PACNORWEST OPAREA. There is an area of secondary occurrence between the 656 ft (200 m) and 3,281-ft (1,000-m)-isobaths, which accounts for the possibility of sightings in more shallow waters. Sperm whale occurrence in waters between the shore and the 656-ft (200-m)-isobath is expected to be rare since this species prefers deep waters. Sperm whales would have a rare occurrence within the Puget Sound area.

4.1.5.5 Diving Behavior

Sperm whales forage during deep dives that routinely exceed a depth of 1,312 ft (400 m) and 30 min duration (Watkins et al. 2002). Sperm whales can diving to depths of over 6,562 ft (2,000 m) with durations of over 60 min (Watkins et al. 1993). Sperm whales spend up to 83 percent of daylight hours underwater (Jaquet et al. 2000; Amano and Yoshioka 2003). Males do not spend extensive periods at the surface (Jaquet et al. 2000). In contrast, females spend prolonged periods at the surface (1 to 5 hours daily) without foraging (Whitehead and Weilgart 1991; Amano and Yoshioka 2003). The average swimming speed is estimated to be 2.3 ft/sec (0.7 m/sec) (Watkins et al. 2002). Dive descents averaged 11 min at a rate of 5.0 ft/sec (1.52 m/sec), and ascents averaged 11.8 min at a rate of 4.6 ft/sec (1.4 m/sec) (Watkins et al. 2002).

4.1.5.6 Acoustics

Sperm whales produce short-duration (generally less than 3 sec), broadband clicks. These clicks range in frequency from 100 Hz to 30 kHz, with dominant energy in two bands (2 to 4 kHz and 10 to 16 kHz). Most of the acoustic energy is present at frequencies below 4 kHz, although diffuse energy up to past 20 kHz has been reported (Thode et al. 2002). The source levels can be up to 236 dB re 1 µPa-m (Møhl et al. 2003). Thode et al. (2002) suggested that the acoustic directivity (angular beam pattern) from sperm whales must range between 10 and 30 dB in the 5- to 20-kHz region. The clicks of neonate sperm whales are very different from the usual clicks of adults, in that they are of low directionality, long duration, and low frequency (centroid frequency between 300 and 1,700 Hz) with estimated source levels between 140 and 162 dB re 1 µPa-m (Madsen et al. 2003). Clicks are heard most frequently when sperm whales are engaged in diving and foraging behavior (Whitehead and Weilgart 1991; Miller et al. 2004; Zimmer et al. 2005). These may be echolocation clicks used in feeding, contact calls (for communication), and orientation during dives. When sperm whales socialize, they tend to repeat series of clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals of a social unit, and are considered to be primarily for intragroup communication (Weilgart and Whitehead 1997; Rendell and Whitehead 2004).

The anatomy of the sperm whale's ear indicates that it hears high-frequency sounds (Ketten 1992). Anatomical studies also suggest that the sperm whale has some ultrasonic hearing, but at a lower maximum frequency than many other odontocetes (Ketten 1992). The sperm whale may also possess better low-frequency hearing than some other odontocetes, although not as extraordinarily low as many baleen whales (Ketten 1992). Auditory brainstem response in a neonatal sperm whale indicated highest sensitivity to frequencies between 5 and 20 kHz (Ridgway and Carder 2001).

4.1.5.7 Impacts of Human Activity

In U.S. waters in the Pacific, sperm whales have been incidentally taken only in drift gillnet operations, which killed or seriously injured an average of nine sperm whales per year from 1991-1995 (Barlow et al. 1997). Of the eight sperm whales taken by the California/Oregon drift gillnet fishery, three were released alive and uninjured (37.5 percent), one was released injured (12.5 percent), and four (50 percent) were killed (NMFS 2000). Therefore, approximately 63 percent of captured sperm whales could be killed accidentally or injured, based on the mortality and injury rate of sperm whales observed taken by the U.S. fleet from 1990-2000. Based on past fishery performance, sperm whales are not taken in every year; they were observed to be taken in four out of the last 10 years (NMFS 2000). During the three years the Pacific Coast Take Reduction Plan has been in place, a sperm whale was taken only once, in a set that did not comply with the Take Reduction Plan (NMFS 2000).

Interactions between longline fisheries and sperm whales in the Gulf of Alaska have been reported over the past decade (Rice 1989, Hill and DeMaster 1999). Observers aboard Alaskan sablefish and halibut longline vessels have documented sperm whales feeding on longline-caught fish in the Gulf of Alaska (Hill and Mitchell 1998) and in the South Atlantic (Ashford and Martin 1996). During 1997, the first entanglement of a sperm whale in Alaska's longline fishery was recorded, although the animal was not seriously injured (Hill and DeMaster 1999). The available evidence does not indicate sperm whales are being killed or seriously injured as a result of these interactions, although the nature and extent of interactions between sperm whales and long-line gear is not yet clear. Ashford and Martin (1996) suggested that sperm whales pluck, rather than bite, the fish from the long-line.

In 2000, the Japanese Whaling Association announced that it planned to kill ten sperm whales and 50 Bryde's whales in the Pacific Ocean for research purposes, which would be the first time sperm whales would be taken since the international ban on commercial whaling took effect in 1987. Despite protests from the U.S. government and members of the IWC, the Japanese government harvested five sperm whales and 43 Bryde's whales in the last six months of 2000. According to the Japanese Institute of Cetacean Research (Institute of Cetacean Research undated), another five sperm whales were killed for research in 2002 – 2003. The consequences of these deaths on the status and trend of sperm whales remains uncertain; however, the renewal of a program that intentional targets and kills sperm whales before we can be certain the population has recovered from earlier harvests places this species at risk in the foreseeable future.

4.1.6 Southern Resident Killer Whale (*Orcinus orca*)

4.1.6.1 Regulatory Status

The southern resident killer whale is listed as endangered under the ESA. This stock is considered a depleted stock under the MMPA. Three pods comprise this stock and are designated as J, K, and L. There is designated critical habitat in the Puget Sound and Strait of Juan de Fuca areas of Washington (NMFS 2006). Southern resident killer whales spend a significant portion of the year in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound, particularly during the spring, summer, and fall. Southern resident killer whales occur in coastal waters of Washington, Oregon, and Vancouver Island and are known to travel as far south as central California. A final species recovery plan has been prepared (National Marine Fisheries Service 2008).

4.1.6.2 Critical Habitat

Critical habitat for the southern resident killer whale was designated in November 2006 (NMFS 2006). The critical habitat area designation encompasses parts of Haro Strait and the waters around the San Juan Islands, the Strait of Juan de Fuca and all of Puget Sound, a total of just over 2,500 mi^2 (6,475 km^2). Critical habitat designation excluded 18 military sites covering nearly 112 mi^2 (290 km^2) of habitat, including the Naval Air Station Whidbey Island, Admiralty Inlet naval restricted area, and the Crescent Harbor Explosive Ordnance Units Testing Area. Federal agencies are required to consult with NMFS to ensure their actions will not destroy or adversely modify the killer whales' designated critical habitat. Critical habitat boundaries are presented in Figure 4-1.

4.1.6.3 Habitat Preferences

Killer whales have been observed in virtually every marine habitat from the tropics to the poles and from shallow, inshore waters (and even rivers) to deep, oceanic regions (Dahlheim and Heyning 1999). In the eastern north Pacific, killer whales range from protected inshore waters to waters off the outer coast (Wiles 2004). Killer whales in the eastern north Pacific occasionally enter the lower reaches of rivers in Washington and Oregon while feeding (Wiles 2004). In October 1931, a killer whale made its way up the Columbia River and was killed in the Oregon Slough, a branch of Portland Harbor, more than 94 nm (175 km) inland from the Pacific Ocean (Shepherd 1932).

Southern resident killer whales feed heavily in areas characterized by high-relief underwater topography, such as subsurface canyons seamounts, ridges, and steep slopes (Heimlich-Boran 1988; Felleman et al. 1991). Salmon are the principle prey for the southern resident killer whales during spring, summer, and fall (Heimlich-Boran 1986; Felleman et al. 1991; Ford et al. 1998; Baird and Hanson 2004; Ford and Ellis 2005; Hanson et al. 2005). Chinook salmon (the area's largest salmonid) are the most commonly targeted species. Other salmonids appear to be eaten less frequently, as are rockfish (*Sebastes* spp.), Pacific halibut (*Hippoglossus stenolepis*), lingcod (*Opiodon elongatus*), and Pacific herring.

4.1.6.4 Population Size and Trends

The abundance estimate for this stock of killer whales is a direct count of individually identifiable animals. It is thought that the entire population is censused every year. This estimate therefore serves as both a best estimate of abundance and a minimum estimate of abundance. Thus, the minimum population estimate for the Eastern North Pacific southern resident stock of killer whales is 89 animals (Carretta et al. 2007).

During the live-capture fishery that existed from 1967 to 1973, it is estimated that 47 killer whales, mostly immature, were taken out of this stock (Ford et al. 1994). The first complete census of this stock occurred in 1974. Between 1974 and 1993 the southern resident killer whale stock increased approximately 35 percent, from 71 to 96 individuals (Ford et al. 1994). This represents a net annual growth rate of 1.8 percent during those years. Since 1995, the population declined to 79 whales before increasing from 2002-2006 to a total of 89 whales (Carretta et al. 2007).

4.1.6.5 Diving Behavior

The maximum depth recorded for free-ranging killer whales diving off British Columbia is 866 ft (264 m) (Baird et al. 2005a). On average, however, for seven tagged individuals, less than 1 percent of all dives examined were to depths greater than 98 ft (30 m) (Baird et al. 2003b). A trained killer whale dove to a maximum of 853 ft (260 m) (Dahlheim and Heyning 1999). The longest duration of a recorded dive from a radio-tagged killer whale was 17 min (Dahlheim and Heyning 1999).

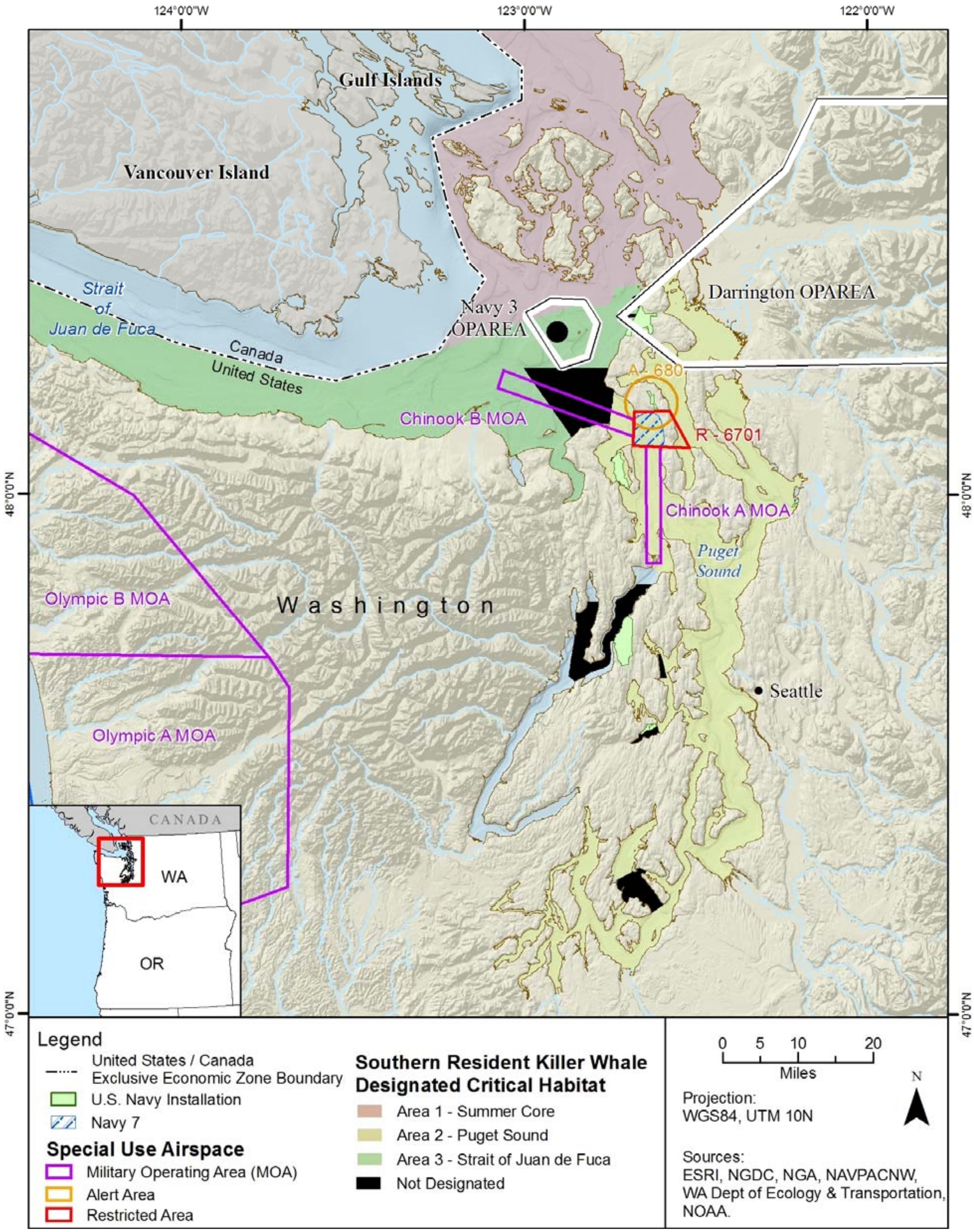


Figure 4-1. Critical Habitat for Southern Resident Killer Whales

4.1.6.6 Distribution

The southern resident killer whale population is a transboundary population that resides for part of the year in the protected inshore waters of the Strait of Georgia and Puget Sound (especially in the vicinity of Haro Strait, west of San Juan Island, and off the southern tip of Vancouver Island) principally during the late spring, summer, and fall (Ford et al. 1994; Krahn et al. 2004). The southern resident population consists of three pods, identified as J (24 animals), K (22 animals), and L (44 animals) pods. Pods have visited coastal sites off Washington and Vancouver Island (Ford et al. 1994) and are known to travel as far south as central California and as far north as the Queen Charlotte Islands. During September and October, they can often be found off the mouth of the Fraser River in the Strait of Georgia, intercepting salmon before they enter the river. Little is known of where the killer whales go when they leave Puget Sound, particularly from November to May, although there are occasional sightings within this area during November through March. The overall range of the killer whale in winter is unknown. During the winter, the J pod is commonly seen in inshore waters, while the K and L pods apparently spend more time in offshore waters. In late Jan 2000, whales from K and L pods were sighted in Monterey Bay; this was the first sighting of residents in waters south of Washington. Members of L pod were sighted in Monterey Bay during March 2007 and January 2008. Members of the K pod were also observed in Monterey Bay in March 2007.

The area of primary occurrence for the southern residence killer whale is north of 47° and inshore of the shelf break, including all of Puget Sound. The area of secondary occurrence north of 47° is between the shelf break and the 3,281-ft (1,000-m) isobath, while south of 47° it is waters shallower than the 3,281-ft (1,000-m) isobath. There is a rare occurrence in waters seaward of the 3,281-ft (1,000-m) isobath. K pod migrates into Washington inland waters as early as March, and L pod joins in June. During summer (the peak feeding time), the pods tend to make a circuit between the mouth of the Fraser River and the Strait of Juan de Fuca, traveling up to 100 mi (161 km) a day and swimming through the San Juan Islands to feed on migrating salmon. The killer whale is common throughout the summer and congregate at particular coastal locations at this time of year in association with high densities of migrating salmon (Heimlich-Boran 1986; Nichol and Shackleton 1996; Olson 1998; NMFS 2005i).

In the PACNORWEST OPAREA and Puget Sound area, southern resident killer whales are most often seen during May through October when they are found in inland waters around the San Juan Islands, including Haro Strait, Boundary Passage, and the eastern portion of the Strait of Juan de Fuca (Heimlich-Boran 1988; Ford et al. 1994; Olson 1998; Wiles 2004). Little is known about the movements and distribution of the killer whales in the winter months. In Washington inland waters, L pod typically departs around October and K pod in October or November, while J pod stays here, ranging as far south in Puget Sound as Olympia. Noteworthy is that in late October 1997, 19 southern resident killer whales spent 30 days in Dyes Inlet near Bremerton, Washington, likely having followed a chum salmon run to Chico Creek.

4.1.6.7 Acoustics

Killer whales produce a wide-variety of clicks and whistles, but most social sounds are pulsed, with frequencies ranging from 0.5 to 25 kHz (dominant frequency range: 1 to 6 kHz) (Thomson and Richardson 1995). Echolocation clicks indicate source levels ranging from 195 to 224 dB re 1 µPa-m peak-to-peak, dominant frequencies ranging from 20 to 60 kHz, and durations of about 0.1 sec (Au et al. 2004). Source levels associated with social sounds have been calculated to range from 131 to 168 dB re 1 µPa-m and vary with vocalization type (Veirs 2004).

Resident killer whales are very vocal, making calls during all types of behavioral states. Acoustic studies of resident killer whales in the Pacific Northwest have found that there are dialects in their highly stereotyped, repetitive discrete calls, which are group-specific and shared by all group members (Ford 1991, 2002b). These dialects likely are used to maintain group identity and cohesion, and may serve as indicators of relatedness that help prevent inbreeding between closely related whales (Ford 1991, 2002b).

Dialects have been documented in northern Norway (Ford 2002a) and southern Alaska killer whales populations (Yurk et al. 2002) and likely occur in other regions.

Both behavioral and auditory brainstem response techniques indicate killer whales can hear a frequency range of 1 to 100 kHz and are most sensitive at 20 kHz, which is one of the lowest maximum-sensitivity frequencies known among toothed whales (Szymanski et al. 1999).

4.1.6.8 Impacts of Human Activity

4.1.6.8.1 Harvests

Commercial or recreational harvests of this species is not conducted at this time. In general, there is little information available regarding the historical abundance of southern resident killer whales. Some evidence suggests that, until the mid- to late-1800s, the southern resident killer whale population may have numbered more than 200 animals (Krahn et al. 2002). In 1967 the population was estimated to be 96 animals. Between 1967 and 1973, 47 animals were trapped and removed for public displays. This removal caused an immediate decline in population numbers. The population recovered to a maximum of 99 animals in 1995 (22 years after live-capture of the whales ended).

4.1.6.8.2 Contaminants, Vessel Traffic, and Prey Availability

Three main human-caused factors that may continue affect the southern resident killer whale population, include environmental contaminants, vessel traffic, and reductions in prey availability.

Exposure to contaminants may result in harm to the species. The presence of high levels of persistent organic pollutants such as PCBs and DDT, have been documented in southern resident killer whales (Ross et al. 2000; Ylitalo et al. 2001; and Herman et al. 2005). These and other chemical compounds have the ability to induce immune suppression, impair reproduction, and produce other adverse physiological effects, as observed in studies of other marine mammals. Although contaminants enter marine waters and sediments from numerous sources, these chemical compounds enter killer whales through their prey. Because of their long life span, position at the top of the food chain, and their blubber stores, killer whales are capable of accumulating high concentrations of contaminants that may be associated with reproductive failure or mortality.

Commercial shipping, whale watching, ferry operations, and recreational boat traffic have increased in recent decades. Several studies have linked vessels with short-term behavioral changes in northern and southern resident killer whales (Kruse 1991; Williams et al. 2002a; 2002b; Foote et al. 2004). Although the potential impacts from vessels and the sounds they generate are poorly understood, these activities may affect foraging efficiency, communication, and/or energy expenditure through their physical presence, increased underwater sound level, or both. Collisions with vessels are another potential source of serious injury and mortality and have been recorded for both southern and northern resident killer whales.

Human competition for Chinook and other salmon species foraged upon by the southern resident killer whale could affect whale welfare and population productivity by inducing nutritional stress. Salmon species declines are being compounded by past and ongoing effects of other activities including salmon habitat loss and degradation from development (e.g., agriculture, timber harvest, dam construction, and urban construction), harvest practices, and past hatchery operations. Some historically productive salmon populations are no longer large.

4.1.7 Steller Sea Lion (*Eumetopias jubatus*)

4.1.7.1 Regulatory Status

The Steller sea lion was originally listed as threatened under the ESA in 1990. In 1997 the NMFS reclassified the Steller sea lion into two distinct populations, based on genetics and population trends (Loughlin 1997; Angliss and Outlaw 2005). The Western U.S. stock was designated as endangered and includes animals at and west of Cape Suckling, Alaska (144°W) (NMFS 1997c). The Eastern U.S. stock remained designated as threatened and includes animals east of Cape Suckling (NMFS 1997c; Loughlin 2002; Angliss and Outlaw 2005) that extend into southeastern Alaska, Canada, and the NWTRC Study Area. Rookeries of the Eastern stock occur along the coasts of Oregon and California (NMFS 2008c). There is a final revised species recovery plan that addresses both the Eastern and Western stocks (NMFS 2008c). The Steller sea lion is listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996).

4.1.7.2 Critical Habitat

Critical habitat has been designated for the Steller sea lion (NMFS 1993). Critical habitat includes so called "aquatic zones" that extend 3,000 ft (0.9 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery in Oregon and California (NMFS 2008c). Three major rookery sites in Oregon (Rogue Reef, Pyramid Roc; Long Brown Rock; and Seal Rock) and three rookery sites in California (Ano Nuevo I; Southeast Farallon I; and Sugarloaf Island and Cape Mendocino) are designated critical habitat (NMFS 1993). Critical habitat locations in Oregon and California are shown in Figure 4-2.

4.1.7.3 Habitat Preferences

Foraging habitat is primarily shallow, nearshore and continental shelf waters, and some Steller sea lions feed in freshwater rivers (Reeves et al. 1992; Robson 2002). They also are known to feed in deep waters past the continental shelf break. Haulout and rookery sites are located on isolated islands, rocky shorelines, and jetties. Steller sea lions also haul out on buoys, rafts, floats, and Navy submarines in the Puget Sound (Jeffries et al. 2000; DoN 2001b).

Steller sea lions are opportunistic predators, feeding primarily on fish and cephalopods, and their diet varies geographically and seasonally (Merrick et al. 1997). They feed near land or in relatively shallow water (Pitcher and Calkins 1981).

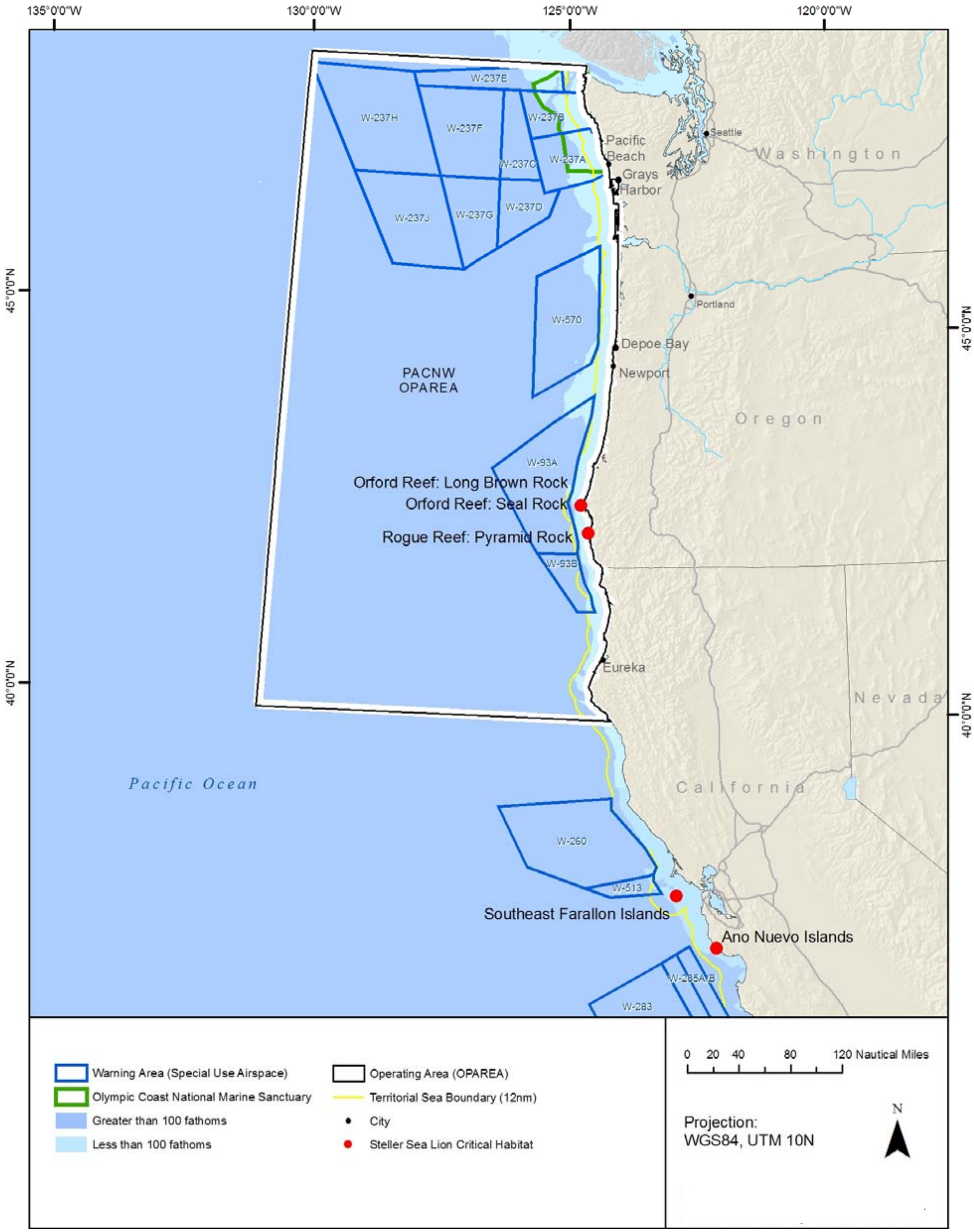
In the Pacific Northwest, breeding rookeries are located in British Columbia, Oregon, and northern California. There are no rookeries in Washington (NMFS 1992; Angliss and Outlaw 2005). Steller sea lions form large rookeries during late spring when adult males arrive and establish territories (Pitcher and Calkins 1981).

4.1.7.4 Population Size and Trends

The eastern stock of Steller sea lions breeds on rookeries located in southeast Alaska, British Columbia, Oregon, and California. There are no rookeries in Washington. Using 2002 to 2005 pup counts at rookeries available by region from aerial surveys across the range of the eastern stock, the total population of the eastern stock of Steller sea lions is estimated to be between 48,500 to 55,000 animals (Angliss and Outlaw, 2008). Trend counts (an index to examine population trends) for Steller sea lions in Oregon and northern California have shown a gradual increase from 1982 to 2002, with counts in the range of 3,100 to 4,900 sea lions (Angliss and Outlaw 2008). There was no estimate for Washington. The Eastern stock is increasing at an annual rate of about 3 percent (NMFS 2008c).

4.1.7.5 Distribution

The range of the Steller sea lion extends throughout most of the north Pacific from southern California through the Aleutian and Pribilof Islands to the Kuril Islands and Okhotsk Sea (Kenyon and Rice 1961). Major haulout sites and rookeries are centered in the Aleutian Islands and at islands and mainland sites in the Gulf of Alaska (Loughlin et al. 1984). In the Pacific Northwest, rookeries are located in British Columbia, Oregon, and northern California; there are no rookeries in Washington (NMFS 1992; Angliss and Outlaw 2008). A rookery is a location that pinnipeds go to breed and give birth to pups. A haulout site is a intertidal rock outcrop, sandbar, shoal, mudflats, sandy beach or other similar terrestrial location where pinnipeds periodically come ashore to rest or loaf.



Source: Source: NOAA NMFS Final Revised Steller Sea Lion Recovery Plan 2008 at (http://www.fakr.noaa.gov/protectedresources/stellers/recovery/sslrpdraft0507.pdf)

Figure 4-2. Critical Habitat for Eastern Stock of Steller Sea Lion

In the Pacific Northwest region, Steller sea lions mostly occur in shallow waters (less than 656 ft [200 m]) but have been sighted in water depths as great as 7,382 ft (2,250 m) off the coast of California (Bonnell et al. 1983). During the summer, Steller sea lions are common in cold, upwelled waters off southern Oregon; they tend to remain near rookeries (less than 19 mi [30 km]), Heceta and Stonewall Banks, and the mouth of the Umpqua River (Bonnell et al. 1992). Steller sea lions are widely-distributed throughout Washington inland waters; they are frequently observed over deep water in the Strait of Georgia (Keple 2002).

In the PACNORWEST OPAREA and Puget Sound area the Steller sea lion regularly occurs in the area year-round. Peak abundance occurs on land during the spring breeding season and at sea during the fall (Bonnell et al. 1992). Steller sea lion haulout sites and rookeries range widely throughout the OPAREA. In Washington, Steller sea lions primarily haul out along the coast from the Columbia River to Cape Flattery and on the southern coast of Vancouver Island near the Strait of Juan de Fuca (Jeffries et al. 2000). Primary rookery sites in Oregon are located along the southern coast at Orford and Rogue Reefs, while main haulout sites are also in Sea Lion Caves, Three Arch Rocks, Ecola Point, and the Columbia River jetty (Bonnell et al. 1992; Brown 1997). St. George Reef is the primary haulout and rookery site in the northern California part of the OPAREA (Loughlin et al. 1992).

The area of primary occurrence extends from the shore to the 1,640-ft (500-m) isobath along the outer coast of the OPAREA. Secondary occurrence is a band between the 1,640-ft (500-m) and 3,281-ft (1,000-m) isobaths. Steller sea lions are rare seaward of this secondary occurrence band. An area of primary occurrence extends into the Strait of Juan de Fuca, around San Juan and Whidbey islands, and through the Strait of Georgia. The southern part of the Puget Sound Study Area is an area of secondary occurrence.

4.1.7.6 Diving Behavior

Diving and foraging activity varies by sex, age, and season. During the breeding season, females with pups feed mostly at night, while territorial males eat little or no food (Loughlin 2002). In the winter, females make long trips of around 81 mi (130 km) and dive deeply to locate prey (Merrick and Loughlin 1997; Loughlin 2002). In the summer, trip length is about 11 mi (18 km) and dives are shallower (Loughlin 2002). Females usually go to sea to feed and return to nurse their pups in 24- to 48-hour cycles (NRC 2003). Steller sea lions tend to make shallow dives of less than 820 ft (250 m). Adult females are known to dive 329 to 820 ft (100 to 250 m) in summer, but maximum depth in the winter may be greater than 820 ft (250 m) (Loughlin 2002). Young Steller sea lions make shallow (230 to 459 ft [70 to 140 m]) and short dives (one to two minutes) and do not travel as far as adults due to developmental constraints (Merrick and Loughlin 1997; Rehberg et al. 2001).

4.1.7.7 Acoustics

On land, territorial male Steller sea lions usually produce low frequency roars (Schusterman et al. 1970; Loughlin et al. 1987). The calls of females range from 30 to 3,000 Hz, with peak frequencies from 150 to 1,000 Hz; typical duration is 1.0 to 1.5 sec (Campbell et al. 2002). Pups produce bleating sounds. Underwater sounds are similar to those produced on land (Loughlin et al. 1987).

When the underwater hearing sensitivity of two Steller sea lions was tested, the hearing threshold of the male was significantly different from than that of the female. The range of best hearing for the male was from 1 to 16 kHz, with maximum sensitivity (77 dB re 1 µPa-m) at 1 kHz. The range of best hearing for the female was from 16 to above 25 kHz, with maximum sensitivity (73 dB re 1 µPa-m) at 25 kHz. However, because of the small number of animals tested, the findings could not be attributed to individual differences in sensitivity or sexual dimorphism (Kastelein et al. 2005).

4.1.7.8 Impacts of Human Activity

4.1.7.8.1 Hunting

Historically, the Eastern stock was subjected to substantial mortality by humans, primarily due to commercial exploitation and both sanctioned and unsanctioned predator control (NMFS 2008c). Commercial exploitation occurred primarily in the 1800s and early 1900s while unsanctioned predator control probably persisted into the 1970s in some locations. Although not well documented, there is little doubt that numbers of Steller sea lions were greatly reduced in many locations by these activities (NMFS 2008c). Commercial hunting and predator control activities have been discontinued and no longer affect this stock. In contrast to the Western stock, which is experiencing potential human-related threats from competition with fisheries (potentially high), incidental take by fisheries (low), and toxic substances (medium) no threats to continued recovery were identified for the Eastern stock. Although several factors affecting the Western stock also affect the Eastern stock (e.g., environmental variability, killer whale predation, toxic substances, disturbance, shooting), these threats do not appear to be at a level sufficient to keep the Eastern stock from continuing to recover, given the long term sustained growth of the population as a whole (NMFS 2008c).

4.1.7.8.2 Fisheries Interactions

Deliberate killing by fishermen is still a threat throughout the species' range. There is also conflict with fish farms in Canada, 87 Steller sea lions being killed legally under predator control permits by the British Columbia fish farming industry in 1999, mostly in the Vancouver Island area. It is thought that other sea lions are also being killed illegally by fish farmers (Seal Conservation Society, http://www.pinnipeds.org/species/steller.htm).

There are two fishery-related theories about what may have contributed most to decline of the Steller sea lion through reductions in prey biomass and quality, which resulted in nutritional stress (proximate cause) and subsequent decreases in vital rates (Trites et al. 2006a). In one case, nutritional stress stems from climate-induced changes in the species composition, distribution or nutritional quality of the sea lion prey base. In the other, fishery-induced reductions in localized or overall prey abundance cause nutritional stress (Braham et al. 1980, NMFS 1998a, 2000). Both climate shift and fisheries induced changes in prey communities may have affected the condition of Steller sea lions over the last 40 years, but the relative importance of each is a matter of considerable debate (NMFS 2008c).

The carrying capacity of the North Pacific for Steller sea lions likely fluctuates in response to changes in the environment. What may have been unusual about the decline in sea lions observed through 2000 is the introduction of large-scale commercial fisheries on sea lion prey. While large-scale groundfish fisheries began in the 1960s, their potential for competitive overlap with Steller sea lions (e.g., catches within what would be designated as critical habitat) increased markedly in the 1980s. Overall and localized fisheries removals of prey could have exacerbated natural changes in carrying capacity, possibly in non-linear and unpredictable ways (Goodman et al. 2002). Reductions in carrying capacity may have contributed to declines in Steller sea lion natality that are believed to have occurred at some rookeries through at least 2002 despite shifts to potentially more favorable environmental conditions that may have occurred in 1989 and 1998 (NMFS 2008c).

4.1.8 Sea Otter (*Enhydra lutris)*

4.1.8.1 Regulatory Status

The USFWS recognizes five stocks in U.S. waters under MMPA guidelines (USFWS 2005c). These include single stocks each in California (i.e., the southern sea otter [*Enhydra lutris nereis*]) and Washington (i.e., the northern sea otter [*Enhydra lutris kenyoni*]) and three stocks in Alaska that are designated southeast, southcentral, and southwest stocks of the northern sea otter. Only the southwest Alaska stock of the northern sea otter (*Enhydra lutris kenyoni*) is listed as threatened under the ESA

(USFWS 2005c). The southwest Alaska stock of the northern sea otter does not occur in the NWTRC Study Area. Sea otters that occur along the coast of Washington (which have no formal federal designation) are the results of reintroduction efforts of the northern sea otter in the late 1960s and early 1970s (Jameson et al. 1982). A federal species recovery plan for the northern sea otter population has not been developed; however, the State of Washington developed a recovery plan to address the northern sea otter population in its waters (Lance et al. 2004). The southern sea otter (*Enhydra lutris nereis*) (California stock) is listed as threatened under the ESA and has a final recovery plan (USFWS 2003). The southern sea otter (California stock) is listed as threatened under the ESA and has a final recovery plan (USFWS 2003). There is no critical habitat designated for this species.

4.1.8.2 Habitat Preferences

Sea otters occupy nearly all coastal marine habitats from fine sediment bays and estuaries to rocky shores exposed to oceanic swells (Riedman and Estes 1990; Bodkin 2003;USFWS 2003b; 2005c). Sea otters prefer rocky shoreline with kelp beds, although this is not an essential habitat requirement (Riedman and Estes 1990; USFWS 2003b). Lower numbers of individuals also use soft-sediment areas where kelp is absent. Beds of giant and bull kelp and shallow rocky substrata provide sheltered resting and feeding areas during all weather conditions (e.g., Jameson et al. 1986). Historically, the Washington sea otter occurred in estuarine and sandy habitats and along the rocky outer coast. This population currently occupies primarily rocky habitats (Lance et al. 2004). Sea otters in Washington occasionally haul out at low tide on offshore rocks and islands.

Sea otters seldom range more than 1 nm (2 km) from shore, although some individuals, particularly juvenile males, travel farther offshore (Riedman and Estes 1990; Ralls et al. 1995 and 1996; USFWS 2003b; Lance et al. 2004). The habitat they occupy is defined by the intertidal zone and extends offshore to about the 328-ft (100-m) depth (Bodkin 2003), although individuals can be found in waters up to 656 ft (200 m) deep (Bodkin and Udevitz 1999). Most animals stay between the shore and 66-ft (20-m) depth (Riedman and Estes 1990; USFWS 2003b), and forage where the bottom depth is less than 131 ft (40 m) (Bodkin et al. 2004).

Sea otters feed on or near the bottom in shallow water. The diet varies with physical and biological habitat characteristics (Riedman and Estes 1990; Estes and Bodkin 2002). Large sea urchins are the preferred prey, to the extent that urchin density and large size classes can be depleted and the otters are forced to a more diverse diet (Kvitek et al. 1989; Kvitek et al. 1998; Kvitek et al. 2001; VanBlaricom and Chambers 2003; Laidre et al. 2004). Along the Washington coast, their diverse diet includes crustaceans, bivalves, urchins, and sea cucumbers (Bowlby et al. 1988; Lance et al. 2004; Jeffries et al. 2005). They also prey on cephalopods, fish, and seabirds (Riedman and Estes 1990). Sea otters occupying new habitat in the Strait of Juan de Fuca have a diet dominated by red urchins (Jeffries et al. 2005).

Sea otters move seasonally to areas where there is food or where sheltered water offers protection from storms and rough seas (Kenyon 1975; Riedman and Estes 1990). Individual sea otters in Washington show such shifts (Lance et al. 2004), but the population as a whole does not migrate, and otters range along the Washington coast year-round.

4.1.8.3 Population Size and Trends

Census data suggest an increasing population trend. Harvesting for pelts during the 1700s and 1800s severely reduced sea otter numbers throughout their range (Kenyon 1975). Until 1969 when reintroduction efforts began, sea otters were absent from Washington. Since then, recovery has been occurring in Washington, Canada, and parts of southeast Alaska. The most recent survey during 2006 in Washington counted 790 sea otters, which continues the 8 percent population increase since 1989, based on a 3-year running average method of tracking population trends (Jameson and Jeffries 2006; USFWS 2008).

4.1.8.4 Distribution

Sea otters are found in shallow, nearshore waters of the north Pacific, from northern Japan north to the coast of the Kamchatka Peninsula, east throughout the Aleutians, and south through the Gulf of Alaska and along the Pacific coast of North America, historically to Baja California (Reeves et al. 2002). The northward limits for this species appear related to the southern limits of sea ice, which can preclude access to foraging habitat (Bodkin 2003). Southern range limits are less well understood but appear to coincide with the southern limits of coastal upwelling, associated canopy-forming kelp forests, and the 68° to 72°F (20° to 22°C) isotherm (Bodkin 2003). The southernmost extent of its range is considered to be Washington and British Columbia (Raum- Suryan et al. 2004; Sea Otter Recovery Team 2004; USFWS 2005c). However, in recent years, sea otter sightings have become increasingly common off the Oregon coast (Lynch 2005). These individuals are considered to be far-ranging animals from the Washington population (Lynch 2005).

The pre-exploitation range of the sea otter included the entire Washington coast, with a major concentration off Point Grenville (Lance et al. 2004). The current population of 743 occurs along 115 mi (185 km) of coastline from Destruction Island in the south to Pillar Point (Neah Bay) in the north, with concentrations at Duk Point, Cape Alava, Sand Point, Cape Johnson, Perkins Reef, and Destruction Island (Lance et al. 2004). Almost half the Washington population occurs at Destruction Island (Lance et al. 2004). Recent sightings have been made as far south as Cape Elizabeth (Calambokidis et al. 2004b; Doughton 2004).

Based on known use, there is an area of primary occurrence for the sea otter between the shore and bottom depth of 131 ft (40 m) from Neah Bay, around the Olympic Peninsula, to Grays Harbor. A secondary occurrence is located in this same area between the 131-ft (40-m) and 328-ft (100-m) depths. All of the Puget Sound is an area of secondary occurrence (Lynch 2005). The Oregon coast from the shore to the 328-ft (100-m) depth is an area of secondary occurrence, based on the historical range of the species and recent sightings that indicate that the species may be expanding its range. There is a rare occurrence offshore from, and south of, the coastal areas of secondary occurrence.

Although the sea otter is not usually seen in the Puget Sound (Osborne et al. 1988), there are confirmed sightings and movements of tagged individuals in the eastern Strait of Juan de Fuca, around the San Juan Islands, and within the Puget Sound near Olympia (Calambokidis et al. 1987; Lance et al. 2004). Prior to recent sightings, the Strait of Juan de Fuca had not been occupied by sea otters for over 100 years (Jeffries et al. 2005). One sea otter was sighted about 6 mi (9 km) inland up McAllister Creek (Jeffries and Allen 2001).

In the last 10 years, there have been only two confirmed sightings of sea otters in northern California. Because these were on consecutive days in August 2005 (Hatfield 2005), they probably involved a single animal.

4.1.8.5 Diving Behavior

The habitat they occupy is defined by the intertidal zone and extends offshore to about the 328-ft (100-m) depth (Bodkin 2003), although individuals can be found in waters up to 656 ft (200 m) deep (Bodkin and Udevitz 1999). Most animals stay between the shore and 66-ft (20-m) depth (Riedman and Estes 1990; USFWS 2003b), and forage where the bottom depth is less than 131 ft (40 m) (Bodkin et al. 2004).

4.1.8.6 Acoustics

Underwater sounds of the sea otter have not been studied. Their airborne sounds include screams, whines, whistles, hisses, deep-throated snarls or growls, soft cooing sounds, grunts, and barks (Kenyon 1975; McShane et al. 1995). Sounds typically range in frequency from 0.2 to 12.8 kHz with various harmonics and a dominant frequency of 0.2 to 4.9 kHz (McShane et al. 1995). The screams of pups and their mothers (dominant frequency range of 3 to 5 kHz) can travel more than 0.6 mi (1 km), and may vary enough to provide individual recognition between mother and pup (Sandegren et al. 1973; McShane et al. 1995).

There are no hearing data available for this species.

4.1.8.7 Impacts of Human Activity

4.1.8.7.1 Harvests

Throughout its range along the Pacific rim from Baja California, Mexico to northern Japan, the sea otter was driven almost to extinction as a result of the intense maritime fur trade by American, Russian and European traders with aboriginal peoples that commenced in the mid 1700s and continued through the 1850s. Crude estimates of the pre-exploitation population size range from 150,000 to 300,000 animals. By 1911 the total sea otter population in the North Pacific is thought to have been reduced to less than 2 percent of its pre-exploitation size.

From about 1911 to 1969, sea otters were absent from Washington State. Reintroduction efforts dating back to 30 years ago are largely responsible for the recovery of northern sea otters in Washington State, Canada, and parts of southeast Alaska. Between 1965 and 1972, 700 northern sea otters were captured at Amchitka, Alaska and Prince William Sound and were translocated to Washington, Oregon, and other locations (Jameson et al. 1982). In 1969 and 1970, 59 otters were reintroduced to the Washington and Oregon coasts from Amchitka Island, Alaska (Jameson et al. 1982). Only the Washington reintroduction was successful.

4.1.8.7.2 Fisheries Interactions

Sea otters are susceptible to drowning in gillnets and have been taken in the Makah Northern Washington Marine Set-gillnet Fishery (Gearin et al. 1996). Based on observer data collected from 1988 through 2001, a total of 11 sea otters were taken when fishing effort occurred (Makah Tribe/Makah Tribal Resources and National Marine Fisheries Service (NMFS)/National Marine Mammal Lab (NMML) observer data). Other fisheries that occur within the range of the sea otter in Washington include treaty and non-treaty gillnet fisheries in the Strait of Juan de Fuca, Puget Sound, and Grays Harbor.

As sea otters expand their range eastward into the Strait of Juan de Fuca or south along the outer Washington coast, they will also encounter important sport and commercial shellfish fisheries (urchins, razor clams, Dungeness crabs, steamer clams, geoducks). Evidence from California and Alaska suggests that the potential for incidental take of sea otters in crab traps will increase as the population expands its range south of Destruction Island into prime Dungeness crab habitat" (Lance et al. 2004). In addition, the potential exists for increased interactions with invertebrate fisheries, particularly sea urchins and geoducks, as the sea otter population expands eastward into the Strait of Juan de Fuca (Gerber and VanBlaricom 1999).

Other sources of human-caused mortality and serious injury affecting the Washington sea otter population are not well documented (USFWS 2008).

4.2 BIRDS

4.2.1 Species Accounts

Information is presented below on federally-listed species known to occur within the OPAREA. Federally listed species are the short-tailed albatross (endangered), marbled murrelet (threatened), California brown pelican (endangered), and western snowy plover (threatened). Descriptions, habitat, and brief life histories of these listed species are included below. Critical habitat is designated for the western snowy plover and the marbled Murrelet.

4.2.1.1 California Brown Pelican (Pelecanus occidentalis californicus)

4.2.1.1.1 Regulatory Status

The brown pelican is one of two pelican species found in North America. The California brown pelican is one of six recognized subspecies of brown pelican. The California brown pelican was listed as endangered under the ESA in 1970, and also is listed as endangered by the State of California. There is no designated critical habitat for the California brown pelican (USFWS 1983). There is a recovery plan for this species (USFWS 1983). In February 2008 the USFWS proposed to delist the brown pelican (including the California brown pelican) as a federal listed species due to successful recovery (USFWS 2008a).

4.2.1.1.2 Habitat Preferences

Brown pelicans are diving birds that feed almost exclusively on fish and dive from up to 60 ft in the air (Carl 1987). In the past, northern anchovies were found to comprise 92 percent of the diet of California brown pelicans (Anderson and Gress 1983). In recent years, however, Pacific sardine (*Sardinops sagax*) populations have been increasing and may now be common items in the California brown pelican diet. In the Pacific Northwest, Pacific herring and Pacific sand lance *(Ammodytes hexapterus)* are frequent prey species (Burger et al. 1998).

California brown pelicans nest in colonies in Mexico and southern California, and wander north as far as British Columbia during the non-breeding period (Briggs et al. 1983). Individuals roost and loaf on sandy beaches, offshore rocks, pilings, jetties, and breakwaters (Briggs et al. 1983) and large numbers can be found roosting during the winter season on sandy islands, protective of predators and winds, in Oregon and Washington (e.g., Grays Harbor, Willapa Bay, and the mouth of the Columbia River; Schreiber and Schreiber 1982; Jaques and Strong 2003; Wahl et al. 2005).

4.2.1.1.3 Population Size and Trends

The brown pelican is the smallest of the world’s pelicans (USFWS 1985). Major declines occurred in the 1960s from the effects of chlorinated hydrocarbons (DDT, DDE). The population was further impacted in the mid-1970s by crashes in stocks of their principle prey, northern anchovy. Since that time, the brown pelican population has recovered dramatically (DoN 2006).

4.2.1.1.4 Distribution

After the breeding season, pelicans migrate north during the summer and early fall into northern California and the Pacific Northwest. Most individuals return south to breeding colonies by January (Briggs et al. 1981; Briggs et al. 1983). A few birds overwinter in southern Oregon (Contreras 1998). Brown pelicans generally forage in the nearshore littoral zone and bay and river channels up to 12 mi (20 km) from nesting islands. They will also forage offshore up to 45 mi (72 km) of the nesting colonies to exploit concentrated prey (Briggs et al. 1983). Pelicans are not strong divers and bob to the surface within seconds of submerging. Foraging offshore beyond the nearshore littoral zone is rare off Washington (Wahl and Tweit 2000).

In the Study Area, there are rare occurrences of brown pelicans in inland marine waters of Washington, with most in the Strait of Juan de Fuca to Point No Point (Wahl et al. 2005). In northern California large numbers of California brown pelicans can be found roosting between Trinidad and the Klamath River between July and October. Surveys conducted offshore the mouth of Grays Harbor between 1972 and 1998, Wahl and Tweit (2000) recorded 32,533 brown pelicans, of which 97 percent were observed in channel or littoral waters (less than 65 ft [20 m] deep), and nearly all the several thousand pelicans observed off Oregon and Washington by Briggs et al. (1992) were found in nearshore waters. Occurrence farther offshore during the late summer and fall appears to be rare off the Pacific Northwest. Briggs et al. (1983) noticed a pattern of pelican distribution with birds in southern California foraging well out to sea, while birds in central and northern California were found foraging much closer to shore, possibly due to nearshore distributions of northern anchovy.

4.2.1.1.5 Impacts of Human Activity

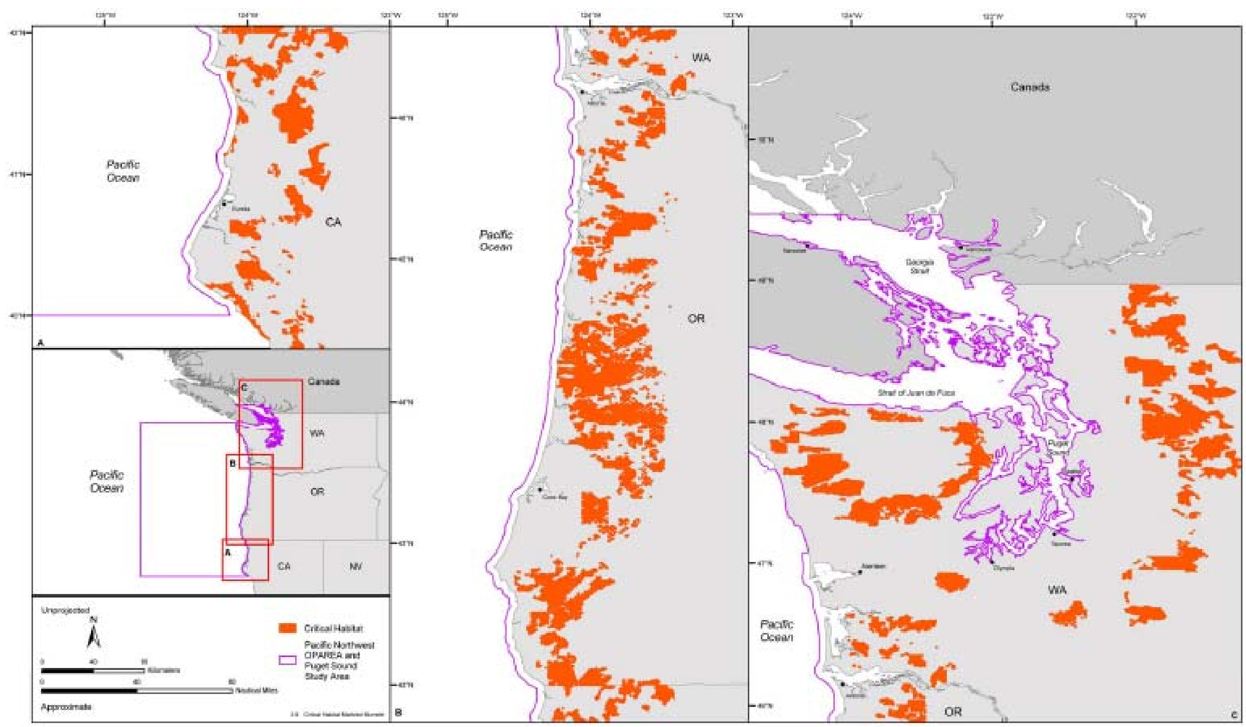
The primary reason for severe declines in the brown pelican population in the U.S., and for designating the species as endangered, was DDT contamination in the 1960s and early 1970s. Additionally, pesticides like dieldrin and endrin were also found to negatively impact brown pelicans. Since the banning of these organochlorine pesticides, brown pelican abundance within the U.S. has shown a dramatic recovery, and although annual reproductive success varies widely, populations have remained generally stable for at least 20 years (USFWS 2008a). Nesting and roosting colonies in the U.S., which previously were subjected to human disturbance that adversely affected nesting success, are expected to continue to be protected from human disturbance through local conservation measures, laws, the numerous restoration plans, and ownership of many of the nesting and roosting habitats by conservation groups and local, state, and federal agencies (USFWS 2008a). Commercial and recreational fishing may affect brown pelicans on a localized basis, but pose no rangewide threat to the continued existence of the species. Oil spills and oil pollution continue to be a potential threat, but the breeding range is large enough that a single spill, even a major one, would likely only affect a small fraction of the population (USFWS 2008a).

4.2.1.2 Marbled Murrelet (Brachyramphus marmoratus)

4.2.1.2.1 Regulatory Status

The marbled murrelet is a small alcid with sooty brown to brownish-black upper parts, rusty margins on the back-feathers, and reddish scapulars (Carter and Stein 1995). The marbled murrelet is listed as threatened under the ESA and is considered endangered by the State of California, and a species of concern in the State of Washington.

Critical habitat for the marbled murrelet has been designated at sites from central California near Santa Cruz, San Francisco, and north to Oregon (DoN 2006). All designated critical habitat for this species is located onshore and outside of the Study Area (Figure 4-3). There is a species recovery plan for the marbled murrelet (USFWS 1997).



Source: Marine Resources Assessment for the Pacific Northwest Operating Area (2006)

Figure 4-3. Critical Habitat for Marbled Murrelet

4.2.1.2.2 Habitat Preferences

In general, marbled murrelets south of southeast Alaska nest in trees, while those west of Kodiak Island nest on the ground, with an overlap in nesting modes between Kodiak and Prince of Wales islands. The great majority (97 percent) of marbled murrelets in Alaska nest in trees (Piatt and Ford 1993). In Alaska, both tree and ground nests are usually found within 4.0 mi (6.4 km) from the coast (Simons 1980; Hirsch et al. 1981; Day et al. 1983; Johnston and Carter 1985; Naslund et al. 1995), while in the Pacific Northwest, most nests are found within 19 mi (30 km) of marine waters (Hamer and Nelson 1995), although Hamer (1995) detected nesting murrelets in western Washington as far as 52 mi (84 km) from the nearest saltwater.

Tree nests are found primarily in old-growth conifer forests, or mature forests with old-growth components or trees with large branch platforms or mistletoe clumps (Naslund et al. 1995; Nelson 1997). Marbled murrelets do not build a nest, but rather are dependent on features, such as moss or needle piles, to hold their single egg on tree limbs, or mistletoe clumps (Nelson 1997). Multi-storied canopy layers and less than average canopy closures are also an important feature in nesting forest stands (Grenier and Nelson 1995; Hamer and Nelson 1995a; Miller and Ralph 1995). In both Washington and Oregon, nesting stands are dominated by trees greater than 81 cm in diameter. In Oregon and Washington, most (71 percent) nests have been found in Douglas-fir (*Pseudotsuga menziesii*) trees, followed by western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), and western red cedar (*Thuja plicata*), while in California, 10 nests have been found equally distributed in coastal redwoods (*Sequoia sempervirens*) and Douglas-fir (Hamer and Nelson 1995a). Habitat along major drainages is a key habitat component.

Although all marbled murrelet critical habitat is located onshore, birds will forage for prey offshore, in the PACNORWEST OPAREA and Puget Sound area. Strong et al. (1995) and Ralph and Miller (1995) looked at summer offshore distributions of marbled murrelets off Oregon and northern California, respectively, and both found murrelet sightings to drop off to near zero at about 4 mi (6 km) offshore. Speich and Wahl (1995) examined murrelet distribution off the Washington coast by water depth and found 97 percent of the sightings inshore of the 164-ft (50-m) isobath and 93 percent inshore of the 66-ft (20-m) isobath (littoral zone; off Grays Harbor, where their study was focused, the 66-ft (20-m) isobath is approximately 4 mi [6 km] offshore). Other studies (Varoujean II and Williams 1995; Thompson 1999) also measured murrelet distance from shore, but their transect lines were truncated (usually less than 1 mi [2 km]) before they reached the outer limits of marbled murrelet occurrence.

Surveys by Nysewander et al. (2005) clearly show that marbled murrelets tend to concentrate in nearshore areas of the inland marine waters of Washington. However, both their summer and winter surveys, as well as surveys conducted by Speich and Wahl (1995) and Pierce et al. (1996) show that these birds can be found throughout all water depths of Puget Sound and the Strait of Juan de Fuca, leading O'Neil et al. (2001) to classify marbled murrelets as highly associated with inland deep water habitats.

Burkett (1995) compiled foraging data from 26 North American studies and determined that, in general, marbled murrelets forage on invertebrates, especially euphausiids, during the winter and spring months, and then switch to small schooling fish during the summer and fall. Pacific sand lance is the most important fish prey item, especially in the northern half of the bird's range. Other important fish prey includes Pacific herring, surf smelt *(Hypomesus pretiosus)*, northern anchovy, and Pacific sardine, the latter two especially in California (Burkett 1995).

4.2.1.2.3 Population Size and Trends

Major declines in Marbled Murrelet populations have been observed across its range since the early 1970s. In central Oregon, a 50 percent population decline occurred over throughout 1990s alone. Marbled Murrelets are also decreasing at a rapid rate in Washington and in California, where they are listed as a threatened species.

Most marbled murrelets live in Alaska where the population is estimated at between 200,000 and 800,000 (Isleib and Kessel 1989; Piatt and Ford 1993; Piatt and Naslund 1995; Nelson 1997). Population estimates for British Columbia are 55,000 to 78,000 (Rodway et al. 1992; Burger 2002), Washington 5,000 to 6,500 (Speich and Wahl 1995; Varoujean II and Williams 1995), Oregon 6,600 to 20,000 (Strong et al. 1995; Varoujean II and Williams 1995), and California 6,450 (Ralph and Miller 1995). The great variation in the Oregon population estimates relates more to differences in how correction factors were applied to observed densities in two separate studies (Strong et al. 1995; Varoujean II and Williams 1995) than to great differences in observed densities. Overall, Beissinger's (1995) demographic trend analyses suggested that the North American marbled murrelet population has been declining as much as 4 to 7 percent per year.

4.2.1.2.4 Distribution

The marbled murrelet occurs only in the north Pacific ranging from the Aleutian archipelago across southern Alaska and south as far as Santa Cruz County in central California (DoN 2006). They are generally found foraging in nearshore waters within 0.53 to 1.08 nm (1 to 2 km) of the shore (Kuletz and Marks 1997). Their common diving depths range from 10 to 100 ft (3 to 30 m) marbled murrelets are unique among alcids in their use of old growth forest stands near the coastline for nesting. Nesting occurs from the Aleutian Islands south through British Columbia, Washington, Oregon, and into central California. The marbled murrelet is more likely to occur in northern California than in southern or central California due to its dependence on old-growth timber for nesting. The species' wintering range is poorly documented but includes most of the marine areas used in the breeding season, and extends south into southern California (Nelson 1997). Demographic trend analyses suggest that the North American marbled murrelet population has been declining as much as 4 to 7 percent per year (DoN 2006).

In the Study Area, marbled murrelets occur year-round in all inland marine waters of the Strait of Juan de Fuca, Puget Sound, and Georgia Strait, and the entire nearshore outer coast from Cape Flattery, Washington, south to south Humboldt County, California (Strong et al. 1995; Varoujean and Williams 1995). Surveys conducted between 1992 and 1999 indicated that marbled murrelets were distributed throughout the inland marine waters of Washington during the summer, with concentrations in the San Juan Islands, north Hood Canal, and along the south coast of the Strait of Juan de Fuca. By winter, there was a definite shift towards the more protective waters of the San Juan Islands, Hood Canal, Discovery Bay, Saratoga Passage, and Port Townsend, although some murrelets could be found throughout the summer range (DoN 2006). Sightings were reported in multiple years at Crescent Harbor/Holmes Harbor, Port Townsend Bay, and Hood Canal between 1992 to 1999 (DoN 2000, Final BA EOD Puget Sound).

4.2.1.2.5 Impacts of Human Activity

Marbled murrelet populations have suffered significant population declines in the Pacific Northwest due primarily to the removal of essential habitat by logging and coastal development (Wahl et al. 2005). Fisheries, especially gill-net fisheries, and oil spills have contributed to population declines. The primary cause of marbled murrelet population decline is the loss and modification of nesting habitat in old growth and mature forests through commercial timber harvests, human-induced fires, and land conversions, and to a lesser degree, through natural causes such as wild fires and wind storms. In general, forest management practices that maximize timber production cut and replant forest stands every 40 to 60 years. Since it takes 100 to 250 years to grow marbled murrelet nesting habitat, this time frame frequently does not allow old-growth characteristics to develop, thus eliminating large areas from providing future nesting habitat. Continued harvest of old growth and mature forests also perpetuates the loss and fragmentation of remaining habitat. Changing the existing habitat by fragmenting the forest into small patches of suitable habitat surrounded by open space also affects the habitat quality. Increased forest fragmentation can reduce nesting success by allowing increased predation of nests by raptors (great horned owls, sharp-shinned hawks, peregrine falcons) and corvids (jays, ravens, crows). In the murrelet's marine habitat, oil spills and gill-net fishing also threaten the population. Recent oil spills off the coast of California and Oregon have contributed to direct mortality of marbled murrelets and other seabirds (USFWS 2008c).

4.2.1.3 Short-tailed Albatross (*Phoebastria albatrus*)

4.2.1.3.1 Regulatory Status

The short-tailed albatross is the largest of the three north Pacific albatrosses (Harrison 1984). The short-tailed albatross was listed as endangered throughout its range under the ESA in 2000 (USFWS 2000). There is no designated critical habitat for this species in the OPAREA. There is a draft species recovery plan (USFWS 2005).

4.2.1.3.2 Habitat Preferences

Very little is known of its marine habitat requirements. However, foraging occurs over open offshore ocean waters (DoN 2006). These birds are pelagic wanderers, traveling thousands of miles at sea during the non-breeding season (DoN 2006). Most of their travel is concentrated along the continental shelf edge upwelling zones where they forage on squid, fish, shrimp and other crustaceans, and flying fish eggs (USFWS 2005b). Their diving ability varies from 15 ft to 40 ft in depth.

4.2.1.3.3 Population Size and Trends

During the late 1800s, the world population of short-tailed albatrosses was decimated for their plumage (Robreson 2000). Short-tailed albatrosses nest on isolated, windswept, offshore islands that have restricted human access. The population has been rebounding in recent years because several Pacific rookeries have been protected from human use (USFWS 2000). The world population is currently estimated to be about 1200 birds and is increasing (USFWS 2001b).

4.2.1.3.4 Distribution

Historically, millions of short-tailed albatrosses bred in the western North Pacific on several islands south of the main islands of Japan. Only two breeding colonies remain active today: Torishima Island and Minami-kojima Island, Japan (USFWS 2001b). Their at-sea distribution includes the entire north Pacific north of about 20°N, but they tend to concentrate along the Aleutians in the Bering Sea (Piatt et al. 2006). This species disperses throughout the north Pacific when it is not breeding. Historic records indicate frequent use of nearshore and coastal waters in the eastern north Pacific, including California (COSEWIC 2003). Current sightings in the eastern north Pacific are concentrated off the shores of Alaska and British Columbia. Sightings off California are gradually increasing as the population rebounds (Unitt 2004). Sightings of short-tailed albatross have the potential to increase in frequency as the species continues recovering.

In the PACNORWEST OPAREA and Puget Sound area there are few records of short-tailed albatross for the Pacific Northwest compared to the shelf waters of Alaska.

4.2.1.3.5 Impacts of Human Activity

Short-tailed albatrosses have survived multiple threats to their existence. During the late 1800s and early 1900s, feather hunters clubbed to death an estimated five million birds, stopping only when the species was nearly extinct. In the 1930s, nesting habitat on the only active nesting island in Japan was damaged by volcanic eruptions, leaving fewer than 50 birds by the 1940s. Loss of nesting habitat to volcanic eruptions, severe storms, and competition with black-footed albatrosses for nesting habitat continue to be natural threats to short-tailed albatrosses today. Human-induced threats include hooking and drowning on commercial longline gear, entanglement in derelict fishing gear, ingestion of plastic debris, contamination from oil spills, and potential predation by introduced mammals on breeding islands (USFWS 2001).

4.2.1.4 Western Snowy Plover (Charadrius alexandrinus nivosus)

4.2.1.4.1 Regulatory Status

After continuing to witness significant declines in the 1980s, the USFWS (1993) listed the Pacific coast population as threatened in 1993. The primary agents causing declines have been habitat degradation by human disturbance (especially recreation), urban development, introduced beachgrass (*Ammophilia* spp.), and expanding predator populations (USFWS 2001a).

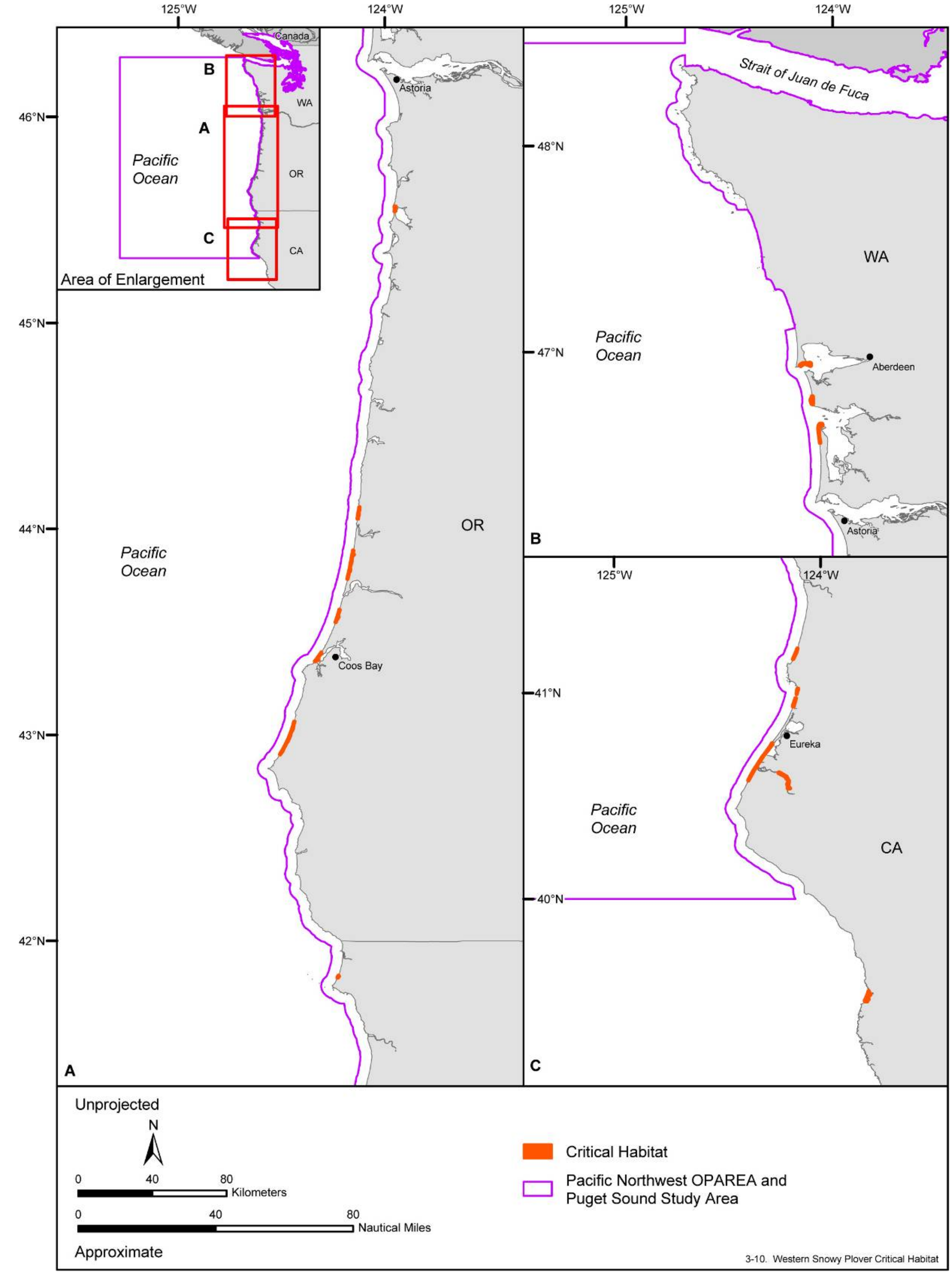
In an effort to ameliorate these impacts, the USFWS (2005e) designated critical habitat at three locations in Washington, seven locations in Oregon, and seven locations in California. There is designated critical habitat for this species in the Study Area (Figure 4-4, USFWS 2005). There is a species recovery plan (USFWS 2007).

4.2.1.4.2 Habitat Preferences

The Pacific coast population of the western snowy plover breeds in March and April and winters on coastal beaches, including sand spits, dune-backed beaches, beaches at river and creek mouths, and lagoon/estuarine saltpans (USFWS 2001a). Individuals also occasionally use bluff-backed beaches, dredged material disposal sites, salt pond levees, dry salt ponds, and river bars. Nest sites are usually found on sandy or saline substrates with little or no vegetation and debris (e.g., driftwood; Widrig 1980; Page and Stenzel 1981). Although western snowy plovers move up and down the west coast during the non-breeding season, they primarily winter on the same beaches used for breeding (Page et al. 1995). The waterlines of these same beaches constitute their foraging habitat (Page et al. 1995). In the Pacific Northwest, western snowy plovers generally feed in the wet sand or among surf-cast kelp, where they visually forage for flies, beetles, small clams and crabs, amphipods, seed shrimp (ostracods), and polychaetes (Page et al. 1995). During the winter, western snowy plovers often feed in loose flocks, and roost in depressions or behind sheltering debris, such as driftwood or kelp.

4.2.1.4.3 Population Size and Trends

When the western snowy plover was listed as a threatened species in 1993, the USFWS (1993) stated that historic records indicated that nesting western snowy plovers were once more widely distributed in coastal California, Oregon, and Washington than at that time. In coastal California, snowy plovers bred at 53 locations prior to 1970. Since that time, no evidence of breeding birds had been found at 33 of these 53 sites, representing a 62 percent decline in breeding sites. The greatest losses of breeding habitat were in southern California, within the central portion of the snowy plover's coastal breeding range. In Oregon, snowy plovers historically nested at 29 locations on the coast. In 1990, only six nesting colonies remained, representing a 79 percent decline in active breeding sites. In Washington, snowy plovers formerly nested in at least five sites on the coast. In 1993 only two colony sites remained active, representing, at minimum, a 60 percent decline in breeding sites (USFWS 1993). Later abundance estimates along the Washington, Oregon, and California coasts, indicated breeding populations had been reduced to about 2,000 birds (DoN 2006; USFWS 2001a).



Source: Marine Resources Assessment for the Pacific Northwest Operating Area (2006)

Figure 4-4. Critical Habitat for Western Snowy Plover

4.2.1.4.4 Distribution

The Pacific coast population of the western snowy plover extends from the mudflats and sandy beaches of Grays Harbor (Damon Point), Washington, south to Baja Sur, Mexico (DoN 2006). In the Study Area, the western snowy plover confines its habitat to the sandy beaches and mudflats of the Oregon, Washington, and California coasts (DoN 2006). This species does not occupy any of the marine or rocky shore areas found in the PACNORWEST OPAREA. In Washington, western snowy plovers breed at Damon Point/Oyhut Wildlife Area, Midway Beach/Cape Shoalwater, and Leadbetter Point. In Oregon they nest at eight locations (Baker Beach/Sutton Beach, Siltcoos Estuary, Oregon Dunes Overlook, Tahkenitch Estuary, Tenmile Estuary, Coos Bay North Spit, New River Spit, and Bandon State Natural Area; Stern et al. 2003). In Humboldt County, California, nesting occurs at Eel River (gravel bars), Eel River Wildlife Area, and Clam Beach. During the winter, snowy plovers may be found at Midway Beach and Leadbetter Point in Washington, breeding sites in Oregon, and several sites in Humboldt County, California.

4.2.1.4.5 Impacts of Human Activity

The most important human-caused problem is physical alteration of coastal habitat by construction of residential, commercial, and recreational facilities, harbors, roads, and campgrounds. Poor reproductive success, resulting from human disturbance, predation, and inclement weather, combined with permanent or long-term loss of nesting habitat to encroachment of introduced European beachgrass (*Ammophila arenaria*) and urban and shoreline development has led to a decline in active nesting colonies, as well as an overall decline in the breeding and wintering population of the western snowy plover along the Pacific coast of the United States.

European beachgrass, which is found at 50 percent of California snowy plover breeding sites and all of the Oregon and Washington breeding sites, eliminates potential snowy plover nesting habitat. The plant reduces the amount of unvegetated area above the surf line, the area where snowy plovers prefer to nest. As examples, at Willapa National Wildlife Refuge in Washington State, the Service documented between 1984 and 1990 invasion of European beachgrass into former snowy plover nesting areas. A decline in the plover breeding population also occurred over this time period. In Oregon, at the Siuslaw National Forest, the U.S. Forest Service reports that European beachgrass has eliminated some of the historically open sand spits where snowy plovers formerly nested or wintered. Remaining birds are forced to use a greatly reduced habitat base. The Oregon Department of Fish and Wildlife considers European beachgrass to be the primary reason for the decline of snowy plovers on the Oregon coast, with human disturbance a secondary factor in remaining habitat.

Interactions between nesting snowy plovers, recreationist on the beach, offroad vehicle use, and horseback riders activity in nesting areas have been identified as factors that result in direct loss of nests or indirect loss of reproductive success from plovers repeatedly being flushed from their nests.

4.3 SEA TURTLES

4.3.1 Introduction

Sea turtles are long-lived reptiles that can be found throughout the world's tropical, subtropical, and temperate seas (Caribbean Conservation Corporation and Sea Turtle Survival League 2003). There are seven living species of sea turtles from two distinct families, the *Cheloniidae* (hard-shelled sea turtles; six species) and the *Dermochelyidae* (leatherback turtle; one species). These two families can be distinguished from one another on the basis of their carapace (upper shell) and other morphological features.

Female sea turtles nest in tropical, subtropical, and warm-temperate latitudes, often in the same region or on the same beach where they hatched (Miller 1997). Upon selecting a suitable nesting beach, most sea turtles tend to re-nest in the same area during subsequent nesting attempts. The leatherback turtle is a notable divergence from this pattern. This species nests primarily on beaches with little reef or rock offshore. On these types of beaches erosion reduces the probability of nest survival. To compensate, leatherbacks scatter their nests over larger geographic areas and lay on average two times as many clutches as other species (Eckert,1987).

The leatherback turtle (*Dermochelys coriacea*) occurs at sea off the coast of the OPAREA. The leatherback turtle is not known to nest on beaches of Washington, Oregon, or northern California.

4.3.2 Species Accounts

4.3.2.1 Leatherback Turtle (*Dermochelys coriacea*)

4.3.2.1.1 Regulatory Status

The leatherback turtle was listed under the ESA as endangered throughout its range in June 1970. Critical habitat has not been identified for this species in the Pacific, largely because no nesting areas or important foraging areas have been identified there (NMFS and USFWS 1998). There is no designated critical habitat in the NWTRC OPAREA. However, because of the high potential for interactions between leatherback turtles and drift gillnet fisheries off the U.S. west coast during periods of warmer water, the NMFS has designated the eastern north Pacific Ocean area shown in Figure 4-5 as a "Pacific Leatherback Conservation Zone.", which has been proposed for critical habitat designation (Center for Biological Diversity et al. 2007). Within the Conservation Zone from August 15 through November 15 every year, fishing with drift gillnets with a mesh size equal to or greater than 14 inches (36 centimeters) is prohibited. The Conservation Zone is roughly located between Point Conception, California (34 °27'N) and northern Oregon (45° N), and is described fully in 50 CFR 660.713(c). The Pacific Leatherback Conservation Zone protects vides this species with a strong level of protection from gillnets at the time of the year when they are known to reside off the U.S. west coast.

In December 2007, the NMFS issued a 90-day finding concluding sufficient evidence had been provide by the petitioners (Center for Biological Diversity et al. 2007) to warrant revising critical habitat for the leatherback turtle to include the Conservation Zone (NMFS 2007c). There is a recovery plan for this species (NMFS and USFWS 1998).

4.3.2.1.2 Habitat Preferences

Leatherbacks feed mainly on jellyfish, tunicates, and other epipelagic soft-bodied invertebrates (Hartog and van Nierop 1984; Davenport and Balazs 1991). There is evidence that leatherbacks are associated with oceanic front systems, such as shelf breaks and the edges of oceanic gyre systems where their prey is concentrated.

The Pacific coast of Mexico is generally regarded as the most important leatherback breeding ground in the world. Based on a single aerial survey in 1980 of Michoacán, Guerrero, and Oaxaca, and on published and anecdotal data, Pritchard (1982) estimated that 30,000 females nested annually in these three Mexican states. Lower-density nesting was (and still is) reported farther north in Jalisco (NMFS and USFWS 1998) and in Baja California, where the northernmost eastern Pacific nesting sites are found (Fritts et al. 1982). Leatherbacks nest along the western coast of Mexico from November to February, although some females arrive as early as August (NMFS and USFWS 1998), and in Central America from October to February (NMFS 2002b; Lux et al. 2003). Females may lay up to nine clutches in a season (although six is more common), and the incubation period is 58–65 days. At Playa Grande, Costa Rica, and in French Guiana, the mean inter-nesting period was 9 days (Lux et al. 2003).

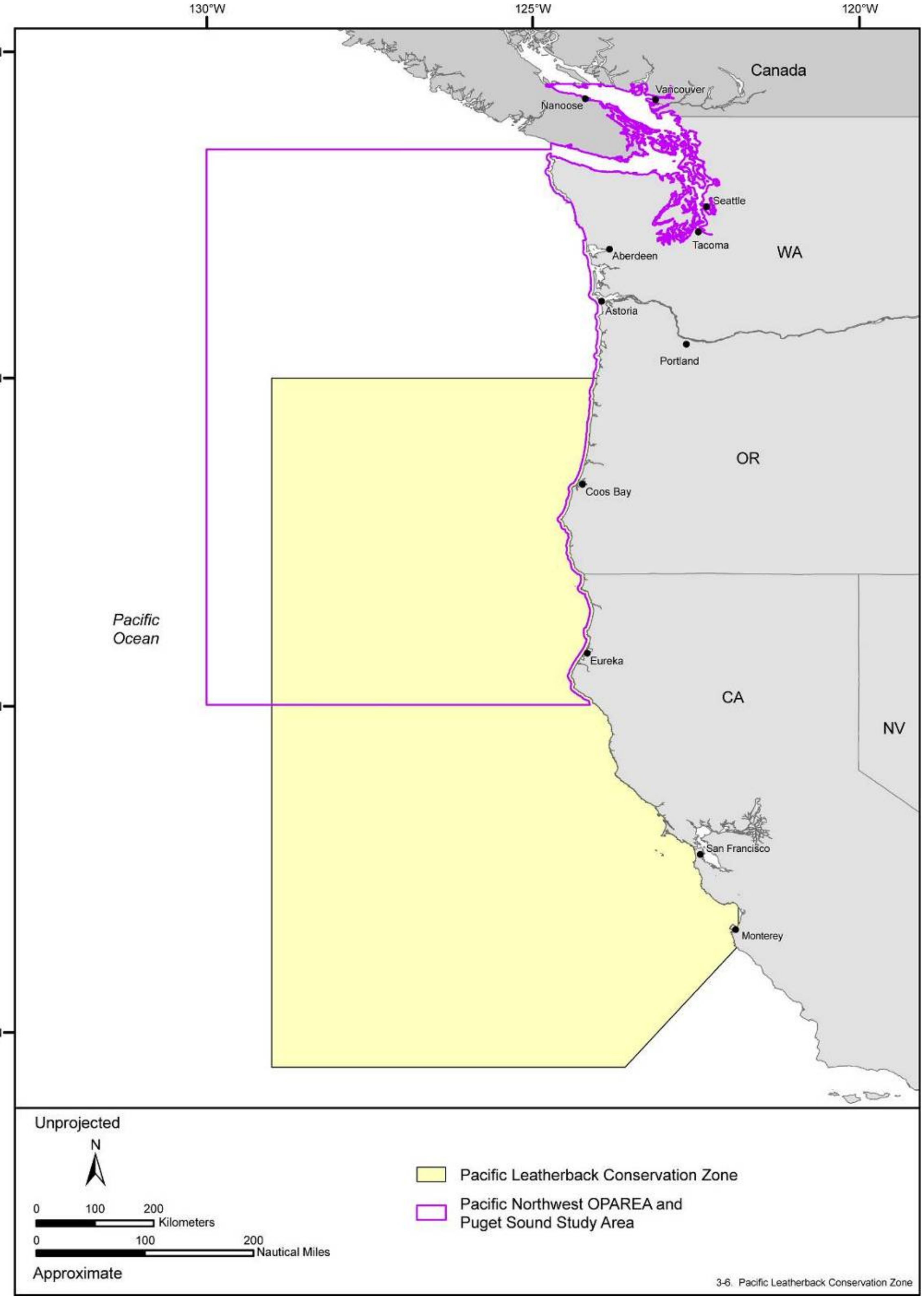


Figure 4-5. Leatherback Turtle Conservation Zone and Proposed Critical Habitat Off the Oregon and California Coasts

Leatherbacks occur north of central California during summer and fall, when sea surface temperatures are highest (Dohl et al. 1983; Brueggeman 1991). There is some evidence that they follow the 16 degrees Celsius (ºC) isotherm into Monterey Bay, and that the length of their stay depends on prey availability (Starbird et al. 1993). Aerial surveys of Washington, Oregon, and California waters suggest that most leatherbacks occur in continental slope waters and few occur over the continental shelf. There were 96 sightings of leatherbacks within 31 mi (50 km) of Monterey Bay from 1986 to 1991, mostly by recreational boaters (Starbird et al. 1993). Fishermen often catch leatherbacks in drift/gill nets off Monterey Bay (NMFS and USFWS 1998).

Stinson (1984) reported that leatherbacks were observed over a broader range of depths out to 3,281 ft (1,000 m). When sea turtles reach subadult size, they move to the shallow, nearshore benthic feeding grounds of adults (Carr 1987; NRC 1990; NMFS and USFWS 1998). Aerial surveys off Washington, Oregon, and California have shown that most leatherbacks occur in slope waters and that few occur over the continental shelf (Eckert 1993). Tracking studies found that migrating leatherback turtles often travel parallel to deepwater contours ranging in depth from 656 to 11,483 ft (200 to 3,500 m) (Morreale et al. 1994).

The leatherback turtle is rare in the waters of the NWTRC. It likely would be encountered only in the offshore waters because of its preference for the pelagic habitat, and likely only from July to September.

4.3.2.1.3 Population Size and Trends

Over the last few centuries, sea turtle populations have declined dramatically due to human-related activities such as coastal development, oil exploration, commercial fishing, marine-based recreation, pollution, and over-harvesting (National Research Council [NRC] 1990; Eckert 1995).

The world leatherback turtle population is estimated at 35,860 females (Spotila 2004). Leatherbacks are seriously declining at all major Pacific basin rookeries, including those in Indonesia, Malaysia, and Mexico. At Mexiquillo, Michoacán, an estimated 4,796 nests were laid on 7 mi (11 km) of beach in 1986–1987, and approximately 1,074 nests were laid in 1989–1990 (NMFS and USFWS 1998). The Mexican decline may be a natural fluctuation but, based on aerial survey data of Sarti-M et al. (1996), a geographic shift in nesting is unlikely. Nesting along the Pacific coast of Mexico has declined at an annual rate of 22 percent over the last 12 years, and the current Malaysian population is 1 percent of the levels recorded in the 1950s (NMFS 2006).

4.3.2.1.4 Distribution

The leatherback is the largest and most widely distributed sea turtle, ranging far from its tropical and subtropical breeding grounds. It has the most extensive range of any adult, from 71ºN to 47ºS latitude (Eckert 1995). Leatherbacks are highly pelagic, approaching coastal waters only during the reproductive season (EuroTurtle 2006). Hatchling leatherbacks are pelagic, but nothing is known about their distribution during the first four years of life (Musick and Limpus 1997). Post-nesting adults appear to migrate along bathymetric contours from 656 to 11,483 ft (200 to 3,500 m) (Morreale et al. 1994), and most of the eastern Pacific nesting stocks migrate south (NMFS 2002c).

After analyzing 363 records of sea turtles sighted along the Pacific coast of North America, Stinson (1984) concluded that the leatherback was the most common sea turtle in U.S. waters north of Mexico. Sightings and incidental capture data indicate that leatherbacks are found in Alaska as far north as 60°N latitude, 145ºW longitude, and as far west as the Aleutian Islands, and documented encounters extend southward through the waters of British Columbia, Washington and Oregon, and California (NMFS and USFWS 1998).

4.3.2.2 Diving Behavior

Sea turtles typically remain submerged for several minutes to several hours depending upon their activity state (Standora et al. 1984; Renaud and Carpenter 1994). Long periods of submergence hamper detection and confound census efforts.

This species is one of the deepest divers in the ocean, with dives deeper than 3,281 ft (1,000 m) (Eckert and Luginbuhl 1988). Leatherbacks dive continually and spend short periods on the surface between dives (Eckert et al. 1986; Southwood et al. 1998). Dives typically average 6.9 to 14.5 minutes each, with a maximum of 42 minutes (Eckert et al. 1996). During migrations or long distance movements, leatherbacks maximize swimming efficiency by traveling within 16 ft (5 m) of the surface (Eckert 2002).

4.3.2.3 Acoustics

Sea turtles do not have an auditory meatus or pinna that channels sound to the middle ear, nor do they have a specialized tympanum (eardrum). Instead, they have a cutaneous layer and underlying subcutaneous fatty layer that function as a tympanic membrane. The subcutaneous fatty layer receives and transmits sound to the extracolumella, a cartilaginous disk, located at the entrance to the columella, a long, thin bone that extends from the middle ear cavity to the entrance of the inner ear or otic cavity (Ridgway et al. 1969). Sound arriving at the inner ear via the columella is transduced by the bones of the middle ear. Sound also arrives by bone conduction through the skull. Sea turtle auditory sensitivity is not well studied, though a few preliminary investigations suggest that it is limited to low frequency bandwidths, such as the sounds of waves breaking on a beach.

The role of underwater low-frequency hearing in sea turtles is unclear. Sea turtles may use acoustic signals from their environment as guideposts during migration and as a cue to identify their natal beaches (Lenhardt et al. 1983). The range of maximum sensitivity for sea turtles is 100 to 800 Hz, with an upper limit of about 2,000 Hertz (Hz) (Lenhardt 1994). Hearing below 80 Hz is less sensitive, but still potentially usable to the animal (Lenhardt 1994). Ridgway et al. (1969) used aerial and mechanical stimulation to measure the cochlea in three specimens of green turtle, and concluded that they have a useful hearing span of perhaps 60 to 1,000 Hz, but hear best from about 200 Hz up to 700 Hz, with their sensitivity falling off considerably below 200 Hz. The maximum sensitivity for one animal was at 300 Hz, and for another was at 400 Hz. At 400 Hz, the turtle's hearing threshold was about 64 decibels (dB) in air (approximately 126 dB in water). At 70 Hz, it was about 70 dB in air (approximately 132 dB in water). Bartol et al. (1999) reported that juvenile loggerheads (*Caretta caretta*) hear sounds between 250 and 1,000 Hz.

Lenhardt et al. (1983) applied audiofrequency vibrations at 250 Hz and 500 Hz to the heads of loggerheads and Kemp’s ridleys submerged in salt water to observe their behavior, measure the attenuation of the vibrations, and assess any neural-evoked response. These stimuli (250 Hz, 500 Hz) were chosen as representative of the lowest sensitivity area of marine turtle hearing (Wever 1978). At the maximum upper limit of the vibratory delivery system, the turtles exhibited abrupt movements, slight retraction of the head, and extension of the limbs in the process of swimming. Lenhardt et al. (1983) concluded that bone-conducted hearing appears to be a reception mechanism for at least some of the sea turtle species, with the skull and shell acting as receiving surfaces. Finally, sensitivity even within the optimal hearing range is apparently low as threshold detection levels in water are relatively high at 160 to 200 dB referenced to one micro-Pascal-meter (re 1 µPa-m) (Lenhardt 1994).

4.3.2.3.1 Impacts of Human Activity

A major factor in the decline of the leatherback turtle worldwide is commercial harvesting for meat and eggs. The crash of the Pacific leatherback turtle population, once the world's largest, is believed to be primarily the result of exploitation by humans for their eggs and meat. Enforcement of existing laws in remote areas also is a major problem. Other human threats to the leatherback turtle include: (1) recreational and commercial uses of nesting beaches; (2) coastal construction that eliminates or degrades turtle nesting habitat; (3) destruction and degradation of sea grass and coral reef feeding and refuge habitats; (4) ingestion and exposure to marine pollutants, contaminants, and debris; (5) entanglement in nets, longlines, and other fishing gear; (6) ship strikes; and (7) commercial and recreational fishing with nets, longlines, trawls, seines, and hook-and-lines.

4.4 FISH

4.4.1 Species Accounts

Information is presented below on federally-listed species known to occur within the OPAREA. Federally listed species are the bull trout (coastal Puget Sound ESU, threatened), Chinook salmon (California Coastal and Puget Sound ESUs, threatened/endangered), chum salmon (Hood Canal ESU, threatened), coho salmon (Oregon Coast ESU, threatened/endangered), steelhead trout (northern California ESU, threatened/endangered) and green sturgeon (Southern DPS). Descriptions, habitat, and brief life histories of these listed species are included below. Critical habitat is proposed for the Southern DPS green sturgeon; critical habitat is designated for the remaining listed species.

4.4.1.1 Bull Trout (*Salvelinus confluentus*), Coastal Puget Sound/Olympic Peninsula River Basins ESUs

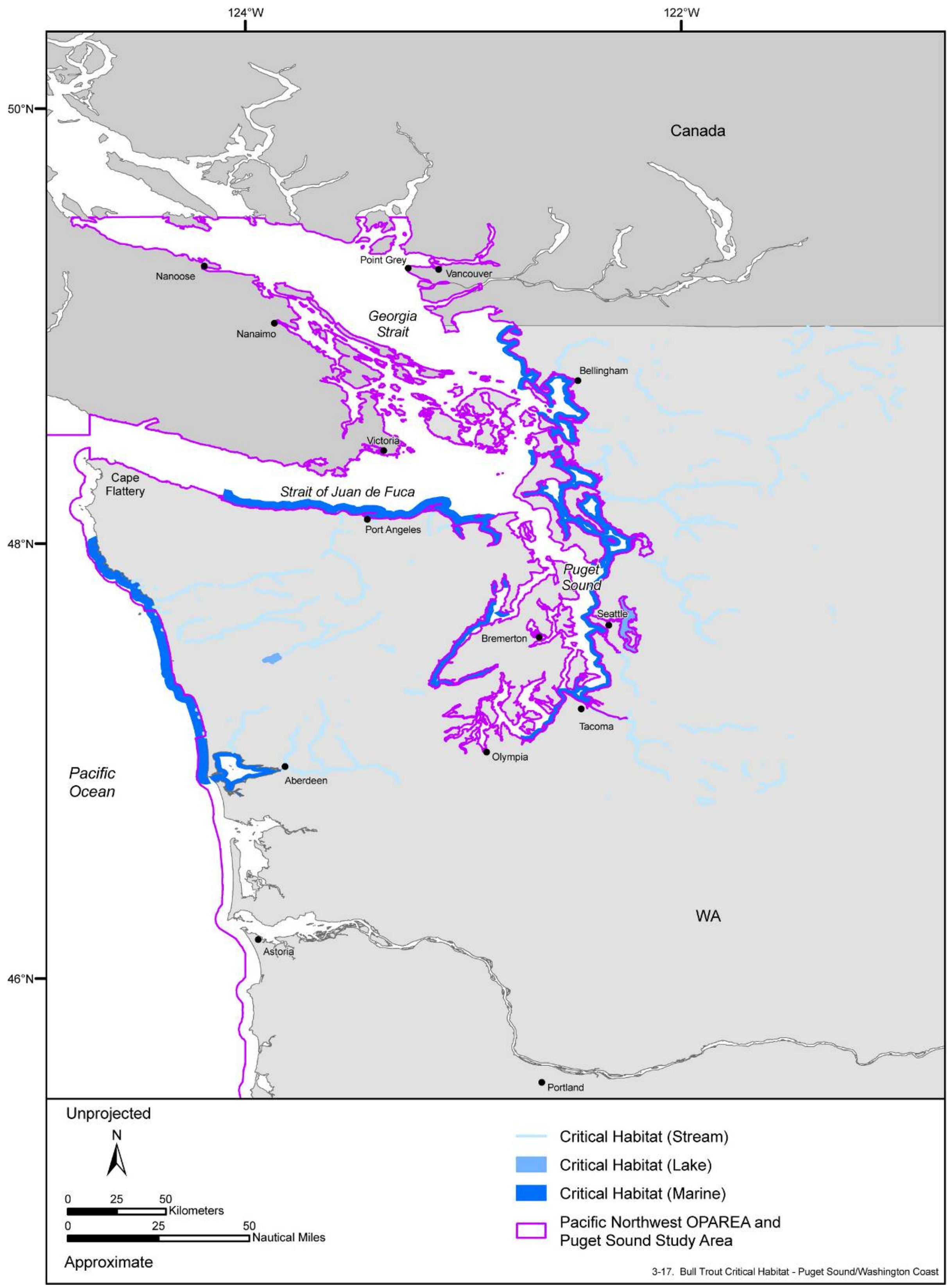
4.4.1.1.1 Regulatory Status

The bull trout is listed as threatened throughout the contiguous U.S. (USFWS 2005). The Coastal Puget Sound Bull Trout ESU was listed as threatened under the ESA in September 2005 (USFWS FR 70(185):56212, September 26, 2005). The ESU includes all Pacific Ocean drainages in Washington including Puget Sound (USFWS 1999a).

Critical habitat was designated in September 2005 for the ESU to include various Olympic Peninsula streams and lakes, and nearshore marine areas along the Pacific Coast of Washington, Strait of Juan de Fuca, and Hood Canal (USFWS 2005). Individuals from this ESU inhabit or migrate through the Study Area. Critical habitat is shown in Figure 4-6. There is a draft recovery plan for each of the two ESUs (USFWS 2004a and 2004b). Factors that define critical habitat (PCEs) for these ESUs are listed in Table 5-9. They include freshwater stream and marine nearshore waters that address water quality, quantity, and temperature; natural cover for different life stages: adequate freshwater spawning and rearing sites; unobstructed migration corridors; and availability of adequate forage food base resources.

4.4.1.1.2 Habitat Preferences

Bull trout are typically found in fresh water to euhaline water but are rarely anadromous (Froese and Pauly). Individuals found in marine waters typically occur inshore of the 33-ft (10-m) isobath (NMFS-NWR 2004a).Little is known about the temperature requirements of bull trout in marine environments but adult and subadult trout in freshwater typically are not found in temperature greater than 59°F (15°C). Eggs, alevins, fry, and parr inhabit freshwater while adults and subadults can be found in river, lakes, or marine waters (NMFS-NWR 2004a). Fry are closely associated with areas around cold-water seeps. This association diminishes as size increases. As bull trout get larger they tend to associate with large boulders and woody debris.



Source: Marine Resources Assessment for the Pacific Northwest Operating Area (2006).

Figure 4-6. Critical Habitat for Bull Trout

Bull trout exhibit a number of different life-history strategies, which determine their habitat requirements and distribution. Stream-resident bull trout complete their entire life history in the tributary streams in which they rear and spawn. Some bull trout are migratory, spawning in tributary streams, where juvenile fish usually rear from 1-4 years before migrating to either a larger river or lake where they spend their adult life, returning to the tributary stream to spawn. Anadromous bull trout, which are reported to only occur in Puget Sound, rear in natal streams for a period of time, migrate to marine environments to mature, and then return to mountain tributaries to spawn. While in marine waters, anadromous bull trout primarily occupy productive estuarine and nearshore habitat. Subadults use marine habitat to forage, generally from late spring to early fall. At maturity, anadromous bull trout begin re-entering mainstream rivers in late spring and early summer to migrate to their spawning tributaries.

The Snohomish and Skagit river basins are the closest and most likely influences on bull trout occurrences within Crescent and Holmes Harbors. Anadromous, fluvial, adfluvial, and resident fish all exist in the Skagit watershed and also spawn in the same areas (WDFW 2002). After spawning, resident fish remain in the area, while fluvial adults move throughout the upper river area and harbor in pools throughout the winter, spring and early summer. After spawning, anadromous adults begin their downriver migration starting in late fall, continuing through the winter and enter marine waters in the spring. The upriver spawning run begins in mid-summer. Anadromous bull trout smolts enter marine waters through summer, smolts return to the lower river in the fall, remain there throughout winter, then move back to marine waters and Puget Sound in the late winter and early spring (WDFW 2002).

All bull trout in the Snohomish River basin (including South and North Fork Skykomish Rivers) are considered a single stock (WDFW 2002). Anadromous, fluvial, and resident life history forms are all found in the Skykomish river system, and similar to the Skagit River watershed, all forms can be found spawning at the same time and place. Anadromous Skykomish River bull trout enter the Snohomish River from mid-May to mid-July (assuming from Puget Sound) (WDFW 2002, Bowles 1999). Further life history characteristics such as timing of movements and spawning for the Skykomish stock are very similar to the Skagit stock.

Based on the life history of anadromous bull trout within the Skagit and Snohomish River basins, it is possible that bull trout occur within the Study Area during certain times of the year. Bull trout found within the Study Area would likely be non-resident, migratory adults. Even though there has been no bull trout recorded within the Crescent/Holmes Harbor area, life history suggests that bull trout could sporadically occur in the area.

The Strait of Juan de Fuca river basins are the closest and most likely influences on bull trout occurrences within Port Townsend Bay. There are four tentatively identified bull trout stocks within the Strait of Juan de Fuca. Run timing and spawning timing are unknown for all of these stocks (WDFW 2002).

Based on the known life histories of Skagit and Snohomish stocks, it is possible, however unlikely, that bull trout sporadically occur within the Port Townsend Bay area. The unlikely occurrence is supported by the fact there are no records of bull trout within Port Townsend Bay or its river systems.

The Skokomish River basin is made up of three distinct bull trout stocks: South Fork Skokomish River, Lake Cushman, and Upper North Fork Skokomish. The South Fork Skokomish River is the only one of these stocks that may contain anadromous life history forms of bull trout (WDFW 2002). Fluvial and resident life history forms may be present as well. However, there is very little information on life history of this stock as well as no harvest, escapement or run-size data.

Spawn timing has not been documented but is assumed to be from mid-September through December and emigrating anadromous smolts have been observed (WDFW 2002). It is very possible that the life history of anadromous forms of bull trout in this stock is similar to those of the Skagit and Snohomish River basins. However, the behavior of anadromous forms is unknown in the marine waters of Hood Canal.

Based on the known life histories of Skagit and Snohomish stocks and applying it to the Skykomish stock, it is possible, however unlikely, that bull trout sporadically occur within the Hood Canal area. The large distance from the Skykomish River mouth to the Hood Canal area, coupled with the fact that no bull trout have been recorded in any other river system within Hood Canal suggests that the likelihood of bull trout occurring within the action area is low.

4.4.1.1.3 Population Size and Trends

Bull trout populations are severely reduced in the PACNORWEST OPAREA and no longer occur in northern California. Bull trout have declined in overall range and numbers of fish. Though still widespread, there have been numerous local extirpations reported throughout the Columbia River basin. Although some strongholds still exist, bull trout generally occur as isolated sub-populations in headwater lakes or tributaries where migratory fish have been lost. Although the bull trout distribution in the Coastal- Puget Sound population is less fragmented than the Columbia River population, bull trout subpopulation distribution within individual river systems has contracted and abundance has declined (USFWS 2005).

4.4.1.1.4 Distribution

Bull trout are native to the Pacific Northwest and western Canada and have historically occurred in major river drainages from about 41°N to 60°N latitude. They range from the southern limits in the McCloud River in northern California and the Jarbidge River in Nevada north to the headwaters of the Yukon River in the Northwest Territories, Canada (USFWS 2003a). The range includes Puget Sound, various coastal rivers of Washington, British Columbia, and southeast Alaska (USFWS 2003a). Bull trout are common in the nearshore areas of Puget Sound, but very little is known about their overall oceanic distribution (NMFS-NWR 2004a).

4.4.1.1.5 Impacts of Human Activity

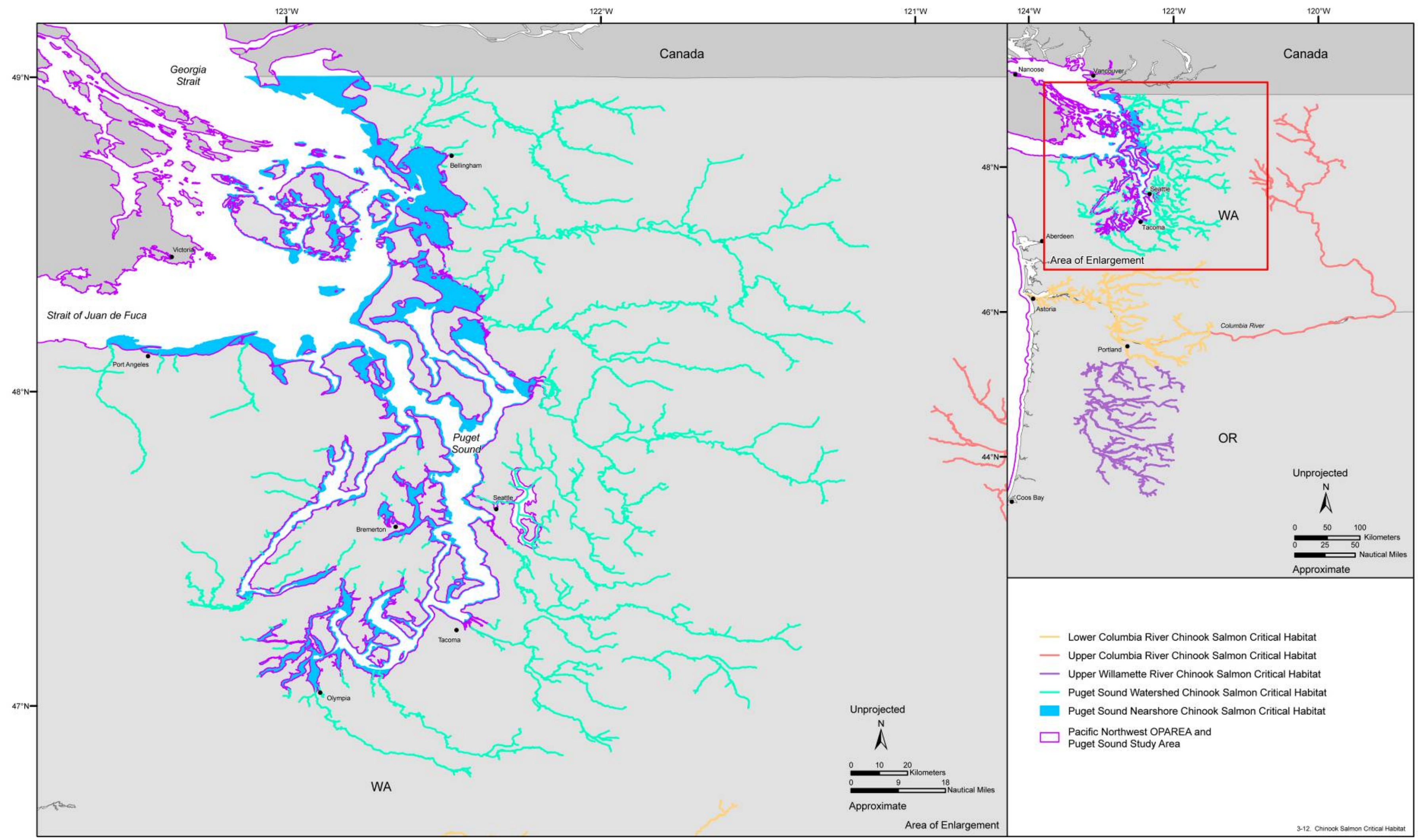
For the Puget Sound management unit historic uses, especially water diversions, hydropower development, forestry, agriculture, fisheries management and residential and urban development within the core areas, may have significantly reduced populations of bull trout. Lasting effects from some, but not all, of these early land and water developments still act to limit bull trout production in core areas. Threats from current activities include aspects of operation and maintenance of dams and other diversion structures, forest management practices, agriculture practices, road construction and maintenance, and residential development and urbanization. The presence of non-native species such as brook trout continue to pose a threat through competition, hybridization, and potential predation in some core areas (USFWS 2004c). Various combinations of these same factors have affected other bull trout populations throughout its range.

4.4.1.2 Chinook Salmon (*Oncorhynchus tshawytscha*), Puget Sound/California Coastal/Lower Columbia River ESUs

4.4.1.2.1 Regulatory Status

The NMFS identified 17 ESUs of chinook salmon in Washington, Oregon, Idaho, and California. Each ESU is treated as a separate species under the ESA (NMFS 2005c). Of these ESUs, two are endangered (Sacramento River winter-run and Upper Columbia River spring-run), seven are threatened (Snake River spring/summer-run, Snake River fall-run, Central Valley spring-run, California coastal, Puget Sound, Lower Columbia River, and Upper Willamette River), and one is listed as a species of concern (Central Valley fall-and late fall-run; NMFS 2005h; NMFS 2005c).

Critical habitat has been designated for three ESUs in the OPAREA, which are the California Coastal ESU, Lower Columbia River ESU, and Puget Sound ESU (Figure 4-7). Factors that define critical habitat (PCEs) for these ESUs are listed in Table 5-9. They include both freshwater and estuarine areas that address water quality and quantity, natural cover for different life stages, and availability of adequate forage resources.



Source: Marine Resources Assessment for the Pacific Northwest Operating Area (2006).

Figure 4-7. Critical Habitat for Chinook Salmon, Puget Sound ESU

4.4.1.2.2 Habitat Preferences

Chinook salmon are found in freshwater to euhaline waters from the surface to depths of 820 ft (250 m) depending on life stage. They spawn in rivers at depths ranging from the surface to 33 ft (10 m) with a preferred depth of greater than 0.8 ft (0.24 m) for spring and fall salmon and greater than 1.0 ft (0.30 m) for summer salmon (Beauchamp et al. 1983). The depth of the redd is inversely related to water velocity (PFMC 2000). Juvenile chinook range from the surface to 3.9 ft (1.2 m) while inhabiting streams, lakes, sloughs, and rivers and continue to stay near the surface during their initial marine stages (Beauchamp et al. 1983; PFMC 2000). After juveniles have advanced past the initial marine phase, they prefer depths ranging from 98 to 230 ft (30 to 70 m) and are often associated with bottom topography (PFMC 2000). Late juveniles and adults may be pelagic, neustonic, or semi-demersal/semi-pelagic (PFMC 2000).

Chinook salmon may be found in water temperatures ranging from 32° to 79°F (0° to 26°C) but this varies depending on lifestage and activity (MBC 1987). Adult chinook salmon prefer water temperatures less than 57°F (14°C) but can survive in deep pools in the summer with surface temperatures of 73°F (23°C) (Beauchamp et al. 1983; PFMC 2000). Chinook cannot spawn at temperatures above 72°F (22°C) (Beauchamp et al. 1983). Ideal spawning temperatures range from 42° to 57°F (5.6° to 13.9°C) but spawning can occur from 40° to 64°F (4.4° to 18.0°C) (Beauchamp et al. 1983).

Adult chinook salmon spawn in gravel ranging from 2 to 5 in (6 to 14 cm) in diameter. Gravel substrates range from 0.5 to 4.0 in (1.3 to 10.2 cm) in diameter (Beauchamp et al. 1983). Chinook salmon require enough current on spawning beds to ventilate the eggs during incubation (Beauchamp et al. 1983). No substrate preference has been documented for adults in the marine environment (Beauchamp et al. 1983).

As chinook salmon grow they move from shallow littoral habitats into deeper river channels inhabiting pools, riffles, off-channel habitat, and undercut banks. Large woody debris or boulder structures provide cover and shelter from predation and storm events. Riparian vegetation provides the following to chinook salmon rearing: shade for temperature regulation, vegetation inputs for food resources, and stream bank stabilization from roots and large woody debris recruitment. Fry and smolt inhabit freshwater from 1 to 18 months (Beauchamp et al. 1983). Timing of migration to seawater for juveniles is highly variable (PFMC 2000). Ocean-type juveniles may migrate to the ocean immediately after hatching but most remain in freshwater for 30 to 90 days (PFMC 2000). Some chinook migrate seaward as fingerlings in the late summer of their first year while others, particularly in less-productive or cold-water systems, migrate as young-of-the-year fish (PFMC 2000). Significant variations of fingerling and yearling migrants within a population may occur from year to year (PFMC 2000). Ocean-type juveniles typically inhabit estuaries for several months before migrating to higher salinity waters (PFMC 2000). Fry enter the upper reaches of estuaries in late winter for the more southern populations or early spring for the more northern populations (PFMC 2000). Regardless of time of entry, ocean-type chinook spend from one to three months in estuaries (PFMC 2000). Smaller fry prefer more protected, lower salinity habitats. As fish get larger, they gradually leave the well protected habitats for higher salinity waters (PFMC 2000).

The primary food source for chinook salmon in freshwater habitats is postulated to be adult and larval insects (Healey 1991). Diets vary considerably from estuary to estuary but chinook utilize a wide range of prey including: gammarid amphipods, insects, mysids, isopods, copepods, and fish larvae (Beauchamp et al. 1983; Healey 1991). As chinook grow and move into marine environments, their diets shift to consist of crab zoea, rockfish, Pacific sand lance, eulachon, herring, anchovy, copepods, euphausiids, cephalopods, isopods, and amphipods (Beauchamp et al. 1983).

4.4.1.2.3 Population Size and Trends

Puget Sound was once home to more populations of Chinook salmon with a greater diversity of traits than present today. There are currently 22 Chinook populations remaining. It is hard to know precisely, but scientists believe Puget Sound has lost over 15 Chinook salmon runs and most of those losses were runs that returned in the spring to their spawning grounds. Currently, Puget Sound Chinook salmon are at only

10 percent of historic numbers; in some river basins that goes down to 1 percent and this is during favorable ocean conditions (USFWS 2004 Chinook salmon recovery plan).

4.4.1.2.4 Distribution

The chinook salmon's historical range in North America extended from the Ventura River in California to Point Hope, Alaska (Myers et al. 1998). The natural freshwater range for chinook salmon extends throughout the Pacific Rim of North America. This species has been identified from the San Joaquin River in California to the Mackenzie River in northern Canada (Healey 1991). The oceanic range encompasses Washington, Oregon, California, throughout the north Pacific Ocean, and as far south as the U.S./Mexico border (PFMC 2000). The majority of stream-type chinook stocks are found in Alaska, north of 56°N and ocean-type chinook are more common near the center of the species range (Healey 1991).

In the PACNORWEST OPAREA, the early life history stages for chinook occur in freshwater, but juveniles and adults utilize marine habitats. Juvenile chinook prefer coastal areas (less than 30 nm [55 km] from shore) throughout Washington, Oregon, and California north to the Strait of Georgia and the Inland Passage, Alaska. The majority of marine juveniles are found within 15 nm (28 km) of the coast. They tend to concentrate around areas of pronounced coastal upwellings. Populations originating north of Cape Blanco, Oregon migrate north to the Gulf of Alaska, while populations originating south of Cape Blanco migrate south and west into the waters off California and Oregon. Chinook salmon spawning in rivers south of the Rogue River in Oregon rear in marine waters off California and Oregon, whereas, salmon spawning in rivers north of the Rogue River migrate north and west along the Pacific coast. In the Fraser and Columbia rivers, adult chinook enter freshwater between March and November, with peaks in spring (March through May), summer (May through July), and fall (August through September). Sacramento River winter-run salmon enter freshwater between December and July (PFMC 2000).

Chinook salmon exhibit one of the more diverse and complex life history strategies of all Pacific salmon and are separated into two generalized life-history types: stream-type and ocean-type fish (Myers et al. 1998; PFMC 2000). The majority of stream-type chinook stocks are found in Alaska, north of 56°N (Healey 1991). For a year or more, they reside as fry or parr in freshwater where they exhibit downstream dispersal and utilize a variety of freshwater rearing environments before migrating to sea (Healey 1991). They perform extensive offshore oceanic migrations and return to their natal river during the spring and early summer, several months prior to spawning (Healey 1991). Ocean residency varies but may last from one to six years (Healey 1991). Stream-type adults often enter freshwater in the spring and summer as immature "bright" fish and spawn in upper watersheds in late summer or early fall (PFMC 2000). Stream-type life history strategies, with long rearing periods that require more stable or less degraded habitats, may be adapted to watersheds or parts of watersheds that are more productive and less susceptible to dramatic changes in water flow, as (Healey 1991). ESUs with stream-type life history strategies include: upper Columbia River spring ESU; and Snake River spring/summer ESU (Myers et al. 1998).

Ocean-type chinook are found near the center of their species range and migrate to the ocean within the first year (typically within a few months) after emergence where they spend an average of four to five years (Myers et al. 1998; PFMC 2000; Augerot and Foley 2005). Estuaries may be more important than freshwater environments in the life history of ocean-type chinook due to longer time spent there (PFMC 2000). Juvenile chinook utilize estuaries for rearing, physiological transition, and refugia, and tend to congregate in areas where estuary morphology favors detritus retention, such as weed beds, salt marshes, and braided or meandering channels (Healey 1991). Ocean-type chinook salmon spend most of their ocean life in coastal waters, and return to their natal river during the spring, summer, fall, late fall and winter (Healey 1991). Ocean-type chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of rivers, and spawn within a few days or weeks of freshwater entry (Healey, 1991). ESUs with ocean-type life history strategies include the Puget Sound and Lower Columbia River ESUs (Myers et al. 1998).

4.4.1.2.5 Impacts of Human Activity

Human activity has substantially affected Chinook salmon populations throughout the Study Area. Recognizing the importance of Chinook and other salmon species to the environmental, cultural, and economic welfare of the region, numerous governmental and non-governmental organizations have initiated protection and restoration activities to help recover the species. The plans are generally organized by watershed to recognize the importance of an ecosystem approach for managing salmon populations. Although each watershed area presents individual threats to Chinook salmon populations, there are common threats to all watersheds that affect salmon. The magnitude of each threat varies by watershed. Common threats include (1) loss of estuarine habitats and functions to development; (2) loss of floodplain rearing and refuge areas; (3) loss of riparian buffer zones and associated rearing habitats along streams; (4) streamflow diversions that reduce water quantity and alter historic flow patterns; (5) water quality and pollution, especially stormwater runoff from developed areas and eroded sediments from agricultural lands; (6) development of physical barriers that block salmon access to spawning and rearing habitats; (7) loss of marine shoreline habitat to shoreline development; (8) excess commercial and recreational harvests; (9) consequences of hatchery releases on native stock genetics and fitness; and (10) hydropower generation.

4.4.1.3 Chum Salmon (*Oncorhynchus keta*), Hood Canal/Columbia River ESUs

4.4.1.3.1 Regulatory Status

There are currently four ESUs of chum, two of which (Hood Canal Summer-run and the Columbia River) have been designated as threatened (NMFS 2005h; NMFS 2005c). The Puget Sound/Strait of Georgia and Pacific Coast ESUs have not yet warranted a designation of threatened or endangered (NMFS 2005c; NMFS 2005h).

Figure 4-8 shows critical habitat for the chum salmon Hood Canal summer run and the Columbia River ESUs. Factors that define critical habitat (PCEs) for these ESUs are listed in Table 5-9. They include both freshwater and estuarine areas that address water quality and quantity, natural cover for different life stages, adequate spawning sites, unobstructed migration corridors, and availability of adequate forage resources.

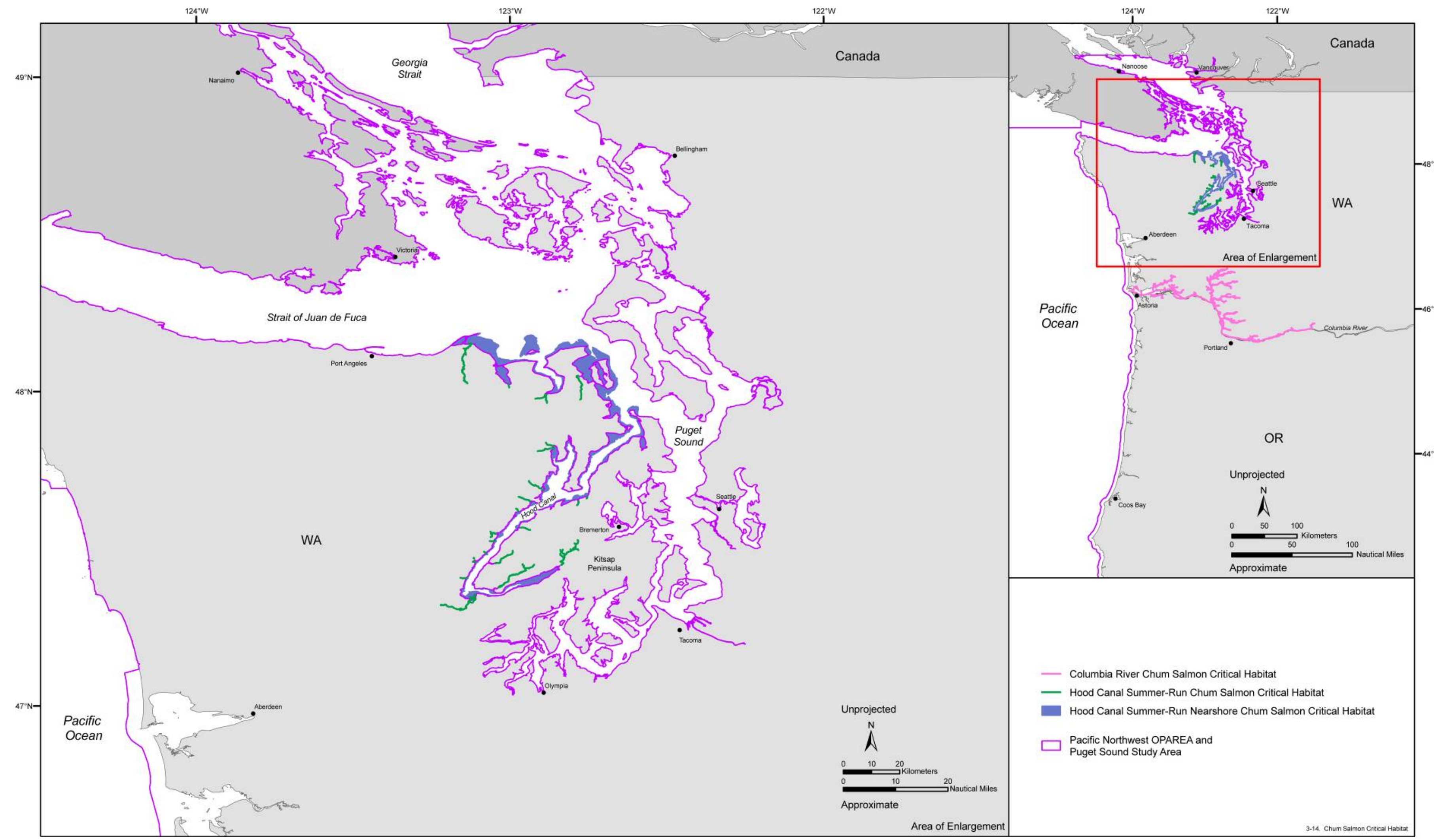
4.4.1.3.2 Habitat Preferences

Chum salmon are found in fresh water to euhaline water at depths ranging from the surface to 820 ft (250 m). Juveniles are primarily epipelagic and are found from the surface down to 312 ft (95 m) (Emmett et al. 1991). Chum salmon are found at a wide range of temperatures from 37° to 72°F (3° to 22°C) but prefer temperatures from 47° to 60°F (8.3° to 15.6°C) (Pauley et al. 1988). Eggs, alevins, fry, and parr inhabit freshwater while juveniles and adults are anadromous (Salo 1991). Juveniles and adults are found over a variety of substrates (Emmett et al. 1991).

Chum salmon fry feed on chironomid larvae if they spend extended periods in fresh water (Emmett et al. 1991). Juveniles initially feed on harpacticoid copepods and gammarid amphipods in shallow waters but may also prey upon terrestrial insects and small crustaceans (Emmett et al. 1991). Food limitations may cause juveniles to shift to more pelagic prey such as calanoid copepods, hyperiid amphipods, crustacean larvae, and larvaceans (Emmett et al. 1991). In marine environments, juveniles and subadults feed on euphausiids, squids, pteropods, and fishes (Emmett et al. 1991).

4.4.1.3.3 Population Size and Trends

In 1993, Washington and western Washington Treaty Tribes published the first state-wide comprehensive inventory of salmon and steelhead stocks. In total, the inventory identified 435 different stocks of salmon and steelhead, and the current status of each stock was reported. For chum salmon, 72 stocks were described for Washington, the majority of which were located in the Puget Sound region.



Source: Marine Resources Assessment for the Pacific Northwest Operating Area (2006).

Figure 4-8. Critical Habitat for Chum Salmon, Hood Canal Summer-Run ESU

A total of 55 separate stocks of chum salmon were identified in the Puget Sound region. The general status of these stocks is one of robust health, with a large majority of the stocks (38 total) in the "healthy" category. Thirteen stocks were of "unknown" status because of the lack of abundance data, however, these stocks are typically naturally small populations that represent a small fraction of the region's chum salmon. The four summer-run stocks in Hood Canal and the Strait of Juan de Fuca were all of either depressed or critical status; a notable exception to the otherwise positive picture for Puget Sound chum salmon.

In December of 1997, NMFS published a coast-wide chum salmon status review. This was the first step in determining if any chum salmon population groups were candidates for listing as "threatened" or "endangered" under the ESA. For the Puget Sound region two groups of chum salmon populations (ESUs) were identified: the Puget Sound/Strait of Georgia ESU, and the Hood Canal Summer-Run ESU. The Puget Sound/Strait of Georgia ESU includes nearly all of the chum salmon stocks of the Puget Sound region: 51 of the 55 total stocks identified in the inventory. NMFS concluded in the status review that:

"...this ESU is neither presently at risk of extinction nor likely to become endangered in the foreseeable future. Current abundance is at or near historic levels, with a total run size averaging more than 1 million fish annually in the past 5 years. The majority of populations within this ESU have stable or increasing population trends, and all populations with significantly significant trends are increasing."

The Hood Canal Summer-Run ESU includes four summer run chum salmon SASSI stocks from Hood Canal and Strait of Juan de Fuca streams. NMFS concluded that this ESU is in danger of extinction, and further stated that for the summer chum populations in twelve streams in Hood Canal;

> "... five may already have become extinct, six of the remaining seven showed strong downward trends in abundance, and all were at low levels of abundance. The populations in Discovery Bay and Sequim Bay were also at low levels of abundance with declining trends."

In March 1999, NMFS formally listed the Hood Canal Summer-Run ESU as a threatened population. (Washington Department of Fish and Wildlife 2008 at http://wdfw.wa.gov/fish/chum/chum-5a.htm).

4.4.1.3.4 Distribution

Chum salmon have the largest range of natural geographic and spawning distribution of all the Pacific salmon species (Pauley et al. 1988). Historically, in North America, chum salmon occur from Monterey, California to the Arctic coast of Alaska and east to the Mackenzie River which flows into the Beaufort Sea. Present spawning populations are now found only as far south as Tillamook Bay on the northern Oregon coast (Salo 1991). Juvenile chum occur along the coast of North America and Alaska in a band that extends out to 19 nm (36 km) (Salo 1991). Chum salmon are more dependent on estuaries and marine waters than the other Pacific salmon species with the exception of ocean-type chinook salmon (Salo 1991).

In the PACNORWEST OPAREA the early life history stages for chum salmon occur in freshwater but juveniles and adults utilize marine habitats within the PACNORWEST OPAREA. Chum salmon runs occur in the Washougal, Lewis, Kalama, and Cowlitz watersheds in Washington. Chum salmon spawning runs can be grouped into three seasonal runs; summer, fall and winter. The chum salmon of the Columbia River chum salmon ESU enter freshwater to spawn from early October to mid-November, with a peak return in early November. Peak spawning occurs in late November and is usually complete by early December (WDFW 1993). Hood Canal ESU summer chum salmon enter freshwater to spawn from August to mid-September (WDFW 1993). Hood Canal summer chum salmon spawning periods vary from August 15 through early October, dependent upon the watershed (WDFW 1993).

Chum salmon are highly migratory with fry heading seaward immediately after emergence (Salo 1991). Chum do not have the clearly defined smolt stages that occur in other salmonids; however they are capable of adapting to seawater soon after emergence from the gravel (Salo 1991). Outmigrations of juvenile chum is correlated with the warming of nearshore waters (Salo 1991). They migrate to estuaries during their first spring or summer and spend little time rearing in freshwater (Pauley et al. 1988). Juveniles enter estuaries from March to mid-May where they remain for several months (Emmett et al. 1991). Juveniles may be found in estuaries off the coast of Washington from January through July (Emmett et al. 1991). As chum salmon grow, there is a general movement toward the ocean moving offshore from April to June (Emmett et al. 1991). They then head north along the continental shelf until they reach the Gulf of Alaska; however, some populations never leave Puget Sound (Emmett et al. 1991). Adults return to their natal streams at various ages but generally within two to five years (Salo 1991). For chum salmon, two spawning stocks exist; a northern stock that spawns from June to September and a southern (late-run) stock that spawns from August to January (Emmett 1991). Washington, Oregon, and California stocks are all late-run populations (Emmett 1991).

4.4.1.3.5 Impacts of Human Activity

Human activity has substantially affected chum salmon populations throughout the Study Area. Recognizing the importance of chum and other salmon species to the environmental, cultural, and economic welfare of the region, numerous governmental and non-governmental organizations have initiated protection and restoration activities to help recover the species. The plans are generally organized by watershed to recognize the importance of an ecosystem approach for managing salmon populations. Although each watershed area presents individual threats to chum salmon populations, there are common threats to all watersheds that affect salmon. The magnitude of each threat varies by watershed. Common threats include (1) loss of estuarine habitats and functions to development; (2) loss of floodplain rearing and refuge areas; (3) loss of riparian buffer zones and associated rearing habitats along streams; (4) streamflow diversions that reduce water quantity and alter historic flow patterns; (5) water quality and pollution, especially stormwater runoff from developed areas and eroded sediments from agricultural lands; (6) development of physical barriers that block salmon access to spawning and rearing habitats; (7) loss of marine shoreline habitat to shoreline development; (8) excess commercial and recreational harvests; (9) consequences of hatchery releases on native stock genetics and fitness; and (10) hydropower generation.

4.4.1.4 Coho Salmon (*Oncorhynchu kisutch*), Oregon Coast/Northern California-Southern Oregon ESUs

4.4.1.4.1 Regulatory Status

There are currently seven ESUs of coho salmon in Washington, Oregon, and California (NMFS 2005h; NMFS 2005c). Of these ESUs, one is endangered (Central California Coast), and three are threatened (Northern California-Southern Oregon Coasts, Lower Columbia River and Oregon Coast; NMFS 2005c; NMFS 2005h, NMFS 2008/OR Coast).

Critical habitat is designated for two ESUs that occur in the OPAREA, the Northern California-Southern Oregon ESU and the Oregon Coast ESU. Figure 4-9 shows critical habitat for these coho salmon ESUs. Factors that define critical habitat (PCEs) for these ESUs are listed in Table 5-9. They include freshwater, estuarine, and nearshore areas that address water quality and quantity, natural cover for different life stages, adequate freshwater spawning and rearing sites, unobstructed migration corridors, and availability of adequate forage resources.

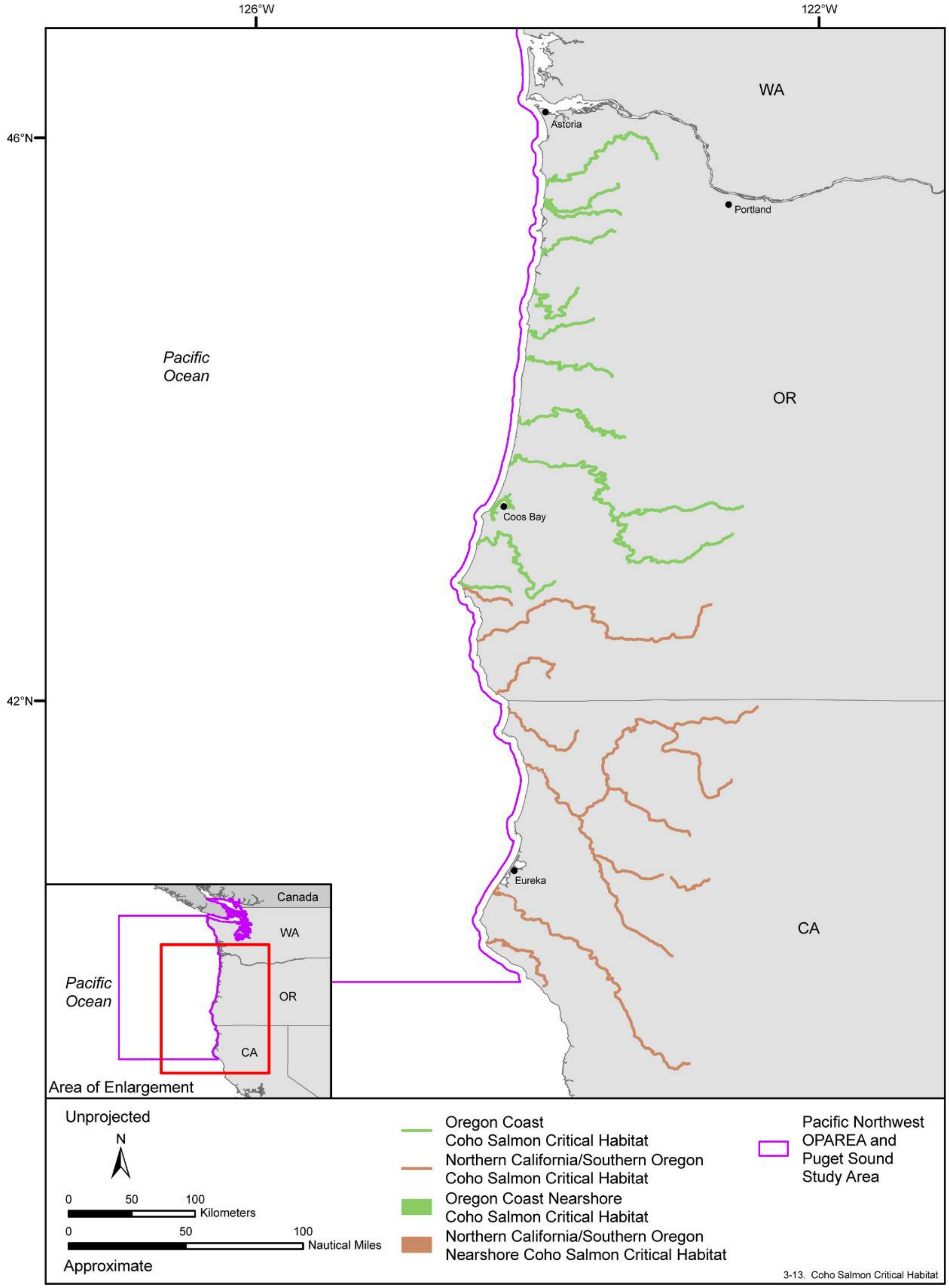


Figure 4-9. Critical Habitat for Coho Salmon ESUs in the NWTRC OPAREA

4.4.1.4.2 Habitat Preferences

Coho salmon are found in fresh water to euhaline water at depths ranging from the surface to 820 ft (250 m). In marine environments, both juveniles and adults stay within 33 ft (10 m) of the surface unless water conditions are considerably warm (Emmett et al. 1991). Eggs and alevins are found buried in gravel bottoms from 3 to 5 in (8 to 15 cm) deep (MBC 1987). Adult coho need a minimum water depth of 7 in (18 cm) to spawn (Laufle et al. 1986). Fry and smolt prefer variable depths with fry ranging from 12 to 48 in (0.3 to 1.2 m), generally associated with submerged riffle areas. Avoidance of strong currents and predators seems to be the most important factor in determining habitat for young fish (Laufle et al. 1986; PFMC 2000).

Smolts, subadults, and adults migrate over a variety of substrates. Cover availability is more important than substrate selection for juvenile coho. Spawning occurs on beds composed of gravel ranging from 0.5 to 4.0 in (1.3 to 10.2 cm) in diameter and, unlike other salmon, coho redd can contain approximately 10 percent mud (Emmett et al. 1991).

Adult coho migrate into streams where they deposit their eggs in gravel. Adult coho salmon die soon after spawning. Eggs incubate throughout the winter and emerge in the spring as free-swimming fry. The fry reside in the stream for a year or more when they begin migrating toward the ocean as smolt. Juveniles spend a minimum of 18 months at sea before returning to their natal streams to repeat the process (Sandercock 1991).

Migration upstream generally occurs when temperatures range from (45° to 60°F (7.2° to 15.6°C), depths are greater than 7 in (18 cm), and water velocity is less than 8 ft/sec (2.44 m/sec) (Sandercock 1991). Juveniles reside in freshwater for about a year (longer in northern streams) before migrating to the ocean (Emmett et al. 1991; PFMC 2000). Most juvenile migration occurs from April to August with a peak in May (Emmett et al. 1991). Generally, higher latitudes result in an increase in estuarine residency time for juveniles (PFMC 2000). Upon entering the ocean, coho may spend several weeks or their entire first summer in coastal waters before migrating north. The later dispersal pattern is the most common within the Study Area (PFMC 2000). Tag, release, and recovery studies suggests that coho salmon of California origin can be found as far north as southeast Alaska and salmon from Oregon and Washington as far north as the northern Gulf of Alaska (PFMC 2000).

Coho salmon are opportunistic feeders with a diet that reflects the availability of the prey in their area. Emerging fry feed on a variety of invertebrates including spiders, mites, and snails. Parr feed on invertebrates and possibly other salmon in stream environments, but in reservoirs their diets consists of zooplankton, insects, and amphipods. Juveniles feed on amphipods, insects, mysids, decapod larvae, and larval and juvenile fishes in estuarine environments. Ocean-dwelling coho initially feed on decapod larvae, gammarid and hyperiid amphipods, euphausiids, terrestrial insects, copepods, cephalopods, Cnideria, gastropods, planktonic annelids, and larval and juvenile fishes. As juveniles get larger they become more piscivorous, feeding on northern anchovy, Pacific herring, Pacific sardine, juvenile scorpaenids, capelin , and other fish species (Emmett et al. 1991).

4.4.1.4.3 Population Size and Trends

The estimated historical abundance of this ESU is 150,000 fish. The recent mean abundance is 5,170 fish, which is the highest such abundance since 1980. Information on the abundance and productivity trends for the naturally spawning component of the California portion of this coho ESU is extremely limited. No long-term time series of spawner abundance exist for individual river systems. The limited trend data for the California portion of the ESU show a flat or continuing decline in abundance (NMFS 2008). The overall ESU trend since the time of listing or first review shows that productivity has remained unchanged, and population abundance has remained unchanged (NMFS 2008d).

4.4.1.4.4 Distribution

Coho salmon are found in freshwater drainages from Monterey Bay, California north along the west coast of North America to Alaska, around the Bering Sea south through Russia to Hokkaido, Japan (CDFG 2002). Oceanic lifestages can be found from Camalu Bay, Baja California north to Point Hope, Alaska and from there, south to Korea (MBC 1987; Sandercock 1991). In the northeastern Pacific, coho can be found south of 40°N, but only in the coastal waters of the California Current (MBC 1987).

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Juvenile coho are generally found within 32 nm (60 km) of the Washington, Oregon, and California coasts but the majority are found within 20 nm (37 km) (PFMC 2000). Tagging studies have shown coho originating from Washington and Oregon as far north as 60°N latitude and coho originating from California as far north as 58°N latitude (PFMC 2000). Oregon coho have been taken in offshore waters near Kodiak Island in the northern Gulf of Alaska. Westward migration of coho salmon appears to extend beyond the EEZ beginning at approximately 45°N latitude off the coast of Oregon (PFMC 2000). In strong upwelling years coho are more dispersed offshore, whereas in weak upwelling years they concentrate near submarine canyons and areas of consistent upwelling.

In the PACNORWEST OPAREA, early life history stages for coho salmon occur in freshwater, but juveniles and adults utilize marine habitats. Coho from Washington, Oregon, and California, typically remain in coastal waters near their natal stream for at least their first summer before migrating north (PFMC 2000). About 3 to 5 percent of the naturally produced yearly coho within Puget Sound and the Strait of Georgia will reside in the Strait of Juan de Fuca throughout their entire ocean residency while others will migrate to the open ocean in late summer (Emmett et al. 1991; PFMC 2000). Puget Sound populations are generally found in the Strait of Juan de Fuca and the coastal waters of Vancouver Island during the summer months (PFMC 2000). As populations leave Puget Sound they can be found migrating northward along the east or west coast of Vancouver Island and out into the Pacific Ocean (PFMC 2000). Coho migrating from Oregon streams may initially be found south of their natal streams due to strong southerly currents (PFMC 2000). These currents weaken during the winter months and the salmon migrate northward (PFMC 2000).

4.4.1.4.5 Impacts of Human Activity

This coho salmon ESU has declined in abundance over the past several decades as a result of loss of, and damage or change to the natural environment. Water diversions for agriculture, flood control, domestic, and hydropower purposes have greatly reduced or eliminated historically accessible habitat and degraded the remaining habitat. Forestry, agriculture, mining, and urbanization have degraded, simplified, and fragmented habitat. The destruction or modification of estuarine areas has resulted in the loss of important rearing and migration habitats. Oregon wetlands are estimated to have diminished by 33 percent, and California wetlands by over 80 percent. Habitat fragmentation and loss of habitat complexity have also contributed to the decline of this ESU. Sedimentation from historic and current extensive and intensive land use activities is recognized as a primary cause of habitat degradation throughout the range of this ESU. Most of the primary producing rivers in the range of the ESU were designated as impaired (primarily due to sediment and water temperature) under the Clean Water Act (CWA) by the U.S. Environmental Protection Agency (EPA) in the 1990s (NMFS 2008d).

The following human activity limiting factors, and their level of threat to this coho salmon ESU, were identified in the 2006 Pacific Coastal Salmonid Restoration Fund Report to Congress: (1) degraded estuarine and nearshore marine habitats (moderate threat); (2) degraded floodplain habitat, connectivity, and function (high threat); (3) degraded channel habitat, structure, and complexity (moderate to high threat); (4) degraded riparian habitat areas and large-woody debris recruitment: (high threat); (5) degraded stream substrate habitat (moderate threat); (6) degraded stream flow (moderate to high threat); (7) degraded water quality (moderate threat); (8) degraded fish passage (moderate threat); (9) hatchery-related adverse effects (very low threat); (10) harvest-related adverse effects (low threat); and (11) predation/competition/disease (moderate to high threat) (NMFS 2008d).

4.4.1.5 Steelhead Trout (*Oncorhynchus mykiss*), Northern California/Central California Coastal/Lower Columbia River ESUs

4.4.1.5.1 Regulatory Status

There are currently 15 ESUs identified for steelhead trout in Washington, Oregon, Idaho, and California (NMFS 1997a). Ten of these ESUs have designations of either endangered or threatened and have designated critical habitat (NMFS 2005h; NMFS 2005c). The Southern California and Upper Columbia River ESUs are designated as endangered. The ESUs listed as threatened include the Snake River Basin (Idaho), Middle Columbia River, Lower Columbia River, Upper Willamette River, South-Central California Coast, Central California Coast, Northern California, and California Central Valley (NMFS 2005h; NMFS 2005c).

Critical habitat is designated for three ESUs that occur in the OPAREA, the Northern California, Central California Coastal, and the Lower Columbia River ESUs. Figure 4-10 shows critical habitat for these steelhead trout ESUs. Factors that define critical habitat (PCEs) for these ESUs are listed in Table 5-9. They include freshwater and estuarine areas that address water quality and quantity, natural cover for different life stages, adequate freshwater spawning and rearing sites, unobstructed migration corridors, and availability of adequate forage resources.

In North America, steelhead are split into two phylogenetic groups, inland and coastal with both occurring in Washington, Oregon and British Columbia (Busby et al. 1996). Coastal steelhead occur in a diverse array of populations in Puget Sound, coastal Washington and the lower Columbia River with modest genetic differences between populations (Busby et al. 1996). Inland steelhead are represented only by populations in the Columbia and Fraser river basins, and consistent genetic differences have been found between populations in the Snake and Columbia rivers (Busby et al. 1996).

4.4.1.5.2 Habitat Preferences

Steelhead are found in fresh water to euhaline water at depths ranging from the surface to 656 ft (200 m). Water temperatures vary with lifestage; 50°F (10°C) is optimum with an upper limit of 75°F (24°C) (Pauley et al. 1986; Froese and Pauly). Eggs, alevins, fry, and parr inhabit freshwater while juveniles and adults may be anadromous or may remain in freshwater. Juveniles and adults occur over a wide variety of substrates and there seems to be no correlation between substrate and distribution.

4.4.1.5.3 Population Size and Trends

Little quantitative abundance information exists for most of these historic populations. The Russian River supports the largest spawning population of Central California Coast Steelhead, but its population is believed to have declined seven-fold since the mid-1960s (NMFS 2008e). Although data were relatively limited, analyses in 1996 and 2005 suggested (1) population abundances were low relative to historical estimates, (2) recent trends were downward, and (3) summer-run steelhead abundance was “very low.” (NMFS 2008e).

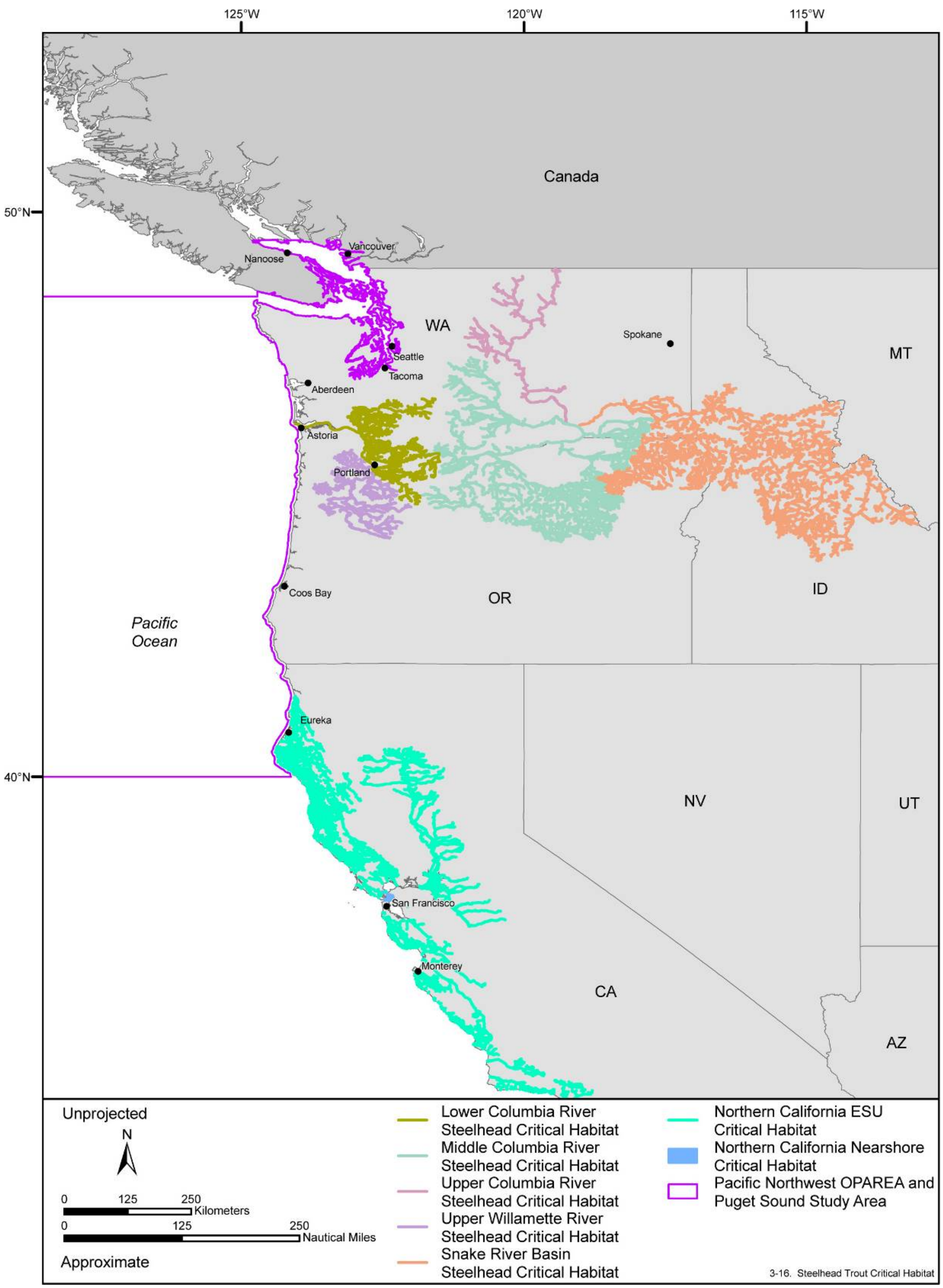

Figure 4-10. Critical Habitats for Steelhead Trout ESUs in the NWTRC OPAREA

4.4.1.5.4 Distribution

Steelhead trout are found from central California to the Bering Sea and Bristol Bay coastal streams of Alaska. Most streams in the Puget Sound region, and many Columbia and Snake river tributaries have populations of steelhead trout present (Pauley et al. 1986). In this region, steelhead are split into two phylogenetic groups, inland and coastal (Busby et al. 1996). These two groups both occur in Washington, Oregon and British Columbia (Busby et al. 1996), and are separated in the Columbia and Fraser systems in the vicinity of the crest of the Cascade Mountains. Coastal steelhead occur in a diverse array of populations in Puget Sound, coastal Washington and the lower Columbia River with modest genetic differences between populations (Busby et al. 1996). Inland steelhead are represented only by populations in the Columbia and Fraser river basins, and consistent genetic differences have been found between populations in the Snake and Columbia rivers (Busby et al. 1996).

In the PACNORWEST OPAREA and Puget Sound area, the early life history stages of the steelhead are found only in freshwater habitats and the later life history stages of the anadromous life form (i.e., juveniles and adults) utilize the marine environment. In Washington coastal populations, total age at maturity is typically 4 years, 2 years in freshwater and 2 years in the ocean. Puget Sound summer-run fish enter fresh water between May and October and spawning occurs anywhere from December to April of the following year. Puget Sound winter-run fish enter freshwater from December through May with peak spawning occurring between March and May of the following year. Steelhead smolts can be found in the nearshore marine environment from April to June (Busby et al. 1996).

For Columbia River Basin inland populations, total age at maturity is 4 years with 2 years in freshwater, 1 year in the ocean and 1 year in freshwater as an adult prior to spawning (Busby et al. 1996).

4.4.1.5.5 Impacts of Human Activity

Steelhead face a wider array of threats from human activity. These threats include loss of habitat critical to juvenile and smolt survival (e.g., loss of side channel and stream complexity), as well as threats from water impoundments, diversions, and water pollution from numerous sources.

The following human activity limiting factors, and their level of threat to this steelhead ESU, were identified in the 2006 Pacific Coastal Salmonid Restoration Fund Report to Congress: (1) degraded estuarine and nearshore marine habitats (high threat); (2) degraded floodplain habitat, connectivity, and function (moderate to high threat); (3) degraded channel habitat, structure, and complexity (moderate threat); (4) degraded riparian habitat areas and large-woody debris recruitment: (moderate threat); (5) degraded stream substrate habitat (moderate to high threat); (6) degraded stream flow (moderate threat); (7) degraded water quality (high threat); (8) degraded fish passage (moderate to high threat); (9) hatchery-related adverse effects (moderate threat); (10) harvest-related adverse effects (high threat); and (11) predation, competition, and disease (high threat) (NMFS 2008e).

4.4.1.6 Green Sturgeon (*Acipenser medirostris*), Southern and Northern DPSs

4.4.1.6.1 Regulatory Status

The NMFS identified two DPSs of green sturgeon: a Northern DPS consisting of populations in coastal watersheds northward of and including the Eel River, and a Southern DPS consisting of coastal and Central Valley populations south of the Eel River. The Northern DPS is not listed under the ESA, but is a Species of Concern (69 Federal Register 19975). On April 7, 2006, NMFS issued a Final Rule to list the Southern DPS as threatened under the ESA (70 Federal Register 17386).

On September 8, 2008, NMFS issued a Proposed Rulemaking to designate critical habitat for the Southern DPS (73 Federal Register 52084). Proposed critical habitat includes coastal U.S. marine waters within 360 ft (110 m) depth from Monterey Bay, California north to Cape Flattery, Washington, including the Strait of Juan de Fuca, but excludes Puget Sound (Figure 4-11).

Factors that define critical habitat (PCEs) for these ESUs are listed in Table 5-9. They include both freshwater and estuarine areas that address water quality and quantity, natural cover for different life stages, and availability of adequate forage resources.

4.4.1.6.2 Habitat Preferences

Adult green sturgeon migrate from the ocean to begin their spawning migrations in late February (Moyle et al. 1995); spawning occurs from March to July, with peak activity from mid-April to mid-June (Emmett et al. 1991). Females produce between 59,000 and 242,000 eggs (Van Eenennaam et al. 2006). Embryos have poor swimming ability and exhibit a strong drive to remain in contact with structure, preferring cover and dark habitats to open bottom and illuminated habitats in laboratory experiments (Kynard et al. 2005). Newly emerged green sturgeon larvae in the laboratory hatched six to nine days after fertilization (approximate incubation temperature of 60ºF [15ºC]). Juveniles grow rapidly, reaching 1 ft (300 mm) in length in one year and over 2 ft (600 mm) within two to three years (Nakamoto et al. 1995). Juveniles disperse into salt water between one and four years of age (Nakamoto et al. 1995).

Green sturgeon spend a large portion of their lives in coastal marine waters as subadults and adults between spawning episodes. Subadult males and females spend approximately 6 to 10 years (respectively) at sea before reaching reproductive maturity and returning to freshwater to spawn for the first time (Nakamoto et al. 1995). Adult green sturgeon spend between 2 to 4 years at sea between spawning events (Erickson and Webb 2007). Length at maturity for green sturgeon is estimated at 57 to 60 inches (145 to 152 cm) for 14- to 16-year old males and 64 to 65 inches (162 to 165 cm) for 16 to 20 year old females. There is evidence that green sturgeon inhabit certain estuaries on the northern California, Oregon, and Washington coasts during the summer, and inhabit coastal marine waters along the central California coast and between Vancouver Island, British Columbia, and southeast Alaska over the winter (Lindley et al. 2008). Adult and subadult green sturgeon in the Columbia River estuary, Willapa Bay, and Grays Harbor feed on shrimp, amphipods, clams, juvenile Dungeness crab, anchovies, sand lances, lingcod, and other fish (Moyle et al. 1995).

4.4.1.6.3 Population Size and Trends

No good data on current population sizes exists and data on population trends is lacking (www.nmfs.noaa.gov).

4.4.1.6.4 Distribution

The green sturgeon is an anadromous fish species that occupy freshwater rivers from the Sacramento River up through British Columbia. Spawning has been confirmed in three rivers: the Rogue River in Oregon (Erickson et al. 2002; Farr and Kern 2005), and the Klamath and Sacramento rivers in California (Moyle et al. 1992; California Department of Fish and Game 2002). Both Northern and Southern DPS green sturgeon occupy coastal estuaries and coastal marine waters from southern California to Alaska. As such, green sturgeon observed in coastal bays, estuaries, and coastal marine waters outside of natal rivers may belong to either DPS.

4.4.1.6.5 Impacts of Human Activity

A principal factor in the decline of the Southern DPS is the reduction of the spawning area to a limited section of the Sacramento River. Insufficient freshwater flow rates in spawning areas, contaminants (e.g., pesticides), bycatch of green sturgeon in fisheries, potential poaching (i.e., for caviar), entrainment by water projects, influence of exotic species, small population size, impassable barriers, and elevated water temperature likely pose a threat to this species.

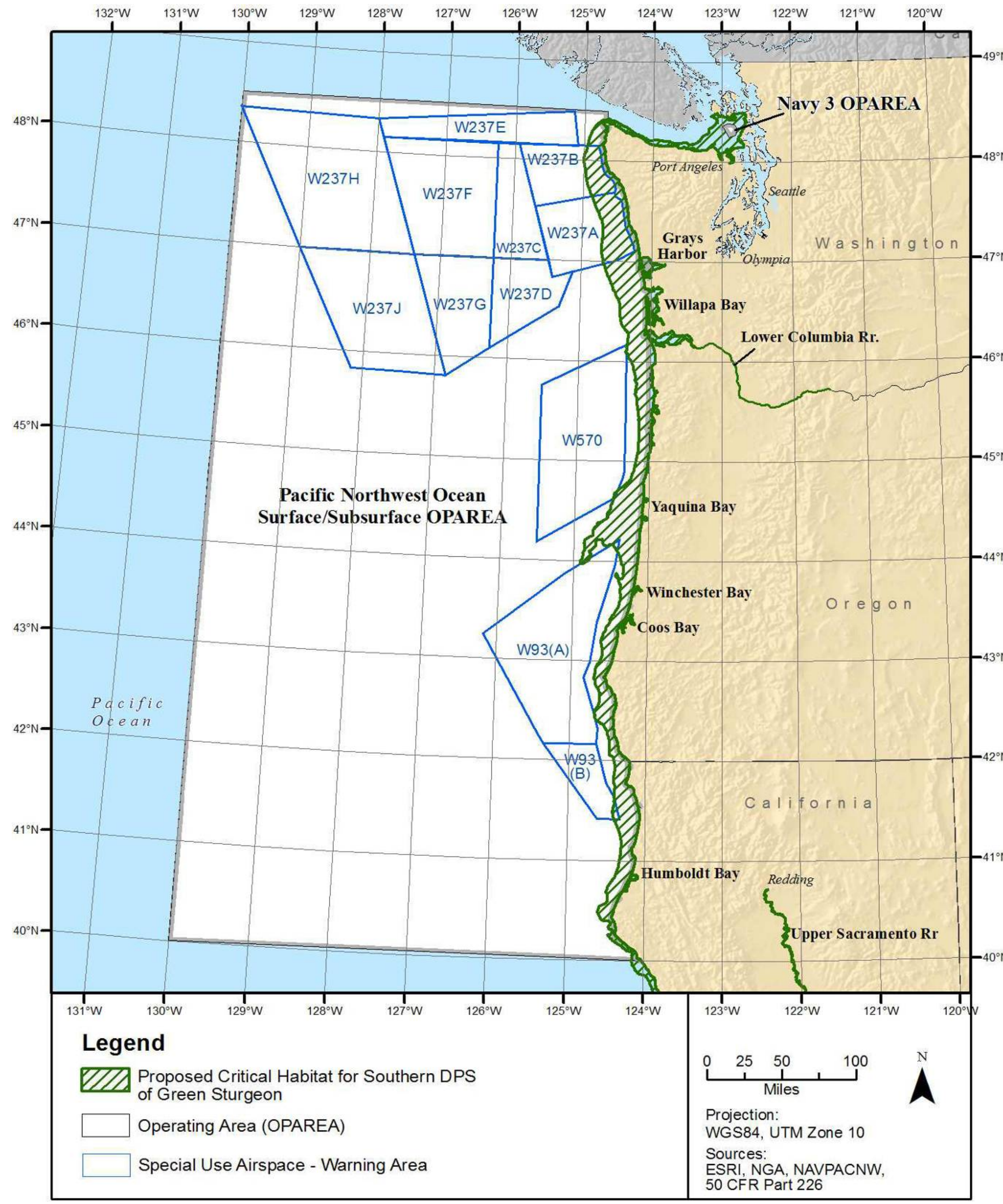

Figure 4-11. Proposed Critical Habitat for Green Sturgeon, Southern DPS

5 EFFECTS ON LISTED SPECIES

5.1 FACTORS USED TO ASSESS THE SIGNIFICANCE OF EFFECTS

This BE analyzes potential effects to listed threatened and endangered species in the context of the ESA. For purposes of ESA compliance, effects of the action were analyzed to make the Navy's determination of effect for listed species (that is either no effect or may affect). The definitions used in making the determination of effect under Section 7 of the ESA are based on the USFWS and NMFS *Endangered Species Consultation Handbook* (USFWS and NMFS 1998). “No effect” is the appropriate conclusion when a listed species will not be affected, either because the species will not be present or because the project does not have any elements with the potential to affect the species. “No effect” does not include a small effect or an effect that is unlikely to occur. If effects are insignificant (in size) or discountable (extremely unlikely), a “may affect” determination is appropriate. Insignificant effects relate to the magnitude or extent of the impact (*i.e.*, they must be small and would not rise to the level of a take of a species). Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

Provisions of the ESA require a determination of whether proposed federal actions may destroy or adversely modify critical habitat for listed endangered or threatened species. Critical habitat designation is based on the presence and condition of certain physical and biological habitat factors (PCEs) that are considered essential for the conservation of the listed species (USFWS and NMFS 1998; ESA §3(5)(A)(i); 50 CFR §424.12(b)).

For Navy compliance with these ESA provisions, an analysis was conducted of the potential effects of the Proposed Action to listed critical habitats in the NWTRC Study Area. The analysis evaluated whether training activities could destroy or adversely modify critical habitat. Factors used to make these determinations are based on whether proposed Navy actions are likely to change the biological or physical character of PCEs identified for species’ critical habitat. The species-specific PCEs are described in the FR announcement listing the final critical habitat designation for each species.

5.2 MARINE MAMMALS

Marine mammals can be affected by non-acoustic sources (for example, ship strikes) and acoustic sources, with sonar and underwater detonations being the primary acoustic concerns. The Navy has conducted, and is continuing to conduct, extensive research on the effects of sound on marine mammals, the modeling of sound effects to marine mammals in areas of Navy training activities, and methods of reducing adverse effects through improved detection of marine mammals and sound reduction.

The threatened and endangered species that may be affected by implementing the NWTRC activities include the blue whale, fin whale , humpback whale, sei whale, sperm whale, southern resident killer whale, Steller sea lion, and sea otter. The effects of mid-frequency sonar and underwater detonations on these species were modeled. The representative modeling areas, sound sources, model assumptions, acoustic and oceanographic parameters, underwater sound propagation and transmission models, and diving behavior of modeled species are described in detail in Appendix B of this BE. .

Although the North Pacific right whale could occur in the action area and may be affected by training activities, the likelihood of such occurrences are considered very low because of the low abundance and density of this species and the relatively low number of Navy training activities in the NWTRC. Thus, potential effects from non-acoustic and acoustic sources are considered extremely unlikely and therefore discountable for the North Pacific right whale.

Critical habitat has been designated for the southern resident killer whale in the Puget Sound area and the Steller sea lion for four locations along the California and Oregon coasts.

5.2.1 Acoustic Effects

The acoustic abilities of marine mammals are important in communicating with others of their species, navigating, foraging, and avoiding predators. Human activities that affect their hearing could have adverse consequences for their survival and recovery. The approach to estimating the potential acoustic effects of ASW training activities in the NWTRC on cetacean species uses methods that were developed for the Navy's Undersea Shallow Water Training Range Draft Oversea Environmental Impact Statement (EIS)/OEIS in cooperation with NOAA (DoN 2005). The method includes the following elements:

- Indicators of physiological effects,
- Sound energy measurement units,
- Regulatory framework,
- Physiological thresholds,
- Behavioral thresholds,
- Consideration of exposure duration and masking,
- Applicability of effect thresholds to a range of species, and
- An accepted acoustic effects analytical model.

This method is described in detail in Appendix B.

5.2.1.1 Physiological and Behavioral Effects of Noise

Sound exposure may affect more than one biological trait of a marine mammal. ESA regulations provide guidance on determining effects of noise on marine mammals. Specifically, injuries to the animals should be considered "harm." Behavioral disruption should be considered harassment. This guidance focuses on the traits that must be considered in establishing a biological framework for assessing effects.

The generally accepted biological framework is structured on the basis of the potential physiological and behavioral effects of sound exposure. The range of effects is then evaluated to determine which effects qualify as harm or harassment.

A physiological effect is one in which the "normal" physiological function of the animal is altered in response to sound exposure. Physiological function is any of a collection of processes, ranging from biochemical reactions to mechanical interactions to operation of organs and tissues. A physiological effect may range from a substantial adverse effect (e.g., mortality or serious injury) to lesser effects that define the lower end of the physiological effect range, such as the non-injurious distortion of auditory tissues.

A "behavioral effect" is one in which the "normal" behavior or patterns of behavior of an animal are overtly disrupted in response to an acoustic exposure. Examples of behaviors of concern can be derived from the harassment definitions in the ESA implementing regulations.

The term "normal" is used to qualify distinctions between physiological and behavioral effects. Its use follows the convention of normal daily variation in physiological and behavioral function without the influence of anthropogenic acoustic sources. The following definitions are used:

A physiological effect is a variation in an animal's physiology that results from an anthropogenic acoustic exposure, and exceeds the normal daily variation in physiological function.

A behavioral effect is a variation in an animal's behavior or behavior patterns that results from an anthropogenic acoustic exposure, and exceeds the normal daily variation in behavior, but which arises through normal physiological process (it occurs without an accompanying physiological effect).

The definitions of physiological effect and behavioral effect used here are specific to this BE, and should not be confused with more global definitions used in the field of biology.

Some physiological effects can be expected to cause subsequent behavioral effects. For example, a marine mammal that suffers a severe injury could alter its diving or foraging to the degree that its variation in these behaviors is outside the range that is considered to be normal for the species. If a physiological effect is accompanied by a behavioral effect, the overall effect is characterized as a physiological effect; physiological effects take precedence over behavioral effects with regard to their ordering. This approach provides the most conservative ordering of effects with respect to severity, provides a rational approach to dealing with the overlap of the definitions, and avoids circular arguments.

The severity of physiological effects generally decreases with decreasing sound exposure or increasing distance from the sound source. The same generalization does not consistently hold for behavioral effects because they do not depend solely on the received sound level. Behavioral responses also depend on an animal's learned responses, innate response tendencies, motivational state, the pattern of the sound exposure, and the context in which the sound is presented. To provide a tractable approach to predicting acoustic effects, however, this analysis assumes that the severities of behavioral effects also decrease with decreasing sound exposure or increasing distance from the sound source.

5.2.1.2 Harm and Harassment

Categorizing potential effects as either physiological or behavioral effects allows them to be related to the definitions of harm and harassment. For military readiness activities, harm includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Injury, defined in previous rulings (NOAA 2001; 2002), is the destruction or loss of biological tissue. The destruction or loss of biological tissue will alter a physiological function to a degree that exceeds the normal daily physiological variation of the intact tissue. For example, increased localized histamine production, edema, production of scar tissue, activation of clotting factors, or white blood cell response may be expected following an injury. All injury is qualified here as a physiological effect and, to be consistent with prior actions and rulings (NOAA 2001). All injuries (slight to severe) are considered harm for the purposes of the ESA.

For military readiness activities, harassment is defined as "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered." Both physiological and behavioral effects may cause harassment.

5.2.1.3 Auditory Tissues as Indicators of Physiological Effects

Exposure to continuous noise may cause a variety of physiological effects in mammals. For example, exposure to very high sound levels may affect the visual system, vestibular system, and internal organs (Ward 1997). Exposure to high-intensity, continuous sounds of sufficient duration may injure the lungs and intestines (Dalecki et al. 2002). Sudden, intense sounds may elicit a "startle" response and may be followed by an orienting reflex (Ward 1997; Jansen 1998). The primary physiological effects of sound, however, are on the auditory system (Ward 1997).

The mammalian auditory system consists of the outer ear, middle ear, inner ear, and central nervous system. Sound waves are transmitted through the outer and middle ears to fluids within the inner ear. The inner ear contains delicate electromechanical hair cells that convert the fluid motions into neural impulses that are sent to the brain. The hair cells within the inner ear are the most vulnerable to over-stimulation by noise exposure (Yost 1994).

Very high sound levels may rupture the eardrum or damage the small bones in the middle ear (Yost 1994). Lower-level exposures may cause permanent or temporary hearing loss; such an effect is called a noise-induced threshold shift, or simply a threshold shift (TS) (Miller 1974). A TS may be either permanent, in which case it is called a PTS, or temporary, in which case it is called a TTS. Still lower exposures may result in auditory masking, which may interfere with an animal's ability to hear other concurrent sounds.

Because the tissues of the ear appear to be the most susceptible to the physiological effects of sound and TSs tend to occur at lower exposures than other more serious auditory effects, PTS and TTS are used here as the biological indicators of physiological effects. Since masking (without a resulting TS) is not associated with abnormal physiological function, it is not considered a physiological effect, but rather a potential behavioral effect.

Navy activities in the NWTRC that generate underwater noise or overpressure include ASW, missile exercise and testing, live fire (e.g., 5-in guns) training activities, aerial bombardment, and underwater detonations. The noise does not constitute a long-term physical alteration of the water column or bottom topography; however, because the occurrences are of limited duration and are intermittent in time. Surface vessels associated with the activities are present for a limited duration and are intermittent as well.

The threatened and endangered species that may be affected by implementing the NWTRC activities include the blue whale, fin whale, humpback whale, sei whale, sperm whale, and southern resident killer whale (NOTE – check whether modeling addressed the North Pacific right whale). The effects of mid-frequency sonar and underwater detonations on these species were modeled. The representative modeling areas, sound sources, model assumptions, acoustic and oceanographic parameters, underwater sound propagation and transmission models, and diving behavior of modeled species are described in detail in Appendix B of this BE.

Every active sonar operation has the potential to harass marine animals in the neighboring waters. The number of animals exposed to potential harassment in any such action is dictated by the propagation field and the manner in which the sonar is operated (i.e., source level, depth, frequency, pulse length, directivity, speed, repetition rate). Protective measures that will be implemented during the proposed activities would reduce the potential for marine mammal exposures to sonar

5.2.1.4 Effects on Listed Species

The following sections discuss the annual exposure of ESA-listed species to sonar and to underwater detonations from all proposed NWTRC training activities. The exposure numbers and discussion of effects do not take mitigation measures into account. Mitigation measures implemented during the ASW or Underwater Detonation Exercises will reduce the potential for marine mammal exposures. For each species, the likelihood of detection is given, based on systematic line-transect surveys (Barlow 2006) but the actual ability to detect marine mammals will depend upon the sea state at the time of observation. The number of sonar hours, dipping sonar, and sonobuoys used per year for the various sonar sources included in the Proposed Action, and upon which the analysis is based, are presented in Table 5-1.

Table 5-1. Annual Sonar Hours and Sources for the Proposed Action

Warfare Area	System	Number or Duration of Events per Year
Antisubmarine Warfare Tracking Exercise – Maritime Patrol Aircraft	SSQ-62 DICASS MFA Sonobuoy	886 events
Antisubmarine Warfare Tracking Exercise - Surface Ships	53C Surface Ship MFA Sonar	39 hours
	56 Surface Ship MFA Sonar	58.5 hours
Antisubmarine Warfare Tracking Exercise - Portable Undersea Tracking Range (PUTR)	MK-84 Ranging Pingers HFA Sonar	180 hours
	Uplink Transmissions MFA and HFA Sonar	150 hours
Mine Countermeasures Exercise	AN/BQS-15 HFA Sonar	42 hours
Antisurface Warfare - Sinking Exercise	MK-48 Torpedo HFA Sonar	2 torpedo runs

The Proposed Action will introduce approximately 372 hours annually of additional, mostly new high-frequency active sonar emissions into the marine environment (Table 5-1). These emissions are associated with training operations conducted at the PUTR and the submarine mine countermeasures range. These facilities are not components of the existing conditions. The high-frequency sonar and mid-frequency uplink emissions were not included in the sonar modeling so potential marine mammals exposures from these sources were not estimated. However, it is unlikely that effects to marine mammals from these sonar sources would be significant because of the limited sonar emission times, rapid attenuation rate of high-frequency sonar, limited area affected by these sonar sources, and the mitigation measures employed by the Navy to exclude marine mammal presence in the training areas.

5.2.1.4.1 Blue Whale

5.2.1.4.1.1 Mid-Frequency Active Sonar

The risk function and Navy post-modeling analysis estimates 17 blue whales will exhibit behavioral responses to sonar NMFS will classify as harassment under the MMPA (Table 5-2). Modeling also indicates there would be zero exposures to accumulated acoustic energy above 195 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. No blue whales would be exposed to sound levels that could cause PTS.

Given the large size (up to 98 ft [30 m]) of individual blue whales (Leatherwood et al. 1982), pronounced vertical blow, and aggregation of approximately two to three animals in a group (probability of track line detection = 0.90 in Beaufort Sea States of 6 or less; Barlow 2003), it is very likely that lookouts would detect a group of blue whales at the surface. Additionally, mitigation measures call for continuous visual observation during training activities with active sonar; therefore, blue whales that migrate into the operating area would be detected by visual observers. Implementation of mitigation measures and probability of detecting a large blue whale reduces the likelihood of exposure.

In the unlikely event that blue whales were exposed to mid-frequency sonar, the anatomical information available on blue whales suggests that they are not likely to hear mid-frequency (1 kHz–10 kHz) sounds (Ketten 1997). There are no audiograms of baleen whales, but blue whales tend to react to anthropogenic sound below 1 kHz (e.g., seismic air guns), and most of their vocalizations are also in that range, suggesting that they are more sensitive to low frequency sounds (Richardson et al. 1995; Croll 2002).

Based on this information, if they do no hear these sounds, they are not likely to respond physiologically or behaviorally to those received levels.

5.2.1.4.1.2 Underwater Detonations

Without taking Navy clearance procedures into account, modeling indicates there would one exposure to impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of behavioral disturbance. Modeling also indicates there would one exposure to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and one exposure to impulsive sound or pressures from explosive sources that could cause slight physical injury (Table 5-3).

5.2.1.4.1.3 Conclusion

Based on the model results, behavioral patterns, acoustic abilities of blue whales, results of past training, and the implementation of procedure mitigation measures presented in Section 6, the Navy finds that the NWTRC training events would not likely result in any death or injury to blue whales. Modeling does indicate the potential for Level B harassment, indicating the proposed exercises may affect blue whales.

5.2.1.4.2 Fin Whale

5.2.1.4.2.1 Mid-Frequency Active Sonar

The risk function and Navy post-modeling analysis estimates 122 fin whales will exhibit behavioral responses to sonar NMFS will classify as harassment under the MMPA (Table 5-2). Modeling also indicates there would be two exposures to accumulated acoustic energy above 195 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. No fin whales would be exposed to sound levels that could cause PTS.

Given the large size (up to 79 ft [24 m]) of individual fin whales (Leatherwood et al. 1982), pronounced vertical blow, mean aggregation of three animals in a group (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; Barlow 2003) it is very likely that lookouts would detect a group of fin whales at the surface. Additionally, mitigation measures call for continuous visual observation during training activities with active sonar, therefore, fin whales in the vicinity of training activities would be detected by visual observers. Implementation of mitigation measures and probability of detecting a large fin whale reduces the likelihood of exposure.

In the unlikely event that fin whales are exposed to mid-frequency sonar, the anatomical information available on fin whales suggests that they are not likely to hear mid-frequency (1 kHz–10 kHz) sounds (Richardson et al. 1995; Ketten 1997). Fin whales primarily produce low frequency calls (below 1 kHz) with source levels up to 186 dB re 1µPa at 1 m, although it is possible they produce some sounds in the range of 1.5 to 28 kHz (review by Richardson et al. 1995; Croll et al. 2002). There are no audiograms of baleen whales, but they tend to react to anthropogenic sound below 1 kHz, suggesting that they are more sensitive to low frequency sounds (Richardson et al. 1995). Based on this information, if they do not hear these sounds, they are not likely to respond physiologically or behaviorally to those received levels.

In the St. Lawrence estuary area, fin whales avoided vessels with small changes in travel direction, speed and dive duration, and slow approaches by boats usually caused little response. Fin whales continued to vocalize in the presence of boat sound (Edds and MacFarlane 1987). Even though any undetected fin whales transiting the NWTRC may exhibit a reaction when initially exposed to active acoustic energy, field observations indicate the effects would not cause disruption of natural behavioral patterns to a point where such behavioral patterns would be abandoned or significantly altered.

5.2.1.4.2.2 Underwater Detonations

Without taking Navy clearance procedures into account, modeling indicates there would 12 exposures to impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of behavioral disturbance. Modeling also indicates there would be seven exposures to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and one exposure to impulsive sound or pressures from explosive sources that could cause slight physical injury (Table 5-3). Although modeling indicates one fin whale exposure that could result in severe injury or mortality, this exposure does not consider existing Navy procedures that would prevent the use of explosive sources in the vicinity of any marine mammals.

5.2.1.4.2.3 Conclusion

Based on the model results, behavioral patterns, acoustic abilities of fin whales, results of past training, and the implementation of procedure mitigation measures presented in Section 6, the Navy finds that the NWTRC training events would not likely result in any death or injury to fin whales. Modeling does indicate the potential for Level B harassment, indicating the proposed exercises may affect fin whales.

5.2.1.4.3 Humpback Whale

5.2.1.4.3.1 Mid-Frequency Active Sonar

The risk function and Navy post-modeling analysis estimates 13 humpback whales will exhibit behavioral responses to sonar NMFS will classify as harassment under the MMPA (Table 5-2). Modeling also indicates there would be no exposures to accumulated acoustic energy above 195 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. No humpback whales would be exposed to sound levels that could cause PTS.

Given the mitigation measures detailed in Section 6, most ASW exercises take place in offshore waters and with the knowledge of the nearshore areas of humpback whale breeding aggregations, the Navy would likely avoid those nearshore areas regularly used by breeding humpback. This makes it is unlikely that mother calf pairs would be disturbed to the point of separation or the cessation of reproductive behaviors.

Given the large size (up to 52 ft [16 m] of individual humpback whales (Leatherwood et al. 1982), and pronounced vertical blow, it is very likely that lookouts would detect humpback whales at the surface. Additionally, mitigation measures call for continuous visual observation during training activities with active sonar, therefore, humpback whales that are present in the vicinity of ASW training activities would be detected by visual observers, further reducing the likelihood of exposure.

There are no audiograms of baleen whales, but they tend to react to anthropogenic sound below 1 kHz, suggesting that they are more sensitive to low frequency sounds (Richardson et al. 1995). Based on this information, if they do not hear these sounds, they are not likely to respond physiologically or behaviorally to those received levels, such that effects would be insignificant. A single study suggested that humpback whales responded to mid-frequency sonar (3.1-3.6 kHz re 1 μPa^2-s) sound (Maybaum 1989). The hand held sonar system had a sound artifact below 1,000 Hz which caused a response to the control playback (a blank tape) and may have affected the response to sonar (i.e. the humpback whale responded to the low frequency artifact rather than the mid-frequency active sonar sound). Humpback whales responded to small vessels (often whale watching boats) by changing swim speed, respiratory rates and social interactions depending on proximity to the vessel and vessel speed, with responses varying by social status and gender (Watkins et al. 1981; Bauer 1986; Bauer and Herman 1986). Animals may even move out of the area in response to vessel noise (Salden 1988). Humpback whale mother-calf pairs are generally in the shallow protected waters. ASW mid-frequency active sonar activities takes place through out the extensive NWTRC but the areas inhabited by humpback whales is represents only a small portion of the NWTRC. Frankel and Clark (2000; 2002) reported that there was only a minor response by humpback whales to the Acoustic Thermometry of Ocean Climate (ATOC) sound source and that response was variable with some animals being found closer to the sound source during operation.

5.2.1.4.3.2 Underwater Detonations

Without taking Navy clearance procedures into account, modeling indicates there would no exposures to impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of behavioral disturbance. Modeling also indicates there would zero exposures to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and zero exposures to impulsive sound or pressures from explosive sources that would cause slight physical injury (Table 5-4).

5.2.1.4.3.3 Conclusion

Based on the model results, behavioral patterns, acoustic abilities of humpback whales, results of past training, and the implementation of procedure mitigation measures presented in Section 6, the Navy finds that the NWTRC training events would not likely result in any death or injury to humpback whales. Modeling does indicate the potential for Level B harassment, indicating the proposed exercises may affect humpback whales.

5.2.1.4.4 Sei Whale

5.2.1.4.4.1 Mid-Frequency Active Sonar

The risk function and Navy post-modeling analysis estimates one sei whale will exhibit behavioral responses to sonar NMFS will classify as harassment under the MMPA (Table 5-2). Modeling also indicates there would be zero exposures to accumulated acoustic energy above 195 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. No sei whales would be exposed to sound levels that could cause PTS.

Given the large size (up to 52 ft [16 m}) of individual sei whales (Leatherwood et al. 1982), pronounced vertical blow, aggregation of approximately three animals (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; Barlow 2003), it is very likely that lookouts would detect a group of sei whales at the surface. Additionally, mitigation measures call for continuous visual observation during training activities with active sonar, therefore, sei whales that migrate into the operating area would be detected by visual observers. Implementation of mitigation measures and probability of detecting a large sei whale reduces the likelihood of exposure.

There is little information on the acoustic abilities of sei whales or their response to human activities. The only recorded sounds of sei whales are frequency modulated sweeps in the range of 1.5 to 3.5 kHz (Thompson et al. 1979) but it is likely that they also vocalized at frequencies below 1 kHz as do fin whales. There are no audiograms of baleen whales but they tend to react to anthropogenic sound below 1 kHz suggesting that they are more sensitive to low frequency sounds (Richardson et al. 1995). Sei whales were more difficult to approach than were fin whales and moved away from boats but were less responsive when feeding (Gunther 1949).

5.2.1.4.4.2 Underwater Detonations

Without taking Navy clearance procedures into account, modeling indicates there would no exposures to impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of behavioral disturbance. Modeling also indicates there would zero exposures to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and zero exposures to impulsive sound or pressures from explosive sources that would cause slight physical injury (Table 5-3).

5.2.1.4.4.3 Conclusion

Based on the model results, behavioral patterns, acoustic abilities of sei whales, results of past training, and the implementation of procedure mitigation measures presented in Section 6, the Navy finds that the

NWTRC training events would not likely result in any death or injury to sei whales. Modeling does indicate the potential for Level B harassment, indicating the proposed exercises may affect sei whales.

5.2.1.4.5 Sperm Whale

5.2.1.4.5.1 Mid-Frequency Active Sonar

The risk function and Navy post-modeling analysis estimates 101 sperm whales will exhibit behavioral responses to sonar NMFS will classify as harassment under the MMPA (Table 5-2). Modeling also indicates there would be two exposures to accumulated acoustic energy above 195 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. No sperm whale would be exposed to sound levels that could cause PTS.

Given the large size (up to 56 ft [17m]) of individual sperm whales (Leatherwood et al. 1982), pronounced blow (large and angled), mean group size of approximately seven animals (probability of trackline detection = 0.87 in Beaufort Sea States of 6 or less; Barlow 2003; 2006), it is very likely that lookouts would detect a group of sperm whales at the surface. Sperm whales can make prolonged dives of up to two hours making detection more difficult but passive acoustic monitoring can detect and localize sperm whales from their calls (Watwood et al. 2006). Additionally, mitigation measures call for continuous visual observation during training activities with active sonar; therefore, sperm whales that migrate into the operating area would be detected by visual observers. Implementation of mitigation measures and probability of detecting a large sperm whale reduces the likelihood of exposure.

In the unlikely event that sperm whales are exposed to mid-frequency sonar, the information available on sperm whales exposed to received levels of active mid-frequency sonar suggests that the response to mid-frequency (1 kHz to 10 kHz) sounds is variable (Richardson et al. 1995). While Watkins et al. (1985) observed that sperm whales exposed to 3.25 kHz to 8.4 kHz pulses interrupted their activities and left the area, other studies indicate that, after an initial disturbance, the animals return to their previous activity. During playback experiments off the Canary Islands, André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not exhibit any general avoidance reactions. When resting at the surface in a compact group, sperm whales initially reacted strongly but then ignored the signal completely (André et al. 1997).

5.2.1.4.5.2 Underwater Detonations

Without consideration of clearance procedures, modeling indicates there would 13 exposures to impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of behavioral disturbance. Modeling also indicates there would 10 exposures to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and one exposure to impulsive sound or pressures from explosive sources that could cause slight physical injury (Table 5-3).

5.2.1.4.5.3 Conclusion

Based on the model results, behavioral patterns, acoustic abilities of sperm whales, results of past training, and the implementation of procedure mitigation measures presented in Section 6, the Navy finds that the NWTRC training events would not likely result in any death or injury to sperm whales. Modeling does indicate the potential for Level B harassment, indicating the proposed exercises may affect sperm whales.

5.2.1.4.6 Southern Resident Killer Whale

5.2.1.4.6.1 Mid-Frequency Active Sonar

Due to the difficulty in determining particular stocks of killer whales in the wild, all stocks of killer whales were combined for modeling exposures. While overly conservative, all killer whales were assumed to belong to the southern resident killer whale stock. The risk function and Navy post-modeling analysis estimates 13 killer whales will exhibit behavioral responses to sonar NMFS will classify as harassment under the MMPA (Table 5-2). Modeling also indicates there would be no exposures to accumulated acoustic energy above 195 dB re 1 µPa^2-s, which is the threshold established indicative of onset TTS. No killer whales would be exposed to sound levels that could cause PTS.

Given their size (up to 23 ft [7.0 m]), conspicuous coloring, pronounce dorsal fin and large mean group size of 6.5 animals (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; Barlow, 2003). It is very likely that lookouts would detect a group of killer whales at the surface. Additionally, mitigation measures call for continuous visual observation during activities with active sonar, therefore, killer whales that migrate into the operating area would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of killer whales reduces the likelihood of exposure.

5.2.1.4.6.2 Underwater Detonations

Without taking Navy clearance procedures into account, modeling indicates there would no exposures to impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of behavioral disturbance. Modeling also indicates there would zero exposures to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and zero exposures to impulsive sound or pressures from explosive sources that would cause slight physical injury (Table 5-3).

5.2.1.4.6.3 Conclusion

Based on the model results, behavioral patterns, acoustic abilities of killer whales, results of past training, and the implementation of procedure mitigation measures presented in Section 11, the Navy finds that the NWTRC training events would not result in any population level effects, death or injury to killer whales. Modeling does indicate the potential for Level B harassment, indicating the proposed exercises may affect killer whales.

5.2.1.4.7 Steller Sea Lion

5.2.1.4.7.1 Mid-Frequency Active Sonar

The risk function and Navy post-modeling analysis estimates 113 Steller sea lions will exhibit behavioral responses to sonar NMFS will classify as harassment under the MMPA (Table 5-2). Modeling also indicates there would be no exposures to accumulated acoustic energy above 195 dB re 1 µPa^2-s, which is the threshold established indicative of onset TTS. No Steller sea lions would be exposed to sound levels that could cause PTS.

5.2.1.4.7.2 Underwater Detonations

Without taking Navy clearance procedures into account, modeling indicates there would three exposures to impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of behavioral disturbance. Modeling also indicates there would three exposures to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and one exposure to impulsive sound or pressure from explosive sources that could cause slight physical injury (Table 5-3).

5.2.1.4.7.3 Conclusion

Based on the model results, behavioral patterns, acoustic abilities of Steller sea lions, results of past training, and the implementation of procedure mitigation measures presented in Section 6, the Navy finds that the NWTRC training events would not likely result in any death or injury to Steller sea lions. Modeling does indicate the potential for Level B harassment, indicating the proposed exercises may affect Steller sea lions.

5.2.1.4.8 Sea Otter

5.2.1.4.8.1 Mid-Frequency Active Sonar

Because there are no density calculations for the sea otter, no acoustic modeling results are available.

5.2.1.4.8.2 Underwater Detonations

Because there are no density calculations for the sea otter, no acoustic modeling results are available.

5.2.1.4.8.3 Conclusion

Sea otters dive for short periods and often rest on the surface between foraging bouts making them easier than whales to detect. Due to the sea otter's primary occurrence near shore, their behavioral patterns, their acoustic abilities, results of past training, and the implementation of procedure mitigation measures presented in Section 6, the Navy finds that the proposed NWTRC training events may affect sea otters.

5.2.1.4.9 Summary

5.2.1.4.9.1 Mid-Frequency Active Sonar

Based on analytical modeling results (Table 5-2), seven threatened and endangered marine mammal species occurring in the NWTRC may be exposed to acoustic energy that could result in TTS or behavioral modification, including the blue whale, fin whale, humpback whale, southern resident killer whale, sei whale, sperm whale, and Steller sea lion. Modeling results indicate no potential for PTS exposures for any of the ESA species. Based on this analysis, the Navy concludes that underwater noise from NWTRC ASW training activities may affect the blue whale, fin whale, humpback whale, southern resident killer whale, sei whale, sperm whale, Stellar sea lion, and the sea otter. Exposure effects to the sea otter were not modeled because density data were unavailable for these species.

Table 5-2. Proposed Action Annual Sonar Exposures

Species	Level B Sonar Exposures		Level A Sonar Exposures
	Risk Function	TTS	PTS
Blue whale	17	0	0
Fin whale	122	2	0
Humpback whale	13	0	0
Sei whale	1	0	0
Sperm whale	101	2	0
Southern resident killer whale	13	0	0
Steller sea lion	113	0	0
Sea otter	N/A	N/A	N/A

5.2.1.4.9.2 Underwater Detonations

Under the Proposed Action, annual underwater detonations would decrease from 60 (baseline conditions) to 4, with continued implementation of resource protection measures.

Annual underwater detonations for the Proposed Action would be less than those analyzed by NMFS and reported in a June 2008 Biological Opinion for Navy EOD Operations, Puget Sound (NMFS 2008f). The Biological Opinion applies to Navy's ongoing EOD training conducted from the date of the Biological Opinion through December 31, 2009.

The findings of NMFS' Biological Opinion have been considered in the analysis for this BE. The Navy will conduct separate consultations with NMFS on the Proposed Action described in this BE, since the 2009 Biological Opinion considers the activities prior to January 1, 2010.

Based on analytical modeling results (Table 5-3), and without taking Navy clearance procedures into account, four marine mammals, the blue whale, fin whale, sperm whale, and Stellar sea lion may be exposed to impulsive noise or pressure that could result in TTS or behavioral modification. Two endangered marine mammal species occurring within the NWTRC, the fin whale and the sperm whale, may be exposed to impulsive noise or pressure that could result in injury.

Table 5-3. Proposed Action Annual Underwater Detonation Exposures

Species	Level B Explosive Exposures		Level A Exposures (23 psi-ms)	Level A Mortality (31 psi-ms)
	Behavioral	TTS		
Blue whale	1	1	1	0
Fin whale	12	7	1	1
Humpback whale	0	0	0	0
Sei whale	0	0	0	0
Sperm whale	13	10	1	0
Southern resident killer whale	0	0	0	0
Steller sea lion	3	3	1	0
Sea otter	N/A	N/A	N/A	N/A

Based on these results, the Navy concludes that underwater impulse noise or pressure from NWTRC training activities may affect the blue whale, fin whale, sperm whale, and the Stellar sea lion. Mitigation measures would be implemented to prevent exposure of marine mammals to impulsive sound or sound pressures from underwater detonations that would cause injury.

Underwater detonation exposures would have no effect to the humpback whale, sei whale, and southern resident killer whale. Exposure effects to the sea otter were not modeled because density data were unavailable for these species.

5.2.2 Explosives and Munitions

Blast injuries from exploding warheads may be caused by the entrance of propelled fragments into the body when in very close proximity to the explosion (Phillips and Richmond 1990; Stuhmiller et al. 1990). A study was conducted about the behavior of propelled fragments using MK-82 bombs detonated at various water depths (O'Keeffe and Young 1984; Swisdak Jr. and Montaro 1992). The MK-82 ballistic bomb has a warhead roughly equivalent in Net Explosive Weight (NEW) as the MK-48 ADCAP torepdo, and therefore is comparable. When the MK-82 was exploded at a depth of 40 ft (12 m), no fragments were seen escaping the water, indicating that they all traveled in plumes underwater extending about 98 ft (30 m) (Swisdak Jr. and Montaro 1992). Fragments from the underwater explosion were larger than those produced during in-air blasts and decelerated rapidly through the water (O'Keeffe and Young 1984; Swisdak Jr. and Montaro 1992). The torpedo explosion is also somewhat obstructed by the surfaced target, which shields the upwardly moving fragments. Therefore, the possibility that propelled fragments would physically impact an animal near the target is negligible at all test sites given the small footprint and Navy protective measures.

5.2.3 Ship Strikes

Collisions with commercial and Navy ships can cause major wounds and may occasionally cause fatalities to cetaceans. The most vulnerable marine mammals are those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (e.g., sperm whale). In addition, some baleen whales, such as the fin whale swim slowly and seem generally unresponsive to ship sound. The combination of a lack of response to ship noise and sensitivity to alarming stimuli may make them more susceptible to ship strikes (Nowacek et al. 2004). Smaller marine mammals-for example, Pacific white-side dolphins and common dolphins move quickly throughout the water column and are often seen riding the bow wave of large ships. Marine mammal responses to vessels may include avoidance and changes in dive pattern (NRC 2003).

The Navy has adopted mitigation measures that reduce the potential for collisions with surfaced marine mammals (See Chapter 6). These standard operating procedures include: (1) use of lookouts trained to detect all objects on the surface of the water, including marine mammals; (2) reasonable and prudent actions to avoid the close interaction of Navy assets and marine mammals; and (3) maneuvering to keep away from any observed marine mammal. Based on these standard operating procedures, collisions with marine mammals are not expected.

5.2.4 Torpedoes

5.2.4.1 Control Wires

The MK-48 torpedo is equipped with a guidance wire that facilitates final command and control functions as the torpedo departs the submarine. Torpedoes are equipped with a single-strand guidance wire, which is laid behind the torpedo as it moves through the water. The guidance wire is a maximum of 0.043 in (0.11 cm) in diameter and composed of a very fine thin-gauge copper-cadmium core with a polyolefin coating. The tensile breaking strength of the wire is a maximum of 42 lb (19 kg) and can be broken by hand. Up to 15 mi (28 km) of wire is deployed during a run, which will sink to the sea floor at a rate of 0.5 feet per second (ft/sec). (0.15 meters per second [m/sec]).At the end of a training torpedo run, the wire is released from the firing vessel and the torpedo to enable torpedo recovery. The wire sinks rapidly and settles on the ocean floor. Guidance wires are expended with each exercise torpedo launched. DoN (1996) analyzed the potential entanglement effects of torpedo control wires on sea turtles. The Navy analysis concluded that the potential for entanglement effects will be low for the following reasons, which apply also to potential entanglement of marine mammals:

The guidance wire is a very fine, thin-gauge copper-cadmium core with a polyolefin coating. The tensile breaking strength of the wire is a maximum of 42 lb (19 kg) and can be broken by hand. With the exception of a chance encounter with the guidance wire while it was sinking to the sea floor (at an estimate rate of 0.5 ft/sec (0.2 m/sec), a marine animal would be vulnerable to entanglement only if its diving and feeding patterns place it in contact with the bottom.

The torpedo control wire is held stationary in the water column by drag forces as it is pulled from the torpedo in a relatively straight line until its length becomes sufficient for it to form a chain-like droop. When the wire is cut or broken, it is relatively straight and the physical characteristics of the wire prevent it from tangling, unlike the monofilament fishing lines and polypropylene ropes identified in the entanglement literatures.

A maximum of two MK-48 torpedoes will be fired each year during NWTRC exercises. While it is possible that a marine mammal would encounter a torpedo guidance wire as it sinks to the ocean floor, the likelihood of such an event is considered remote, as is the likelihood of entanglement after the wire has descended to and rests upon the ocean floor.

Given the low potential probability of marine mammal entanglement with guidance wires, the potential for any harm or harassment to these species is extremely low. Therefore, there will be no impact to marine mammals resulting from interactions with torpedo guidance wire during NWTRC activities under the Proposed Action. The torpedo guidance wires associated with NWTRC activities will have no effect on ESA-listed marine mammal species.

5.2.4.2 Torpedo Strikes

There is a negligible risk that a marine mammal could be struck by a torpedo during ASW training activities. This conclusion is based on (1) review of torpedo design features, (2) review of a large number of previous naval exercise ASW torpedo activities, and (3) the low number of annual torpedo firings in the NWTRC. The acoustic homing programs of torpedoes are designed to detect either the mechanical sound signature of the submarine or active sonar returns from its metal hull with large internal air volume interface. The torpedoes are specifically designed to ignore false targets. As a result, their homing logic does not detect or recognize the relatively small air volume associated with the lungs of marine mammals. They do not detect or home to marine mammals. The Navy has conducted exercise torpedo activities since 1968. At least 14,322 exercise torpedo runs have been conducted since 1968. There have been no recorded or reported instances of a marine species strike by an exercise torpedo. Every exercise torpedo activity is monitored acoustically by on-scene range personnel listening to range hydrophones positioned on the ocean floor in the immediate vicinity of the torpedo activity. After each torpedo run, the recovered exercise torpedo is thoroughly inspected for any damage. The torpedoes then go through an extensive production line refurbishment process for re-use. This production line has stringent quality control procedures to ensure that the torpedo will safely and effectively operate during its next run. Since these exercise torpedoes are frequently used against manned Navy submarines, this post activity inspection process is thorough and accurate. Inspection records and quality control documents are prepared for each torpedo run. This post exercise inspection is the basis that supports the conclusion of negligible risk of marine mammal strike. The probability of direct strike of torpedoes associated with NWTRC training is negligible and therefore will have no effect on ESA-listed marine mammal species.

5.2.4.3 Torpedo Air Launch Accessories

Because some torpedo air launch accessories remain in the marine environment, the potential for affecting marine mammals through ingestion or entanglement has been previously analyzed. Ingestion of pieces of the launch accessories is unlikely because most of those are large and metallic and will sink rapidly (DoN 1996). With the exception of a chance encounter as the air launch accessories sink to the bottom, marine animals would only be vulnerable to entanglement or ingestion if their diving and feeding behaviors place them in contact with the sea floor.

In previous studies, the Naval Ocean Systems Center identified two potential effects of the MK-50 torpedo air launch accessories (Naval Ocean Systems Center 1990). As the air launch accessories for the MK-46 torpedo are similar in function, materials, and size to those of the MK-50 torpedo, the following potential effects identified by the Naval Ocean Systems Center are applicable to both torpedoes (DoN 1996).

Upon water entry and engine startup, the air stabilizer would be released from the torpedo and sink to the bottom. Bottom currents may cause the air stabilizer canopy to billow, potentially posing an entanglement threat to marine animals that feed on the bottom. However, the canopy is large and highly visible compared to materials such as gill nets and nylon fishing line in which marine animals may become entangled. Thus, entanglement of marine animals in the canopy or suspension lines would be unlikely.

Non-floating air launch debris ranges in length from 11 to 44 inches. Because of the relatively large size of this debris, the potential risk for ingestion of this debris by marine animals other than bottom-feeding whales would be small. The probability of a whale coming in contact with and ingesting the debris likewise would be small.

5.2.4.4 MK-48 Torpedo Flex Hoses

The Navy analyzed the potential for the flex hoses to affect marine mammals. The analysis concluded that the potential for entanglement impact of marine animals would be unlikely for reasons similar to those stated for the potential for entanglement by control wires, specifically (DoN 1996). Due to its weight, the flex hose would sink to the bottom upon release. With the exception of a chance encounter with the flex hose while it was sinking to the sea floor, a marine animal would be vulnerable to entanglement only if its diving and feeding patterns placed it in contact with the bottom. Due to its stiffness, the 250-ft-long flex hose would not form loops that could entangle marine animals.

5.2.5 Parachutes

Sonobuoys, lightweight torpedoes, EMATTs, and other devices deployed from aircraft use nylon parachutes of varying sizes; for example, a typical sonobuoy parachute is about 8 ft in diameter, with nylon suspension lines about 20 ft long. At water impact, the parachute assembly is jettisoned and sinks away from the exercise weapon or target. The parachute assembly would potentially be at the surface for a short time before sinking to the sea floor. Sonobuoy parachutes are designed to sink within 15 minutes, but the rate of sinking depends upon sea conditions and the shape of the parachute. Some ingestion of plastics by marine mammals is known to occur. However, the parachutes used on the NWTRC are large in comparison with these animals' normal food items, and would be very difficult to ingest.

Marine mammals are also subject to entanglement in marine debris, particularly anything incorporating loops or rings, hooks and lines, or sharp objects. Entanglement and the eventual drowning of a marine mammal in a parachute assembly would be unlikely, since the parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. The potential for a marine mammal to encounter an expended parachute assembly is extremely low, given the generally low probability of a marine mammal being in the immediate location of deployment. If bottom currents are present, the canopy may billow and pose an entanglement threat to marine animals with bottom-feeding habits; however, the probability of a marine mammal encountering a parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines is considered to be unlikely.

Overall, the possibility of marine mammals ingesting nylon parachute fabric or being entangled in parachute assemblies is very remote.

5.3 BIRDS

Marine and coastal birds would have the potential to be affected by vessel movement, aircraft overflights, ordnance strikes, detonations, and expended materials. Threatened and endangered species that may be affected by NWTRC training activities include the short-tailed albatross, marbled murrelet, California brown pelican, and western snowy plover.

Critical habitat has been designated for the marbled murrelet in the Puget Sound and coastal zones of Washington, Oregon, and northern California. Critical habitat for the western snowy plover occurs at beaches, mudflats, sandbars and other similar locations along the Washington, Oregon, and California coasts.

Some of the standard operating procedures and best management practices implemented by the Navy for resource protection that would reduce potential effects to all bird species in this BE are identified below.

- Avoidance of birds and their nesting and roosting habitats provides the greatest degree of protection from potential impacts within the NWTRC Study Area. For example, pursuant to Navy instruction, measures to evaluate and reduce or eliminate bird/aircraft strike hazards to aircraft, aircrews, and birds are implemented.
- Guidance involving land or water detonations contains instructions to personnel to observe the surrounding area within 500 yards (457 m) for 30 minutes prior to detonation. If birds (or marine mammals or sea turtles) are seen, the operation must be relocated to an unoccupied area or postponed until animals leave the area.
- Monitoring of seabird populations and colonies by conservation groups and researchers is conducted intermittently within coastal areas and offshore islands with limited support from various military commands.

5.3.1 Short-tailed Albatross

5.3.1.1 Vessel Movements

During a year of operations, 6,940 steaming hours occur in the NWTRC, with 4,320 of those in transit, and 2,610 during training activities. Based on the low Navy vessel density and patchy distribution of short-tailed albatross in the Study Area, the probability of vessel collisions is low. Navy mitigation measures, which include avoidance of large *Sargassum* mats where seabirds may concentrate, further reduce the probability of collisions. In the unlikely event that a short-tailed albatross were to collide with a vessel, injury or mortality could occur. No community or population level effects would be anticipated.

5.3.1.2 Aircraft Overflights

Short-tailed albatross could be exposed to airborne noise associated overflights and to potential aircraft strike.

Aircraft overflights would increase by approximately 55 percent to 11,786 per year. Of these, 109 would be helicopter flights. The majority of these flights would occur beyond 12 nm (22 km) at elevations in excess of 3,000 ft (914 m) above sea level.

Albatross exposure to aircraft noise could occur while foraging or migrating in open water environments within the Pacific Ocean or nearshore environments. Periods of elevated noise levels would be brief and repeated exposure of individual birds over a short period of time (hours or days) is extremely unlikely. Furthermore, the sound exposure levels would range from just above ambient to approximately 97 dB and most sound exposure levels would be lower than 97 dBA because overflights would occur above 3,000 ft (914 m). If birds were to respond to an overflight, the responses would be limited to short-term behavioral or physiological reactions and the general health of individual short-tailed albatross would not be compromised.

Few aircraft strikes to sea birds are expected to occur in the NWTRC area. The potential for bird strikes to occur in offshore areas is relatively low because training activities are widely dispersed and at relatively high altitudes (above 3,000 ft [914 m]) where bird densities are low. For example, from 2002 through 2004 only five known bird strikes involving vessel-based aircraft occurred Navy-wide. About 1 percent of the Navy-wide wildlife strike events from for 2002 through 2004 involved seabirds (Navy Safety Center, 2004).

5.3.1.3 Ordnance Use

Current Navy training activities include firing a variety of non-explosive training rounds and explosive rounds. These materials are used in the open ocean beyond 12 nm (22 km). Direct ordnance strikes from firing weapons are possible, but unlikely, threats to the short-tailed albatross. With the Proposed Action, the increase in ordnance use would result in 5.3 pieces of ordnance used per square nautical mile of the W-237 range. However, the potential for a direct bird strike would remain quite low. Effects could include disturbance and relocations, sub-lethal injury, or mortality. However, the vast area (33,997 nm^2 [116,606 km^2]) over which training activities occur and implementation of Navy resource protection measures, combined with the small size of the birds and the ability of the birds to flee, would make direct strikes unlikely. Individual short-tailed albatross could be affected, but ordnance strikes would have no effect on the species population.

5.3.1.4 Underwater Detonations

Underwater detonations have the potential to affect the short-tailed albatross. Effects would depend on the distance from the detonation and size of the explosion and would include disturbance and relocation, temporary effects, sub-lethal injuries, or direct mortality. Impacts would be possible, but have a low potential for occurrence.

Approximately 1,200 detonations would occur in the W-237 training area each year. This usage would produce a very low density of offshore detonations per year in the Study Area (just under 0.04 detonations/nm^2). This, coupled with patchy albatross distribution would make the potential for adverse effects quite low.

The four annual EOD activities conducted in nearshore environments would pose a low potential for effects to the short-tailed albatross because this species is typically associated with offshore ocean areas. Individual albatrosses present in relatively close proximity to a detonation or explosion could be disturbed and relocate, injured, or killed. Impacts to the short-tailed albatross from detonations are possible, but have a low potential for occurrence. Navy resource protection measures implemented prior to EOD activities would provide a high level of protection for the short-tailed albatross during these exercises, making the potential for effects quite low.

5.3.1.5 Expended Materials

The Navy expends a variety of materials during training exercises in the NWTRC Study Area. Most expended materials rapidly sink to the sea floor, become encrusted by natural processes, and become incorporated into the sea floor, with no substantial accumulations in any particular area and no measurable negative effects to water quality or marine benthic communities. Nonetheless, birds could be exposed to some expended materials through contact and ingestion.

Sea birds of many species are known to ingest a wide variety of marine debris, which they might mistake for prey. Plastic bags, plastic sheeting, and other plastic debris are most commonly swallowed by birds but balloons, styrofoam beads, monofilament fishing line, and tar are also known to be ingested (Lutz 1990; Bjorndal et al 1994; Tomas 2002). The total number of expended ordnance in the Study Area would be approximately 191,000 pieces per year. Assuming all ordnance would be expended in W-237 and an even distribution, the concentration of expended rounds would be 5.3/nm^2 (1.6/km^2). However, ordnance related materials quickly settle to the sea floor where they would not be available for foraging by short-tailed albatross. With the exception of EOD detonations in nearshore environments, all ordnance use would occur in areas more than 12 nm (22 km) offshore where water depths in excess of 3,000 ft (914 m). The diving range of the short-tailed albatross is limited to 40 ft (12 m) or less, and ordnance use is limited to areas beyond the continental shelf. In addition, the at-sea targets expended in the Study Area are 2 and 3 ft (0.5 and 1.0 m) in length, respectively, sink to the bottom intact, and present no ingestion hazard to the short-tailed albatross. Thus, expended materials would have no effect on short-tailed albatross.

5.3.1.6 Entanglement

Entanglement in persistent marine debris causes mortality in birds in the eastern Pacific Ocean. Birds that become entangled could drown, starve to death, lose a limb, or attract predators with their struggling. Debris, such as parachutes could be encountered by the short-tailed albatross in the offshore waters of the Study Area. The greatest risk of entanglement would occur when the parachutes are on or near the surface. Materials that are expended in training exercises, including sonobuoys and markers usually sink shortly after they are deployed. Approximately 9,000 sonobuoy parachutes would be deployed and not recovered. Assuming all parachutes were expended in W-237 over an even distribution, the concentration of entanglement hazards would be 0.27/nm^2 (0.06/km^2). Given the sparse concentration of entanglement hazards, the potential for sea bird entanglement in Navy debris would be low.

5.3.1.7 Conclusion

In accordance with ESA, under the Proposed Action, vessel movements, aircraft overflights, ordnance use, underwater detonations, and entanglement may affect the short-tailed albatross. However, these stressors would not have population level effects.

5.3.2 Marbled Murrelet

5.3.2.1 Vessel Movements

The 4 percent increase in steaming hours over current conditions would not measurably increase potential effects to the marbled murrelet. The potential for this species to be affected by these activities would be quite low. Most of the steaming hours by Navy vessels would occur in offshore environs beyond 12 nm (22 km) from shore. This is outside the range of the marbled murrelet. In the unlikely event that a marbled murrelet were to collide with a vessel, injury or mortality could occur.

5.3.2.2 Aircraft Overflights

The 21 percent increase in overflights compared to current conditions would not be expected to measurably affect this species. Most flights would occur at altitudes in excess of 3,000 and aircraft strikes would be unlikely because bird densities are low at that altitude. Individual birds may be affected, but there would be no population-level effects.

Marbled murrelets could be affected by airborne noise associated overflights and potential aircraft strike. Exposure to aircraft noise could occur while foraging or migrating in nearshore environments. Periods of elevated noise levels would be brief and repeated exposure of individual birds over a short period of time would be extremely unlikely. Sound exposure levels would range from just above ambient to approximately 97 dBA, and most sound exposure levels would be lower than 97 dB because overflights would occur above 3,000 ft (914 m). If murrelets were to respond to an overflight, the responses would be limited to short-term behavioral or physiological reactions and the general health of individual marbled murrelets would not be compromised.

Few aircraft strikes to birds are expected to occur in the NWTRC Study Area. One percent of annual Navy-wide aircraft strikes involve birds (Navy Safety Center 2004). While bird strikes can occur anywhere aircraft are operated, Navy data indicate they occur most often over land or close to shore. However, even from a Navy-wide perspective, the numbers of bird mortalities that occur annually would not affect the marbled murrelet population.

5.3.2.3 Ordnance Use

Weapons are not fired in the nearshore environments of the Study Area, and this activity would have no effect on the marbled murrelet.

5.3.2.4 Underwater Detonations

Under the Proposed Action, annual underwater detonations would decrease from 60 (baseline conditions) to 4, with continued implementation of resource protection measures.

Annual underwater detonations for the Proposed Action would be less than those analyzed by USFWS and repored in a November 7, 2008 Biological Opinion for Navy EOD Operations, Puget Sound (USFWS 2008). The Biological Opinion applies to Navy's ongoing EOD training conducted from the date of the Biological Opinion through December 31, 2009.

The findings of USFWS' Biological Opinion have been considered in the analysis for this BE. The Navy will conduct separate consultations with USFWS on the Proposed Action described in this BE, since the 2009 Biological Opinion considers the activities prior to January 1, 2010.

Underwater EOD exercises that occur in the nearshore environments have the potential to affect the marbled murrelet. Effects would depend on the distance from the detonation and size of the explosive charge. Impacts would be possible, but have a low potential for occurrence. Individual murrelets present in relatively close proximity could be disturbed and relocate, injured, or killed. Navy resource protection measures implemented prior to EOD activities would provide a high level of protection for marbled murrelets during these exercises, making the potential for adverse effects quite low.

5.3.2.5 Expended Materials

Ordnance-related materials quickly settle to the sea floor where they would not be available to marbled murrelets. At-sea targets expended in the Study Area are 2 and 3 ft (0.5 and 1.0 m) long and sink to the bottom intact, thus presenting no ingestion hazard to the marbled murrelet. Expended materials would have no effect on the marbled murrelet.

5.3.2.6 Entanglement

It would be highly unlikely that marbled murrelet would encounter debris, such as sonobuoys, parachutes, and markers. These materials are used in the Offshore Areas of the W-237 training area, which is outside the nearshore habitat of the marbled murrelet. These materials all sink, and would rest in water depths beyond 1,000 ft (305 m). Thus, there would be no potential for entanglement of marbled murrelet.

5.3.2.7 Beach and Inland Activities

NSW training would involve beach and inland training activities at Indian Island at current levels and at currently used inland training facilities. None of the locations or activities would involve areas designated as critical habitat for the marbled murrelet. Thus, there would be no potential for adverse effects to the marbled murrelet or its designated critical habitat.

5.3.2.8 Conclusion

In accordance with ESA, under the under the Proposed Action, vessel movements, aircraft overflights, and underwater detonations, may affect the marbled murrelet. There would be no destruction or adverse modification of critical habitat.

5.3.3 California Brown Pelican

5.3.3.1 Vessel Movements

Most of the steaming hours by Navy vessels would occur in offshore environs beyond 12 nm (22 km) from shore. This is outside the typical foraging range of the California brown pelican. The potential for this species to be affected by these activities would be quite low. In the unlikely event that a California brown pelican were to be struck by a vessel, injury or mortality could occur.

5.3.3.2 Aircraft Overflights

California brown pelicans could be affected by airborne noise associated overflights and potential aircraft strike. Exposure to aircraft noise could occur while foraging or migrating in nearshore environments. Periods of elevated noise levels would be brief and infrequent, and repeated exposure of individual birds over a short period of time would be extremely unlikely. The sound exposure levels would range from just above ambient to approximately 97 dB, but most sound exposure levels would be lower than 97 dB because overflights would occur above 3,000 ft (914 m). If California brown pelicans were to respond to an overflight, the responses would be limited to short-term behavioral or physiological reactions and the general health of individuals would not be compromised.

Few, if any, bird/aircraft strikes and associated bird mortalities or injuries are expected to occur in the NWTRC Study Area. Navy-wide, an annual average of 596 wildlife/aircraft strike events have occurred, and most of these involved birds (Navy Safety Center, 2004). While bird strikes can occur anywhere aircraft operate, Navy data indicate they occur most often over land or close to shore.

5.3.3.3 Ordnance Use

Weapons are not fired in the nearshore environments of the Study Area. This activity would have no effect on the California brown pelican.

5.3.3.4 Underwater Detonations

Underwater EOD exercises that occur in the nearshore environments have the potential to affect California brown pelicans. Effects would depend on the distance from the detonation and size of the explosive charge. Impacts would be possible, but have a low potential for occurrence. Individual pelicans present in relatively close proximity could be disturbed, injured, or killed. Navy resource protection measures implemented prior to EOD activities would provide a high level of protection for the California brown pelican during these exercises, making the potential for effects quite low.

5.3.3.5 Expended Materials

Ordnance-related materials quickly settle to the sea floor where, in depths greater than 100 ft, they would not be available for foraging by the California brown pelican. With the exception of EOD detonations in nearshore environments, all ordnance use would occur in areas more than 12 nm (22 km) offshore where water depths in excess of 3,000 ft (914 m).

In addition, the at-sea targets expended in the Study Area are 2 to 3 ft (0.6 to 1 m) long and sink to the bottom intact, thus presenting no ingestion hazard. Thus, expended ordnance would have no effect on the California brown pelican.

5.3.3.6 Entanglement

It would be highly unlikely that California brown pelicans would encounter debris, such as sonobuoys, parachutes, and markers. These materials are used in the Offshore Areas of the W-237 training area, which is outside the nearshore habitat of this species. These materials all sink, and would rest in water depths beyond 1,000 ft (305 m). Thus, there would be no potential for entanglement of California brown pelicans.

5.3.3.7 Conclusion

Under the Proposed Action, vessel movements, aircraft overflights, and underwater detonations, may affect the California brown pelican.

5.3.4 Western Snowy Plover

5.3.4.1 Vessel Movements

The snowy plover does not forage over or rest on open water. Consequently, there would be no potential for this species to be struck by steaming vessels.

5.3.4.2 Aircraft Overflights

It is conceptually possible the western snowy plovers could be affected by airborne noise associated overflights and potential aircraft strike. Exposure to aircraft noise could occur while the birds forage or migrate over beaches and nearshore waters. Periods of elevated noise levels would be brief and infrequent, and repeated exposure of individual birds over a short period of time would be extremely unlikely. The sound exposure levels would range from just above ambient to approximately 97 dB, but most sound exposure levels would be lower than 97 dB because overflights would occur above 3,000 ft (914 m). If western snowy plovers were to respond to an overflight, the responses would be limited to short-term behavioral or physiological reactions and the general health of individuals would not be compromised. None of the threat factors identified for this species includes noise emissions.

Few, if any, bird/aircraft strikes and associated bird mortalities or injuries are expected to occur in the NWTRC Study Area. Navy-wide, an annual average of 596 wildlife/aircraft strike events have occurred, and most of these involved birds (Navy Safety Center, 2004). While bird strikes can occur anywhere aircraft operate, Navy data indicate they occur most often over land or close to shore.

5.3.4.3 Ordnance Use

Weapons are not fired in shoreline environments of the Study Area. Consequently, this activity would have no effect on the western snowy plover.

5.3.4.4 Underwater Detonations

Noise from underwater EOD exercises that occur in the nearshore environments have to potential to disturb the western snowy plover. Effects of noise would depend on the distance from the detonation and size of the explosive charge. Adverse effects could range from physiological responses to the birds fleeing and relocating to another area. Because the western snowy plover is essentially a terrestrial species that is closely affiliated with shorelines and mudflats, there is very little likelihood of the species being affected by energy impulses from underwater detonations. None of the threat factors identified for this species includes noise emissions. Navy resource protection measures implemented prior to EOD activities would provide protection for the western snowy plover during these exercises, making the potential for effects quite low.

5.3.4.5 Expended Materials

The habitat of the western snowy plover includes shoreline and mudflats. No materials would be expended in these locations. There would be no potential for this species to be affected by expended materials.

5.3.4.6 Entanglement

There would be no potential for western snowy plovers to encounter debris, such as sonobuoys, parachutes, and markers. These materials are used in the Offshore Areas of the W-237 training area, which is well beyond the shoreline habitat of this species. These materials all sink, and would rest in water depths beyond 1,000 ft (305 m). Thus, there would be no potential for entanglement of western snowy plovers.

5.3.4.7 Beach and Inland Activities

NSW training would involve beach and inland training activities at Indian Island at current levels and at currently used inland training facilities. None of the locations or activities would involve areas designated as critical habitat for the western snowy plover or areas known to support nesting activities by this species. Thus, there would be no potential for adverse effects to nesting by the western snowy plover or its designated critical habitat.

5.3.4.8 Conclusion

Under the Proposed Action, vessel movements, ordnance use, and expended materials would have no effect on the western snowy plover; aircraft overflights and underwater detonations may affect the western snowy plover. Although it is possible that noise emissions from either aircraft overflights and underwater detonations could be detected by nearby birds, it is unlikely that irregular and infrequent noise emissions from training activities would affect the species. Poor reproductive success, resulting from human disturbance, predation, and inclement weather, combined with permanent or long-term loss of nesting habitat to encroachment of non-native European beachgrass and urban development are the primary factors identified as responsible for the decline in active nesting, as well as an overall decline in the breeding and wintering population of the western snowy plover along the Pacific coast (USFWS 1993). Onshore activities would avoid areas designated as critical habitat. Thus, there would be no destruction or adverse modification of critical habitat.

5.4 SEA TURTLES

Four species of sea turtles could occur in the action area, all of which are protected under the ESA: leatherback, loggerhead, green, and olive ridley sea turtles. Only the leatherback sea turtle is known to occur regularly in the action area. The other three species occur irregularly in the southern fringe of the OPAREA. For these reasons only the leatherback sea turtle is evaluated in detail. Although the other three species of sea turtles may be affected by activities in the action area, the likelihood of such occurrences are considered very low. Thus, those potential effects are considered extremely unlikely and therefore discountable for the loggerhead, green, and olive ridley sea turtles.

5.4.1 Acoustic Effects Approach

5.4.1.1 Turtle Density

There are no formal density estimates for sea turtles in the NWTRC. The marine mammal and sea turtle density study undertaken to support the analysis presented in the EIS/OEIS (DoN 2007) estimated the average density of sea turtles along the northern California coast to be 0.01 animals/nm^2 (0.3 animals/100 km^2); with an estimated maximum of 0.1 animals over the same area (2.8 animals/100 km^2). Although the cold water temperatures of the remainder of the Pacific Northwest make occurrence of several hard-shelled species unlikely, the density estimate for northern California is employed here as a potential maximum range of occurrence for sea turtles in the Study Area. Thus, the assumed density of 0.1 turtles/nm^2 is an extrapolation that represents a high rate of occurrence that may exceed actual conditions.

Extrapolation from human and marine mammal data to turtles is inappropriate given the morphological differences between the auditory systems of mammals and turtles. However, the measured hearing threshold for the green sea turtle (and by extrapolation, at least the leatherback) is only slightly lower than the maximum levels to which this species could be exposed. It is not believed that a temporary threshold shift would occur at such a small margin over threshold in any species. Therefore, no threshold shifts in the green sea turtle is expected. Given the lack of audiometric information, the potential for temporary threshold shifts among leatherback turtles must be classified as unknown, but would likely follow those of other sea turtles.

Studies indicate that the auditory capabilities of sea turtles are centered in the low-frequency range (less than 1,000 Hz or 1.0 kHz). Ridgway et al. (1969) found that green turtles exhibit maximum hearing sensitivity between 300 and 500 Hz, and speculated that the turtles had a useful hearing span of 60–1,000 Hz. (However, there was some response to strong vibration signals at frequencies down to the lowest one tested - 30 Hz.). Bartol et al. (1999) tested the response of juvenile loggerhead turtles to brief, low-frequency broadband clicks, and brief tone bursts at four frequencies from 250 to 1,000 Hz. They demonstrated that loggerheads hear well between 250 and 1,000 Hz; within that frequency range, the turtles were most sensitive at 250 Hz.

Even if sea turtles were able to sense the sonar output, it is unlikely that any physiological stress leading to endocrine and corticosteroid imbalances over the long term (allostatic loading) would result (McEwen and Lashley 2002). An example of plasma hormone responses to stress was described by Jessop et al. (2002) for breeding adult male green turtles. Using capture/restraint as a stressor, they found a smaller corticosterone response and significant decreases in plasma androgen for breeding migrant males compared to nonbreeding males. These responses were highly correlated with the relatively poorer body condition and body length of the migrant breeders compared to nonmigrant and premigrant males. While this study illustrates the complex relationship between stress/physiological state and plasma hormone responses, these kinds of effects from mid-frequency active sonar in the NWTRC are unlikely for sea turtles.

The sonar with the lowest operating frequency operates at a center frequency of 3.5 kHz (or 3,500 Hz). The best hearing range for sea turtles most likely is less than 1 kHz, which is below that level. Although there may be many hours of active Anti-Submarine Warfare (ASW) sonar events, the actual "pings" of the sonar signal may only occur several times a minute, as it is necessary for the ASW operators to listen for the return echo of the sonar ping before another ping is transmitted. Thus, acoustic sources used during ASW exercises in the action area will have no effect on the leatherback sea turtle.

5.4.1.2 Weapons Firing Disturbance

A gun fired from a ship on the surface of the water propagates a blast wave away from the gun muzzle. As the blast wave hits the water, sound is carried into the water in proportion to the blast strike. Propagating energy is transmitted into the water in a finite region below the gun. A critical angle (about 13°, as measured from the vertical) can be calculated to determine the region of transmission in relation to a ship and gun (DoN 2006d).

The largest proposed shell size for NWTRC training activities is a 5-inch shell. This will produce the highest pressure of all ammunition used in the Study Area. All analysis will be done using the 5-inch shell as a source of produced and transmitted pressure, with the recognition that all other, smaller ammunition sizes would fall under these levels.

In June 2000, the Navy collected a series of pressure measurements during the firing of a 5-inch gun. Average pressure measured approximately 200 decibels with reference pressure of one micro Pascal (200 dB re 1 μPa) at the point of the air and water interface. Based on these values, down-range peak pressure levels were calculated to be less than 186 dB re 1 μPa at 100 meters (DoN 2001d), and as the distance increased, the pressure decreased. The rapid dissipation of the sound pressure wave, the low potential for occurrence of sea turtles in the NWTRC Study Area, and the protective measures implemented by the Navy to detect sea turtles in an area prior to implementing training activities, would result in the gun muzzle blasts having no effect on sea turtle species. This topic is not addressed further in the analyses of effects on sea turtles.

Ordnance cannot be released and explosives cannot be detonated until the target area is determined to be clear. Training activities are halted immediately if cetaceans, pinnipeds, or sea turtles are observed in the target area. Training activities are delayed until the animal clears the target area. All observers are in continuous communication to be able to immediately halt training activities. The exercise can be altered, as necessary, to obtain a clear target area. If the area cannot be cleared, the operation is canceled.

5.4.1.3 Underwater Detonations

Criteria and thresholds for estimating the impacts on sea turtles from a single underwater detonation event were determined during the environmental assessments for the two Navy ship-shock trials: the *Seawolf Final EIS* (DoN 1998) and the *Churchill Final EIS* (DoN 2001). In the analysis of the effects of detonations on sea turtles and marine mammals conducted by the Navy for the *Churchill EIS*, analysts compared the injury levels reported by the best of these experiments to the injury levels that would be predicted using the modified Goertner method, and found them to be similar (DoN 2001, Goertner 1982). The criteria and thresholds for injury and harassment are summarized in Table 5-4.

The criterion for non-injurious harassment is TTS, which is a temporary, recoverable, loss of hearing sensitivity (NMFS 2001; DoN 2001). The criterion for TTS is 182 dB re 1 μPa^2-s maximum Energy Flux Density Level (EL) level in any 1/3-octave band at frequencies greater than100 Hz for sea turtles. There is a second criterion for estimating TTS threshold: 12 pounds per square inch (psi) peak pressure. Navy policy is to use the 23 psi criterion for explosive charges less than 2,000 lb (909 kg) and the 12 psi criterion for explosive charges larger than 2,000 lb (909 kg). It was introduced to provide a safety zone for TTS when the explosive or the animal approaches the sea surface (for which case the explosive energy is reduced but the peak pressure is not reduced).

Two criteria are used for injury: onset of slight lung hemorrhage and 50 percent eardrum (tympanic membrane [TM]) rupture. These criteria are considered indicative of the onset of injury. The threshold for onset of slight lung injury is calculated for a small animal (a dolphin calf weighing 27 lb [12 kg]), and is given in terms of the "Goertner modified positive impulse," indexed to 13 psi-millisecond (ms) (DoN 2001). This threshold is conservative because the positive impulse needed to cause injury is proportional to animal mass and, therefore, larger animals require a higher impulse to cause the onset of injury. The threshold for TM rupture corresponds to a 50 percent rate of rupture (i.e., 50 percent of animals exposed to the level are expected to suffer TM rupture); this threshold is stated in terms of an EL value of 205 dB re 1 μPa^2-s. The criterion indicates that TM rupture is not necessarily a serious or life-threatening injury, but is a useful index of possible injury that is well correlated with measures of permanent hearing impairment (e.g., Ketten 1998 indicates a 30 percent incidence of permanent threshold shift [PTS] at the same threshold).

Table 5-4. Criteria and Acoustic Thresholds for Underwater Detonation Impacts on Sea Turtles and Marine Mammals

	Criterion	Threshold
Level A Harassment		
Mortality	Onset of Severe Lung Injury	Goertner Modified Positive Impulse Indexed to 31 psi-ms
Injury	Tympanic membrane rupture	50-percent rate of rupture; 205 dB re 1 μPa2-s (Energy Flux Density)
	Onset of slight lung injury	Goertner Modified Positive Impulse Indexed to 13 psi-ms
Level B Harassment		
Non-Injury	Temporary Threshold Shift (TTS)	182 dB re 1 μPa2-s (Energy Flux Density) in any 1/3-octave band at frequencies above 100 Hz for all toothed whales (e.g. sperm whales, beaked whales); above 10 Hz for all baleen whales
Dual Criteria	Onset Temporary Threshold Shift	23 psi peak pressure level (for small explosives)
psi-ms = pounds per square inch-milliseconds, μPa2-s = squared micropascal-second		

The criterion for mortality for marine mammals used in the *Churchill Final EIS* is "onset of severe lung injury." This criterion is conservative because it corresponds to a 1 percent chance of mortal injury, and yet any animal experiencing onset severe lung injury is counted as a lethal exposure. The threshold is stated in terms of the Goertner (1982) modified positive impulse with value "indexed to 31 psi-ms." The Goertner approach depends on propagation, source/animal depths, and animal mass in a complex way, so the actual impulse value corresponding to the 31-psi-ms index is a complicated calculation. Again, to be conservative, the *Churchill* analysis used the mass of a calf dolphin (at 27 lb [12 kg]), so that the threshold index is 30.5 psi-ms.

The lead time to set up and clear the impact area before an event using explosives takes place may be 30 minutes to several hours. There will, therefore, be a long period of area monitoring before any detonation or live-fire event begins. Ordnance cannot be released until the target area is determined to be clear. Training activities are immediately halted if sea turtles are observed within the target area. Training activities are delayed until the animal clears the target area. These practices lower the risk of harming sea turtles.

5.4.2 Results

5.4.2.1 Underwater Detonations and Explosive Ordnance

Underwater detonations and explosive ordnance would have the potential to affect the leatherback sea turtle in the action area. Approximately 1,200 marine detonations would take place under the Proposed Action; an increase of 100 events over current conditions. This would produce 0.035 detonations/nm^2

annually. Given the low potential for turtle occurrence and standard Navy protective measures, the potential for sea turtles to be affected by underwater detonations is quite low.

Little is known about the effects of underwater detonations on sea turtles. Given the mitigation measures described in Section 6, in particular, the 1,000 to 2,000 ft (305 to 610 m) protection zones, shallow underwater demolition exercises will not affect the endangered leatherback sea turtle in the action area.

Under existing conditions, approximately 93 bomb and missile detonations occur during training activities in the NWTRC. In addition, 149 explosive sonobuoys are used. Although use of these explosive training components would be concentrated in W-237, their use may occur in all areas of the NWTRC beyond 3 nm (6 km). The occurrence density of annual ordnance use would be approximately 0.002 detonations/nm^2 over the 122,241 nm^2 (420,000 km^2) range.

The leatherback sea turtle generally occurs offshore, but they have been sited in Puget Sound. In the event that a sea turtle were in the vicinity of underwater EOD activities, they could be exposed to noise and the pressure wave from the detonation. Monitoring and resource protection undertaken prior to any detonation of EOD would reduce the likelihood of sea turtles being exposed to such detonations. Although the potential exists for leatherbacks to be affected by underwater EOD, the low occurrence rate of turtles in the EOD area and protective measures that are used during training activities to identify turtle presences and suspend detonation activities if a turtle should be spotted, would make these effects discountable.

The turtle density estimates extrapolated from Southern California were used in conjunction with modeling (as described in 3.9 Marine Mammals) to estimate the number of sea turtles that could be affected by detonations. Table 5-5 provides a summary of the explosive analysis for the Proposed Action, which indicates the number of leatherback turtles potentially affected.

Table 5-5. Summary of Potential Annual Exposures from Explosive Ordnance for Leatherback Turtle

Ordnance Type	Dual Criteria	Level B Harassment (Non-Injury)	Injury	Level A Harassment (Mortality_
	23 psi for small explosives	Potential Exposures @ 182 dB re 1 μPa^2-s or 23 psi	Potential Exposures @ 205 dB re 1 μPa^2-s or 13 psi	Potential Exposures @ 30.5 psi
EOD Underwater Detonations	0	0	0	0
Bombs and Missiles	3	3	0	0
Sonobuoys	0	0	0	0
Total Exposures	**3**	**3**	**0**	**0**

In accordance with the ESA, use of explosive ordnance in the marine environment under The Proposed Action may affect the leatherback turtle.

5.4.2.2 Non-explosive Ordnance Use

Current Navy training activities in the NWTRC Study Area include firing a variety of weapons that employ non-explosive training rounds, including inert bombs, missiles, naval gun shells, cannon shells, and small-caliber ammunition. These materials are used in the open ocean beyond 3 nm (6 km) and represent potential stressors to the leatherback turtle. Ordnance strikes have the potential to injure or kill leatherback turtles in the Study Area. Turtles swimming or feeding at or just beneath the water surface are particularly vulnerable to an ordnance strike.

Non-explosive ordnance strikes on leatherback turtles have a low potential for occurrence under the Proposed Action. Approximately 191,000 non-explosive ordnance rounds would be used in the NWTRC annually under the Proposed Action. This use could be concentrated in W-237, but ordnance would be used in all areas of the NWTRC beyond 3 nm (6 km). The density of annual ordnance use would be approximately 1.5 items/nm^2 (5.2 items/km^2) over the 122,241 nm^2 (420,000 km^2) range.

In accordance with the ESA, non-explosive ordnance strikes under the Proposed Action may affect sea turtles.

5.4.2.3 IEER/EER

IEER sonobuoy detonations may harm or harass sea turtles but, if so, numbers would be very small because of their distribution, the low abundance of the leatherback, the relatively small number of exercises and the mitigation measures described in Section 6. Annual rates of adult survival likely would not be reduced, and recruitment would not be affected. Planned IEER sonobuoy detonations may affect the endangered leatherback sea turtle.

5.4.2.4 Ship and Torpedo Collisions

The number of Navy vessels operating during training exercises would average one vessel per exercise. During a year of training activities, steaming hours would be about 7,628 hours. Vessel movements would be widely dispersed throughout the NWTRC Study Area, with approximately 0.06 hours of steaming per square nautical mile. The modest number of steaming hours would not measurably increase potential effects to sea turtles. Disturbance impacts to sea turtles from vessel movements under the Proposed Action would be similar to existing conditions.

The ability of turtles to detect approaching vessels via auditory and/or visual cues would be expected based on knowledge of their sensory biology (Bartol and Musick 2003; Ketten and Bartol 2006; Moein Bartol and Ketten 2006; Bartol and Musick 2001; Levenson et al. 2004). Little information is available on how turtles respond to vessel approaches. Hazel et al. (2007) reported that greater vessel speeds increased the probability turtles would fail to flee from an approaching vessel. Turtles fled frequently in encounters with a slow-moving (2.2 knots) vessel, but infrequently in encounters with a moderate-moving (5.9 knots) vessel, and only rarely in encounters with a fast-moving (10.3 knots) vessel. It is difficult to differentiate whether a sea turtle reacts to a vessel due to the produced sound, the presence of the vessel itself, or a combination of both.

Sea turtles possess an overall hearing range of approximately 100 to 1,000 Hz, with an upper limit of 2,000 Hz (Ridgway et al. 1969; Lenhardt et al. 1994; Bartol et al. 1999; Ketten and Moein Bartol 2006). Although it is difficult to determine whether sea turtle response to vessel traffic is visual or auditory in nature, it is assumed sea turtles can hear approaching vessels given their hearing range.

Hazel et al. (2007) found that sea turtles reacted to approaching vessels in a variety of ways. Benthic turtles launched upwards at a shallow angle and began swimming. The majority of the turtles swam away from the vessel while some swam along the vessel's track and some crossed in front of the vessel's track before swimming away. Sea turtle reaction time was greatly dependant on the speed of the vessel; sea turtles were able to react faster to slower moving vessels than to faster moving vessels. Sea turtle reactions to vessels elicited short-term responses.

Human disturbance to wild animals may elicit similar reactions to those caused by natural predators (Gill et al. 2001; Beale and Monaghan 2004). Behavioral responses may also be accompanied by a physiological response (Romero 2004), although this is very difficult to study in the wild. Immature Kemp's ridley turtles have shown physiological responses to the acute stress of capture and handling through increased levels of corticosterone (Gregory and Schmid 2001). In the short term, exposure to stressors results in changes in immediate behavior (Frid 2003). For turtles, this can include intense behavioral reactions such as biting and rapid flipper movement (Gregory and Schmid 2001). Repeated exposure to stressors, including human disturbance such as vessel disturbance and anthropogenic sound, can result in negative consequences to the health and viability of an individual or population. Chronic stress can result in decreased reproductive success (Lordi et al. 2000; Beale and Monaghan 2004), decreased energy budget (Frid 2003), displacement from habitat (Southerland and Crockford 1993), and lower survival rates of offspring (Lordi et al. 2000). Although this study related to natural induced stressors, similar physiological changes may result from other types of stressors such as anthropogenic disturbance. At this time, it is unknown what the long-term implications of chronic stress may be on sea turtle species.

Sea turtles exposed to the general disturbance associated with a passing Navy ship could exhibit a short-term behavioral response such as fleeing. Therefore, in accordance with the ESA, general ship activities associated with the Proposed Action may affect sea turtles.

Collisions between vessels and sea turtles are possible, but are less likely than collisions with marine mammals because sea turtles are much smaller and less abundant than marine mammals in the NWTRC.

The Navy's standard operating procedures include a number of measures that will prevent a collision between a naval vessel and a sea turtle (see Section 6). Navy vessels use safety lookouts 24 hours a day, who look for any and all objects in the water, including sea turtles. Ships and surfaced submarines use caution and operate at safe speeds consistent with weather and sea state conditions, and ships and submarines maneuver to avoid collision if a sea turtle closes within 200 yds (183 m) confirm, to the extent possible, with safety of the vessel paramount.

Thus, the combination of the low initial probability of collision with sea turtle and the active attempts to avoid such an event reduces the likelihood of a ship colliding with a sea turtle to an extremely low level. Collisions with vessels may affect sea turtle species.

There is negligible risk that a sea turtle could be struck by a torpedo during ASW training events. This conclusion is based on: (1) a review of ASW torpedo design features, and (2) review of a large number of previous Navy exercise ASW torpedo events, (3) the very low density of sea turtles in the NWTRC, and (4) the low number of annual torpedo firings in the NWTRC. The torpedoes are specifically designed to ignore false targets. Given the relatively small size of sea turtles, there is negligible risk that a turtle could be struck by a torpedo during ASW training events.

Thus, vessel operations and ship and torpedo strikes may affect the endangered leatherback sea turtle known to inhabit the Proposed Action Area.

5.4.2.5 Aircraft Overflights

Under the Proposed Action, 11,786 overflights would occur annually. This would be a 55 percent increase over the number of overflights under existing conditions. Most overflights would occur over marine environments of the NWTRC, at elevations in excess of 3,000 ft (914 m) above sea level and beyond 3 nm (6 km).

The increase in potential exposure to visual and noise disturbance that would be associated with a 55 percent increase in overflights would not measurably increase effects to sea turtles. Sea turtles could exhibit no response, or may change their behavior to avoid the disturbance. Any behavioral avoidance reaction would be short-term and would not permanently displace animals or result in physical harm. Overflights are not expected to result in chronic stress, because it is extremely unlikely that individual animals would be repeatedly exposed to low-altitude overflights.

In accordance with the ESA, aircraft overflights under the Proposed Action may affect sea turtles.

5.4.2.6 Entanglement and Ingestion

Use of parachuted sonobuoys would increase by approximately 6 percent over current conditions. The entanglement in and ingestion of persistent marine debris threatens the survival of sea turtles in the eastern Pacific Ocean (NMFS and USFWS, 1998a). Turtles can become entangled in abandoned fishing gear and cannot submerge to feed or surface to breathe; they may lose a limb or attract predators with their struggling. Even though sea turtles may be affected by entanglement in Navy debris in the NWTRC, the effects would be considered discountable because of the low abundance and density of the turtles and low concentration and temporary availability of debris. Turtles have been reported to ingest or become entangled in plastics and other buoyant and persistent synthetic debris discarded into the ocean (Balazs 1985; Carr 1987).

Debris such as sonobuoy floats and parachutes, and missile and target components that float may be encountered by sea turtles in the waters of the NWTRC. Entanglement in military-related debris was not cited as a source of injury or mortality for any sea turtle recorded in a large marine mammal and sea turtle stranding database for Californian waters. That is most likely attributable to the relatively low density of military debris that remains on or near the sea surface where it might be encountered by a sea turtle. Parachute and cable assemblies used to facilitate target recovery are collected in conjunction with the target during normal training activities. Sonobuoys and flares sink along with the attached parachutes. Debris that leads to entanglement or injestion may affect the leatherback sea turtle in the action area.

5.4.2.7 Torpedo Control Wires

The MK-48 torpedo uses a control wire that is deployed along the path of the torpedo. The potential for sea turtles to become entangled in this wire is very low. The single-strand wire is very thin (approximately 0.02 in) and has a relatively low breaking strength (42 lb [19 kg]). In addition, when the wire is released or broken, it is relatively straight and the physical characteristics of the wire prevent it from tangling.

The potential for entanglement of sea turtles by MK-48 torpedo control wires is very low for the reasons discussed in torpedo strike in Section 5.4.2.4. In addition:

- The control wire is very thin and has a relatively low breaking strength. Even with the exception of a chance encounter with the control wire while it was sinking to the sea floor (at an estimated rate of 0.5 ft [0.2 m] per second), a marine animal would not be vulnerable to entanglement given the low breaking strength.

- The torpedo control wire is held stationary in the water column by drag forces as it is pulled from the torpedo in a relatively straight line until its length becomes sufficient for it to form a catenary droop (DoN 1996). When the wire is released or broken, it is relatively straight and the physical characteristics of the wire prevent it from tangling, unlike the monofilament fishing lines and polypropylene ropes identified in the entanglement literature (DoN 1996).

5.4.2.8 Target-Related Materials

A variety of at-sea targets would potentially be used in the NWTRC OPAREA, ranging from high-tech remotely operated airborne and surface targets (such as airborne drones) to low-tech floating at-sea targets (such as inflatable targets) and airborne towed banners. Many of the targets are designed to be recovered for reuse and are not destroyed during training. The expendable targets used in the Study Area are the EMATT (Expendable Mobile ASW Training Target) and the MK-58 Marine Marker. These units are 2 and 3 ft long, respectively, and sink to the bottom intact, and present no ingestion hazard to sea turtles. The total number of expended ordnance in the action area would be approximately 181,000 pieces per year. Assuming all ordnance would be expended in W-237 and an even distribution, the concentration of expended rounds would be 5.3/nm^2 (1.6/km^2). Target and marine maker use would increase from current conditions by 5 percent. This modest change in expended materials would not result in changes to sea turtle impacts over current conditions.

MK-58 marine markers produce chemical flames and regions of surface smoke and are used in various training exercises to mark a surface position to simulate divers, ships, and points of contact on the surface of the ocean. The smoke dissipates in the air having little effect on the marine environment. The marker burns similar to a flare, producing a flame until all burn components have been used. While the light generated from the marker is bright enough to be seen up to 3 mi (5 km) away in ideal conditions, the resulting light would either be reflected off the water's surface or would enter the water and attenuate in brightness over depth. Approximately 25 marine markers are used in the Study Area under the Baseline condition. Given the size of the Study Area and the low number of markers used, it would be very unlikely that sea turtles would be affected by use of marine markers.

Sonobuoys, lightweight torpedoes, Expendable Mobile ASW Training Targets (EMATTs), and other devices deployed from aircraft use nylon parachutes of varying sizes. For example, a typical sonobuoy parachute is about 8 ft (3 m) in diameter, with nylon suspension lines about 20 ft (6 m) long. At water impact, the parachute assembly is jettisoned and sinks away from the exercise weapon or target. The parachute assembly could remain on the surface for a short period before sinking to the sea floor. Sonobuoy parachutes are designed to sink within 15 minutes, but the rate of sinking depends upon sea conditions and the shape of the parachute.

Many large sea turtles subsist mainly on jellyfish, and the incidence of plastic bags being found in dead turtles indicates that the turtles may mistake floating plastic bags for jellyfish (Cottingham 1989). Sea turtles also ingest pieces of polystyrene foam, monofilament fishing line, and several other kinds of synthetic drift items. Some ingestion of plastics by marine mammals is known to occur. However, the parachutes used on the NWTRC are large in comparison with these animals' normal food items, and would be very difficult to ingest.

Sea turtles are also subject to entanglement in marine debris, particularly anything incorporating loops or rings, hooks and lines, or sharp objects. Entanglement and the eventual drowning of a sea turtle in a parachute assembly would be unlikely, because the parachute would have to land directly on an animal or an animal would have to swim into it before it sinks. The potential for a sea turtle to encounter an expended parachute assembly is extremely low, given the generally low probability of a sea turtle being in the immediate area of deployment. If bottom currents are present, the canopy may billow and pose an entanglement threat to marine animals with bottom-feeding habits. However, the probability of a sea turtle encountering a parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines is considered to be very low.

Overall, the possibility of sea turtles ingesting nylon parachute fabric or being entangled in parachute assemblies is very remote. The use of devices with parachutes in training exercises in the NWTRC may affect the endangered leatherback sea turtle.

5.4.3 Conclusion

This assessment considered the potential effects of sonar; underwater detonations, explosives and munitions; aircraft overflights; surface ship activities; ship and torpedo collisions; and entanglement or ingestion of training materials on the leatherback sea turtle in the Proposed Action Area. Based on the evaluations presented above, the Navy finds that the proposed NWTRC training events may affect the leatherback sea turtle in the Proposed Action Area. Mitigation and standard operating measures that serve to reduce or eliminate potential impacts of Navy activities on leatherback turtles that may be present in the training area vicinity, include personnel and watchstander training, establishment of turtle-free exclusion zones for underwater detonations of explosives, and pre- and post-exercise surveys.

5.5 FISH

Listed salmon, green sturgeon, and trout species can potentially be affected by non-acoustic sources (for example, ship strikes) and acoustic sources, with sonar and underwater detonations and explosives being the primary acoustic concerns.

The threatened fish species that may be affected by NWTRC activities include the green sturgeon (Southern DPS), bull trout (Coastal Puget Sound and Olympic Peninsula River ESUs), Chinook salmon (California Coastal, Puget Sound, and Lower Columbia River ESUs), chum salmon (Hood Canal and Columbia River ESUs), coho salmon (Oregon Coast and Northern California-Southern Oregon Coasts ESUs), and steelhead trout (Lower Columbia River, Northern California, Central California Coastal and Puget Sound ESUs). Critical habitat has been proposed for the Southern DPS green sturgeon; critical habitats have been designated for the remaining species. Potential effects to related groups of fish species and to designated critical habitats are addressed separately (reference Table 1-3).

Based on similarities in habitat requirements, life history characteristics, distribution, and similarities in responses to NWTRC OPAREA training activities, the Pacific Northwest Coast green sturgeon, salmon and steelhead trout ESUs/DPSs have been analyzed according to stressors associated with the potential Proposed Action effects in order to present determinations more efficiently.

5.5.1 Acoustic Effects of Underwater Sounds

There have been very few studies on the effects that human-generated sound may have on fish. These have been reviewed in a number of places (*e.g.*, NRC 1994, 2003; Popper 2003; Popper et al. 2004; Hastings and Popper 2005; Popper 2008), and some more recent experimental studies have provided additional insight into the issues (*e.g.*, Govoni et al. 2003; McCauley et al. 2003; Popper et al. 2005, 2007; Song et al., submitted). Most investigations, however, have been in the gray literature (non peer-reviewed reports – see Hastings and Popper 2005; and Popper 2008 for extensive critical reviews of this material).

There are a wide range of potential effects on fish that range from no effect at all (*e.g.*, the fish does not detect the sound or it “ignores” the sound) to immediate mortality. In between these extremes are a range of potential effects that parallel the potential effects on marine mammals that were illustrated by Richardson et al. (1995). These include, but may not be limited to:

- No effect behaviorally or physiologically: The animal may not detect the signal, or the signal is not one that would elicit any response from the fish.
- Small and inconsequential behavioral effects: Fish may show a temporary “awareness” of the presence of the sound but soon return to normal activities.
- Behavioral changes that result in the fish moving from its current site: This may involve leaving a feeding or breeding ground. This affect may be temporary, in that the fish return to the site after some period of time (perhaps after a period of acclimation or when the sound terminates), or permanent.
- Temporary loss of hearing (TTS): This recovers over minutes, hours, or days.
- Physical damage to auditory or non-auditory tissues (*e.g.*, swim bladder, blood vessels, brain): The damage may be only temporary, and the tissue “heals” with little impact on fish survival, or it may be more long-term, permanent, or may result in death. Death from physical damage could be a direct effect of the tissue damage or the result of the fish being more subject to predation than a healthy individual.

Studies on effects on hearing have generally been of two types. In one set of studies, the investigators exposed fish to long-term increases in background noise to determine if there are changes in hearing, growth, or survival of the fish. Such studies were directed at developing some understanding of how fish might be affected if they lived in an area with constant and increasing shipping or in the presence of a wind farm, or in areas where there are long-term acoustic tests. Other similar environments might be aquaculture facilities or large marine aquaria. In most of these studies examining long-term exposure, the sound intensity was well below any that might be expected to have immediate damage to fish (*e.g.*, damage tissues such as the swim bladder or blood vessels).

In the second type of studies, fish were exposed to short duration but high intensity signals such as might be found near a high intensity sonar, pile driving, or seismic air gun survey. The investigators in such studies were examining whether there was not only hearing loss and other long-term effects, but also short-term effects that could result in death to the exposed fish.

5.5.1.1 Effects of Long-Duration Increases in Background Sounds on Fish

Effects of long-duration relatively low intensity sounds (*e.g.*, below 170 – 180 dB re 1 µPa received level ([RL]) indicate that there is little or no effect of long-term exposure on hearing generalists (*e.g.*, Scholik and Yan 2001; Amoser and Ladich 2003; Smith et al. 2004a,b; Wysocki et al. 2007). The longest of these studies exposed young rainbow trout (*Oncorhynchus mykiss*), to a level of noise equivalent to one that fish would experience in an aquaculture facility (*e.g.*, on the order of 150 dB re 1 µPa RL) for about nine months. The investigators found no effect on hearing or on any other measures including growth and effects on the immune system as compared to fish raised at 110 dB re 1 µPa RL. The sound level used in the study would be equivalent to ambient sound in the same environment without the presence of pumps and other noise sources of an aquaculture facility (Wysocki et al. 2007).

Studies on hearing specialists have shown that there is some hearing loss after several days or weeks of exposure to increased background sounds, although the hearing loss seems to recover (*e.g.*, Scholik and Yan 2002; Smith et al. 2004b, 2006). Smith et al. (2004a, 2006) investigated the goldfish (*Carassius auratus*). They exposed fish to noise at 170 dB re 1 µPa and there was a clear relationship between the level of the exposure sound and the amount of hearing loss. There was also a direct correlation of level of hearing loss and the duration of exposure, up to 24-hours, after which time the maximum hearing loss was found.

Similarly, Wysocki and Ladich (2005) investigated the influence of noise exposure on the auditory sensitivity of two freshwater hearing specialists, the goldfish and the lined Raphael catfish (*Platydoras costatus*), and on a freshwater hearing generalist, a sunfish (*Lepomis gibbosus*). Baseline thresholds showed greatest hearing sensitivity around 0.5 kHz in the goldfish and catfish and at 0.1 kHz in the sunfish. For the hearing specialists (goldfish and catfish), continuous white noise of 130 dB re 1 µPa RL resulted in a significant threshold shift of 23 to 44 dB. In contrast, the auditory thresholds in the hearing generalist (sunfish) declined by 7 to 11 dB.

In summary, it appears that some increase in ambient noise level, even to above 170 dB re 1 µPa does not permanently alter the hearing ability of the hearing generalist species studied, even if the increase in sound level is for an extended period of time. However, this may not be the case for all hearing generalists, though it is likely that any temporary hearing loss in such species would be considerably less than for specialists receiving the same noise exposure. It is also clear that there is a larger temporary hearing loss in hearing specialists.

5.5.1.2 Effects of High Intensity Sounds on Fish

There is a small group of studies that discusses effects of high intensity sound on fish. However, as discussed in Hastings and Popper (2005), much of this literature has not been peer reviewed, and there are substantial issues with regard to the actual effects of these sounds on fish. More recently, however, there have been two studies of the effects of high intensity sound on fish that, using experimental approaches, provided insight into overall effects of these sounds on hearing and on auditory and non-auditory tissues. One study tested effects of seismic air guns, a highly impulsive and intense sound source, while the other study examined the effects of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar.

5.5.1.3 Effects of Seismic Air guns on Fish

Popper et al. (2005; Song et al., submitted) examined the effects of exposure to a seismic air gun array on three species of fish found in the Mackenzie River Delta near Inuvik, Northwest Territories, Canada. The species included a hearing specialist, the lake chub (*Couesius plumbeus*), and two hearing generalists, the northern pike (*Esox lucius*), and the broad whitefish (*Coregonus nasus*) (a salmonid). In this study, fish in cages were exposed to 5 or 20 shots from a 730 cubic inch (12,000 cc) calibrated air gun array. And, unlike earlier studies, the received exposure levels were not only determined for RMS sound pressure level, but also for peak sound levels and for SELs (*e.g.*, average mean peak SPL 207 dB re 1 µPa RL; mean RMS sound level 197 dB re 1 µPa RL; mean SEL 177 dB re 1 µPa2s).

The results showed a temporary hearing loss for both lake chub and northern pike, but not for the broad whitefish, to both 5 and 20 air gun shots. Hearing loss was on the order of 20 to 25 dB at some frequencies for both the northern pike and lake chub, and full recovery of hearing took place within 18 hours after sound exposure. While a full pathological study was not conducted, fish of all three species survived the sound exposure and were alive more than 24 hours after exposure. Those fish of all three species had intact swim bladders and there was no apparent external or internal damage to other body tissues (*e.g.*, no bleeding or grossly damaged tissues), although it is important to note that the observer in this case (unlike in the following LFA study) was not a trained pathologist. Recent examination of the ear tissues by an expert pathologist showed no damage to sensory hair cells in any of the fish exposed to sound (Song et al., submitted).

A critical result of this study was that it demonstrated differences in the effects of air guns on the hearing thresholds of different species. In effect, these results substantiate the argument made by Hastings et al. (1996) and McCauley et al. (2003) that it is difficult to extrapolate between species with regard to the effects of intense sounds.

5.5.1.4 Effects of SURTASS LFA Sonar on Fish

Popper et al. (2007) studied the effect of SURTASS LFA on hearing, the structure of the ear, and select non-auditory systems in the rainbow trout (*Oncorhynchus mykiss*) and channel catfish (*Ictalurus punctatus*).

The SURTASS LFA sonar study was conducted in an acoustic free-field environment that enabled the investigators to have a calibrated sound source and to monitor the sound field throughout the experiments. In brief, experimental fish were placed in a test tank, lowered to depth, and exposed to LFA sonar for 324 or 648 seconds, an exposure duration that is far greater than any fish in the wild would get since, in the wild, the sound source is on a vessel moving past the far slower swimming fish. For a single tone, the maximum RL was approximately 193 dB re 1 µPa at 196 Hz and the level was uniform within the test tank to within approximately ±3 dB. The signals were produced by a single SURTASS LFA sonar transmitter giving an approximate source level of 215 dB. Following exposure, hearing was measured in the test animals. Animals were also sacrificed for examination of auditory and non-auditory tissues to determine any non-hearing effects. All results from experimental animals were compared to results obtained from baseline control and control animals.

A number of results came from this study. Most importantly, no fish died as a result of exposure to the experimental source signals. Fish all appeared healthy and active until they were sacrificed or returned to the fish farm from which they were purchased. In addition, the study employed the expertise of an expert fish pathologist who used double-blind methods to analyze the tissues of the fish exposed to the sonar source, and compared these to control animals. The results clearly showed that there were no pathological effects from sound exposure including no effects on all major body tissues (brain, swim bladder, heart, liver, gonads, blood, etc.). There was no damage to the swim bladder and no bleeding as a result of LFA sonar exposure. Furthermore, there were no short- or long-term effects on ear tissue (Popper et al. 2007).

Moreover, behavior of caged fish after sound exposure was no different than that prior to tests. It is critical to note, however, that behavior of fish in a cage in no way suggests anything about how fish would respond to a comparable signal in the wild. Just as the behavior of humans exposed to a noxious stimulus might show different behavior if in a closed room as compared to being out-of-doors, it is likely that the behaviors shown by fish to stimuli will also differ, depending upon their environment.

The study also incorporated effects of sound exposure on hearing both immediately post exposure and for several days thereafter to determine if there were any long-term effects, or if hearing loss showed up at some point post exposure. Catfish and some specimens of rainbow trout showed 10 to 20 dB of hearing loss immediately after exposure to the LFA sonar when compared to baseline and control animals; however another group of rainbow trout showed no hearing loss. Recovery in trout took at least 48 hours, but studies could not be completed. The different results between rainbow trout groups is difficult to understand, but may be due to developmental or genetic differences in the various groups of fish. Catfish hearing returned to, or close to, normal within about 24 hours.

5.5.1.5 Additional Sonar Data

While there are no other data on the effects of sonar on fish, there are two recent unpublished reports of some relevance since it examined the effects on fish of a mid-frequency sonar (1.5 to 6.5 kHz) on larval and juvenile fish of several species (Jørgensen et al. 2005; Kvadsheim and Sevaldsen 2005). In this study, larval and juvenile fish were exposed to simulated sonar signals in order to investigate potential effects on survival, development, and behavior. The study used herring (*Clupea harengus*) (standard lengths 2 to 5 cm), Atlantic cod (*Gadus morhua*) (standard length 2 and 6 cm), saithe (*Pollachius virens*) (4 cm), and spotted wolffish (*Anarhichas minor*) (4 cm) at different developmental stages.

Fish were placed in plastic bags 10 ft (3 m) from the sonar source and exposed to between four and 100 pulses of 1-second duration of pure tones at 1.5, 4 and 6.5 kHz. Sound levels at the location of the fish ranged from 150 to 189 dB. There were no effects on fish behavior during or after exposure to sound (other than some startle or panic movements by herring for sounds at 1.5 kHz) and there were no effects on behavior, growth (length and weight), or survival of fish kept as long as 34 days post exposure. All exposed animals were compared to controls that received similar treatment except for actual exposure to the sound. Excellent pathology of internal organs showed no damage as a result of sound exposure. The only exception to almost full survival was exposure of two groups of herring tested with sound pressure levels (SPLs) of 189 dB, where there was a post-exposure mortality of 20 to 30 percent. While these were statistically significant losses, it is important to note that this sound level was only tested once and so it is not known if this increased mortality was due to the level of the test signal or to other unknown factors.

In a follow-up unpublished analysis of these data, Kvadsheim and Sevaldsen (2005) sought to understand whether the mid-frequency continuous wave (CW) signals used by Jørgensen et al. (2005) would have a significant impact on larvae and juveniles in the wild exposed to this sonar. The investigators concluded that the extent of damage/death induced by the sonar would be below the level of loss of larval and juvenile fish from natural causes, and so no concerns should be raised. The only issue they did suggest needs to be considered is when the CW signal is at the resonance frequency of the swim bladders of small clupeids. If this is the case, the investigators predict (based on minimal data that is in need of replication) that such sounds might increase the mortality of small clupeids that have swim bladders that would resonate.

5.5.1.6 Other High Intensity Sources

A number of other sources have been examined for potential effects on fish. These have been critically and thoroughly reviewed recently by Hastings and Popper (2005) and so only brief mention will be made of a number of such studies.

One of the sources of most concern is pile driving, as occurs during the building of bridges, piers, off-shore wind farms, and the like. There have been a number of studies that suggest that the sounds from pile driving, and particularly from driving of larger piles, kill fish that are very close to the source. The source levels in such cases often exceed 230 dB re 1 µPa (peak) and there is some evidence of tissue damage accompanying exposure (*e.g*., Caltrans 2001, 2004; reviewed in Hastings and Popper 2005). However, there is reason for concern in analysis of such data since, in many cases the only dead fish that were observed were those that came to the surface. It is not clear whether fish that did not come to the surface survived the exposure to the sounds, or died and were carried away by currents.

There are also a number of gray literature experimental studies that placed fish in cages at different distances from the pile driving operations and attempted to measure mortality and tissue damage as a result of sound exposure. However, in most cases the studies' (*e.g*., Caltrans 2001, 2004; Abbott et al. 2002, 2005; Nedwell et al. 2003) work was done with few or no controls, and the behavioral and histopathological observations done very crudely (the exception being Abbott et al. 2005). As a consequence of these limited and unpublished data, it is not possible to know the real effects of pile driving on fish.

In a widely cited unpublished report, Turnpenny et al. (1994) examined the behavior of three species of fish in a pool in response to different sounds. While this report has been cited repeatedly as being the basis for concern about the effects of human-generated sound on fish, there are substantial issues with the work that make the results unusable for helping understand the potential effects of any sound on fish, including mid- and high-frequency sounds. The problem with this study is that there was a complete lack of calibration of the sound field at different frequencies and depths in the test tank, as discussed in detail in Hastings and Popper (2005). The issue is that in enclosed chambers that have an interface with air, such as tanks and pools used by Turnpenny et al. (1994), the sound field is known to be very complex and will change significantly with frequency and depth. Thus, it is impossible to know the stimulus that was actually received by the fish. Moreover, the work done by Turnpenny et al. (1994) was not replicated by the investigators even within the study, and so it is not known if the results were artifact, or were a consequence of some uncalibrated aspects of the sound field that cannot be related, in any way, to human-generated high intensity sounds in the field, at any frequency range.

Several additional studies have examined effects of high intensity sounds on the ear. While there was no effect on ear tissue in either the SURTASS LFA study (Popper et al. 2007) or the study of effects of seismic air guns on hearing (Popper et al. 2005; Song et al., submitted), three earlier studies suggested that there may be some loss of sensory hair cells due to high intensity sources. However, none of these studies concurrently investigated effects on hearing or non-auditory tissues. Enger (1981) showed some loss of sensory cells after exposure to pure tones in the Atlantic cod. A similar result was shown for the lagena of the oscar (*Astronotus oscellatus*), a cichlid fish, after an hour of continuous exposure (Hastings et al. 1996). In neither study was the hair cell loss more than a relatively small percent of the total sensory hair cells in the hearing organs.

Most recently, McCauley et al. (2003) showed loss of a small percent of sensory hair cells in the saccule (the only end organ studied) of the pink snapper (*Pagrus auratus*), and this loss continued to increase (but never to become a major proportion of sensory cells) for up to at least 53 days post exposure. It is not known if this hair cell loss, or the ones in the Atlantic cod or oscar, would result in hearing loss since fish have tens or even hundreds of thousands of sensory hair cells in each otolithic organ (Popper and Hoxter, 1984; Lombarte and Popper, 1994) and only a small portion were affected by the sound. The question remains as to why McCauley et al. (2003) found damage to sensory hair cells while Popper et al. (2005)

did not. The problem is that there are so many differences in the studies, including species, precise sound source, spectrum of the sound (the Popper et al. 2005 study was in relatively shallow water with poor low-frequency propagation), that it is hard to even speculate.

Beyond these studies, there have also been questions raised as to the effects of other sound sources such as shipping, wind farm operations, and the like. However, there are limited or no data on actual effects of the sounds produced by these sources on any aspect of fish biology.

5.5.1.7 Intraspecific Variation in Effects

One unexpected finding in several of the recent studies is that there appears to be variation in the effects of sound, and on hearing, that may be a correlated with environment, developmental history, or even genetics.

During the aforementioned LFA sonar study on rainbow trout, Popper et al. (2007) found that some fish showed a hearing loss, but other animals, obtained a year later but from the same supplier and handled precisely as the fish used in the earlier part of the study, showed no hearing loss. The conclusion reached by Popper et al. (2007) was that the differences in responses may have been related to differences in genetic stock or some aspect of early development in the two groups of fish studied.

The idea of a developmental effect was strengthened by findings of Wysocki et al. (2007) who found differences in hearing sensitivity of rainbow trout that were from the same genetic stock, but that were treated slightly differently in the egg stage. This is further supported by studies on hatchery-reared Chinook salmon (*Oncorhynchus tshawytscha*) which showed that some animals from the same stock and age class had statistical differences in their hearing capabilities that was statistically correlated with differences in otolith structure (Oxman et al. 2007). While a clear correlation could not be made between these differences in otolith structure and specific factors, there is strong reason to believe that the differences resulted from environmental effects during development.

The conclusion one must reach from these findings is that there is not only variation in effects of intense sound sources on different species, but that there may also be differences based on genetics or development. Indeed, one can go even further and suggest that there may ultimately be differences in effects of sound on fish (or lack of effects) that are related to fish age as well as development and genetics since it was shown by Popper et al. (2005) that identical seismic air gun exposures had very different effects on hearing in young-of-the-year northern pike and sexually mature animals.

5.5.1.8 Effects of Anthropogenic Sound on Fish Behavior

There have been very few studies of the effects of anthropogenic sounds on the behavior of wild (unrestrained) fishes. This includes not only immediate effects on fish that are close to the source but also effects on fish that are further from the source.

Several studies have demonstrated that human-generated sounds may affect the behavior of at least a few species of fish. Engås et al. (1996) and Engås and Løkkeborg (2002) examined movement of fish during and after a seismic air gun study although they were not able to actually observe the behavior of fish per se. Instead, they measured catch rate of haddock and Atlantic cod as an indicator of fish behavior. These investigators found that there was a significant decline in catch rate of haddock (*Melanogrammus aeglefinus*) and Atlantic cod (*Gadus morhua*) that lasted for several days after termination of air gun use. Catch rate subsequently returned to normal. The conclusion reached by the investigators was that the decline in catch rate resulted from the fish moving away from the fishing site as a result of the air gun sounds. However, the investigators did not actually observe behavior, and it is possible that the fish just changed depth. Another alternative explanation is that the air guns actually killed the fish in the area, and the return to normal catch rate occurred because of other fish entering the fishing areas.

More recent work from the same group (Slotte et al. 2004) showed parallel results for several additional pelagic species including blue whiting and Norwegian spring spawning herring. However, unlike earlier studies from this group, Slotte et al. (2004) used fishing sonar to observe behavior of the local fish schools. They reported that fishes in the area of the air guns appeared to go to greater depths after the air gun exposure compared to their vertical position prior to the air gun usage. Moreover, the abundance of animals 16 to 27 nm (30 to 50 km) away from the ensonification increased, suggesting that migrating fish would not enter the zone of seismic activity. It should be pointed out that the results of these studies have been refuted by Gausland (2003) who, in a non peer-reviewed study, suggested that catch decline was from factors other than exposure to air guns and that the data were not statistically different than the normal variation in catch rates over several seasons.

Similarly Skalski et al. (1992) showed a 52 percent decrease in rockfish (Sebastes sp.) catch when the area of catch was exposed to a single air gun emission at 186 to 191 dB re 1 µPa (mean peak level) (see also Pearson et al., 1987, 1992). They also demonstrated that fishes would show a startle response to sounds as low as 160 dB, but this level of sound did not appear to elicit decline in catch.

Wardle et al. (2001) used a video system to examine the behaviors of fish and invertebrates on a coral reef in response to emissions from seismic air guns that were carefully calibrated and measured to have a peak level of 210 dB re 1 µPa at 52 ft (16 m) from the source and 195 dB re 1 µPa at 358 ft (109 m) from the source. They found no substantial or permanent changes in the behavior of the fish or invertebrates on the reef throughout the course of the study, and no animals appeared to leave the reef. There was no indication of any observed damage to the animals.

Culik et al. (2001) and Gearin et al. (2000) studied how noise may affect fish behavior by looking at the effects of mid-frequency sound produced by acoustic devices designed to deter marine mammals from gillnet fisheries. Gearin et al. (2000) studied responses of adult sockeye salmon (*Oncorhynchus nerka*) and sturgeon (Acipenser sp.) to pinger sounds. They found that fish did not exhibit any reaction or behavior change to the onset of the sounds of pingers that produced broadband energy with peaks at 2 kHz or 20 kHz. This demonstrated that the alarm was either inaudible to the salmon and sturgeon, or that neither species was disturbed by the mid-frequency sound (Gearin et al. 2000). Based on hearing threshold data (Table 3.7-4), it is highly likely that the salmonids did not hear the sounds.

Culik et al. (2001) did a very limited number of experiments to determine catch rate of herring (*Clupea harengus*) in the presence of pingers producing sounds that overlapped the frequency range of hearing of herring (2.7 kHz to over 160 kHz). They found no change in catch rate in gill nets with or without the higher frequency (greater than 20 kHz) sounds present, although there was an increase in catch rate with the signals from 2.7 kHz to 19 kHz (a different source than the higher frequency source). The results could mean that the fish did not "pay attention" to the higher frequency sound or that they did not hear it, but that lower frequency sounds may be attractive to fish. At the same time, it should be noted that there were no behavioral observations on the fish, and so how the fish actually responded when they detected the sound is not known.

5.5.1.9 Masking

Any sound detectable by a fish can have an impact on behavior by preventing the fish from hearing biologically important sounds including those produced by prey or predators (Myrberg, 1980; Popper et al. 2003). This inability to perceive biologically relevant sounds as a result of the presence of other sounds is called masking. Masking may take place whenever the received level of a signal heard by an animal exceeds ambient noise levels or the hearing threshold of the animal. Masking is found among all vertebrate groups, and the auditory system in all vertebrates, including fishes, is capable of limiting the effects of masking signals, especially when they are in a different frequency range than the signal of biological relevance (Fay, 1988; Fay and Megela-Simmons, 1999).

One of the problems with existing fish masking data is that the bulk of the studies have been done with goldfish, a freshwater hearing specialist. The data on other species are much less extensive. As a result, less is known about masking in non-specialist and marine species. Tavolga (1974a, b) studied the effects of noise on pure-tone detection in two non-specialists and found that the masking effect was generally a linear function of masking level, independent of frequency. In addition, Buerkle (1968, 1969) studied five frequency bandwidths for Atlantic cod in the 20 to 340 Hz region and showed masking in all hearing ranges. Chapman and Hawkins (1973) found that ambient noise at higher sea states in the ocean have masking effects in cod, haddock, and Pollock, and similar results were suggested for several sciaenid species by Ramcharitar and Popper (2004). Thus, based on limited data, it appears that for fish, as for mammals, masking may be most problematic in the frequency region of the signal of the masker. Thus, for mid-frequency sonars, which are well outside the range of hearing of most all fish species, there is little likelihood of masking taking place for biologically relevant signals to fish since the fish will not hear the masker.

There have been a few field studies which may suggest that masking could have an impact on wild fish. Gannon et al. (2005) showed that bottlenose dolphins (*Tursiops truncatus*) move toward acoustic playbacks of the vocalization of Gulf toadfish (*Opsanus beta*). Bottlenose dolphins employ a variety of vocalizations during social communication including low-frequency pops. Toadfish may be able to best detect the low-frequency pops since their hearing is best below 1 kHz, and there is some indication that toadfish have reduced levels of calling when bottlenose dolphins approach (Remage-Healey et al. 2006). Silver perch have also been shown to decrease calls when exposed to playbacks of dolphin whistles mixed with other biological sounds (Luczkovich et al. 2000). Results of the Luczkovich et al. (2000) study, however, must be viewed with caution because it is not clear what sound may have elicited the silver perch response (Ramcharitar et al. 2006a).

Of considerable concern is that human-generated sounds could mask the ability of fish to use communication sounds, especially when the fish are communicating over some distance. In effect, the masking sound may limit the distance over which fish can communicate, thereby having an impact on important components of the behavior of fish. For example, the sciaenids, which are primarily inshore species, are probably the most active sound producers among fish, and the sounds produced by males are used to “call” females to breeding sights (Ramcharitar et al. 2001; reviewed in Ramcharitar et al. 2006a). If the females are not able to hear the reproductive sounds of the males, this could have a significant impact on the reproductive success of a population of sciaenids.

Also potentially vulnerable to masking is navigation by larval fish, although the data to support such an idea are still exceedingly limited. There is indication that larvae of some species may have the potential to navigate to juvenile and adult habitat by listening for sounds emitted from a reef (either due to animal sounds or non-biological sources such as surf action) (*e.g.*, Higgs 2005). In a study of an Australian reef system, the sound signature emitted from fish choruses was between 0.8 and 1.6 kHz (Cato, 1978) and could be detected by hydrophones 3 to 4 nm (5 to 8 km) from the reef (McCauley and Cato 2000). This bandwidth is within the detectable bandwidth of adults and larvae of the few species of reef fish that have been studied (Kenyon, 1996; Myrberg, 1980). At the same time, it has not been demonstrated conclusively that sound, or sound alone, is an attractant of larval fish to a reef, and the number of species tested has been very limited. Moreover, there is also evidence that larval fish may be using other kinds of sensory cues, such as chemical signals, instead of, or alongside of, sound (*e.g.*, Atema et al. 2002; Higgs et al. 2005).

Finally, it should be noted that even if a masker prevents a larval (or any) fish from hearing biologically relevant sounds for a short period of time (*e.g.*, while a sonar-emitting ship is passing), this may have no biological effect on the fish since they would be able to detect the relevant sounds before and after the masking, and thus would likely be able to find the source of the sounds.

5.5.1.10 Stress

Although an increase in background sound may cause stress in humans, there have been few studies on fish (*e.g.*, Smith et al. 2004a; Remage-Healey et al. 2006; Wysocki et al. 2006, 2007). There is some indication of physiological effects on fish such as a change in hormone levels and altered behavior in some (Pickering, 1981; Smith et al. 2004a, 2004b), but not all, species tested to date (*e.g.*, Wysocki et al. 2007). Sverdrup et al. (1994) found that Atlantic salmon subjected to up to 10 explosions to simulate seismic blasts released primary stress hormones, adrenaline and cortisol, as a biochemical response. There was no mortality. All experimental subjects returned to their normal physiological levels within 72 hours of exposure. Since stress affects human health, it seems reasonable that stress from loud sound may impact fish health, but available information is too limited to adequately address the issue.

5.5.1.11 Effects of Underwater Impulsive Sounds

There are few studies on the effects of impulsive sounds on fish, and no studies that incorporated mid- or high-frequency signals. The most comprehensive studies using impulsive sounds are from seismic air guns (*e.g*., Popper et al. 2005; Song et al., submitted). Additional studies have included those on pile driving (reviewed in Hastings and Popper 2005) and explosives (*e.g*., Yelverton et al. 1975; Keevin et al. 1997; Govoni et al. 2003; reviewed in Hastings and Popper 2005).

As discussed earlier in this report, the air gun studies on very few species resulted in a small hearing loss in several species, with complete recovery within 18 hours (Popper et al. 2005). Other species showed no hearing loss with the same exposure. There appeared to be no effects on the structure of the ear (Song et al. submitted), and a limited examination of non-auditory tissues, including the swim bladder, showed no apparent damage (Popper et al. 2005). One other study of effects of an air gun exposure showed some damage to the sensory cells of the ear (McCauley et al. 2003), but it is hard to understand the differences between the two studies. However, the two studies had different methods of exposing fish, and used different species. There are other studies that have demonstrated some behavioral effects on fish during air gun exposure used in seismic exploration (*e.g.*, Pearson et al. 1987, 1992; Engås et al. 1996; Engås and Løkkeborg 2002; Slotte et al. 2004), but the data are limited and it would be very difficult to extrapolate to other species, as well as to other sound sources.

5.5.1.12 Explosive Sources

A number of studies have examined the effects of explosives on fish. These are reviewed in detail in Hastings and Popper (2005). One of the real problems with these studies is that they are highly variable and so extrapolation from one study to another, or to other sources, such as those used by the Navy, is not really possible. While many of these studies show that fish are killed if they are near the source, and there are some suggestions that there is a correlation between size of the fish and death (Yelverton et al. 1975), little is known about the very important issues of non-mortality damage in the short- and long-term, and nothing is known about effects on behavior of fish.

The major issue in explosives is that the gas oscillations induced in the swim bladder or other air bubble in fishes caused by high sound pressure levels can potentially result in tearing or rupturing of the chamber. This has been suggested to occur in some (but not all) species in several gray literature unpublished reports on effects of explosives (*e.g*., Aplin 1947; Coker and Hollis 1950; Gaspin 1975; Yelverton et al. 1975), whereas other published studies do not show such rupture (*e.g*., the very well done peer reviewed study by Govoni et al. 2003). Key variables that appear to control the physical interaction of sound with fishes include the size of the fish relative to the wavelength of sound, mass of the fish, anatomical variation, and location of the fish in the water column relative to the sound source (*e.g*., Yelverton et al. 1975; Govoni et al. 2003).

Explosive blast pressure waves consist of an extremely high peak pressure with very rapid rise times (< 1 ms). Yelverton et al. (1975) exposed eight different species of freshwater fish to blasts of 1-lb spheres of Pentolite in an artificial pond. The test specimens ranged from 0.02 g (guppy) to 744 g (large carp) body mass and included small and large animals from each species. The fish were exposed to blasts having extremely high peak overpressures with varying impulse lengths. The investigators found what appears to be a direct correlation between body mass and the magnitude of the "impulse," characterized by the product of peak overpressure and the time it took the overpressure to rise and fall back to zero (units in psi-ms), which caused 50% mortality (see Hastings and Popper 2005 for detailed analysis).

One issue raised by Yelverton et al. (1975) was whether there was a difference in lethality between fish which have their swim bladders connected by a duct to the gut and fish which do not have such an opening. The issue is that it is potentially possible that a fish with such a connection could rapidly release gas from the swim bladder on compression, thereby not increasing its internal pressure. However, Yelverton et al. (1975) found no correlation between lethal effects on fish and the presence or lack of connection to the gut.

While these data suggest that fishes with both types of swim bladders are affected in the same way by explosive blasts, this may not be the case for other types of sounds, and especially those with longer rise or fall times that would allow time for a biomechanical response of the swim bladder (Hastings and Popper 2005). Moreover, there is some evidence that the effects of explosives on fishes without a swim bladder are less than those on fishes with a swim bladder (*e.g.*, Gaspin 1975; Geortner et al. 1994; Keevin et al. 1997). Thus, if internal damage is, even in part, an indirect result of swim bladder (or other air bubble) damage, fishes without this organ may show very different secondary effects after exposure to high sound pressure levels. Still, it must be understood that the data on effects of impulsive sources and explosives on fish are limited in number and quality of the studies, and in the diversity of fish species studied. Thus, extrapolation from the few studies available to other species or other devices must be done with the utmost caution.

In a more recent published report, Govoni et al. (2003) found damage to a number of organs in juvenile pinfish (*Lagodon rhomboids*) and spot (*Leiostomus xanthurus*) when they were exposed to submarine detonations at a distance of 12 ft (4 m), and most of the effects, according to the authors, were sublethal. Effects on other organ systems that would be considered irreversible (and presumably lethal) only occurred in a small percentage of fish exposed to the explosives. Moreover, there was virtually no effect on the same sized animals when they were at a distance of 25 ft (8 m), and more pinfish than spot were affected.

Based upon currently available data it is not possible to predict specific effects of Navy impulsive sources on fish. At the same time, there are several results that are at least suggestive of potential effects that result in death or damage. First, there are data from impulsive sources such as pile driving and seismic air guns that indicate that any mortality declines with distance, presumably because of lower signal levels. Second, there is also evidence from studies of explosives (Yelverton et al. 1975) that smaller animals are more affected than larger animals. Finally, there is also some evidence that fish without an air bubble, such as flatfish and sharks and rays, are less likely to be affected by explosives and other sources than are fish with a swim bladder or other air bubble.

Yet, as indicated for other sources, the evidence of short- and long-term behavioral effects, as defined by changes in fish movement, etc., is non-existent. Thus, it is unknown if the presence of an explosion or an impulsive source at some distance, while not physically harming a fish, will alter its behavior in any significant way.

5.5.1.13 Underwater Detonations and Explosive Ordnance

Explosions that occur in the Study Area are associated with training exercises that use explosive ordnance, including bombs (BOMBEX), missiles (MISSILEX), sink exercises (SINKEX) and naval gun shells (GUNEX, 5-inch high explosive rounds), as well as underwater detonations associated with EOD training. Explosive ordnance use and underwater detonation is limited to a few specific training areas (see Table 2-6 for a summary of operations by training area).

Under the Proposed Action, annual underwater detonations would decrease from 60 (baseline conditions) to 4, with continued implementation of resource protection measures.

Annual underwater detonations for the Proposed Action would be less than those analyzed by USFWS and repored in a November 7, 2008 Biological Opinion for Navy EOD Operations, Puget Sound (USFWS 2008). The Biological Opinion applies to Navy's ongoing EOD training conducted from the date of the Biological Opinion through December 31, 2009.

The findings of USFWS' Biological Opinion have been considered in the analysis for this BE. The Navy will conduct separate consultations with USFWS on the Proposed Action described in this BE, since the 2009 Biological Opinion considers the activities prior to January 1, 2010.

The findings of these Biological Opinions have been considered in the analysis for this BE. Utilizing criteria and analysis methodology as presented previously for non-listed species, vessel movements, aircraft overflight, underwater detonations, explosive ordnance use, sonar, non-explosive ordnance use, weapons firing, and expended materials may affect individual ESA-listed fish in the NWTRC, However, these activities would not have community or population level effects.

Physical injury to salmon could occur within the following distances of a detonation site for detonation of 20-lb. and 5-lb. charges, as shown in Table 5-6. These distances should be used to define "not properly functioning habitat" for noise/impulse conditions.

Table 5-6. Approximate Distances from Detonation Resulting in No Injury or 1 percent Mortality to Fish

Fish Species	No Effects (no injury) Distance (feet [meters])	
	20-lb. (9-kg) Charge	5-lb. (2-kg) Charge
Juvenile chum	2,789 (850)	1,903 (580)
Juvenile chinook	2,560 (780)	1,729 (527)
Adult chum	1,149 (350)	771 (235)
Adult chinook	1,050 (320)	709 (216)

Source: DoN, 2000 (Final BA EOD Puget Sound)

During their migration and rearing, juvenile salmon occur almost exclusively in shallow water directly adjacent to the shoreline. Therefore, the potential for injury effects on juveniles depends on the size of the charge and the distance from the EOD training area at any site to the nearest shoreline. This distance indicates that there is a potential for injury or mortality of juvenile salmon at both of the underwater detonation sites, if detonations occur when juvenile salmon are present along the nearest shorelines. The number of juveniles potentially affected would be small, because of the infrequent nature of the detonations. For some detonations, it is possible that no salmon would be injured, because none would be closer than the no-effects distances.

As shown above, the distances over which adult Chinook or chum salmon could be injured or killed are considerably smaller than the injury distances for juveniles. When adults are in the general vicinity of the training areas, they could be injured or killed as a result. The number of adult salmon expected to be affected depends on the frequency of the detonations, and the likelihood of adult salmon to be present at the sites. Crescent Harbor is outside the major migration corridor for river systems in the area. The Indian Island EOD OPAREA, adjacent to Naval Magazine Indian Island, is seldom used for underwater detonations. This area lies on a migration corridor for Chinook, chum, and other salmon species in the Hood Canal system. As such, the Indian Island EOD area is expected to support larger numbers of adult salmon than Crescent Harbor. Resident Chinook (blackmouth) may occur in low densities. At any time of the year, small numbers of adult salmon are expected to occur within the injury distances of the detonation sites at the time of detonation. Therefore, a small number of adult salmon are expected to be injured by EOD detonations.

Effects to bull trout would be similar to those described for salmon. Regarding the potential for physical injury, Table 5-7 shows “safe distances,” based on no injury and 90 percent survival for adult and juvenile bull trout, using the method of Young (1991). As with juvenile salmon, juvenile bull trout could be injured by explosions of the largest charges at the detonations sites, if the juveniles occurred at nearby shorelines when an explosion occurred. However, juvenile bull trout are less likely to be present near the explosion sites than juvenile salmon. Anadromous juvenile bull trout are most likely to stay within their natal estuaries (none of which are near the detonation sites) to feed and mature before moving back upriver. Anadromous juvenile bull trout are much less likely than juvenile salmon to migrate long distances in the marine environment, which would bring them into the vicinity of the EOD training areas. Therefore, very few, if any, juvenile bull trout would be injured by EOD detonations, considering the infrequent nature of these detonations.

Table 5-7. Approximate Distances from Detonation Resulting in No Injury or 90 percent Survival to Bull Trout

Fish	No Effects (no injury) Distance (m)		90% Survival Distance (m)	
	5-lb. Charge	20-lb. Charge	5-lb. Charge	20-lb. Charge
Juvenile bull trout	480	710	161	237
Adult bull trout	250	375	85	125

Note: Based on method of Young (1991). Assumes charge is at a depth of 50 feet and fish are in “shallow” water. No injury distances are estimated from 90% survival distances.

The evidence of short- and long-term behavioral effects, as defined by changes in fish movement, etc., is non-existent (Popper 2008). It is unknown if the presence of an explosion or impulsive source at some distance, while not physically harming a fish, will alter its behavior in any significant way (Popper 2008).

Impacts to fish from detonations would be possible, but have a low potential for occurrence. While serious injury and/or mortality to individual fish would be expected if they were present in the immediate vicinity of underwater detonations and high explosive ordnance use, detonations under the Baseline would not result in impacts to fish populations based on the low number of fish that would be affected. Disturbances to water column and benthic habitats from detonations would be short-term and localized. The Navy conducts a limited number of training activities over a large area (112,241 nm^2miles [430,000 km^2]). Habitat disturbance and fish injury and mortality from detonations are reduced by Navy mitigation measures.

5.5.1.14 Sonar

Effects to EFH from sonar use could potentially result from either acoustic impacts or from explosive forces and expended material introduced into the water column and sediments.

Antisubmarine warfare (ASW) and mine warfare (MIW) exercises include training sonar operators to detect, classify, and track underwater objects and targets. There are two basic types of sonar: passive and active. Passive sonars only listen to incoming sounds and, since they do not emit sound energy in the water, lack the potential to acoustically affect the environment. Active sonars emit acoustic energy to obtain information about a distant object from the reflected sound energy. Active sonars are the most effective detection systems against modern, ultra-quiet submarines and sea mines in shallow water.

Modern sonar technology has developed a multitude of sonar sensor and processing systems. In concept, the simplest active sonars emit acoustic pulses (“pings”) and time the arrival of the reflected echoes from the target object to determine range. More sophisticated active sonars emit a ping and then scan the received beam to provide directional as well as range information. Only about half of the Navy's ships are equipped with active sonar and their use is generally limited to training and maintenance activities - 90% of sonar activity by the Navy is passive (DoN 2007a).

Active sonars operate at different frequencies, depending on their purpose. High frequency sonar (>10 kHz) is mainly used for establishing water depth, detecting mines, and guiding torpedoes. At higher frequencies, sound energy is greatly attenuated by scattering and absorption as it travels through the water. This results in shorter ranges, typically less than 5 nm (10 km). Mid frequency sonar is the primary tool for identifying and tracking submarines. Mid frequency sonar (1 kHz - 10 kHz) suffers moderate attenuation and has typical ranges of 1-10 nm (2 to 19 km). Low frequency sonar (<1 kHz) has the least attenuation, achieving ranges over 100 nm (185 km). Low frequency sonars are primarily used for long-range search and surveillance of submarines. Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) is the U.S. Navy's low frequency sonar system (DoN 2001d). It employs a vertical array of 18 projectors using the 100-500 Hz frequency range.

Sonars used in ASW are predominantly in the mid frequency range (DoN 2007a). ASW sonar systems may be deployed from surface ships, submarines, and rotary and fixed wing aircraft. The surface ships are typically equipped with hull mounted sonar but may tow sonar arrays as well. Helicopters are equipped with dipping sonar (lowered into the water). Helicopters and fixed wing aircraft and may also deploy both active and passive sonobuoys and towed sonar arrays to search for and track submarines.

Submarines also use sonars to detect and locate other subs and surface ships. A submarine's mission revolves around stealth, and therefore submarines use their active sonar very infrequently since the pinging of active sonar gives away their location. Submarines are also equipped with several types of auxiliary sonar systems for mine avoidance, for top and bottom soundings to determine the submarine's position in the water column, and for acoustic communications. ASW training targets simulating submarines may also emit sonic signals through acoustic projectors.

Sonars employed in MIW training are typically high frequency (greater than 10 kHz). They are used to detect, locate, and characterize mines that are moored, laid on the bottom, or buried. MIW sonars can be deployed from multiple platforms including towed systems or surface ships.

Torpedoes use high-frequency, low-power, active sonar. Their guidance systems can be autonomous or electronically controlled from the launching platform through an attached wire. The autonomous guidance systems are acoustically based. They operate either passively, exploiting the emitted sound energy by the target, or actively, ensonifying the target and using the received echoes for tracking and targeting.

Military sonars for establishing depth and most commercial depth sounders and fish finders operate at high frequencies, typically between 24 and 200 kHz.

5.5.1.14.1 Low Frequency Sonar

Low frequency sound travels efficiently in the deep ocean and is used by whales for long-distance communication (Richardson et al. 1995, NRC 2003, 2005). Concern about the potential for low frequency sonar (<1 kHz) to interfere with cetacean behavior and communication has prompted extensive debate and research (DoN 2001d, 2005a, 2007; NRC 2000, 2003).

Some studies have shown that low frequency noise will alter the behavior of fish. For example, research on low frequency devices used to deter fish away from turbine inlets of hydroelectric power plants showed stronger avoidance responses from sounds in the infrasound range (5-10 Hz) than from 50 and 150 Hz sounds (Knudsen et al. 1992, 1994). In test pools, wild salmon exhibit an apparent avoidance response by swimming to a deeper section of the pool when exposed to low frequency sound (Knudsen et al. 1997).

Turnpenny et al. (1994) reviewed the risks to marine life, including fish, of high intensity, low frequency sonar. Their review focused on the effects of pure tones (sine waves) at frequencies between 50-1,000 Hz. Johnson (2001) evaluated the potential for environmental impacts of employing the SURTASS LFA sonar system. While concentrating on the potential effects on whales, the analysis did consider the potential effects on fish, including bony fish and sharks. It appears that the swim bladders of most fish are too small to resonate at low frequencies and that only large pelagic species such as tunas have swim bladders big enough to resonate in the low frequency range. However, investigations by Sand and Hawkins (1973), and Sand and Karlsen (1986) revealed resonance frequencies of cod swim bladders from 2 kHz down to 100 Hz.

Hastings et al. (1996) studied the effects of low frequency underwater sound on fish hearing. More recently, Popper et al. (2005, 2007) investigated the impact of Navy SURTASS LFA sonar on hearing and on non-auditory tissues of several fish species. In this study, three species of fish in Plexiglas cages suspended in a freshwater lake were exposed to high intensity LFA sonar pulses for periods of time considerably longer than likely LFA exposure. Results showed no mortality and no damage to body tissues either at the gross or histological level. Some individuals exhibited temporary hearing loss but recovered within several days of exposure. The study suggests that SURTASS LFA sonar does not kill or damage fish even in a worst case scenario.

Although some behavioral modification might occur, adverse effects from low frequency sonar on fish are not expected.

5.5.1.14.2 Mid-Frequency Sonar

ASW training activities use mid frequency (1-10 kHz) sound sources. Most fish only detect sound within the 1-3 kHz range (Popper 2003, Hastings and Popper 2005). Thus, it is expected that most fish species would be able to detect the ASW mid frequency sonar at the lower end of its frequency range.

Some investigations have been conducted on the effect on fish of acoustic devices designed to deter marine mammals from gillnets (Gearin et al. 2000, Culik et al. 2001). These devices generally have a mid frequency range, similar to the sonar devices that would be used in ASW exercises. Adult sockeye salmon exhibited an initial startle response to the placement of inactive acoustic alarms designed to deter harbor porpoise. The fish resumed their normal swimming pattern within 10 to 15 seconds. After 30 seconds, the fish approached the inactive alarm to within 30 cm (1 ft). The same experiment was conducted with the alarm active. The fish exhibited the same initial startle response from the insertion of the alarm into the tank; however, within 30 seconds, the fish were swimming within 30 cm (1 ft) of the active alarm. After five minutes of observation, the fish did not show any reaction or behavior change except for the initial startle response. This demonstrated that the alarms were either inaudible to the fish, or the fish were not disturbed by the mid frequency sound.

Jørgensen et al. (2005) carried out experiments examining the effects of mid frequency (1 to 6.5 kHz) sound on survival, development, and behavior of fish larvae and juveniles. Experiments were conducted on the larvae and juveniles of Atlantic herring, Atlantic cod, saithe *Pollachius virens,* and spotted wolfish *Anarhichas minor*. Swim bladder resonance experiments were attempted on juvenile Atlantic herring, saithe, and Atlantic cod. Sound exposure simulated Naval sonar signals. These experiments did not cause any significant direct mortality among the exposed fish larvae or juveniles, except in two (of a total of 42) experiments on juvenile herring where significant mortality (20-30%) was observed. Among fish kept in tanks one to four weeks after sound exposure, no significant differences in mortality or growth related parameters (length, weight and condition) between exposed groups and control groups were observed. Some incidents of behavioral reactions were observed during or after the sound exposure - 'panic' swimming or confused and irregular swimming behavior. Histological studies of organs, tissues, or neuromasts from selected Atlantic herring experiments did not reveal obvious differences between control and exposed groups.

The work of Jørgensen et al. (2005) was used in a study by Kvadsheim and Sevaldsen (2005) to examine the possible 'worse case' scenario of sonar use over a spawning ground. They conjectured that normal sonar operations would affect less than 0.06% of the total stock of a juvenile fish of a species, which would constitute less than 1% of natural daily mortality. However, these authors did find that the use of continuous-wave transmissions within the frequency band corresponding to swim bladder resonance will escalate this impact by an order of magnitude. The authors therefore suggested that modest restrictions on the use of continuous-wave transmissions at specific frequencies in areas and at time periods when there are high densities of Atlantic herring present would be appropriate.

The results of several studies have indicated that acoustic communication and orientation of fish, in particular of hearing specialists, may be limited by noise regimes in their environment (Wysocki and Ladich 2004). Most marine fish are hearing generalists, though a few have been shown to detect sounds in the mid-frequency and ultrasonic range. While these species can detect mid-frequency sounds, their best hearing sensitivities are not in the mid-frequency range. If a sound is at the edge of a fish's hearing range, the sound must be louder in order for it to be detected than if in the more sensitive range

Experiments on fish classified as hearing specialists (but not those classified as hearing generalists) have shown that exposure to loud sound can result in temporary hearing loss, but it is not evident that this may lead to long-term behavioral disruptions in fish that are biologically significant (Amoser and Ladich 2003, Smith et al. 2004a, 2004b). There is no information available that suggests that exposure to non-impulsive acoustic sources results in fish mortality.

In summary, 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, reversible, and not biologically significant. 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. The use of Navy mid frequency sonar would not compromise the productivity of fish or adversely modify their habitat.

5.5.1.14.3 High-Frequency Sonar

Although most fish cannot hear sound frequencies over 10 kHz, some shad and herring species can detect sounds in the ultrasonic range, i.e., over 20 kHz. (Mann 2001, Higgs et al. 2004). Ross et al. (1995, 1996) reviewed the use of high frequency sound to deter alewives from entering power station inlets. The alewife, a member of the shad family (Alosinae) which can hear sounds at ultrasonic frequencies (Mann et al. 2001), uses high frequency hearing to detect and avoid predation by cetaceans. Wilson and Dill (2002) demonstrated that exposure to broadband sonar-type sounds with high frequencies cause behavioral modification in Pacific herring.

Since high-frequency sound attenuates quickly in water, high levels of sound from mine hunting sonars would be restricted to within a few meters of the source. Even for fish able to hear sound at high frequencies, only short-term exposure would occur, thus high frequency military sonars are not expected to have significant effects on resident fish populations.

Because a torpedo emits sonar pulses intermittently and is traveling through the water at a high speed, individual fish would be exposed to sonar from a torpedo for a brief period. At most, an individual animal would hear one or two pings from a torpedo and would be unlikely to hear pings from multiple torpedoes over an exercise period. Most fish hear best in the low- to mid-frequency range and therefore are unlikely to be disturbed by torpedo pings.

Dipping sonar is also only active for short periods. Sonobuoys operate at relatively high frequencies, well beyond the hearing range of most fish. The area within which fish could hear the high frequency signals from active sonobuoys would be limited by the low signal strengths emitted.

The effects of high frequency sonar, on fish behavior, for species that can hear high frequency sonar, would be transitory and of little biological consequence. Most species would probably not hear these sounds and would therefore experience no disturbance.

5.5.1.14.4 Conclusion – Sonar Use

While the impact of anthropogenic noise on marine mammals has been extensively studied, the effects of noise on fish are largely unknown (Popper 2003, Hastings and Popper 2005, Popper 2008). There is a dearth of empirical information on the effects of exposure to sound, let alone sonar, for the vast majority of fish. The few studies on sonar effects have focused on behavior of individuals of a few species and it is unlikely their responses are representative of the wide diversity of other marine fish species (ICES 2005, Jorgensen et al. 2005). The literature on vulnerability to injury from exposure to loud sounds is similarly limited, relevant to particular species, and, because of the great diversity of fish, not easily extrapolated. More well-controlled studies are needed on the hearing thresholds for fish species and on temporary and permanent hearing loss associated with exposure to sounds. The effects of sound may not only be species specific, but also depend on the mass of the fish (especially where any injuries are being considered) and life history phase (eggs and larvae may be more or less vulnerable to exposure than adult fish). The use of sounds during spawning by some fish, and their potential vulnerability to masking by anthropogenic sound sources, also requires further investigation. No studies have established effects of cumulative exposure of fish to any type of sound or have determined whether subtle and long-term effects on behavior or physiology could have an impact upon survival of fish populations. The use of sounds during spawning by some fish and their potential vulnerability to masking by anthropogenic sound sources requires closer investigation.

5.5.2 Analytical Approach

The potential effects of the Proposed Action on the habitat of ESA-designated species within the NWTRC are analyzed using two approaches. First, an approach developed by NMFS (1996) and USFWS (1998) that uses a matrix of pathways (water quality and physical and biological habitat elements) and indicators (various elements of the pathway categories) for salmonid estuarine habitat present in the NWTRC and then characterizes the baseline environmental conditions of salmonid estuarine habitat (non-critical habitat) present in the NWTRC by level of habitat function using the matrix of pathways. Finally, the potential project effects on salmonid estuarine habitat present in the action area are characterized by their potential to restore, maintain, or degrade existing environmental baseline conditions for each habitat indicator within the matrix of pathways.

Based on the analysis methods presented in Section 5.5.1.13, physical injury to salmonoids could occur within the distances of a detonation site shown in Tables 5-6 and 5-7. These distances are used to define “not properly functioning habitat” for noise/impulse conditions.

Second, an approach that relies upon habitat PCEs as defined by either the NMFS or the USFWS at the time the species-specific critical habitat is listed is used to determine whether Navy activities are likely substantially change one or more of the biological, physical, or chemical PCEs. If a Navy training activity is considered likely to substantially alter one or more PCEs, then it is concluded that the action is likely to destroy or adversely modify the designated critical habitat for the species. The species-specific PCEs are listed in Table 5-9.

Implementation of the Proposed Action would be a significant decrease of baseline activities, therefore, conditions of properly functioning habitat would improve.

In accordance with ESA, the Navy finds the NWTRC underwater explosion activities associated with the Proposed Action may affect the threatened fish species in the NWTRC.

5.5.3 Chum and Chinook Salmon – Puget Sound-Hood Canal

5.5.3.1 Underwater Detonations

Potential noise and impulse effects of EOD underwater detonation training activities at Naval facilities at Crescent Harbor, Holmes Harbor, Port Townsend, and Naval Base Kitsap at Bangor in the Puget Sound and Hood Canal areas were evaluated on adult and juvenile chum and Chinook salmon (DoN 2000, Final BA, EOD Puget Sound 2000; NMFS 2008f). The analyses concluded that juvenile and adult chum and Chinook salmon (and presumably other salmon species that might be present) could be injured or killed within the following distances of 5-pound (2-kg) explosive charges (Table 5-6):

During their migration and rearing, juvenile salmon occur almost exclusively in shallow water directly adjacent to the shoreline. Therefore, the potential for injury effects on juveniles depends on the distance from the EOD training area at any site to the nearest shoreline. These distances indicate that there is a potential for injury or mortality of juvenile salmon at all of the training sites, if detonations occur when juvenile salmon are present along the nearest shorelines. The number of juveniles potentially affected would be small, because of the infrequent nature of the detonations: no more than four detonations per year in all three underwater detonation ranges. For some detonations, it is possible that no salmon would be injured, because none would be closer than the above no-effects distances. However, injury or mortality of juvenile salmon as a result of the EOD detonations is a situation that should be avoided. Therefore, conservation measures (including the location of detonations and charge sizes during the juvenile migration period) are proposed in Section 6 that would prevent such effects on juvenile salmon.

The distances over which adult chinook or chum salmon could be injured or killed are considerably smaller than injury distances for juveniles (adverse effects decrease as fish body weight and size increase). Adults typically occur in deeper water than juveniles, however. Therefore, when adults are in the general vicinity of the training areas, they could occur closer to the detonation sites than juveniles, and could be injured or killed as a result.

The number of adult salmon that could be similarly affected is small, for two reasons. The first is the infrequent nature of the detonations. The second is that adult salmon are expected to occur at low densities at these sites, except during adult migration periods at some of the sites. Crescent Harbor lies outside the major migration corridors for river systems in the area (such as the Skagit or Snohomish), and chinook are not known to run into any rivers or streams on Whidbey Island. Therefore, small numbers of migrating adults are expected at these sites. Port Townsend Bay and Naval Base Kitsap at Bangor lie on migration corridors for chinook, chum and other salmon species in the Hood Canal system. These areas are expected to support larger numbers of adult salmon than Crescent Harbor and Homes Harbor during the migration season. Resident chinook (blackmouth) may occur at any of the sites at low densities. At any time of year, very small numbers of adult salmon are expected to occur within the injury distances of the detonation sites at the time of detonation. This is especially true for the Crescent Harbor and Holmes Harbor sites. Therefore, very small numbers of adult salmon are expected to be injured by EOD detonations. Most of the detonations are unlikely to injure adult salmon.

Regarding behavioral effects, the analysis showed that EOD detonations would produce sound capable of startling salmon or other fish at distances of approximately 17 nm (32 km) for a 5-lb (2-kg) charge. Certainly, many adult and juvenile salmon would occur within these distances and could be startled by the detonations. However, the available studies of fish response to loud noise indicated consistently that behavior returns to normal shortly after the noise ceased, as long as physical injury did not occur.

In addition, salmon are less responsive to sound than other species of fish. Therefore, it is most likely that the detonations would temporarily startle salmon and other fish within the effect distances, but that behavior would return to normal soon thereafter. Considering the infrequent nature of the EOD detonations, the behavioral effects of these detonations would be transitory, and have very little potential to affect fish behavior to the extent that survival or reproduction would be affected. This is especially true for the EOD Mobile Unit 11 detonations, which consist of a fewer than two detonations per year at any given site. The Naval Base Kitsap at Bangor uses no more than 1 detonation per year, usually very small charges (1 to 8 ounces [28 to 227 grams]). Based on the available evidence, these actions would seem to have very little potential for adverse behavioral effects on salmon and other fish species. This potential would generally be lower for salmon than for other types of fish.

Puget Sound chinook salmon occur, or potentially occur, at all of the EOD training sites, and Hood Canal summer-run chum salmon occur at the Port Townsend Bay and Naval Base Kitsap at Bangor training sites. Therefore, the EOD training program may affect Puget Sound chinook salmon and Hood Canal summer-run chum salmon. The EOD training program would not have adverse effects on most aspects of salmon habitat. In most cases, the charges are lifted above the seafloor before detonation, so that physical impact to the seafloor is minimal. The depressions that are created when the charge is detonated on the seafloor are very infrequent and physically separated. These depressions would fill in fairly quickly and the benthic community would become re-established.

Because of the infrequent nature of the EOD detonations and the expected low abundance of adult salmon in the training areas, EOD detonations are expected to injure very few, if any, adult salmon. Detonations would kill small numbers of forage fish, but, considering the infrequent nature of the detonations, no significant effect on the salmon food resource would result. The EOD training program may affect Puget Sound chinook salmon and Hood Canal summer-run chum salmon (DoN 2000, Final BA Puget Sound EOD; NMFS 2008f).

5.5.3.2 Pathway Analysis

The potential effects of the Proposed Action on the habitat (non-critical habitat) of ESA-designated species within the NWTRC using the pathway matrix approach indicated physical injury to salmonoids could occur within the distances of a detonation site shown in Tables 5-6 and 5-7. These distances are used to define "not properly functioning habitat" for noise/impulse conditions.

The Proposed Action includes reduction in net explosive weight underwater detonations from baseline activities, therefore, conditions of properly functioning habitat would improve. Evaluation of the proposed project activities within the NWTRC found that implementing the Proposed Action has the potential to restore existing environmental baseline conditions for salmonid estuarine habitat. The basis for these conclusions is summarized in Table 5-8.

In accordance with ESA, the Navy finds the NWTRC underwater explosion activities associated with the Proposed Action may affect the threatened salmonid species in the NWTRC Study Area.

5.5.3.3 Sonar

Under the Proposed Action, sonar would have the potential to affect listed salmonids in the Study Area. However, effects on fish behavior for those species that can hear and that do respond to the sounds would be transitory and of no biological consequence to the fish. Most species would probably not hear the sounds and would therefore experience no disturbance. Sonar use would not result in adverse effects to ESA-listed fish populations.

5.5.4 Bull Trout and Steelhead Trout – Coastal Puget Sound

The principal effects of the EOD program on bull trout and steelhead trout would be noise and impulse effects from underwater detonations. These effects would be similar to those described for salmon. Regarding the potential for physical injury, analyses indicated the "safe distances", based on no injury was 1,230 ft (375 m) (adult) and 2,329 ft (710 m) (juvenile) and 90 percent survival for adult (410 ft [125 m]) and juvenile (778 ft [237 m]) bull trout for a 20-lb (9-kg) charge, using the method of Young (1991).

As with juvenile salmon, juvenile bull trout could be injured by detonations of the largest charges at any of the sites, if the juveniles occurred at nearby shorelines when an explosion occurred. However, juvenile bull trout are less likely than juvenile salmon to occur near the explosion sites. Anadromous juvenile bull trout are most likely to stay within their natal estuaries to feed and mature before moving back upriver. They are much less likely than juvenile salmon to migrate long distances in the marine environment, which would bring them into the vicinity of the EOD training areas. Therefore, very few, if any, juvenile bull trout would be injured by EOD detonations, considering the infrequent nature of these detonations (DoN 2000; NMFS 2008f).

Table 5-8. Summary of Effects of Proposed NWTRC Activities on Salmonid Habitat Elements in the NWTRC Study Area

Pathway	Indicator	Effects of the Proposed Action
Water Quality	Turbidity, Dissolved Oxygen, Water Contamination/ Nutrients, Sediment Contamination	With implementation of the Proposed Action, net explosive weight of underwater detonations would be limited to 2.5 pounds. As such, water quality conditions of the Baseline would be improved. Implementation of the Proposed Action has the potential to restore existing environmental baseline conditions for salmonid estuarine habitat.
Physical Habitat Features	Substrate/Armoring, Depth/Slope, Tideland Conditions, Marsh Prevalence, Refugia, Physical Barriers, Current Patterns, Salt/Fresh Water Mixing Patterns and Locations	Direct physical impacts to intertidal or shallow subtidal substrata or habitats utilized by salmonids in the vicinity of Crescent Harbor would be lessened with implementation of the Proposed Action due to the reduction in explosives use, compared to baseline conditions. Implementation of the Proposed Action has the potential to restore existing environmental baseline conditions for salmonid estuarine habitat.
Biological Habitat Features	Salmon Prey Availability, Forage Fish Community, Aquatic Vegetation, Exotic Species	Baseline conditions of salmon prey availability, forage fish community, and aquatic vegetation in the vicinity of Crescent Harbor would be improved with implementation of The Proposed Action due to the reduction in explosives use, compared to baseline conditions. Implementation of The Proposed Action would result in no change to baseline conditions for exotic species. Implementation of The Proposed Action has the potential to restore existing environmental baseline conditions for salmonid estuarine habitat.

Available information indicates that adult bull trout move about in the marine environment less than adult salmon, moving primarily from one river system to another. This means that adults are less likely than adult salmon to occur in the vicinity of the EOD training areas. None of the training areas lie along direct routes between rivers known to support anadromous bull trout populations. Adult bull trout could still occur in or near these areas, but at low frequency and abundance. Analysis indicated an adult bull trout would have to be within about 1,230 ft (375 m) of a 20-lb (9-kg) charge, or within about 820 ft (250 m) of a 5-lb (2-kg) charge when detonated to be injured. Considering these relatively small distances, the infrequent occurrence of bull trout in the training areas, and the infrequent nature of the EOD detonations, the number of adult bull trout injured or killed by these detonations would be very small (DoN 2000; NMFS 2008f).

As with salmon, the behavioral effects of EOD detonations on bull trout (outside the zone of potential injury) would be limited to transitory startling on a very infrequent basis. There would be no resulting effect on reproductive success, migration, or survival. The EOD detonations of the Proposed Action may affect individual bull trout but are not expected to affect bull trout populations within the respective EOD action areas.

The NMFS (2008f) evaluated underwater and surface detonation effects on Puget Sound steelhead trout for the EOD BO. The assessment considered the implications of conducting 36 underwater and 24 surface water detonations of 2.5-lb and 20-lb NEW charges annually to juvenile and adult steelheads. The analysis was based on areas of impact produced by detonations of 2.5-lb and 20-lb NEW charges, which were areas of impact for juvenile steelheads of 26.0- and 205.7 acres, respectively. For adult steelheads, the areas of impact were 16.3 and 130.4 acres for 2.5-lb and 20-lb underwater detonations, respectively. For a total of 60 detonations per year, the analysis concluded that 202 juvenile and adult steelhead trout would be taken annually. The NMFS concluded this impact may affect but would be unlikely to adversely affect this species (NMFS 2008f). Because the Proposed Action will reduce the number of detonations from 60 to 4 events annually (a 93 percent reduction) and because the analysis was largely based on the proportion of the total habitat that would be affected by the areas of impact, the Navy concludes the Proposed Action may affect the Puget sound steelhead trout.

5.6 CRITICAL HABITATS

Provisions of the ESA require a determination of whether proposed federal actions may destroy or adversely modify critical habitat for listed endangered or threatened species. Critical habitat designation is based on the presence and condition of certain physical and biological habitat factors (i.e., PCEs) that are considered essential for the conservation of the listed species (USFWS and NMFS 1998; ESA §3(5)(A)(i); 50 CFR §424.12(b)).

For Navy compliance with these ESA provisions, an analysis was conducted of the potential effects of the Proposed Action to designated critical habitats in the NWTRC Study Area. The analysis evaluated whether training activities could destroy or adversely modify the physical and biological habitat attributes that define critical habitat. Professional judgment used to make these determinations is based on whether proposed Navy actions are considered likely to change the biological or physical character of PCEs identified for species' critical habitat. If the Navy action is considered unlikely to occur in or to affect the specified habitat attributes for the species, it is concluded that critical habitat would not be destroyed or adversely modified. The species-specific PCEs are described in the FR announcement listing the final critical habitat designation for each species (Table 5-9).

Critical habitat is designated for four marine mammal and bird species (southern resident killer whale, Steller sea lion, marbled murrelet, and western snowy plover). In the case of the fish species, critical habitat is proposed for one DPS (green sturgeon Southern DPS) and critical habitat has been designated for 12 fish ESUs or CHUs in the NWRTC Study Area. Evolutionarily significant units and CHUs are treated as separate species under the ESA. The following critical habitats were evaluated:

- Southern resident killer whale
- Steller sea lion
- Marbled murrelet
- Western snowy plover
- Chinook salmon (California coastal ESU; Puget Sound ESU; and Lower Columbia River ESU)
- Steelhead trout (Northern California ESU; Central California Coastal ESU; and Lower Columbia River ESU)
- Chum salmon (Hood Canal ESU and Columbia River ESU)
- Coho salmon (Oregon Coast ESU and Northern California-Southern Oregon Coasts ESU)
- Bull trout (Coastal Puget Sound CHU and Olympic Peninsula River Basins CHU)
- Green sturgeon (Southern DPS)

The results of the analysis are presented in Table 5-9, which shows the determination of effect and basis for effect determination for each species, DPS, ESU, or CHU. The analysis concludes that Navy activities in the NWTRC Study Area will not destroy or cause adverse modification of designated critical habitat for any listed species because these activities will not adversely affect or substantially modify the PCEs identified as important for the continued conservation of the listed species.

In the case of the Steller sea lion and southern resident killer whale, additional clarification is needed. Steller sea lion PCEs are not specifically addressed by the Federal Register critical habitat announcement (NMFS 1993b) because the announcement pre-dates the current convention of describing PCEs. However, critical habitat is defined for the California and Oregon Steller sea lion rookeries and associated air and aquatic zones as follows:

- Critical habitat includes an air zone that extends 3,000 ft (0.9 km) above areas historically occupied by sea lions at each major rookery in California and Oregon, measured vertically from sea level and
- Critical habitat includes an aquatic zone that extends 3,000 ft (0.9 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery in California and Oregon.

Although the critical habitat locations are within the NWTRC OPAREA, the rookeries are outside areas normally associated with Navy training and testing activities. In addition, the Navy has standard operating procedures that require its operations remain outside the critical habitat zone around each rookery. Thus, there is very little likelihood that Navy sea and air operations will adversely affect the breeding rookeries for the Steller sea lion. Therefore, in accordance with ESA provisions to assess potential effects of proposed actions to critical habitat, it is concluded that Navy activities will not destroy or adversely modify critical habitat for the Steller sea lion.

The PCEs for the southern resident killer whale critical habitat (NMFS 2006i):are as follows:

- Water quality to support growth and development;
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and
- Passage conditions to allow for migration, resting, and foraging.

Based on these PCEs and anticipated Navy activities in the critical habitat for the southern resident killer whale, none of the training and testing activities are expected to substantially change water quality conditions sufficiently to degrade existing water quality conditions; decrease or substantially alter prey species abundance sufficiently to affect southern resident killer whale individuals or populations; or create barriers that would prevent or impede southern resident killer whale passage through the critical habitat. Therefore, in accordance with ESA provisions to assess potential effects of proposed actions to critical habitat, it is concluded that Navy activities will not destroy or adversely modify critical habitat for the southern resident killer whale.

Table 5-9. Summary Table of NWTRC Critical Habitat Primary Constituent Elements (PCE) and Potential Effects

Species	Critical Habitat Designation Location	Primary Constituent Elements (PCE)	Source (Fed. Reg.)	Effect	Basis for Effect Determination
Killer Whale – Southern Resident Population	Puget Sound and Strait of Juan de Fuca areas, Washington	The primary constituent elements essential for conservation of the Southern Resident killer whale are: (1) Water quality to support growth and development; (2) Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) Passage conditions to allow for migration, resting, and foraging.	FR 71(229):69070. (11/11/06)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will occur in the critical habitat area, but the level of activity would be too small to substantially affect the PCEs; DOD lands where the most intensive Navy training and other activity would occur are excluded from critical habitat designation.,.
Steller Sea Lion	Oregon and California rookeries (as listed in Table 1): Oregon: Rogue Reef Pyramid Rock Orford Reef Long Brown Rock Seal Rock California: Ano Nuevo Island Southeast Farallon Island Sugarloaf Island Cape Mendocino	PCEs are not specifically addressed by the Federal Register critical habitat announcement. However, critical habitat is defined for the California and Oregon rookeries and associated areas as follows: (1) In California and Oregon, all major Steller sea lion rookeries identified in Table 1 and associated air and aquatic zones. (2) Critical habitat includes an air zone that extends 3,000 ft (0.9 km) above areas historically occupied by sea lions at each major rookery in California and Oregon, measured vertically from sea level. (3) Critical habitat includes an aquatic zone that extends 3,000 ft (0.9 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery in California and Oregon.	FR 58(165):45278. (8/27/93)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in critical habitat area and will not affect designated PCEs; air and aquatic Navy activities will not occur within the designated protection zone.
Marbled Murrelet	Washington, Oregon, and California	The primary constituent elements essential for conservation of the marbled murrelet are: (1) individual trees with potential nesting platforms, and (2) forested areas within 0.5 mi (0.8 km) of individual trees with potential nesting platforms, and with a canopy height of at least one-half the site-potential tree height. This includes all such forest, regardless of contiguity.	FR 61(102):26264. (5/24/96)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in critical habitat area and will not affect designated PCEs

Species	Critical Habitat Designation Location	Primary Constituent Elements (PCE)	Source (Fed. Reg.)	Effect	Basis for Effect Determination
		These primary constituent elements are essential to provide and support suitable nesting habitat for successful reproduction of the marbled murrelet.			
Western Snowy Plover	Washington, Oregon, and California	(1) Sparsely vegetated areas above daily high tides (e.g., sandy beaches, dune systems immediately inland of an active beach face, salt flats, seasonally exposed gravel bars, dredge spoil sites, artificial salt ponds and adjoining levees) that are relatively undisturbed by the presence of humans, pets, vehicles or human-attracted predators; (2) Sparsely vegetated sandy beach, mud flats, gravel bars or artificial salt ponds subject to daily tidal inundation but not currently under water, that support small invertebrates such as crabs, worms, flies, beetles, sand hoppers, clams, and ostracods; and, (3) Surf or tide-cast organic debris such as seaweed or driftwood located on open substrates such as those mentioned above (essential to support small invertebrates for food, and to provide shelter from predators and weather for reproduction).	FR 70(188):56994. (9/29/05).	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in critical habitat area and will not affect designated PCEs
Chinook Salmon	California Coastal ESU, California	The primary constituent elements essential for the conservation of these ESUs are those sites and habitat components that support one or more life stages, including: (1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. (3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. (4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and	FR 70(170):52537; (9/2/05)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in the freshwater components of critical habitat areas and will not affect the designated estuarine PCEs.

Species	Critical Habitat Designation Location	Primary Constituent Elements (PCE)	Source (Fed. Reg.)	Effect	Basis for Effect Determination
		saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.			
	Puget Sound ESU, Washington and Lower Columbia River ESU, Washington/Oregon	(c) Within these areas, the primary constituent elements essential for the conservation of these ESUs are those sites and habitat components that support one or more life stages, including: (1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. (3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival; (4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. (5) Nearshore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. (6) Offshore marine areas with water quality conditions and forage,	FR 70(170):52684; (9/2/05)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in the freshwater components of critical habitat areas; Navy training and operations will occur in critical habitats but will not substantially affect the designated estuarine, nearshore marine, and offshore marine PCEs.

Species	Critical Habitat Designation Location	Primary Constituent Elements (PCE)	Source (Fed. Reg.)	Effect	Basis for Effect Determination
		including aquatic invertebrates and fishes, supporting growth and maturation.			
Steelhead Trout	Northern California ESU and Central California Coastal ESU, California	(c) Within these areas, the PCEs essential for the conservation of these ESUs are those sites and habitat components that support one or more life stages, including: (1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. (3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. (4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.	FR 70(170):52537; (9/2/05)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in the freshwater components of critical habitat areas and will not affect the designated estuarine PCEs.
	Lower Columbia River ESU, Washington/Oregon	(c) Within these areas, the primary constituent elements essential for the conservation of these ESUs are those sites and habitat components that support one or more life stages, including: (1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility;	FR 70(170):52684; (9/2/05)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in the freshwater components of critical habitat areas and will not affect the designated estuarine, nearshore marine, and offshore marine PCEs.

Species	Critical Habitat Designation Location	Primary Constituent Elements (PCE)	Source (Fed. Reg.)	Effect	Basis for Effect Determination
		(ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. (3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival; (4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. (5) Nearshore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. (6) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.			
Chum Salmon	Hood Canal ESU Washington and Columbia River ESU, Washington/Oregon	(c) Within these areas, the primary constituent elements essential for the conservation of these ESUs are those sites and habitat components that support one or more life stages, including: (1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large	FR 70(170):52684; (9/2/05)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in the freshwater components of critical habitat areas; Navy training and operations will occur in critical habitats but will not substantially affect the designated estuarine, nearshore marine, and offshore marine PCEs.

Species	Critical Habitat Designation Location	Primary Constituent Elements (PCE)	Source (Fed. Reg.)	Effect	Basis for Effect Determination
		wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. (3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival; (4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. (5) Nearshore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. (6) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.			
Coho Salmon	Oregon Coast ESU, Oregon	The specific PCEs include: (1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. (2) Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. (3) Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and	FR 73(28):7832; (2/11/08)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in the freshwater components of critical habitat areas and will not affect the designated estuarine, nearshore marine, and offshore marine PCEs.

Species	Critical Habitat Designation Location	Primary Constituent Elements (PCE)	Source (Fed. Reg.)	Effect	Basis for Effect Determination
		boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. (4) Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. (5) Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. (6). Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.			
	Northern California-Southern Oregon Coasts ESU, California and Oregon	In addition to these factors, NMFS also focuses on the known physical and biological features (primary constituent elements) within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. These essential features may include, but are not limited to: (1) spawning sites, (2) food resources, (3) water quality and quantity, and (4) riparian vegetation. Riparian areas form the basis of healthy watersheds and affect these primary constituent elements; therefore, they are essential to the conservation of the species and need to be included as critical habitat. NMFS has revised its designation of freshwater and estuarine critical habitat to include riparian areas that provide the following functions: (1) shade, (2) sediment, (3) nutrient or chemical regulation, (4) streambank stability, and (5) input of large woody debris or organic matter. It is important to note that habitat quality in this range is intrinsically related to the quality of riparian and upland areas and of inaccessible headwater or intermittent streams which provide key habitat elements (e.g., large woody debris, gravel, water quality) crucial for coho in downstream reaches.	FR 64(86): 24050, 24053, 24059; (5/5/99)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in the freshwater and riparian components of critical habitat areas and will not affect the designated PCEs.
Bull Trout	Coastal Puget Sound, Washington (CHU 28)	For stream waters: (1) Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32 to 72 deg F (0 to 22	FR 70(185):56266; (9/26/05)	No destruction or adverse modification of	Navy training activities and operations will occur in the critical

Species	Critical Habitat Designation Location	Primary Constituent Elements (PCE)	Source (Fed. Reg.)	Effect	Basis for Effect Determination
	and Olympic Peninsula River Basins Washington (CHU 27)	deg C) but are found more frequently in temperatures ranging from 36 to 59 deg F (2 to 15 deg C). These temperature ranges may vary depending on bull trout life history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation; (2) Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures; (3) Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 cm) in diameter. (4) A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operate under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation: This rule finds that reservoirs currently operating under a biological opinion that addresses bull trout provides management for PCEs as currently operated; (5) Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a cold water source; For marine nearshore waters: (1) Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32 to 72 deg. F (0 to 22 deg. C) but are found more frequently in temperatures ranging from 36 to 59 deg. F (2 to 15 deg. C). These temperature ranges may vary depending on bull trout life history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation; (6) Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and foraging habitats, including intermittent or seasonal barriers induced by		designated critical habitat	habitat area, but the level of activity would be too small to substantially affect the PCEs; DOD lands where the most intensive Navy training and other activities will occur are excluded from critical habitat designation, thereby further reducing total effects on the PCEs.

Species	Critical Habitat Designation Location	Primary Constituent Elements (PCE)	Source (Fed. Reg.)	Effect	Basis for Effect Determination
		high water temperatures or low flows; (7) An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish; and (8) Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.			
Green sturgeon	Southern DPS	Specific PCEs essential for conservation of the Southern DPS in estuarine areas include the following: (1) Abundant food resources (i.e., fly larvae, shrimp, clams and benthic fishes) within estuarine habitats and substrates for juvenile, subadult, and adult life stages. (2) Sufficient water flow within bays and estuaries adjacent to the Sacramento River to attract adults to migrate upstream to spawning grounds. (3) Water quality, including: temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures for juveniles should be below 75º F (24º C). Suitable salinities range from brackish water (10 parts per thousand) to salt water (33 parts per thousand. Subadult and adult may need a minimum dissolved oxygen level of at least 6.54 mg oxygen per liter. Suitable water quality also includes water with acceptably low levels of contaminants for normal development of juvenile life stages, or the growth, survival, or reproduction of subadult or adult stages. Acceptably low contaminant levels would be determined on a case-by-case basis (e.g., pesticides, organochlorines, elevated levels of heavy metals). (4) A migratory pathway is necessary for the safe and timely passage of Southern DPS fish within estuarine habitats and between estuarine and riverine or marine habitats (i.e., free from human-induced impediments that compromise the ability of fish to reach thermal refugia by the time they enter a particular life stage). (5) A diversity of water depths necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Subadult and adult green sturgeon occupy a diversity of depths within bays and estuaries for feeding and migration. (6) Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth and viability of all life stages for riverine habitats. Specific PCEs essential for conservation of the Southern DPS in coastal	FR 73(174):52084; (9/8/08)	No destruction or adverse modification of designated critical habitat	Navy training activities and operations will not occur in the freshwater components of critical habitat areas and will not affect the designated estuarine, nearshore marine, and offshore marine PCEs.

Species	Critical Habitat Designation Location	Primary Constituent Elements (PCE)	Source (Fed. Reg.)	Effect	Basis for Effect Determination
		marine areas include the following: (1) A migratory pathway is necessary for the safe and timely passage of Southern DPS fish within marine and between estuarine and marine habitats (i.e., free from human-induced impediments that compromise the ability of fish to reach abundant prey resources in Northwest Pacific estuaries and habitat within coastal waters). (2) Coastal marine waters with adequate dissolved oxygen levels and acceptably low levels of contaminants that may disrupt the normal behavior, growth, and viability of subadult and adult green sturgeon. Subadult and adult may need a minimum dissolved oxygen level of at least 6.54 mg oxygen per liter. Acceptably low contaminant levels would be determined on a case-by-case basis (e.g., pesticides, organochlorines, elevated levels of heavy metals). (3) Abundant prey items for subadults and adults, which may include benthic invertebrates and fishes.			

5.7 CUMULATIVE EFFECTS

5.7.1 Fish

The overall effect on fish stocks from certain activities such as vessel movement, aircraft overflight, sonar, non-explosive ordnance use, weapons firing disturbance, expended materials, would be negligible additions to impacts of fish stocks in the NWTRC. The NWRTC Study Area includes critical habitat areas proposed for the Southern DPS green sturgeon and designated for the Puget Sound chinook salmon, Hood Canal summer-run chum salmon, and Coastal-Puget Sound bull trout. Threatened species potentially affected include the Southern DPS green sturgeon, Puget Sound chinook salmon ESU, Hood Canal summer-run chum salmon ESU, Coastal-Puget Sound bull trout DPS, or Puget Sound steelhead trout DPS.

There will be minimal impacts to these protected species from aircraft, missile and target overflights; weapons firing; non-explosive ordnance; sonar activities; or expended materials. Explosive ordnance used in offshore areas would have the potential to affect green sturgeon. Underwater detonations and explosive ordnance would have the potential to affect juvenile salmon and bull trout. This depends on the size of the charge and the distance from the shoreline that the explosions occur. When adults are in the general vicinity of the training areas, they too could be injured or killed as a result. However, the distances over which adult Chinook or chum salmon could be injured or killed are considerably smaller than the injury distances for juveniles.

There would be no long-term changes in species abundance or diversity, no loss or degradation of sensitive habitats, and only potential effects to threatened and endangered species. None of the potential impacts would affect Essential Fish Habitat, sustainability of resources, the regional ecosystem, or the human community.

5.7.2 Sea Turtles

Incidental take in fishing operations, or bycatch, is one of the most serious threats to sea turtle populations. In the Pacific, NMFS requires measures (e.g., gear modifications, changes to fishing practices, and time/area closures) to reduce sea turtle bycatch in the California/Oregon/Washington drift gillnet fishery.

Marine debris affects marine turtles, which commonly ingest or become entangled in marine debris (e.g., tar balls, plastic bags, plastic pellets, balloons, and ghost fishing gear) as they feed along oceanographic fronts, where debris and their natural food items converge. Marine pollution from coastal runoff, marina and dock construction, dredging, aquaculture, oil and gas exploration and extraction, increased underwater noise, and boat traffic can degrade marine habitats used by marine turtles. Turtles swimming or feeding at or just beneath the surface of the water are vulnerable to boat and vessel strikes, which can result in serious propeller injuries and death. Global warming could potentially have an extensive impact on all aspects of a turtle's life cycle, as well as impact the abundance and distribution of prey items. Loss or degradation of nesting habitat resulting from erosion control through beach nourishment and armoring, beachfront development, artificial lighting, and non-native vegetation is a serious threat affecting nesting females and hatchlings (NOAA 2007).

5.7.2.1 Cumulative Impacts

Sea turtles are generally uncommon in the NWTRC and do not nest there, but may forage in or transit through the area. Temporary disturbance incidents associated with NWTRC activities could result in an incremental contribution to cumulative impacts on sea turtles. The protective measures identified in Section 6.2 would minimize any potential adverse effects on sea turtles. The impacts of the Proposed Action are not likely to affect the species' or stock's annual rates of recruitment or survival. Therefore, the incremental impacts of the Proposed Action would not present a significant contribution to the effects on sea turtles when added to effects on sea turtles from other past, present, and reasonably foreseeable future actions.

5.7.3 Marine Mammals

Risks to marine mammals emanate primarily from ship strikes, exposure to chemical toxins or biotoxins, exposure to fishing equipment that may result in entanglements, and disruption or depletion of food sources from fishing pressure and other environmental factors. Potential cumulative impacts of Navy activities on marine mammals would result primarily from possible ship strikes and sonar use. Human-caused stressors are described in the following sections.

5.7.3.1 Anthropogenic Stressors

With the exception of historic whaling in the 19th and early 20th century, during the past few decades there has been an increase in marine mammal mortalities associated with a variety of human activities (Geraci et al. 1999; NMFS 2007). These activities include fisheries interactions (bycatch and directed catch), pollution (marine debris, toxic compounds), habitat modification (degradation, prey reduction), ship strikes (Laist et al. 2001), and gunshots. Figure 5-1 provides a summary of human threats to marine mammals.

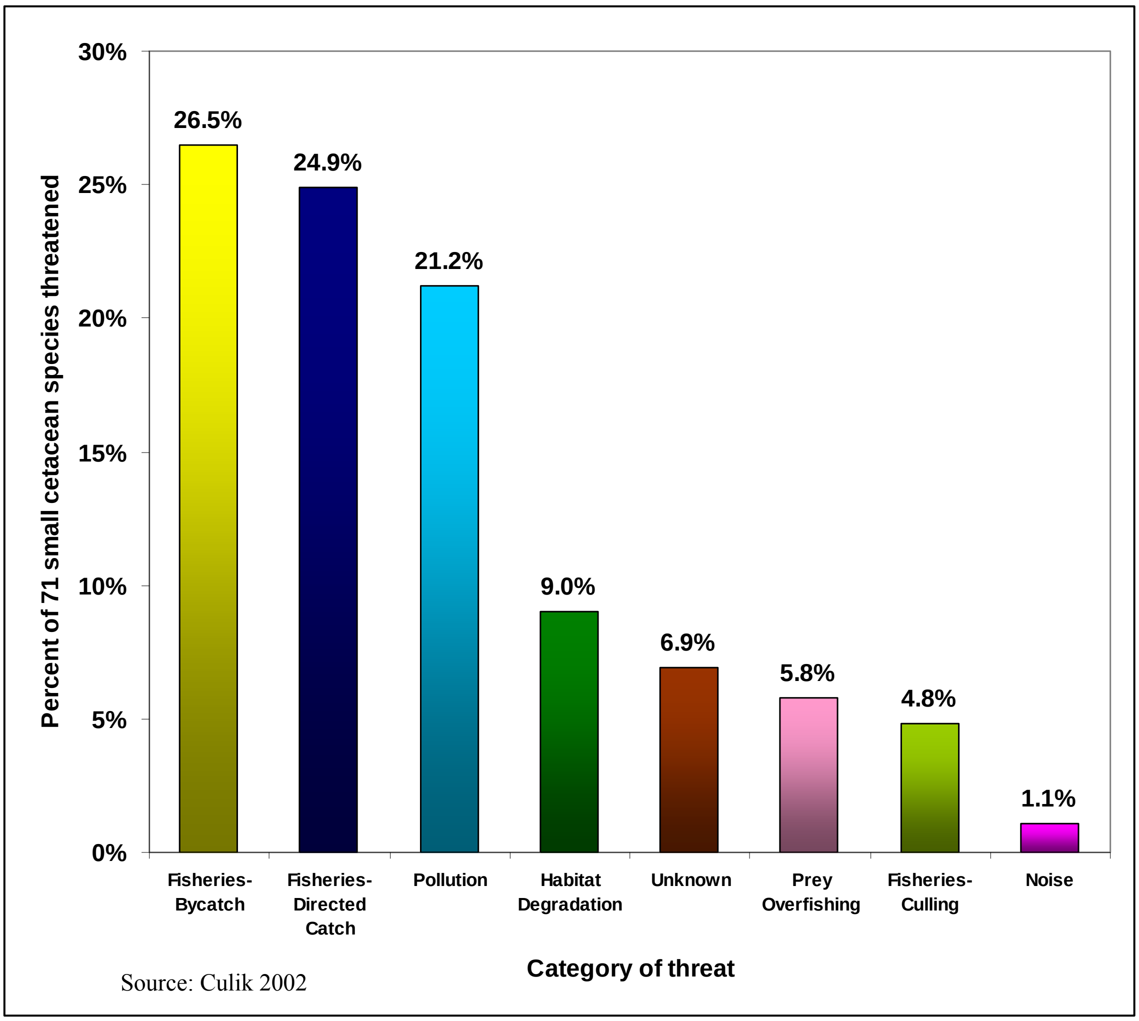

Figure 5-1. Human Threats to World-wide Small Cetacean Populations

5.7.3.1.1 Fisheries Interaction: By-Catch, Directed Catch, and Entanglement

The incidental catch of marine mammals in commercial fisheries is a significant threat to the survival and recovery of many populations of marine mammals (Geraci et al. 1999; Baird 2002; Culik 2002; Carretta et al. 2004; Geraci and Lounsbury 2005; NMFS 2007). Interactions with fisheries and entanglement in discarded or lost gear continue to be a major factor in marine mammal deaths worldwide (Geraci et al. 1999; Nieri et al. 1999; Geraci and Lounsbury 2005; Read et al. 2006; Zeeber et al. 2006). For instance, baleen whales and pinnipeds have been found entangled in nets, ropes, monofilament line, and other fishing gear that has been discarded out at sea (Geraci et al. 1999; Campagna et al. 2007).

Bycatch- Bycatch is the catching of non-target species within a given fishing operation and can include non-commercially used invertebrates, fish, sea turtles, birds, and marine mammals (NRC 2006). Read et al. (2006) attempted to estimate the magnitude of marine mammal bycatch in U.S. and global fisheries. Within U.S. fisheries, between 1990 and 1999 the mean annual bycatch of marine mammals was 6,215 animals. Eighty-four percent of cetacean bycatch occurred in gill-net fisheries, with dolphins and porpoises constituting most of the cetacean bycatch (Read et al. 2006). Over the decade there was a 40 percent decline in marine mammal bycatch, primarily due to effective conservation measures that were implemented during this time period.

Read et al. (2006) extrapolated data for the same period (1990-1999) and calculated an annual estimate of 653,365 of marine mammals globally, with most of the world's bycatch occurring in gill-net fisheries. With global marine mammal bycatch likely to be in the hundreds of thousands every year, bycatch in fisheries will be the single greatest threat to many marine mammal populations around the world (Read et al. 2006).

Entanglement- Entanglement in active fishing gear is a major cause of death or severe injury among the endangered whales in the action area. Entangled marine mammals may die as a result of drowning, escape with pieces of gear still attached to their bodies, or manage to be set free either of their own accord or by fishermen. Many large whales carry off gear after becoming entangled (Read et al. 2006). When a marine mammal swims off with gear attached, the result can be fatal. The gear may become too cumbersome for the animal or it can be wrapped around a crucial body part and tighten over time. Stranded marine mammals frequently exhibit signs of previous fishery interaction, such as scarring or gear attached to their bodies. For stranded marine mammals, death is often attributed to such interactions (Baird and Gorgone, 2005). Because marine mammals that die due to fisheries interactions may not wash ashore and not all animals that do wash ashore exhibit clear signs of interactions, data probably underestimate fishery-related mortality and serious injury (NMFS 2005a).

An estimated 78 baleen whales were killed annually in the offshore southern California/Oregon drift gillnet fishery during the 1980s (Heyning and Lewis 1990). From 1998-2005, based on observer records, five fin whales (CA/OR/WA stock), 12 humpback whales (ENP stock), and six sperm whales (CA/OR/WA stock) were either seriously injured or killed in fisheries off the west coast of the U.S. (California Marine Mammal Stranding Network Database 2006).

<u>Ship Strike</u>

Ship strikes of marine mammals are another cause of mortality and stranding (Laist et al. 2001; Geraci and Lounsbury 2005; de Stephanis and Urquiola 2006). An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel and the size of the animal (Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007).

The growth in commercial ports and associated commercial vessel traffic is a result of the globalization in trade. The Final Report of the NOAA International Symposium on "Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology" stated that the worldwide commercial fleet has grown from approximately 30,000 vessels in 1950 to over 85,000 vessels in 1998 (NRC 2003; Southall 2005). It is unknown how international shipping volumes and densities will continue to grow. However, current statistics support the prediction that the international shipping fleet will continue to grow at the current rate or at greater rates in the future. Shipping densities in specific areas and trends in routing and vessel design are as, or more, significant than the total number of vessels. Densities along existing coastal routes are expected to increase both domestically and internationally. New routes are also expected to develop as new ports are opened and existing ports are expanded. Vessel propulsion systems are also advancing toward faster ships operating in higher sea states for lower operating costs; and container ships are expected to become larger along certain routes (Southall 2005).

While there are reports and statistics of whales struck by vessels in U.S. waters, the magnitude of the risks that commercial ship traffic poses to marine mammal populations is difficult to quantify or estimate. In addition, there is limited information on vessel strike interactions between ships and marine mammals outside of U.S. waters (de Stephanis and Urquiola 2006). Laist et al. (2001) concluded that ship collisions may have a negligible effect on most marine mammal populations in general, except for regionally-based small populations where the significance of low numbers of collisions would be greater, given smaller populations or populations segments.

U.S. Navy vessel traffic is a small fraction of the overall U.S. commercial and fishing vessel traffic. While U.S. Navy vessel movements may contribute to the ship strike threat, given the lookout and mitigation measures adopted by the U.S. Navy, probability of vessel strikes is greatly reduced. Furthermore, actions to avoid close interaction of U.S. Navy ships and marine mammals and sea turtles, such as maneuvering to keep away from any observed marine mammal and sea turtle are part of existing at-sea protocols and standard operating procedures. Navy ships have up to three or more dedicated and trained lookouts as well as two to three bridge watchstanders during at-sea movements who would be searching for any whales, sea turtles, or other obstacles on the water surface. Such lookouts are expected to further reduce the chances of a collision.

Ingestion of Plastic Objects and Other Marine Debris and Toxic Pollution Exposure

For many marine mammals, debris in the marine environment is a great hazard. Not only is debris a hazard because of possible entanglement, animals may mistake plastics and other debris for food (NMFS, 2007g). Sperm whales have been known to ingest plastic debris, such as plastic bags (Evans et al. 2003; Whitehead 2003). While this has led to mortality, the scale on which this is affecting sperm whale populations is unknown, but Whitehead (2003) suspects it is not substantial at this time.

High concentrations of potentially toxic substances within marine mammals along with an increase in new diseases have been documented in recent years. Scientists have begun to consider the possibility of a link between pollutants and marine mammal mortality events. NMFS takes part in a marine mammal bio-monitoring program not only to help assess the health and contaminant loads of marine mammals, but also to assist in determining anthropogenic impacts on marine mammals, marine food chains, and marine ecosystem health. Using strandings and bycatch animals, the program provides tissue/serum archiving, samples for analyses, disease monitoring and reporting, and additional response during disease investigations (NMFS 2007).

The impacts of these activities are difficult to measure. However, some researchers have correlated contaminant exposure with possible adverse health effects in marine mammals (Borell 1993; O'Shea and Brownell 1994; O'Hara and Rice 1996; O'Hara et al. 1999).

The manmade chemical PCB (polychlorinated biphenyl), and the pesticide DDT (dichlorodiphyenyltrichloroethane), are both considered persistent organic pollutants that are currently banned in the United States for their harmful effects in wildlife and humans (NMFS, 2007c). Despite having been banned for decades, the levels of these compounds are still high in marine mammal tissue samples taken along U.S. coasts (Hickie et al. 2007; Krahn et al. 2007; NMFS 2007c). Both compounds are long-lasting, reside in marine mammal fat tissues (especially in the blubber), and can have toxic effects such as reproductive impairment and immunosuppression (NMFS 2007c).

In addition to direct effects, marine mammals are indirectly affected by habitat contamination that degrades prey species availability, or increases disease susceptibility (Geraci et al. 1999).

U.S. Navy vessel operation between ports and exercise locations has the potential to release small amounts of pollutant discharges into the water column. U.S. Navy vessels are not a typical source, however, of either pathogens or other contaminants with bioaccumulation potential such as pesticides and PCBs. Furthermore, any vessel discharges such as bilge water and deck runoff associated with the vessels would be in accordance with international and U.S. requirements for eliminating or minimizing discharges of oil, garbage, and other substances, and not likely to contribute significant changes to ocean water quality or to affect marine mammals.

5.7.3.1.2 Anthropogenic Sound

As one of the potential stressors to marine mammal populations, noise and acoustic influences may disrupt marine mammal communication, navigational ability, and social patterns, and may or may not influence stranding. Many marine mammals use sound to communicate, navigate, locate prey, and sense their environment. Both anthropogenic and natural sounds may interfere with these functions, although comprehension of the type and magnitude of any behavioral or physiological responses resulting from man-made sound, and how these responses may contribute to strandings, is rudimentary at best (NMFS 2007). Marine mammals may respond both behaviorally and physiologically to anthropogenic sound exposure, (e.g., Richardson et al. 1995; Finneran et al. 2000; Finneran et al. 2003; Finneran et al. 2005). However, the range and magnitude of the behavioral response of marine mammals to various sound sources is highly variable (Richardson et al. 1995) and appears to depend on the species involved, the experience of the animal with the sound source, the motivation of the animal (e.g., feeding, mating), and the context of the exposure.

Marine mammals are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noise that could affect ambient noise arises from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include: transportation; dredging; construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonar; explosions; and ocean research activities (Richardson et al. 1995). Commercial fishing vessels, cruise ships, transport boats, recreational boats, and aircraft, all contribute sound into the ocean (NRC 2003; NRC 2006). Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (NRC 1994, 1996, 2000, 2003, 2005; Richardson et al. 1995; Jasny et al. 2005; McDonald et al. 2006). Much of this increase is due to increased shipping due to ships becoming more numerous and of larger tonnage (NRC 2003; McDonald et al. 2006). Andrew et al. (2002) compared ocean ambient sound from the 1960s with the 1990s for a receiver off the California coast. The data showed an increase in ambient noise of approximately 10 dB in the frequency range of 20 to 80 Hz and 200 and 300 Hz, and about 3 dB at 100 Hz over a 33-year period.

Sound emitted from large vessels, particularly in the course of transit, is the principal source of noise in the ocean today, primarily due to the properties of sound emitted by civilian cargo vessels (Richardson et al. 1995; Arveson and Vendittis 2000). Ship propulsion and electricity generation engines, engine gearing, compressors, bilge and ballast pumps, as well as hydrodynamic flow surrounding a ship's hull and any hull protrusions, contribute to a large vessels' noise emissions in the marine environment. Prop-driven vessels also generate noise through cavitation, which accounts much of the noise emitted by a large vessel depending on its travel speed. Military vessels underway or involved in naval operations or exercises, also introduce anthropogenic noise into the marine environment. Noise emitted by large vessels can be characterized as low-frequency, continuous, and tonal. The sound pressure levels at the vessel will vary according to speed, burden, capacity, and length (Richardson et al. 1995; Arveson and Vendittis

2000). Vessels ranging from 135 to 337 m generate peak source sound levels from 169 - 200 dB between 8 Hz and 430 Hz, although Arveson and Vendittis (2000) documented components of higher frequencies (10-30 kHz) as a function of newer merchant ship engines and faster transit speeds. Given the propagation of low-frequency sounds, a large vessel in this sound range can be heard 87 to 288 mi (139 to 463 km) away (Ross 1976 in Polefka 2004). U.S. Navy vessels, however, have incorporated significant underwater ship quieting technology to reduce their acoustic signature (as compared to a similarly-sized vessel) and thus reduce their vulnerability to detection by enemy passive acoustics (Southall, 2005).

Naval sonars are designed for three primary functions: submarine hunting, mine hunting, and shipping surveillance. There are two classes of sonars employed by the U.S. Navy: active sonars and passive sonars. Most active military sonars operate in a limited number of areas, and are most likely not a significant contributor to a comprehensive global ocean noise budget (ICES 2005b).

Cumulative Impacts

Both natural and human-induced factors affect the health of marine mammal populations. Temporary disturbance incidents associated with Navy activities on the NWTRC could result in an incremental contribution to cumulative impacts on marine mammals. Both current protective measures and additional mitigation measures identified in Section 6 would be implemented to minimize any potential adverse effects to marine mammals from Navy activities. Impacts of the Proposed Action may affect the species through effects on annual rates of recruitment or survival. The Navy is consulting with the NMFS in accordance with the MMPA concerning the potential for impacts to marine mammals resulting from NWTRC activities.

Other Navy activities are being conducted in the NWTRC that may incrementally contribute to the cumulative effect of sonar emissions. Naval Sea Systems Command (NAVSEA) Naval Undersea Warfare Center (NUWC) conducts research, development, test & evaluation (RDT&E) of future navy systems within the Study Area of the NWTRC EIS/OEIS. Based on modeling for NUWC’s RDT&E activities (analyzed under a separate EIS/OEIS), no ESA-listed species will receive Level A or Level B exposures. Estimated acoustic exposures are provided in Tables 5-11 and 5-12 for the Dabob Bay Range Complex (DBRC) and the Quinault Underwater Tracking Range (QUTR) sites (see Figure 5-2). Local impacts on marine mammals may be increased with these activities and other past, present, and reasonably foreseeable future actions.

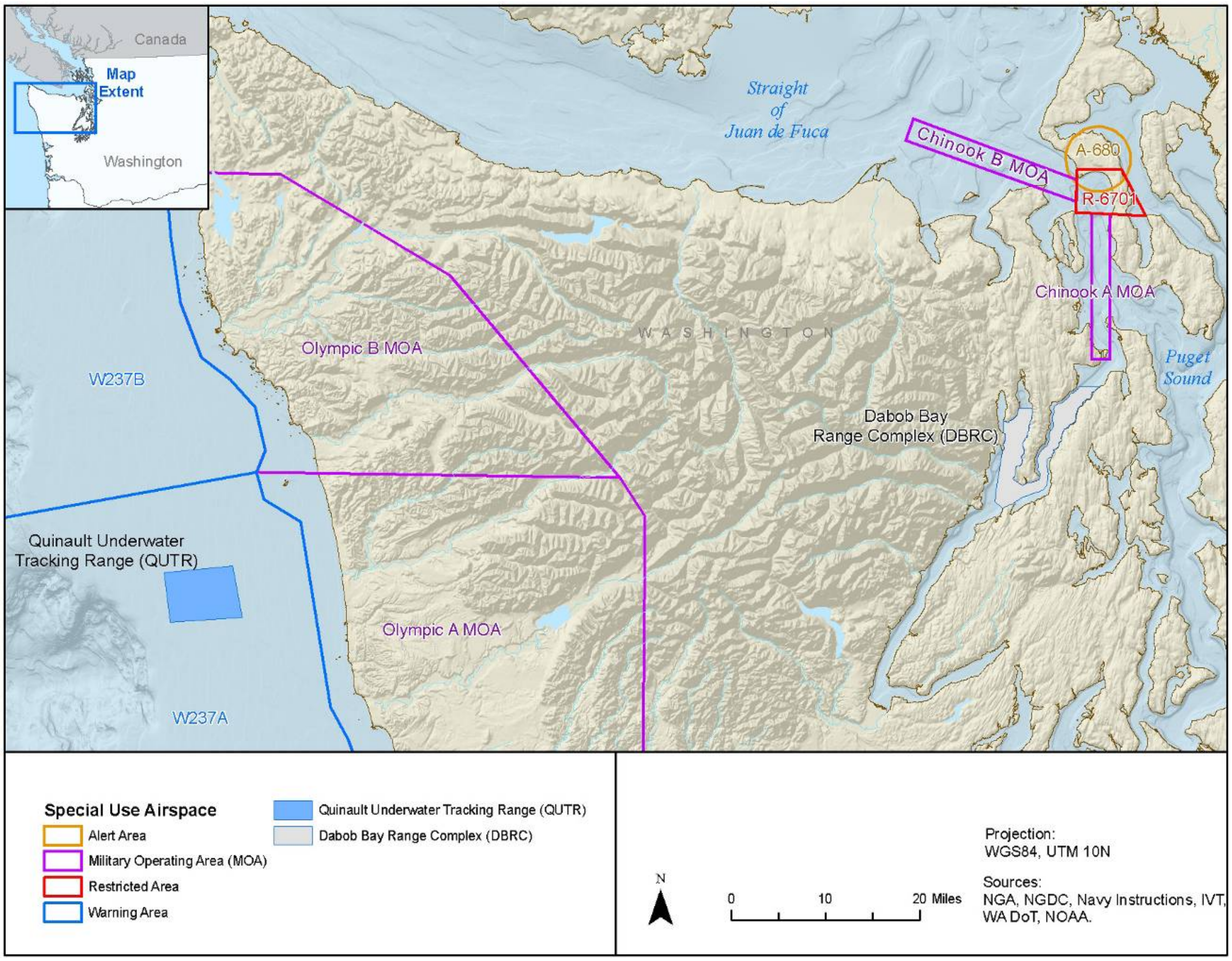

Figure 5-2. Naval Undersea Warfare Center Sites in the Northwest Training Range Complex

Table 5-11. Estimated Annual MMPA Level B Exposures For Inland Water - DBRC Site

Species	EL TTS (Level B) Exposures	Risk Function Behavioral Exposures
Killer Whale	0	0
California Sea Lion	0	109
Harbor Seal	1,998	3,320
Total Level B Exposures (by criteria method)	1,998	3,429

Table 5-12. Estimated Annual MMPA Level B Exposures for Open Ocean - QUTR Site

	EL TTS (Level B) Exposures	Risk Function Behavioral Exposures
Endangered or Threatened Species		
Blue Whale	0	0
Fin Whale	0	0
Humpback Whale	0	0
Sei Whale	0	0
Sperm Whale	0	0
Killer Whale	0	0
Steller Sea Lion	0	0
Non-ESA Listed Species		
Minke Whale	0	0
Gray Whale	0	0
Dwarf and Pygmy Sperm Whale	0	0
Baird's Beaked Whale	0	0
Mesoplodons	0	0
Risso's Dolphin	0	0
Pacific White Sided Dolphin	0	0
Short Beaked Common Dolphin	0	0
Striped Dolphin	0	0
Northern Right Whale Dolphin	0	0
Dall's Porpoise	0	0
Harbor Porpoise	0	11,282
Northern Fur Seal	0	44
California Sea Lion	0	5
Northern Elephant Seal	0	14
Harbor Seal	23	78
Total Level B Exposures (by criteria method)	23	11,423

5.7.4 Sea Birds

Seabird populations within the NWTRC are affected by direct and indirect perturbations to breeding and foraging locations on the coastal mainland and inshore islands. The single greatest concern is the loss of suitable habitat for nesting and roosting seabirds throughout coastal northwest due to land development and human encroachment. Historically, seabird populations have sustained numerous impacts from pollution and human activities from a variety of sources, including the discharge of hazardous chemicals and sewage. Though the Proposed Action does not directly reduce available seabird habitat within the NWTRC, current seabird populations residing within the NWTRC become more susceptible to potential impacts due to the concentrated nature of those populations. Large-scale effects on seabird populations such as global warming, reduced fish populations, and development in other regions are not well defined for individual species but have been attributed to the overall decline of seabirds.

Training activities take place in oceanic waters well offshore, are of short duration, and have a small operational footprint, thus avoiding sensitive seabird colonies and critical shore habitats and reducing disturbance.

Listed sea bird species in the NWTRC include the short-tailed albatross, the marbled murrelet, the California brown pelican, and the western snowy plover. In accordance with ESA, under the Proposed Action, vessel movements, aircraft overflights, ordnance use, underwater explosions and detonations, and entanglement may affect individual sea birds, but would have no effect on species populations, overall foraging success, or breeding opportunities. Critical habitat is designated for the marbled murrelet and western snowy plover on upland areas and shoreline areas, respectively. None of the training activities occur onshore in either of these designated areas so there is no adverse modification or destruction of critical habitat for either species.

5.8 SUMMARY

Table 5-13 summarizes the effects determinations for ESA-listed species and their designated critical habitat that occur in the NWTRC OPAREA. Table 5-14 provides details the stressors responsible for the effects determinations for ESA-listed marine mammals, while Tables 5-15 and 5-16 provide the equivalent stressor effect determinations for ESA-listed bird, turtle, and plant species and fish species, respectively.

Table 5-13. Summary of Effect Determinations for Species and Critical Habitats

Species And Critical Habitat	Status	Jurisdiction	Effect Determination
Marine Mammals			
Blue Whale	Endangered	NMFS	May Affect
Fin Whale	Endangered	NMFS	May Affect
Humpback Whale	Endangered	NMFS	May Affect
Sei Whale	Endangered	NMFS	May Affect
Sperm Whale	Endangered	NMFS	May Affect
Killer Whale, southern resident DPS	Endangered	NMFS	May Affect
Critical Habitat in Puget Sound and Strait of Juan de Fuca areas	Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
North Pacific Right Whale	Endangered	NMFS	No Effect
Stellar Sea Lion - eastern DPS	Threatened	NMFS	May Affect
Critical Habitat at Oregon and California rookeries	Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
Sea Otter	Threatened	USFWS	May Affect
Birds			
Short-tailed Albatross	Endangered	USFWS	May Affect
California Brown Pelican	Endangered	USFWS	May Affect
Marbled Murrelet	Threatened	USFWS	May Affect
Critical Habitat in Washington, Oregon, and California at some near-coast uplands; mostly inland	Critical Habitat	USFWS	No destruction or adverse modification of critical habitat
Western Snowy Plover	Threatened	USFWS	May Affect
Critical Habitat in Washington, Oregon, and California at beaches, sand dunes, and mudflats	Critical Habitat	USFWS	No destruction or adverse modification of critical habitat
Sea Turtles			
Leatherback Sea Turtle	Endangered	NMFS	May Affect
Loggerhead Sea Turtle	Threatened	NMFS	No Effect
Olive Ridley Sea Turtle	Threatened/ Endangered	NMFS	No Effect
Green Sea Turtle	Threatened/ Endangered	NMFS	No Effect

Table 5-13. Summary of Effect Determinations for Species and Critical Habitats (cont.)

Species And Critical Habitat	Status	Jurisdiction	Effect Determination
Fish (with critical habitats for ESUs that interface with coastal waters)			
Chinook Salmon - California Coastal ESU)	Threatened/ Endangered	NMFS	May Affect
Critical Habitat - California Coastal ESU	Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
Critical Habitat – Lower Columbia River, Washington/Oregon ESU	Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
Critical Habitat – Puget Sound, Washington ESU	Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
Steelhead Trout Northern California ESU	Threatened/ Endangered	NMFS	May Affect
Critical Habitat – Northern California ESU	Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
Critical Habitat – Central California Coastal ESU	Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
Steelhead Trout Puget Sound DPS	Threatened	NMFS	May Affect
Chum Salmon – Hood Canal ESU	Threatened	NMFS	May Affect
Critical Habitat – Hood Canal Washington ESU	Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
Coho Salmon – Oregon Coast ESU	Threatened/ Endangered	NMFS	May Affect
Critical Habitat –Northern California-Southern Oregon Coasts, Oregon ESU	Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
Critical Habitat – Oregon Coast, Oregon ESU	Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
Bull Trout – Coastal Puget Sound ESU	Threatened	USFWS	May Affect
Critical Habitat – Coastal Puget Sound, Washington (CHU 28) including near-shore marine waters	Critical Habitat	USFWS	No destruction or adverse modification of critical habitat
Critical Habitat – Olympic Peninsula River Basins Washington (CHU 27) including near-shore marine waters	Critical Habitat	USFWS	No destruction or adverse modification of critical habitat
Green Sturgeon – Southern DPS	Threatened	NMFS	May Affect
Proposed Critical Habitat – Southern DPS	Proposed Critical Habitat	NMFS	No destruction or adverse modification of critical habitat
Plants			
Golden Paintbrush	Threatened	USFWS	No Effect
Notes: DPS – Distinct Population Segment; ESU - Evolutionarily Significant Unit; CHU – Critical Habitat Unit; Status - some species designations change for different portions of their range.			
Sources: National Marine Fisheries Service 2007; NMFS FR 70(170):52488 (9/2/05); NMFS FR 70(170):52630 (9/2/05); NMFS FR 73(28):7816 (2/11/08); NMFS FR 64(86):24049 (5/5/99); USFWS FR 70(185):56212 (9/26/05); NMFS FR 72(91):26722 (5/11/07); NMFS FR 73(174):52084.			

Table 5-14. Summary Effect Determinations for Marine Mammal Species and Critical Habitats by Stressor

STRESSOR	Blue Whale	Fin Whale	Humpback Whale	Sei Whale	Sperm Whale	Southern Resident Killer Whale (SP/CH)[b/]	Steller Sea Lion (SP/CH)[b/]	Sea Otter
Vessel Movements								
Vessel Disturbance	MA[a/]	MA	MA	MA	MA	MA/NAMCH	MA/NAMCH	MA
Vessel Collisions	MA	MA	MA	MA	MA	NE/NAMCH	NE/NAMCH	NE
Aircraft Overflights								
Aircraft Disturbance	MA	MA	MA	MA	MA	MA/NAMCH	MA/NAMCH	MA
Non-Explosive Practice Ordnance								
Weapons Firing Disturbance	NE	NE	NE	NE	NE	NE/NAMCH	NE/NAMCH	NE
Non-Explosive Ordnance Strikes	NE	NE	NE	NE	NE	NE/NAMCH	NE/NAMCH	NE
High Explosive Ordnance								
Underwater Detonation	MA	MA	MA	MA	MA	MA	MA	MA
Explosive Ordnance	MA	MA	MA	MA	MA	MA	MA	MA
Active Sonar								
Mid- and High-Frequency Sonar	MA	MA	MA	MA	MA	MA	MA	MA
Expended Materials								
Ordnance Related Materials	NE	NE	NE	NE	MA	NE/NAMCH	NE/NAMCH	NE
MK-58 Marine Markers	MA	MA	MA	MA	MA	MA/NAMCH	MA/NAMCH	MA
Target Related Materials	NE	NE	NE	NE	NE	NE/NAMCH	NE/NAMCH	NE
EMMATS	NE	NE	NE	NE	NE	NE/NAMCH	NE/NAMCH	NE
Sonobuoys	MA	MA	MA	MA	MA	MA/NAMCH	MA/NAMCH	MA

a/ MA = May Affect; NE = No Effect; NAMCH = No Adverse Modification of Critical Habitat
b/ SP/CH = Species effect/critical habitat effect determination made only for species with listed critical habitat

Table 5-15. Summary Effect Determinations for Bird and Turtle Species and Critical Habitats by Stressor

STRESSOR	Short-tailed Albatross	California Brown Pelican	Western Snowy Plover (SP/CH)[b/]	Marbled Murrelet (SP/CH)[b/]	Leatherback Turtle
Vessel Movements					
Vessel Disturbance	MA[a/]	MA	NE/NAMCH	MA/NAMCH	MA/NAMCH
Vessel Collisions	MA	MA	NE/NAMCH	MA/NAMCH	MA/NAMCH
Aircraft Overflights					
Aircraft Disturbance	MA	MA	MA/NAMCH	MA/NAMCH	MA/NAMCH
Non-Explosive Practice Ordnance					
Weapons Firing Disturbance	MA	NE	NE/NAMCH	NE/NAMCH	MA/NAMCH
Non-Explosive Ordnance Strikes	MA	NE	NE/NAMCH	NE/NAMCH	MA/NAMCH
High Explosive Ordnance					
Underwater Detonation	MA	MA	MA/NAMCH	MA/NAMCH	MA/NAMCH
Explosive Ordnance	MA	NE	NE/NAMCH	NE/NAMCH	MA/NAMCH
Active Sonar					
Mid- and High-Frequency Sonar	NE	NE	NE/NAMCH	NE/NAMCH	NE/NAMCH
Expended Materials					
Ordnance Related Materials	NE	NE	NE/NAMCH	NE/NAMCH	NE/NAMCH
MK-58 Marine Markers	NE	NE	NE/NAMCH	NE/NAMCH	NE/NAMCH
Target Related Materials	NE	NE	NE/NAMCH	NE/NAMCH	NE/NAMCH
Entanglement	MA	NE	NE/NAMCH	NE/NAMCH	MA/NAMCH

a/ MA = May Affect; NE = No Effect; NAMCH = No Adverse Modification of Critical Habitat
b/ SP/CH = Species effect/critical habitat effect determination made only for species with listed critical habitat

Table 5-16. Summary Effect Determinations for Fish Species and Critical Habitats by Stressor

STRESSOR	Chinook Salmon (SP/CH)[b/]	Coho Salmon	Chum Salmon (SP/CH)[b/]	Steelhead Trout (SP/CH)[b/]	Bull Trout	Green Sturgeon (SP/CH)
Vessel Movements						
Vessel Disturbance	MA/NAMCH [a/]	MA	MA/NAMCH	MA/NAMCH	MA	MA/NAMCH
Aircraft Overflights						
Aircraft Disturbance	MA/NAMCH	MA	MA/NAMCH	MA/NAMCH	MA	MA/NAMCH
Non-Explosive Practice Ordnance						
Weapons Firing Disturbance	MA/NAMCH	MA	MA/NAMCH	MA/NAMCH	MA	MA/NAMCH
Non-Explosive Ordnance Strikes	MA/NAMCH	MA	MA/NAMCH	MA/NAMCH	MA	MA/NAMCH
High Explosive Ordnance						
Underwater Detonation	MA/NAMCH	MA	MA/NAMCH	MA/NAMCH	MA	MA/NAMCH
Explosive Ordnance	MA/NAMCH	MA	MA/NAMCH	MA/NAMCH	MA	MA/NAMCH
Active Sonar						
Mid- and High-Frequency Sonar	MA/NAMCH	MA	MA/NAMCH	MA/NAMCH	MA	MA/NAMCH
Expended Materials						
Ordnance Related Materials	MA/NAMCH	MA	MA/NAMCH	MA/NAMCH	MA	MA/NAMCH
Target Related Materials	MA/NAMCH	MA	MA/NAMCH	MA/NAMCH	MA	MA/NAMCH

a/ MA = May Affect; NE = No Effect; NAMCH = No Adverse Modification of Critical Habitat
b/ SP/CH = Species effect/critical habitat effect determination made only for species with listed critical habitat

6 MITIGATION AND CONSERVATION MEASURES

As part of the Navy's commitment to sustainable use of resources and environmental stewardship, the Navy incorporates measures that are protective of the environment into all of its activities. These include employment of best management practice, standard operating procedures (SOPs), adoption of conservation recommendations, and other measures that mitigate the impacts of Navy activities on the environment. Some of these measures are generally applicable and others are designed to apply to certain geographic areas during certain times of year, for specific types of Navy training. Mitigation measures covering habitats and species occurring in the NWTRC have been developed through various environmental analyses conducted by the Navy for land and sea ranges and adjacent coastal waters. In addition, the Navy also has a Protective Measures Assessment Protocol (PMAP) initiative in place which is intended to ensure the latest protected species/habitats mitigation data and guidance are available to the operators conducting training exercises in the open ocean. For major training exercises, these mitigation measures are promulgated through the use of Navy messages issued to all units and commands participating in the exercise as well as to non-Navy participants (e.g., DoD agencies). The following discussion describes mitigation measures applied to each associated resource area during Navy activities in the NWTRC.

6.1 MARINE MAMMALS

Effective training in the NWTRC dictates that ship, submarine, and aircraft participants utilize their sensors and exercise weapons to their optimum capabilities as required by the mission. The Navy recognizes that such use could cause behavioral disruption of some marine mammal species in the vicinity of an exercise. Although any disruption of natural behavioral patterns is not likely to be to a point where such behavioral patterns are abandoned or significantly altered, this section presents the Navy's mitigation measures, outlining steps that would be implemented to protect marine mammals and federally ESA-listed species during training activities. These mitigation measures have been standard operating procedures for unit level anti-submarine warfare (ASW) training since 2004. In addition, the Navy coordinated with the NMFS to further develop measures for protection of marine mammals during the period of the National Defense Exemption (NDE), and those mitigations for mid-frequency active sonar are detailed in this section.

The typical ranges, or distances, from the most powerful and common active sonar sources used in the NWTRC to receive sound energy levels associated with TTS and PTS are shown in Table 6-1. In addition, the range to effects for explosive source sonobuoys (AN/SSQ-110A) are shown in Table 6-2. Due to spreading loss, sound attenuates logarithmically from the source, so the area in which an animal could be exposed to potential injury (PTS) is small. Because the most powerful sources would typically be used in deep water and the range to effect is limited, spherical spreading is assumed for 195 dB referenced to 1 micro-Pascal squared second (dB re 1 μPa^2-s) and above. Also, due to the limited ranges, interactions with the bottom or surface ducts are rarely an issue.

Table 6-1. Range to Effects for Active Sonar

Sonar Source	215 dB re 1 µPa2-s received EL (PTS)	195 dB re 1 µPa2-s received EL (TTS)
AN/SQS-53	33 ft (10 m)	328-985 ft (100-300 m)
AN/SQS-56 or AN/AQS-22	16 ft (5 m)	98-197 ft (30-60 m)
DICASS sonobuoy	N/A	9-20 ft (3-6 m)

Table 6-2. Range to Effects for Explosive Source Sonobuoys (AN/SSQ-110A)

Explosive Source	30.5 psi-ms impulse pressure (Mortality)	205 dB re 1 μPa^2-s received EL in total spectrum (PTS)	23 psi (TTS)
AN/SSQ-110A	46-145 ft (14–44 m)	89-253 ft (27–77 m)	387-643 ft (118–196 m)

The comprehensive suite of protective measures and SOPs implemented by the Navy to reduce impacts to marine mammals and sea turtles also serves to mitigate potential impacts on sea turtles. In particular, personnel and watchstander training, establishment of turtle-free exclusion zones for underwater detonations of explosives, and pre- and post-exercise surveys, all serve to reduce or eliminate potential impacts of Navy activities on sea turtles that may be present in the vicinity.

This section also presents a discussion of other measures that have been considered and rejected because they are either: (1) not feasible; (2) present a safety concern; (3) provide no known or ambiguous mitigation benefit; or (4) impact the effectiveness of the required ASW training military readiness activity.

A Letter of Instruction, Mitigation Measures Message or Environmental Annex to the Operational Order will be issued prior to each exercise to further disseminate the personnel training requirement and general marine mammal mitigation measures including monitoring and reporting. The Navy will continue to fund marine mammal research as outlined below.

The Navy has developed and implemented a comprehensive suite of measures intended to mitigate the potential effects of its activities on marine mammals and sea turtles. The Navy's current mitigation and protective measures are discussed in Section 6.2.

6.2 GENERAL MARITIME MEASURES

6.2.1 Personnel Training – Watchstanders and Lookouts

The use of shipboard lookouts is a critical component of all Navy protective measures. Navy shipboard lookouts (also referred to as “watchstanders”) are highly qualified and experienced observers of the marine environment. Their duties require that they report all objects sighted in the water to the Officer of the Deck (e.g., trash, a periscope, marine mammals, sea turtles) and all disturbances (e.g., surface disturbance, discoloration) that may be indicative of a threat to the vessel and its crew. There are personnel serving as lookouts on station at all times (day and night) when a ship or surfaced submarine is moving through the water.

1. All commanding officers, executive officers, lookouts, officers of the deck, junior officers of the deck, maritime patrol aircraft aircrews, and AWS/MIW helicopter crews will complete the NMFS-approved Marine Species Awareness Training (MSAT) by viewing the U.S. Navy MSAT digital versatile disk (DVD). MSAT may also be viewed on-line at https://mmrc.tecquest.net. All bridge watchstanders/lookouts will complete both parts one and two of the MSAT; part two is optional for other personnel. This training addresses the lookout’s role in environmental protection, laws governing the protection of marine species, Navy stewardship commitments and general observation information to aid in avoiding interactions with marine species.
2. Navy lookouts will undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (Naval Education Training [NAVEDTRA] 12968-D).

3. Lookout training will include on-the-job instruction under the supervision of a qualified, experienced watchstander. Following successful completion of this supervised training period, lookouts will complete the Personal Qualification Standard Program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects). Personnel being trained as lookouts can be counted among required lookouts as long as supervisors monitor their progress and performance.
4. Lookouts will be trained in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of protective measures if marine species are spotted.

6.2.2 Operating Procedures and Collision Avoidance

1. Prior to major exercises, a Letter of Instruction, Mitigation Measures Message or Environmental Annex to the Operational Order will be issued to further disseminate the personnel training requirement and general marine species protective measures.
2. Commanding Officers will make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible consistent with safety of the ship.
3. While underway, surface vessels will have at least two lookouts with binoculars; surfaced submarines will have at least one lookout with binoculars. Lookouts already posted for safety of navigation and man-overboard precautions may be used to fill this requirement. As part of their regular duties, lookouts will watch for and report to the officer of the deck the presence of marine mammals and sea turtles.
4. On surface vessels equipped with a multi-function active sensor, pedestal mounted “Big Eye” (20x10) binoculars will be properly installed and in good working order to assist in the detection of marine mammals and sea turtles in the vicinity of the vessel.
5. Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).
6. After sunset and prior to sunrise, lookouts will employ Night Lookouts Techniques in accordance with the Lookout Training Handbook. (NAVEDTRA 12968-D)
7. While in transit, naval vessels will be alert at all times, use extreme caution, and proceed at a “safe speed” so that the vessel can take proper and effective action to avoid a collision with any marine animal and can be stopped within a distance appropriate to the prevailing circumstances and conditions.
8. When marine mammals have been sighted in the area, Navy vessels will increase vigilance and take reasonable and practicable actions to avoid collisions and activities that might result in close interaction of naval assets and marine mammals. Actions may include changing speed and/or direction and are dictated by environmental and other conditions (e.g., safety, weather).
9. Naval vessels will maneuver to keep at least 1,500 ft (457 m) away from any observed whale and avoid approaching whales head-on. This requirement does not apply if a vessel’s safety is threatened, such as when change of course will create an imminent and serious threat to a person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. Restricted maneuverability includes, but is not limited to, situations when vessels are engaged in dredging, submerged training activities, launching and recovering aircraft or landing craft, minesweeping training activities, replenishment while underway and towing training activities that severely restrict a vessel’s ability to deviate course. Vessels will take reasonable steps to alert other vessels in the vicinity of the whale.

10. Where feasible and consistent with mission and safety, vessels will avoid closing to within 200 yd (183 m) of sea turtles and marine mammals other than whales (whales addressed above).
11. Floating weeds and kelp, algal mats, clusters of seabirds, and jellyfish are good indicators of sea turtles and marine mammals. Therefore, where these circumstances are present, the Navy will exercise increased vigilance in watching for sea turtles and marine mammals.
12. Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties. Marine mammal detections will be immediately reported to assigned Aircraft Control Unit for further dissemination to ships in the vicinity of the marine species as appropriate when it is reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammal.
13. All vessels will maintain logs and records documenting training activities should they be required for event reconstruction purposes. Logs and records will be kept for a period of 30 days following completion of a major training exercise.

6.2.3 Measures for Specific Training Events

6.2.3.1 Mid-Frequency Active Sonar Training Activities

6.2.3.1.1 General Maritime Mitigation Measures: Personnel Training

1. All lookouts onboard platforms involved in ASW training events will review the NMFS-approved Marine Species Awareness Training material prior to use of mid-frequency active sonar.
2. All Commanding Officers, Executive Officers, and officers standing watch on the bridge will have reviewed the MSAT material prior to a training event employing the use of mid-frequency active sonar.
3. Navy lookouts will undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).
4. Lookout training will include on-the-job instruction under the supervision of a qualified, experienced watchstander. Following successful completion of this supervised training period, lookouts will complete the Personal Qualification Standard program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects). This does not forbid personnel being trained as lookouts from being counted as those listed in previous measures so long as supervisors monitor their progress and performance.
5. Lookouts will be trained in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of mitigation measures if marine species are spotted.

6.2.3.1.2 General Maritime Mitigation Measures: Lookout and Watchstander Responsibilities

1. On the bridge of surface ships, there will always be at least three people on watch whose duties include observing the water surface around the vessel.
2. All surface ships participating in ASW training events will, in addition to the three personnel on watch noted previously, have at all times during the exercise at least two additional personnel on watch as marine mammal lookouts.
3. Personnel on lookout and officers on watch on the bridge will have at least one set of binoculars available for each person to aid in the detection of marine mammals.

4. On surface vessels equipped with mid-frequency active sonar, pedestal mounted “Big Eye” (20x110) binoculars will be present and in good working order to assist in the detection of marine mammals in the vicinity of the vessel.
5. Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).
6. After sunset and prior to sunrise, lookouts will employ Night Lookouts Techniques in accordance with the Lookout Training Handbook.
7. Personnel on lookout will be responsible for reporting all objects or anomalies sighted in the water (regardless of the distance from the vessel) to the Officer of the Deck, since any object or disturbance (e.g., trash, periscope, surface disturbance, discoloration) in the water may be indicative of a threat to the vessel and its crew or indicative of a marine species that may need to be avoided as warranted.

6.2.3.1.3 Operating Procedures

1. A Letter of Instruction, Mitigation Measures Message, or Environmental Annex to the Operational Order will be issued prior to the exercise to further disseminate the personnel training requirement and general marine mammal mitigation measures.
2. Commanding Officers will make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible consistent with safety of the ship.
3. All personnel engaged in passive acoustic sonar operation (including aircraft, surface ships, or submarines) will monitor for marine mammal vocalizations and report the detection of any marine mammal to the appropriate watch station for dissemination and appropriate action.
4. During mid-frequency active sonar training activities, personnel will utilize all available sensor and optical systems (such as night vision goggles) to aid in the detection of marine mammals.
5. Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.
6. Aircraft with deployed sonobuoys will use only the passive capability of sonobuoys when marine mammals are detected within 200 yd (183 m) of the sonobuoy.
7. Marine mammal detections will be immediately reported to assigned Aircraft Control Unit for further dissemination to ships in the vicinity of the marine species as appropriate where it is reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammal.
8. Safety Zones—When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) within or closing to inside 1,000 yd (914 m) of the sonar dome (the bow), the ship or submarine will limit active transmission levels to at least 6 decibels (dB) below normal operating levels. (A 6-dB reduction equates to a 75 percent power reduction. The reason is that decibel levels are on a logarithmic scale, not a linear scale. Thus, a 6-dB reduction results in a power level only 25 percent of the original power.)
    a. Ships and submarines will continue to limit maximum transmission levels by this 6-dB factor until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.
    b. Should a marine mammal be detected within or closing to inside 500 yd (457 m) of the sonar dome, active sonar transmissions will be limited to at least 10 dB below the equipment's normal operating level. (A 10-dB reduction equates to a 90 percent power reduction from normal operating levels.) Ships and submarines will continue to limit maximum ping levels by this 10-

dB factor until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.

c. Should the marine mammal be detected within or closing to inside 200 yd (183 m) of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.

d. Special conditions applicable for dolphins and porpoises only: If, after conducting an initial maneuver to avoid close quarters with dolphins or porpoises, the Officer of the Deck concludes that dolphins or porpoises are deliberately closing to ride the vessel's bow wave, no further mitigation actions are necessary while the dolphins or porpoises continue to exhibit bow-wave-riding behavior.

e. If the need for power-down should arise as detailed in “Safety Zones” above, the Navy shall follow the requirements as though they were operating at 235 dB — the normal operating level (i.e., the first power-down will be to 229 dB, regardless of at what level above 235 dB sonar was being operated).

9. Prior to start up or restart of active sonar, operators will check that the Safety Zone radius around the sound source is clear of marine mammals.

10. Sonar levels (generally) - Navy will operate sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.

11. Helicopters will observe/survey the vicinity of an ASW training event for 10 minutes before the first deployment of active (dipping) sonar in the water.

12. Helicopters will not dip their sonar within 200 yd (183 m) of a marine mammal and will cease pinging if a marine mammal closes within 200 yd (183 m) after pinging has begun.

13. Submarine sonar operators will review detection indicators of close-aboard marine mammals prior to the commencement of ASW training events involving active mid-frequency sonar.

14. Increased vigilance during major ASW training exercises with tactical active sonar when critical conditions are present.

Based on lessons learned from strandings in Bahamas 2000, Madeiras 2000, Canaries 2002 and Spain 2006, beaked whales are of particular concern since they have been associated with mid-frequency active sonar training activities. The Navy should avoid planning major ASW training exercises with mid-frequency active sonar in areas where they will encounter conditions which, in their aggregate, may contribute to a marine mammal stranding event.

15. The conditions to be considered during exercise planning include:

a. Areas of at least 3,281-ft (1,000-m) depth near a shoreline where there is a rapid change in bathymetry on the order of 1,000 to 6,000 yd (914 to 5,486 m) occurring across a relatively short horizontal distance (e.g., 5 nm [9 km]).

b. Cases for which multiple ships or submarines ($\geq$ 3) operating mid-frequency active sonar in the same area over extended periods of time ($\geq$ 6 hours) in close proximity ($\leq$ 10 nm [18 km] apart).

c. An area surrounded by land masses, separated by less than 35 nm (65 km) and at least 10 nm (18 km) in length, or an embayment, wherein training activities involving multiple ships/subs ($\geq$ 3) employing mid-frequency active sonar near land may produce sound directed toward the channel or embayment that may cut off the lines of egress for marine mammals.

d. Though not as dominant a condition as bathymetric features, the historical presence of a significant surface duct (i.e., a mixed layer of constant water temperature extending from the sea surface to 100 or more ft [30 or more m]).

If the Major Range Event is to occur in an area where the above conditions exist in their aggregate, these conditions must be fully analyzed in environmental planning documentation. The Navy will increase vigilance by undertaking the following additional mitigation measures:

16. A dedicated aircraft (Navy asset or contracted aircraft) will undertake reconnaissance of the embayment or channel ahead of the exercise participants to detect marine mammals that may be in the area exposed to active sonar. Where practical, advance survey should occur within about 2 hours prior to mid-frequency active sonar use and periodic surveillance should continue for the duration of the exercise. Any unusual conditions (e.g., presence of sensitive species, groups of species milling out of habitat, and any stranded animals) shall be reported to the Office in Tactical Command, who should give consideration to delaying, suspending, or altering the exercise.
17. All safety zone power down requirements described above apply.
18. The post-exercise report must include specific reference to any event conducted in areas where the above conditions exist, with exact location and time/duration of the event, and noting results of surveys conducted.

6.2.3.2 Surface-to-Surface Gunnery (5-inch, 76 mm, 20 mm, 25 mm and 30 mm Explosive Rounds)

1. Lookouts will visually survey for floating weeds and kelp., and algal mats. Intended impact will not be within 600 yd (549 m) of known or observed floating weeds and kelp, and algal mats .
2. For exercises using targets towed by a vessel or aircraft, target-towing vessels/aircraft shall maintain a trained lookout for marine mammals and sea turtles. If a marine mammal or sea turtle is sighted in the vicinity, the tow aircraft/vessel will immediately notify the firing vessel, which will suspend the exercise until the area is clear.
3. A 600-yd (549-m) radius buffer zone will be established around the intended target.
4. From the intended firing position, trained lookouts will survey the buffer zone for marine mammals and sea turtles prior to commencement and during the exercise as long as practicable. Due to the distance between the firing position and the buffer zone, lookouts are only expected to visually detect breaching whales, whale blows, and large pods of dolphins and porpoises.
5. The exercise will be conducted only when the buffer zone is visible and marine mammals and sea turtles are not detected within it.

6.2.3.3 Surface-to-Surface Gunnery (non-explosive rounds)

1. Lookouts will visually survey for floating weeds and kelp, and algal mats. Intended impact will not be within 200 yd (183 m) of known or observed floating weeds and kelp, and algal mats.
2. A 200-yd (183-m) radius buffer zone will be established around the intended target.
3. From the intended firing position, trained lookouts will survey the buffer zone for marine mammals and sea turtles prior to commencement and during the exercise as long as practicable. Due to the distance between the firing position and the buffer zone, lookouts are only expected to visually detect breaching whales, whale blows, and large pods of dolphins and porpoises.
4. If applicable, target towing vessels will maintain a lookout. If a marine mammal or sea turtle is sighted in the vicinity of the exercise, the tow vessel will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

5. The exercise will be conducted only when the buffer zone is visible and marine mammals and sea turtles are not detected within the target area and the buffer zone.

6.2.3.4 Surface-to-Air Gunnery (explosive and non-explosive rounds)

1. Vessels will orient the geometry of gunnery exercises in order to prevent debris from falling in the area of sighted marine mammals and sea turtles.
2. Vessels will expedite the recovery of any parachute deploying aerial targets to reduce the potential for entanglement of marine mammals and sea turtles.
3. Target towing aircraft will maintain a lookout. If a marine mammal or sea turtle is sighted in the vicinity of the exercise, the tow aircraft will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

6.2.3.5 Air-to-Surface Gunnery (explosive and non-explosive rounds)

1. If surface vessels are involved, lookouts will visually survey for floating weeds, kelp and algal mats in the target area. Impact will not occur within 200 yd (183 m) of known or observed floating weeds and kelp or algal mats .
2. A 200-yd (183-m) radius buffer zone will be established around the intended target.
3. If surface vessels are involved, lookout(s) will visually survey the buffer zone for marine mammals and sea turtles prior to and during the exercise.
4. Aerial surveillance of the buffer zone for marine mammals and sea turtles will be conducted prior to commencement of the exercise. Aerial surveillance altitude of 500 ft to 1,500 ft (152 to 457 m) is optimum. Aircraft crew/pilot will maintain visual watch during exercises. Release of ordnance through cloud cover is prohibited: Aircraft must be able to actually see ordnance impact areas.
5. The exercise will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

6.2.3.6 Small Arms Training (grenades, explosive and non-explosive rounds)

1. Lookouts will visually survey for floating weeds or kelp, algal mats, marine mammals, and sea turtles. Weapons will not be fired in the direction of known or observed floating weeds or kelp, algal mats, marine mammals, or sea turtles.

6.2.3.7 Air-to-Surface At-Sea Bombing Exercises (explosive bombs and rockets)

1. If surface vessels are involved, trained lookouts will survey for floating kelp, marine mammals, and sea turtles. Ordnance will not be targeted to impact within 1,000 yd (914 m) of known or observed floating kelp, sea turtles, or marine mammals.
2. A buffer zone of 1,000-yd (914-m) radius will be established around the intended target.
3. Aircraft will visually survey the target and buffer zone for marine mammals and sea turtles prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 ft (457 m) or lower, if safe to do so, and at the slowest safe speed. Release of ordnance through cloud cover is prohibited: aircraft must be able to actually see ordnance impact areas. Survey aircraft should employ most effective search tactics and capabilities.
4. The exercises will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

6.2.3.8 Air-to-Surface At-Sea Bombing Exercises (non-explosive bombs and rockets)

1. If surface vessels are involved, trained lookouts will survey for floating kelp, which may be inhabited by immature sea turtles, and for sea turtles and marine mammals. Ordnance shall not be targeted to impact within 1,000 yd (914 m) of known or observed floating kelp, sea turtles, or marine mammals.
2. A 1,000-yd (914-m) radius buffer zone will be established around the intended target.
3. Aircraft will visually survey the target and buffer zone for marine mammals and sea turtles prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 ft (457 m) or lower, if safe to do so, and at the slowest safe speed. Release of ordnance through cloud cover is prohibited: aircraft must be able to actually see ordnance impact areas. Survey aircraft should employ most effective search tactics and capabilities.
4. The exercise will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

6.2.3.9 Air-to-Surface Missile Exercises (explosive and non-explosive)

1. Ordnance will not be targeted to impact within 1,800 yd (1,646 m) of known or observed floating kelp.
2. Aircraft will visually survey the target area for marine mammals and sea turtles. Visual inspection of the target area will be made by flying at 1,500 ft (457 m) ft or lower, if safe to do so, and at slowest safe speed. Firing or range clearance aircraft must be able to actually see ordnance impact areas. Explosive ordnance shall not be targeted to impact within 1,800 yd (1,646 m) of sighted marine mammals and sea turtles.

6.2.3.10 Underwater Detonations (up to 2.5-lb charges)

To ensure protection of marine mammals and sea turtles during underwater detonation training, the operating area must be determined to be clear of marine mammals and sea turtles prior to detonation. Implementation of the following mitigation measures continue to ensure that marine mammals would not be exposed to temporary threshold shift (TTS), permanent threshold shift (PTS), or injury from physical contact with training mine shapes during training events.

6.2.3.10.1 Exclusion Zones

All Mine Warfare and Mine Countermeasures Operations involving the use of explosive charges must include exclusion zones for marine mammals and sea turtles to prevent physical and/or acoustic effects to those species. These exclusion zones will extend in a 700-yd (640-m) radius around the detonation site.

6.2.3.10.2 Pre-Exercise Surveys

For Demolition and Ship Mine Countermeasures Operations, pre-exercise survey will be conducted within 30 minutes prior to the commencement of the scheduled explosive event. The survey may be conducted from the surface, by divers, and/or from the air, and personnel will be alert to the presence of any marine mammal or sea turtle. Should such an animal be present within the survey area, the exercise will be paused until the animal voluntarily leaves the area. The Navy will suspend detonation exercises and ensure the area is clear for a full 30 minutes prior to detonation. Personnel will record marine mammal and sea turtle observations during the exercise.

6.2.3.10.3 Post-Exercise Surveys

Surveys within the same radius will also be conducted within 30 minutes after the completion of the explosive event.

6.2.3.10.4 Reporting

If there is evidence that a marine mammal or sea turtle may have been stranded, injured or killed by the action, Navy training activities will be immediately suspended and the situation immediately reported by the participating unit to the Officer in Charge of the Exercise (OCE), who will follow Navy procedures for reporting the incident to Commander, Pacific Fleet, Commander, Navy Region Southwest, Environmental Director, and the chain-of-command. The situation will also be reported to NMFS (see Stranding Plan for details).

6.2.3.11 Mining Training Activities

Mining training activities involve aerial drops of inert training shapes on target points. Aircrews are scored for their ability to accurately hit the target points. Although this operation does not involve live ordnance, marine mammals have the potential to be injured if they are in the immediate vicinity of a target points; therefore, the safety zone shall be clear of marine mammals and sea turtles around the target location. Pre- and post-surveys and reporting requirements outlined for underwater detonations shall be implemented during mining training activities. To the maximum extent feasible, the Navy shall retrieve inert mine shapes dropped during mining training activities.

6.2.3.12 Sinking Exercise

The selection of sites suitable for Sinking Exercises (SINKEXs) involves a balance of operational suitability, requirements established under the Marine Protection, Research and Sanctuaries Act (MPRSA) permit granted to the Navy (40 Code of Federal Regulations § 229.2), and the identification of areas with a low likelihood of encountering ESA-listed species. To meet operational suitability criteria, locations must be within a reasonable distance of the target vessels' originating location. The locations should also be close to active military bases to allow participating assets access to shore facilities. For safety purposes, these locations should also be in areas that are not generally used by non-military air or watercraft. The MPRSA permit requires vessels to be sunk in waters which are at least 1,000 fathoms (6,000 ft [1,829 m]) deep and at least 50 nm (93 km) from land.

In general, most listed species prefer areas with strong bathymetric gradients and oceanographic fronts for significant biological activity such as feeding and reproduction. Typical locations include the continental shelf and shelf-edge.

6.2.3.12.1 SINKEX Range Clearance Plan

The Navy has developed range clearance procedures to maximize the probability of sighting any ships or protected species in the vicinity of an exercise, which are as follows:

1. All weapons firing will be conducted during the period 1 hour after official sunrise to 30 minutes before official sunset.

2. Extensive range clearance operations will be conducted in the hours prior to commencement of the exercise, ensuring that no shipping is located within the hazard range of the longest-range weapon being fired for that event.

3. Prior to conducting the exercise, remotely sensed sea surface temperature maps will be reviewed. SINKEX and ASM training activities will not be conducted within areas where strong temperature discontinuities are present, thereby indicating the existence of oceanographic fronts. These areas will be avoided because concentrations of some listed species, or their prey, are known to be associated with these oceanographic features.

4. An exclusion zone with a radius of 1.0 nm (2 km) will be established around each target. An additional buffer of 0.5 nm (1 km) will be added to account for errors, target drift, and animal

movements. Additionally, a safety zone, which extends from the exclusion zone at 1.0 nm (2 km) out an additional 0.5 nm (1 km), will be surveyed. Together, the zones extend out 2 nm (4 km) from the target.

5. A series of surveillance over-flights will be conducted within the exclusion and the safety zones, prior to and during the exercise, when feasible. Survey protocol will be as follows:
   a. Overflights within the exclusion zone will be conducted in a manner that optimizes the surface area of the water observed. This may be accomplished through the use of the Navy's Search and Rescue Tactical Aid, which provides the best search altitude, ground speed, and track spacing for the discovery of small, possibly dark objects in the water based on the environmental conditions of the day. These environmental conditions include the angle of sun inclination, amount of daylight, cloud cover, visibility, and sea state.
   b. All visual surveillance activities will be conducted by Navy personnel trained in visual surveillance. At least one member of the mitigation team will have completed the Navy's marine mammal training program for lookouts.
   c. In addition to the overflights, the exclusion zone will be monitored by passive acoustic means, when assets are available. This passive acoustic monitoring will be maintained throughout the exercise. Potential assets include sonobuoys, which can be utilized to detect any vocalizing marine mammals (particularly sperm whales) in the vicinity of the exercise. The sonobuoys will be re-seeded as necessary throughout the exercise. Additionally, passive sonar onboard submarines may be utilized to detect any vocalizing marine mammals in the area. The Officer in Charge of the Exercise (OCE) will be informed of any aural detection of marine mammals and will include this information in the determination of when it is safe to commence the exercise.
   d. On each day of the exercise, aerial surveillance of the exclusion and safety zones will commence 2 hours prior to the first firing.
   e. The results of all visual, aerial, and acoustic searches will be reported immediately to the OCE. No weapons launches or firing will commence until the OCE declares the safety and exclusion zones free of marine mammals and threatened and endangered species.
   f. If a protected species observed within the exclusion zone is diving, firing will be delayed until the animal is re-sighted outside the exclusion zone, or 30 minutes have elapsed. After 30 minutes, if the animal has not been re-sighted it will be assumed to have left the exclusion zone. This is based on a typical dive time of 30 minutes for traveling listed species of concern. The OCE will determine if the listed species is in danger of being adversely affected by commencement of the exercise.
   g. During breaks in the exercise of 30 minutes or more, the exclusion zone will again be surveyed for any protected species. If protected species are sighted within the exclusion zone, the OCE will be notified, and the procedure described above will be followed.
   h. Upon sinking of the vessel, a final surveillance of the exclusion zone will be monitored for 2 hours, or until sunset, to verify that no marine mammals or sea turtles were harmed.

6. Aerial surveillance will be conducted using helicopters or other aircraft based on necessity and availability. The Navy has several types of aircraft capable of performing this task; however, not all types are available for every exercise. For each exercise, the available asset best suited for identifying objects on and near the surface of the ocean will be used. These aircraft will be capable of flying at the slow safe speeds necessary to enable viewing of marine vertebrates with unobstructed, or minimally obstructed, downward and outward visibility. The exclusion and safety zone surveys may

be cancelled in the event that a mechanical problem, emergency search and rescue, or other similar and unexpected event preempts the use of one of the aircraft onsite for the exercise.

7. Every attempt will be made to conduct the exercise in sea states that are ideal for marine mammal sighting, Beaufort Sea State 3 or less. In the event of a 4 or above, survey efforts will be increased within the zones. This will be accomplished through the use of an additional aircraft, if available, and conducting tight search patterns.

8. The exercise will not be conducted unless the exclusion zone could be adequately monitored visually.

9. In the event that any marine mammals or sea turtles are observed to be harmed in the area, a detailed description of the animal will be taken, the location noted, and if possible, photos taken. This information will be provided to NMFS via the Navy's regional environmental coordinator for purposes of identification.

10. An after action report detailing the exercise's time line, the time the surveys commenced and terminated, amount, and types of all ordnance expended, and the results of survey efforts for each event will be submitted to NMFS.

6.2.3.13 Mitigation Measures Related to Explosive Source Sonobuoys (AN/SSQ-110A) (AN/SSQ-110A)

6.2.3.13.1 AN/SSQ-110A Pattern Deployment

1. Crews will conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search should be conducted below 1,500 ft (457 m) at a slow speed when operationally feasible and weather conditions permit. In dual aircraft activities, crews may conduct coordinated area clearances.
2. Crews shall conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post (source/receiver sonobuoy pair) detonation. This 30 minute observation period may include pattern deployment time.
3. For any part of the briefed pattern where a post will be deployed within 1,000 yds(914 m) of observed marine mammal activity, the Navy will deploy the receiver ONLY and monitor while conducting a visual search. When marine mammals are no longer detected within 1,000 yds (914 m) of the intended post position, the Navy will co-locate the AN/SSQ-110A sonobuoy (source) with the receiver.
4. When operationally feasible, the Navy will conduct continuous visual and aural monitoring of marine mammal activity, including monitoring of their aircraft sensors from first sensor placement to checking off-station and out of RF range of the sensors.

6.2.3.13.2 AN/SSQ-110A Pattern Employment

1. Aural Detection – If the presence of marine mammals is detected aurally, then that shall cue the Navy aircrew to increase the diligence of their visual surveillance. Subsequently, if no marine mammals are visually detected, then the crew may continue multi-static active search.
2. Visual Detection – If marine mammals are visually detected within 1,000 yds (914 m) of the explosive source sonobuoy (AN/SSQ-110A) intended for use, then that payload will not be detonated. Aircrews may utilize this post once the marine mammals have not been re-sighted for 30 minutes or are observed to have moved outside the 1,000 yd (914 m) safety buffer. Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 1,000 yd (914 m) safety buffer.

6.2.3.13.3 AN/SSQ-110A Scuttling Sonobuoys

1. Aircrews will make every attempt to manually detonate the unexploded charges at each post in the pattern prior to departing the operations area by using the “Payload 1 Release” command followed by the “Payload 2 Release” command. Aircrews will refrain from using the “Scuttle” command when two payloads remain at a given post. Aircrews will ensure a 1,000 yd (914 m) safety buffer, visually clear of marine mammals, is maintained around each post as is done during active search operations.
2. Aircrews will only leave posts with unexploded charges in the event of a sonobuoy malfunction, an aircraft system malfunction, or when an aircraft must immediately depart the area due to issues such as fuel constraints, inclement weather, and in-flight emergencies. In these cases, the sonobuoy will self-scuttle using the secondary method or tertiary method.
3. The Navy will ensure all payloads are accounted for. Explosive source sonobuoys (AN/SSQ-110A) that cannot be scuttled shall be reported as unexploded ordnance via voice communications while airborne and, then upon landing, via Naval message.
4. Marine mammal monitoring will continue until out of their own aircraft sensor range.

6.2.4 Conservation Measures

6.2.4.1 Monitoring: Integrated Comprehensive Monitoring Program

The U.S. Navy is committed to demonstrating environmental stewardship while executing its National Defense mission and is responsible for compliance with federal environmental and natural resources laws and regulations that apply to the marine environment. As part of those responsibilities, an assessment of the long-term and/or population-level effects of Navy training activities as well as the efficacy of mitigation measures is necessary. The Navy is developing an Integrated Comprehensive Monitoring Program (ICMP) for marine species in order to assess the effects of training activities on marine species and investigate population 1trends in marine species distribution and abundance in various range complexes and geographic locations where Navy training occurs. This program will emphasize active sonar training.

The primary goals of the ICMP are to:

- Monitor Navy training exercises, especially those involving mid-frequency sonar and underwater detonations, for compliance with the terms and conditions of Biological Opinions or Marine Mammal Protection Act (MMPA) authorizations.
- Estimate the number individuals (primarily marine mammals) exposed to sound levels above current regulatory thresholds.
- Assess the effectiveness of the Navy’s marine species mitigation.
- Minimize exposure of protected species (primarily marine mammals) to sound levels from active sonar or sound pressure levels from underwater detonations currently
- Considered to result in harassment.
- Document trends in species distribution and abundance in Navy training areas.
- Add to the knowledge base on potential behavioral and physiological effects to marine species from MFA sonar and underwater detonations.
- Assess the practicality and usefulness of a number of mitigation tools and techniques.

The ICMP will serve as the basis for establishing Implementation Plans (IPs) for training activities as well as geographically based long-term monitoring sites. Training exercise IPs will be focused on short-term monitoring and mitigation for individual training activities. These exercise-specific Implementation

Plans will be tailored to the specific logistical constraints for each exercise and include specifics concerning dates, location, spatial extent, appropriate monitoring methods, and reporting protocols. The IP will utilize information specific to the exercise to determine the most effective, logistically and financially feasible means to monitor each training event. Each IP will be developed to ensure compliance with all ESA Section 7 and MMPA authorization requirements.

By using a combination of monitoring techniques or tools appropriate for the species of concern, type of Navy activities conducted in the area, sea state conditions, and the size of the OPAREA, the detection, localization, and observation of marine species can be maximized. This ICMP will evaluate the range of potential monitoring techniques that can be tailored to any Navy range or exercise and the appropriate species of concern. The limitations and benefits to each type of monitoring technique and the type of environment or species of concern that would best be served by the technique will be addressed and a matrix of feasibility, temporal and spatial use, limitations, costs and availability of resources to accommodate the technique will be developed.

The primary tools available for monitoring include the following:

- Visual Observations – Surface vessel, aerial and shore-based surveys, providing data on long term population trends (abundance and distribution) and response of marine species to Navy training activities. Both Navy personnel and independent visual observers will be considered.
- Acoustic Monitoring – Autonomous Acoustic Recorders (moored buoys), High Frequency Acoustic Recording Packages (HARPS), sonobuoys, passive acoustic towed arrays, shipboard passive sonar, and Navy Instrumented Acoustic Ranges can provide presence/absence and movement data which are particularly important for species that are difficult to detect visually or when conditions limit the effectiveness of visual monitoring.
- Photo identification and tagging – Contributes to understanding of movement patterns and stock structure which is important to determine how potential effects may relate to individual stocks or populations. Tagging with sophisticated D-tags may also allow direct monitoring of behaviors not readily apparent to surface observers.
- Oceanographic and environmental data collection – Data to be used for analyzing distribution patterns and developing predictive habitat and density models.

In addition, the ICMP will propose to continue or initiate studies of behavioral response, abundance, distribution, habitat utilization, etc. for species of concern using a variety of methods which may include visual surveys, passive and acoustic monitoring, radar and data logging tags (to record data on acoustics, diving and foraging behavior, and movements). This work will help to build the collective knowledgebase on the geographic and temporal extent of key habitats and provide baseline information to account for natural perturbations such as El Niño or La Niña events as well as establish baseline information to determine the spatial and temporal extent of reactions to Navy training activities, or indirect effects from changes in prey availability and distribution.

The Navy will coordinate with the local NMFS Stranding Coordinator for any unusual marine mammal behavior and any stranding, beached live/dead or floating marine mammals that may occur at any time during or within 24 hours after completion of MFA sonar use associated with ASW training activities. The Navy will submit a report to the Office of Protected Resources, NMFS, within 120 days of the completion of a Major Exercise. This report must contain a discussion of the nature of the effects, if observed, based on both modeled results of real-time events and sightings of marine mammals.

In combination with previously discussed mitigation and protective measures, exercise-specific implementation plans developed under the ICMP will ensure thorough monitoring and reporting of NWTRC training activities. A Letter of Instruction, Mitigation Measures Message, or Environmental Annex to the Operational Order will be issued prior to each exercise to further disseminate the personnel training requirement and general marine mammal protective measures including monitoring and reporting.

6.2.4.2 Monitoring: NWTRC Marine Species Monitoring Plan

The Navy is developing a Marine Species Monitoring Plan (MSMP) that provides recommendations for site-specific monitoring for MMPA and ESA listed species (primarily marine mammals) within the NWTRC, including during training exercises. The primary goals of monitoring are to evaluate trends in marine species distribution and abundance in order to assess potential population effects from Navy training activities and determine the effectiveness of the Navy's mitigation measures. The information gained from the monitoring will also allow the Navy to evaluate the models used to predict effects to marine mammals.

By using a combination of monitoring techniques or tools appropriate for the species of concern, type of Navy activities conducted, sea state conditions, and the size of the Range Complex, the detection, localization, and observation of marine mammals and sea turtles can be maximized. The following available monitoring techniques and tools are described in this monitoring plan for monitoring for range events (several days or weeks) and monitoring of population effects such as abundance and distribution (months or years):

- Visual Observations – Vessel-, Aerial- and Shore-based Surveys (for marine mammals and sea turtles) will provide data on population trends (abundance, distribution, and presence) and response of marine species to Navy training activities. Navy lookouts will also record observations of detected marine mammals from Navy ships during appropriate training and test events.
- Acoustic Monitoring – Passive Acoustic Monitoring possibly using towed hydrophone arrays, Autonomous Acoustic Recording buoys and U.S. Navy Instrument Acoustic Range (for marine mammals only) may provide presence/absence data on cryptic species that are difficult to detect visually (beaked whales and minke whales) that could address long term population trends and response to Navy training exercises.
- Additional Methods – Oceanographic Observations and Other Environmental Factors will be obtained during ship-based surveys and satellite remote sensing data. Oceanographic data is important factor that influences the abundance and distribution of prey items and therefore the distribution and movements of marine mammals.

The monitoring plan will be reviewed annually by Navy biologists to determine the effectiveness of the monitoring elements and to consider any new monitoring tools or techniques that may have become available.

6.2.5 Research

The Navy provides a significant amount of funding and support to marine research. The agency provides nearly 18 million dollars annually to universities, research institutions, federal laboratories, private companies, and independent researchers around the world to study marine mammals. The U.S. Navy sponsors 70 percent of all U.S. research concerning the effects of human-generated sound on marine mammals and 50 percent of such research conducted worldwide. Major topics of Navy-supported research include the following:

- Better understanding of marine species distribution and important habitat areas,
- Developing methods to detect and monitor marine species before and during training,
- Understanding the effects of sound on marine mammals, sea turtles, fish, and birds, and
- Developing tools to model and estimate potential effects of sound.

This research is directly applicable to Pacific Fleet training activities, particularly with respect to the investigations of the potential effects of underwater noise sources on marine mammals and other protected species. Proposed training activities employ sonar and underwater explosives, which introduce sound into the marine environment.

The Marine Life Sciences Division of the Office of Naval Research currently coordinates six programs that examine the marine environment and are devoted solely to studying the effects of noise and/or the implementation of technology tools that will assist the Navy in studying and tracking marine mammals. The six programs are as follows:

- Environmental Consequences of Underwater Sound,
- Non-Auditory Biological Effects of Sound on Marine Mammals,
- Effects of Sound on the Marine Environment,
- Sensors and Models for Marine Environmental Monitoring,
- Effects of Sound on Hearing of Marine Animals, and
- Passive Acoustic Detection, Classification, and Tracking of Marine Mammals.

The Navy has also developed the technical reports referenced within this document, which include the Marine Resource Assessments and the Navy OPAREA Density Estimates (NODE) reports. Furthermore, research cruises by the National Marine Fisheries Service (NMFS) and by academic institutions have received funding from the U.S. Navy.

The Navy has sponsored several workshops to evaluate the current state of knowledge and potential for future acoustic monitoring of marine mammals. The workshops brought together acoustic experts and marine biologists from the Navy and other research organizations to present data and information on current acoustic monitoring research efforts and to evaluate the potential for incorporating similar technology and methods on instrumented ranges. However, acoustic detection, identification, localization, and tracking of individual animals still requires a significant amount of research effort to be considered a reliable method for marine mammal monitoring. The Navy supports research efforts on acoustic monitoring and will continue to investigate the feasibility of passive acoustics as a potential mitigation and monitoring tool.

Overall, the Navy will continue to fund ongoing marine mammal research, and is planning to coordinate long term monitoring/studies of marine mammals on various established ranges and operating areas. The Navy will continue to research and contribute to university/external research to improve the state of the science regarding marine species biology and acoustic effects. These efforts include mitigation and monitoring programs; data sharing with NMFS and via the literature for research and development efforts; and future research as described previously.

6.2.6 Coordination and Reporting

The Navy is required to cooperate with the NMFS, and any other Federal, state, or local agency monitoring the impacts of training activities on marine mammals. The Navy will coordinate with the local NMFS Stranding Coordinator for any unusual marine mammal behavior and any stranding, beached live/dead or floating marine mammals that may occur coincident with Navy training activities. Details of required reporting and coordination will be defined in the Letter of Authorization for the NWTRC training and RDT&E activities. It is anticipated the following reporting and coordination may be required for these types of activities:

1. SINKEX, GUNEX, MISSILEX, BOMBEX, and Mine Warfare/ Countermeasures exercises — A yearly report detailing the exercise's timelines, the time the surveys commenced and terminated,

amount, and types of all ordnance expended, and the results of marine mammal survey efforts for each event will be submitted to NMFS.

2. IEER exercises — A yearly report detailing the number of exercises along with the hours of associated marine mammal survey and associated marine mammal sightings, number of times deployment was delayed by marine mammal sightings, and the number of total detonated charges and self-scuttled charges will be submitted to NMFS.

3. MFAS/HFAS exercises — The Navy will submit an After Action Report to the Office of Protected Resources, NMFS, within 120 days of the completion of any Major Training or Integrated Unit-Level Exercise (Sustainment Exercise, IAC2, SHAREM). For other ASW exercises, the Navy will submit a yearly summary report. The After Action Reports and the annual reports will, at a minimum, include the following information:

    a. The estimated total number of hours of active sonar operation and the types of sonar utilized in the exercise;

    b. The total number of hours of observation effort (including observation time when active sonar was not operating), if obtainable;

    c. All marine mammal sightings (at any distance—not just within a particular distance) to include details of the sighting circumstances;

    d. The status of any active sonar sources (what sources were in use) and whether or not they were powered down or shut down as a result of the marine mammal observation; and

    e. The platform that the marine mammals were initially sighted from.

4. Comprehensive National Sonar Report — By June 2014, the Navy will submit a draft National Report that analyzes, compares, and summarizes the active sonar data gathered (through November 2013) from the watchstanders and pursuant to the implementation of the Monitoring Plans for SOCAL, the Hawaii Range Complex (HRC), the Southern California (SOCAL) Range Complex, the Marianas Range Complex, and the Northwest Training Range Complex (NWTRC).

6.2.7 Alternative Mitigation Measures Considered but Eliminated

The vast majority of estimated sound exposures of marine mammals during proposed active sonar activities would not cause injury. Potential acoustic effects on marine mammals would be further reduced by the mitigation measures described above. Therefore, the Navy concludes the Proposed Action and mitigation measures would achieve the least practical adverse impact on species or stocks of marine mammals.

A determination of "least practicable adverse impacts" includes consideration of personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity in consultation with the DoD. Therefore, the following additional mitigation measures were analyzed and eliminated from further consideration:

1. Reduction of training. The requirements for training have been developed through many years of iteration to ensure sailors achieve levels of readiness to ensure they are prepared to properly respond to the many contingencies that may occur during an actual mission. These training requirements are designed provide the experience needed to ensure sailors are properly prepared for operational success. There is no extra training built in to the plan, as this would not be an efficient use of the resources needed to support the training (e.g. fuel, time). Therefore, any reduction of training would not allow sailors to achieve satisfactory levels of readiness needed to accomplish their mission.

2. Use of ramp-up to attempt to clear the range prior to the conduct of exercises. Ramp-up procedures, (slowly increasing the sound in the water to necessary levels), are not a viable alternative for training exercises because the ramp-up would alert opponents to the participants' presence. This affects the

realism of training in that the target submarine would be able to detect the searching unit prior to themselves being detected, enabling them to take evasive measures. This would insert a significant anomaly to the training, affecting its realism and effectiveness. Though ramp-up procedures have been used in testing, the procedure is not effective in training sailors to react to tactical situations, as it provides an unrealistic advantage by alerting the target. Using these procedures would not allow the Navy to conduct realistic training, thus adversely impacting the effectiveness of the military readiness activity.

3. Visual monitoring using third-party observers from air or surface platforms, in addition to the existing Navy-trained lookouts.

   a. The use of third-party observers would compromise security due to the requirement to provide advance notification of specific times/locations of Navy platforms.

   b. Reliance on the availability of third-party personnel would also impact training flexibility, thus adversely affecting training effectiveness.

   c. The presence of other aircraft in the vicinity of naval exercises would raise safety concerns for both the commercial observers and naval aircraft.

   d. Use of Navy observers is the most effective means to ensure quick and effective implementation of mitigation measures if marine species are spotted. A critical skill set of effective Navy training is communication. Navy lookouts are trained to act swiftly and decisively to ensure that appropriate actions are taken.

   e. Use of third-party observers is not necessary because Navy personnel are extensively trained in spotting items on or near the water surface. Navy spotters receive more hours of training, and use their spotting skills more frequently, than many third-party trained personnel.

   f. Crew members participating in training activities involving aerial assets have been specifically trained to detect objects in the water. The crew's ability to sight from both surface and aerial platforms provides excellent survey capabilities using the Navy's existing exercise assets.

   g. Security clearance issues would have to be overcome to allow non-Navy observers onboard exercise participants.

   h. Some training events will span one or more 24-hour periods, with operations underway continuously in that timeframe. It is not feasible to maintain non-Navy surveillance of these training activities, given the number of non-Navy observers that would be required onboard.

   i. Surface ships having active mid-frequency sonar have limited berthing capacity. As exercise planning includes careful consideration of this limited capacity in the placement of exercise controllers, data collection personnel, and Afloat Training Group personnel on ships involved in the exercise. Inclusion of non-Navy observers onboard these ships would require that in some cases there would be no additional berthing space for essential Navy personnel required to fully evaluate and efficiently use the training opportunity to accomplish the exercise objectives.

   j. Contiguous ASW events may cover many hundreds of square miles. The number of civilian ships and/or aircraft required to monitor the area of these events would be considerable. It is, thus, not feasible to survey or monitor the large exercise areas in the time required ensuring these areas are devoid of marine mammals. In addition, marine mammals may move into or out of an area, if surveyed before an event, or an animal could move into an area after an exercise took place. Given that there are no adequate controls to account for these or other possibilities and there are no identified research objectives, there is no utility to performing either a before or an after the event survey of an exercise area.

k. Survey during an event raises safety issues with multiple, slow civilian aircraft operating in the same airspace as military aircraft engaged in combat training activities. In addition, most of the training events take place far from land, limiting both the time available for civilian aircraft to be in the exercise area and presenting a concern should aircraft mechanical problems arise.

l. Scheduling civilian vessels or aircraft to coincide with training events would impact training effectiveness, since exercise event timetables cannot be precisely fixed and are instead based on the free-flow development of tactical situations. Waiting for civilian aircraft or vessels to complete surveys, refuel, or be on station would slow the unceasing progress of the exercise and impact the effectiveness of the military readiness activity.

m. Multiple simultaneous training events continue for extended periods. There are not enough qualified third-party personnel to accomplish the monitoring task.

4. Reducing or securing power during the following conditions.

   a. Low-visibility / night training: ASW can require a significant amount of time to develop the "tactical picture," or an understanding of the battle space such as area searched or unsearched, identifying false contacts, understanding the water conditions, etc. Reducing or securing power in low-visibility conditions would affect a commander's ability to develop this tactical picture and would not provide realistic training.

   b. Strong surface duct: The complexity of ASW requires the most realistic training possible for the effectiveness and safety of the sailors. Reducing power in strong surface duct conditions would not provide this training realism because the unit would be operating differently than it would in a combat scenario, reducing training effectiveness and the crew's ability. Additionally, water conditions may change rapidly, resulting in continually changing mitigation requirements, resulting in a focus on mitigation versus training.

5. Vessel speed: Establish and implement a set vessel speed. Navy personnel are required to use caution and operate at a slow, safe speed consistent with mission and safety. Ships and submarines need to be able to react to changing tactical situations in training as they would in actual combat. Placing arbitrary speed restrictions would not allow them to properly react to these situations, resulting in decreased training effectiveness and reduction the crew proficiency.

6. Increasing power down and shut down zones:

   a. The current power down zones of 500 and 1,000 yd (457 and 914 m), as well as the 200-yd (183-m) shut down zone were developed to minimize exposing marine mammals to sound levels that could cause TTS or PTS, levels that are supported by the scientific community. Implementation of the safety zones discussed above will prevent exposure to sound levels greater than 195 dB re 1μPa for animals sighted. The safety range the Navy has developed is also within a range sailors can realistically maintain situational awareness and achieve visually during most conditions at sea.

   b. Although the Proposed Action was developed using marine mammal density data and areas believed to provide habitat features conducive to marine mammals, not all such areas could be avoided. ASW requires large areas of ocean space to provide realistic and meaningful training to the sailors. These areas were considered to the maximum extent practicable while ensuring Navy's ability to properly train its forces in accordance with federal law. Avoiding any area that has the potential for marine mammal populations is impractical and would impact the effectiveness of the military readiness activity.

7. Using active sonar with output levels as low as possible consistent with mission requirements and use of active sonar only when necessary.

a. Operators of sonar equipment are always cognizant of the environmental variables affecting sound propagation. In this regard, the sonar equipment power levels are always set consistent with mission requirements.

b. Active sonar is only used when required by the mission since it has the potential to alert opposing forces to the sonar platform's presence. Passive sonar and all other sensors are used in concert with active sonar to the maximum extent practicable when available and when required by the mission.

6.3 BIRDS

General conservation measures that help minimize impacts to marine bird resources include:

1. Avoidance of birds and their nesting and roosting habitats provides the greatest degree of protective measure from potential impacts within the EIS Study Area. Pursuant to Navy instruction, measures to evaluate and reduce or eliminate this hazard to aircraft, aircrews, and birds are implemented.
2. Guidance involving land or water detonations of explosives contains instructions to personnel to observe the surrounding area within 500 yd (457 m) for 30 minutes prior to detonation. If birds are seen, the operation must be relocated to an unoccupied area or postponed until animals leave the area.
3. Monitoring of seabird populations and colonies by conservation groups and researchers is conducted intermittently within coastal areas and offshore islands with limited support from various military commands.

6.4 FISH

General conservation measures that help minimize impacts to marine biological resources include:

1. Using inert versions of ordnance and passive acoustical and tracking tools,
2. Avoiding protected and/or sensitive habitats,
3. Conducting most exercises during daylight hours in calm seas, and visual monitoring to assure an area is clear of significant concentrations of sea life including fish before ordnance or explosives are used.
4. Designating zones of influence (or buffer zones) for various types of training activities.

7 LIST OF PREPARERS

Timberley Belish (Parsons Infrastructure and Technology) Terrestrial Biological Resources

B.S. Biology, Gannon University
M.S. Ecology and Evolution, University of Pittsburgh
Years of Experience: 14

Jacklyn Bryant (Parsons Infrastructure and Technology), Assistant Task Order Manager, Sea Turtles, Birds
B.S. Natural Resources Management, Colorado State University
M.S. Watershed Sciences, Colorado State University
Years of Experience: 13

Bruce Campbell (Parsons Infrastructure and Technology), Lead Analyst, Geology/Soils, Noise
B.S. Environmental Biology, University of California, Santa Barbara
M.S. Environmental Management, University of San Francisco
Years of Experience: 26

Colleen Conklin (Parsons Infrastructure and Technology), Fish, Essential Fish Habitat Assessment
B.S. Chemistry, University of South Florida, Tampa
Years of Experience: 23

Wes Norris (Kaya & Associates, Inc.), Acoustic Analysis
B.S., 1976, Geology, Northern Arizona University
Years of Experience: 31

Bruce Snyder (Parsons Infrastructure and Technology), Wildlife Biologist, Marine Mammals/Birds/Fish
B.S. Biology, University of South Carolina
M.S. Wildlife Biology, Clemson University
Years of Experience: 39

Janet L. Snyder (Parsons Infrastructure & Technology), Technical Editing
B.S Zooloogy, Clemson University
Years of Experience: 34

Philip Thorson (ManTech SRS Technologies, Inc.), Senior Research Biologist/Marine Mammal Biologist
Ph.D. Biology, University of California at Santa Cruz
Years of Experience: 27

Karen Waller (ManTech SRS Technologies, Inc.), Vice President/Quality Assurance
B.S. Public and Environmental Affairs, Indiana University
Years of Experience: 21

Brian D. Wauer (ManTech SRS Technologies, Inc.), Director, Range and Environmental Services
B.S., Administrative Management, University of Arkansas
B.S., Industrial Management, University of Arkansas
Years of Experience: 24

Lawrence F. Wolski (ManTech SRS Technologies, Inc.), Senior SME, Biology/Bioacoustics
B.S., Biology, Loyola Marymount University
M.S., Marine Sciences, University of San Diego
Years of Experience: 12

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Appendix A Cetacean Stranding Report

A.1 CETACEAN STRANDINGS AND THREATS

Strandings can be a single animal or several to hundreds of animals. An event where animals are found out of their normal habitat is considered a stranding even though animals do not necessarily end up beaching (such as the July 2004 Hanalei Mass Stranding Event; Southall et al. 2006). Several hypotheses have been given for the mass strandings which include the impact of shallow beach slopes on odontocete sonar, disease or parasites, geomagnetic anomalies that affect navigation, following a food source in close to shore, avoiding predators, social interactions that cause other cetaceans to come to the aid of stranded animals, and human actions. Generally, inshore species do not strand in large numbers but generally just as a single animal. This may be due to their familiarity with the coastal area whereas pelagic species that are unfamiliar with obstructions or sea bottom tend to strand more often in larger numbers (Woodings 1995). The Navy has studied several stranding events in detail that may have occurred in association with Navy sonar activities. To better understand the causal factors in stranding events that may be associated with Navy sonar activities, the main factors, including bathymetry (i.e. steep drop offs), narrow channels (less than 35 nm [65 km]), environmental conditions (e.g. surface ducting), and multiple sonar ships (see Section on Stranding Events Associated with Navy Sonar) were compared between the different stranding events.

A.1.1 What is a Stranded Marine Mammal?

When a live or dead marine mammal swims or floats onto shore and becomes "beached" or incapable of returning to sea, the event is termed a "stranding" (Geraci et al. 1999; Perrin and Geraci 2002; Geraci and Lounsbury 2005; NMFS 2007). The legal definition for a stranding within the U.S. is that "a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance." (16 United States Code [U.S.C.] 1421h).

The majority of animals that strand are dead or moribund (NMFS 2007). For animals that strand alive, human intervention through medical aid and/or guidance seaward may be required for the animal to return to the sea. If unable to return to sea, rehabilitation at an appropriate facility may be determined as the best opportunity for animal survival. An event where animals are found out of their normal habitat is may be considered a stranding depending on circumstances even though animals do not necessarily end up beaching (Southhall 2006).

Three general categories can be used to describe strandings: single, mass, and unusual mortality events. The most frequent type of stranding is a single stranding, which involves only one animal (or a mother/calf pair) (NMFS 2007).

Mass stranding involves two or more marine mammals of the same species other than a mother/calf pair (Wilkinson, 1991), and may span one or more days and range over several miles (Simmonds and Lopez-Jurado 1991; Frantzis 1998; Walsh et al. 2001; Freitas 2004). In North America, only a few species typically strand in large groups of 15 or more and include sperm whales, pilot whales, false killer whales, Atlantic white-sided dolphins, white-beaked dolphins, and rough-toothed dolphins (Odell 1987, Walsh et al. 2001). Some species, such as pilot whales, false-killer whales, and melon-headed whales occasionally strand in groups of 50 to 150 or more (Geraci et al. 1999). All of these normally pelagic off-shore species are highly sociable and usually infrequently encountered in coastal waters. Species that commonly strand in smaller numbers include pygmy killer whales, common dolphins, bottlenose dolphins, Pacific white-sided dolphin Frasier's dolphins, gray whale and humpback whale (West Coast only), harbor porpoise, Cuvier's beaked whales, California sea lions, and harbor seals (Mazzuca et al. 1999, Norman et al. 2004, Geraci and Lounsbury 2005).

Unusual mortality events (UMEs) can be a series of single strandings or mass strandings, or unexpected mortalities (i.e., die-offs) that occur under unusual circumstances (Dierauf and Gulland, 2001; Harwood, 2002; NMFS, 2007). These events may be interrelated: for instance, at-sea die-offs lead to increased stranding frequency over a short period of time, generally within one to two months. As published by the NMFS, revised criteria for defining a UME include include (71 FR 75234, 2006):

(1) A marked increase in the magnitude or a marked change in the nature of morbidity, mortality, or strandings when compared with prior records.

(2) A temporal change in morbidity, mortality, or strandings is occurring.

(3) A spatial change in morbidity, mortality, or strandings is occurring.

(4) The species, age, or sex composition of the affected animals is different than that of animals that are normally affected.

(5) Affected animals exhibit similar or unusual pathologic findings, behavior patterns, clinical signs, or general physical condition (e.g., blubber thickness).

(6) Potentially significant morbidity, mortality, or stranding is observed in species, stocks or populations that are particularly vulnerable (e.g., listed as depleted, threatened or endangered or declining). For example, stranding of three or four right whales may be cause for great concern whereas stranding of a similar number of fin whales may not.

(7) Morbidity is observed concurrent with or as part of an unexplained continual decline of a marine mammal population, stock, or species.

UMEs are usually unexpected, infrequent, and may involve a significant number of marine mammal mortalities. As discussed below, unusual environmental conditions are probably responsible for most UMEs and marine mammal die-offs (Vidal and Gallo-Reynoso 1996; Geraci et al. 1999; Walsh et al. 2001).

United States Stranding Response Organization

Stranding events provide scientists and resource managers information not available from limited at-sea surveys, and may be the only way to learn key biological information about certain species such as distribution, seasonal occurrence, and health (Rankin 1953; Moore et al. 2004; Geraci and Lounsbury 2005). Necropsies are useful in attempting to determine a reason for the stranding, and are performed on stranded animals when the situation and resources allow.

In 1992, Congress amended the MMPA to establish the Marine Mammal Health and Stranding Response Program (MMHSRP) under authority of the NMFS. The MMHSRP was created out of concern started in the 1980s for marine mammal mortalities, to formalize the response process, and to focus efforts being initiated by numerous local stranding organizations and as a result of public concern.

Major elements of the MMHSRP include (NMFS 2007):

• National Marine Mammal Stranding Network

• Marine Mammal UME Program

• National Marine Mammal Tissue Bank (NMMTB) and Quality Assurance Program

• Marine Mammal Health Biomonitoring, Research, and Development

• Marine Mammal Disentanglement Network

• John H. Prescott Marine Mammal Rescue Assistance Grant Program (a.k.a. the Prescott Grant Program)

• Information Management and Dissemination.

The United States has a well-organized network in coastal states to respond to marine mammal strandings. Overseen by the NMFS, the National Marine Mammal Stranding Network is comprised of smaller organizations manned by professionals and volunteers from nonprofit organizations, aquaria, universities, and state and local governments trained in stranding response animal health, and diseased investigation. Currently, 141 organizations are authorized by NMFS to respond to marine mammal strandings (NMFS, 2007o). Through a National Coordinator and six regional coordinators, NMFS authorizes and oversees stranding response activities and provides specialized training for the network.

NMFS Regions and Associated States and Territories

NMFS Northeast Region- ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, VA

NMFS Southeast Region- NC, SC, GA, FL, AL, MS, LA, TX, PR, VI

NMFS Southwest Region- CA

NMFS Northwest Region- OR, WA

NMFS Alaska Region- AK

NMFS Pacific Islands Region- HI, Guam, American Samoa, Commonwealth of the Northern Mariana Islands (CNMI)

Stranding reports by region are provided in Table A-1. Stranding reporting and response efforts over time have been inconsistent, although effort and data quality within the U.S. have been improving within the last 20 years (NMFS 2007). Given the historical inconsistency in response and reporting, however, interpretation of long-term trends in marine mammal stranding is difficult (NMFS 2007). During the past decade (1995 – 2004), approximately 40,000 stranded marine mammals (about 12,400 are cetaceans) have been reported by the regional stranding networks, averaging 3,600 strandings reported per year (NMFS 2007). The highest number of strandings were reported between the years 1998 and 2003 (NMFS 2007). Detailed regional stranding information including most commonly stranded species can be found in Zimmerman (1991), Geraci and Lounsbury (2005), and NMFS (2007).

Table A-1. Cetacean And Pinniped Stranding Count By NMFS Region 2001-2004.

NMFS Region	# of Cetaceans	# of Pinnipeds
Northeast	1,620	4,050
Southeast	2,830	45
Southwest	12,900	45
Northwest	188	1,430
Alaska	269	348
Pacific Islands	59	10
Four Year Total	17,866	5,928

Unusual Mortality Events (UMEs)

Table A-2 contains a list of documented UMEs within the U.S.

Table A-2. Documented UMEs within the United States.

Year	Composition	Determination
1993	Harbor seals, Steller sea lions, and California sea lions on the central Washington coast	Human Interaction
1993/1994	Bottlenose dolphins in the Gulf of Mexico	Morbillivirus
1994	Common dolphins in California	Cause not determined
1996	Right whales off Florida/Georgia coast	Evidence of human interactions
1996	Manatees on the west coast of Florida	Brevetoxin
1996	Bottlenose dolphins in Mississippi	Cause not determined
1997	Harbor seals in California	Unknown infectious respiratory disease
1997	Pinnipeds on the Pacific coast	El Niño
1998	California sea lions in central California	Harmful algal bloom; Domoic acid
1999	Harbor porpoises on the East Coast	Determined not to meet criteria for UME because of multiplicity of causes
1999/2000	Bottlenose dolphins in the Panhandle of Florida	Harmful algal bloom is suspected; still under investigation
1999/2000	Gray whales from Alaska to Mexico	Still under investigation
2004	Bottlenose dolphins along the Florida Panhandle	Uncertain, red tide is suspected
2005	Bottlenose dolphins, manatees, sea turtles, and seabirds in west central Florida	Unknown
Source: NMFS 2007c		

A.1.2 Threats to Marine Mammals and Potential Causes for Stranding

Reports of marine mammal strandings can be traced back to ancient Greece (Walsh et al. 2001). Like any wildlife population, there are normal background mortality rates that influence marine mammal population dynamics, including starvation, predation, aging, reproductive success, and disease (Geraci et al. 1999; Carretta et al. 2007). Strandings in and of themselves may be reflective of this natural cycle or, more recently, may be the result of anthropogenic sources (i.e., human impacts). Current science suggests that multiple factors, both natural and man-made, may be acting alone or in combination to cause a marine mammal to strand (Geraci et al. 1999; Culik 2002; Perrin and Geraci 2002; Hoelzel 2003; Geraci and Lounsbury 2005; NRC 2006). While post-stranding data collection and necropsies of dead animals are attempted in an effort to find a possible cause for the stranding, it is often difficult to pinpoint exactly one factor that can be blamed for any given stranding. An animal suffering from one ailment becomes susceptible to various other influences because of its weakened condition, making it difficult to determine a primary cause. In many stranding cases, scientists never learn the exact reason for the stranding.

Specific potential stranding causes can include both natural and human influenced (anthropogenic) causes listed below and described in the following sections:

Natural Stranding Causes
- Disease
- Natural toxins
- Weather and climatic influences
- Navigation errors
- Social cohesion
- Predation

Human Influenced (Anthropogenic) Stranding Causes
- Fisheries interaction
- Vessel strike
- Pollution and ingestion
- Noise

A.1.2.1 Natural Stranding Causes

Significant natural causes of mortality, die-offs, and stranding discussed below include disease and parasitism; marine neurotoxins from algae; navigation errors that lead to inadvertent stranding; and climatic influences that impact the distribution and abundance of potential food resources (i.e., starvation). Other natural mortality not discussed in detail includes predation by other species such as sharks (Cockcroft et al. 1989; Heithaus 2001), killer whales (Constantine et al. 1998; Guinet et al. 2000; Pitman et al. 2001), and some species of pinniped (Hiruki et al. 1999; Robinson et al. 1999).

Disease

Like other mammals, marine mammals frequently suffer from a variety of diseases of viral, bacterial, parasitic, and fungal origin (Visser et al. 1991; Dunn et al. 2001; Harwood 2002).

Microparasites such as bacteria, viruses, and other microorganisms are commonly found in marine mammal habitats and usually pose little threat to a healthy animal (Geraci et al. 1999). For example, long-finned pilot whales that inhabit the waters off of the northeastern coast of the U.S. are carriers of the morbillivirus, yet have grown resistant to its usually lethal effects (Geraci et al. 1999). Since the 1980s, however, virus infections have been strongly associated with marine mammal die-offs (Domingo et al. 1992; Geraci and Lounsbury 2005). Morbillivirus is the most significant marine mammal virus and suppresses a host's immune system, increasing risk of secondary infection (Harwood 2002). A bottlenose dolphin UME in 1993 and 1994 was caused by infectious disease. Die-offs ranged from northwestern Florida to Texas, with an increased number of deaths as it spread (NMFS 2007c). A 2004 UME in Florida was also associated with dolphin morbillivirus (NMFS 2004). Influenza A was responsible for the first reported mass mortality in the U.S., occurring along the coast of New England in 1979-1980 (Geraci et al. 1999; Harwood 2002). Canine distemper virus (a type of morbillivirus) has been responsible for large scale pinniped mortalities and die-offs (Grachev et al. 1989; Kennedy et al. 2000), while a bacteria, *Leptospira pomona*, is responsible for periodic die-offs in California sea lions about every four years. It is difficult to determine whether microparasites commonly act as a primary pathogen, or whether they show up as a secondary infection in an already weakened animal (Geraci et al. 1999). Most marine mammal die-offs from infectious disease in the last 25 years, however, have had viruses associated with them (Simmonds and Mayer 1997; Geraci et al. 1999; Harwood 2002).

Macroparasites are usually large parasitic organisms and include lungworms, trematodes (parasitic flatworms), and protozoans (Geraci and St.Aubin 1987; Geraci et al. 1999). Marine mammals can carry many different types, and have shown a robust tolerance for sizeable infestation unless compromised by illness, injury, or starvation (Morimitsu et al. 1987; Dailey et al. 1991; Geraci et al. 1999). Nasitrema, a usually benign trematode found in the head sinuses of cetaceans (Geraci et al. 1999), can cause brain damage if it migrates (Ridgway and Dailey 1972). As a result, this worm is one of the few directly linked to stranding in the cetaceans (Dailey and Walker 1978; Geraci et al. 1999).

Non-infectious disease, such as congenital bone pathology of the vertebral column (osteomyelitis, spondylosis deformans, and ankylosing spondylitis [AS]), has been described in several species of cetacean (Paterson 1984; Alexander et al. 1989; Kompanje 1995; Sweeny et al. 2005). In humans, bone pathology such as AS, can impair mobility and increase vulnerability to further spinal trauma (Resnick and Niwayama 2002). Bone pathology has been found in cases of single strandings (Paterson 1984; Kompanje 1995), and also in cetaceans prone to mass stranding (Sweeny et al. 2005), possibly acting as a contributing or causal influence in both types of events.

Naturally Occurring Marine Neurotoxins

Some single cell marine algae common in coastal waters, such as dinoflagellates and diatoms, produce toxic compounds that can accumulate (termed bioaccumulation) in the flesh and organs of fish and invertebrates (Geraci et al. 1999; Harwood 2002). Marine mammals become exposed to these compounds when they eat prey contaminated by these naturally produced toxins although expsosure can also occur through inhalation and skin contact (Van Dolah 2005). Figure A-1 shows U.S. animal mortalities from 1997-2006 resulting from toxins produced during harmful algal blooms.

In the Gulf of Mexico and mid- to southern Atlantic states, "red tides," a form of harmful algal bloom, are created by a dinoflagellate (*Karenia brevis*). *K. brevis* is found throughout the Gulf of Mexico and sometimes along the Atlantic coast (Van Dolah 2005; NMFS 2007). It produces a neurotoxin known as brevetoxin. Brevetoxin has been associated with several marine mammal UMEs within this area (Geraci 1989; Van Dolah et al. 2003; NMFS 2004; Flewelling et al. 2005; Van Dolah 2005; NMFS 2007). On the U.S. west coast and in the northeast Atlantic, several species of diatoms produce a toxin called domoic acid which has also been linked to marine mammal strandings (Geraci et al. 1999; Van Dolah et al. 2003; Greig et al. 2005; Van Dolah 2005; Brodie et al. 2006; NMFS 2007; Bargu et al. 2008; Goldstein et al. 2008). Other algal toxins associated with marine mammal strandings include saxitoxins and ciguatoxins and are summarized by Van Dolah (2005).

Figure A-1. Animal Mortalities From Harmful Algal Blooms Within The U.S. From 1997-2006.

Source: Woods Hole Oceanographic Institute (WHO) http://www.whoi.edu/redtide/HABdistribution/HABmap.html

Weather events and climate influences

Severe storms, hurricanes, typhoons, and prolonged temperature extremes may lead to localized marine mammal strandings (Geraci et al. 1999; Walsh et al. 2001). Hurricanes may have been responsible for mass strandings of pygmy killer whales in the British Virgin Islands and Gervais' beaked whales in North Carolina (Mignucci-Giannoni et al. 2000; Norman and Mead 2001). Storms in 1982-1983 along the California coast led to deaths of 2,000 northern elephant seal pups (Le Boeuf and Reiter 1991). Ice movement along southern Newfoundland has forced groups of blue whales and white-beaked dolphins ashore (Sergeant 1982). Seasonal oceanographic conditions in terms of weather, frontal systems, and local currents may also play a role in stranding (Walker et al. 2005).

The effect of large scale climatic changes to the world's oceans and how these changes impact marine mammals and influence strandings is difficult to quantify given the broad spatial and temporal scales involved, and the cryptic movement patterns of marine mammals (Moore 2005; Learmonth et al. 2006). The most immediate, although indirect, effect is decreased prey availability during unusual conditions. This, in turn, results in increased search effort required by marine mammals (Crocker et al. 2006), potential starvation if not successful, and corresponding stranding due directly to starvation or succumbing to disease or predation while in a more weakened, stressed state (Selzer and Payne 1988; Geraci et al. 1999; Moore 2005; Learmonth et al. 2006; Weise et al. 2006).

Two recent papers examined potential influences of climate fluctuation on stranding events in southern Australia, including Tasmania, an area with a history of more than 20 mass stranding since the 1920s (Evans et al. 2005; Bradshaw et al. 2006). These authors note that patterns in animal migration, survival, fecundity, population size, and strandings will revolve around the availability and distribution of food resources. In southern Australia, movement of nutrient-rich waters pushed closer to shore by periodic meridinal winds (occurring about every 12 – 14 years) may be responsible for bringing marine mammals closer to land, thus increasing the probability of stranding (Bradshaw et al. 2006). The papers conclude, however, that while an overarching model can be helpful for providing insight into the prediction of strandings, the particular reasons for each one are likely to be quite varied.

Navigation Error

Geomagnetism- It has been hypothesized that, like some land animals, marine mammals may be able to orient to the Earth's magnetic field as a navigational cue, and that areas of local magnetic anomalies may influence strandings (Bauer et al. 1985; Klinowska 1985; Kirschvink et al. 1986; Klinowska 1986; Walker et al. 1992; Wartzok and Ketten 1999). In a plot of live stranding positions in Great Britain with magnetic field maps, Klinowska (1985; 1986) observed an association between live stranding positions and magnetic field levels. In all cases, live strandings occurred at locations where magnetic minima, or lows in the magnetic fields, intersect the coastline. Kirschvink et al. (1986) plotted stranding locations on a map of magnetic data for the east coast of the U.S., and were able to develop associations between stranding sites and locations where magnetic minima intersected the coast. The authors concluded that there were highly significant tendencies for cetaceans to beach themselves near these magnetic minima and coastal intersections. The results supported the hypothesis that cetaceans may have a magnetic sensory system similar to other migratory animals, and that marine magnetic topography and patterns may influence long-distance movements (Kirschvink et al. 1986). Walker et al. (1992) examined fin whale swim patterns off the northeastern U.S. continental shelf, and reported that migrating animals aligned with lows in the geometric gradient or intensity. While a similar pattern between magnetic features and marine mammal strandings at New Zealand stranding sites was not seen (Brabyn and Frew 1994), mass strandings in Hawaii typically were found to occur within a narrow range of magnetic anomalies (Mazzuca et al. 1999).

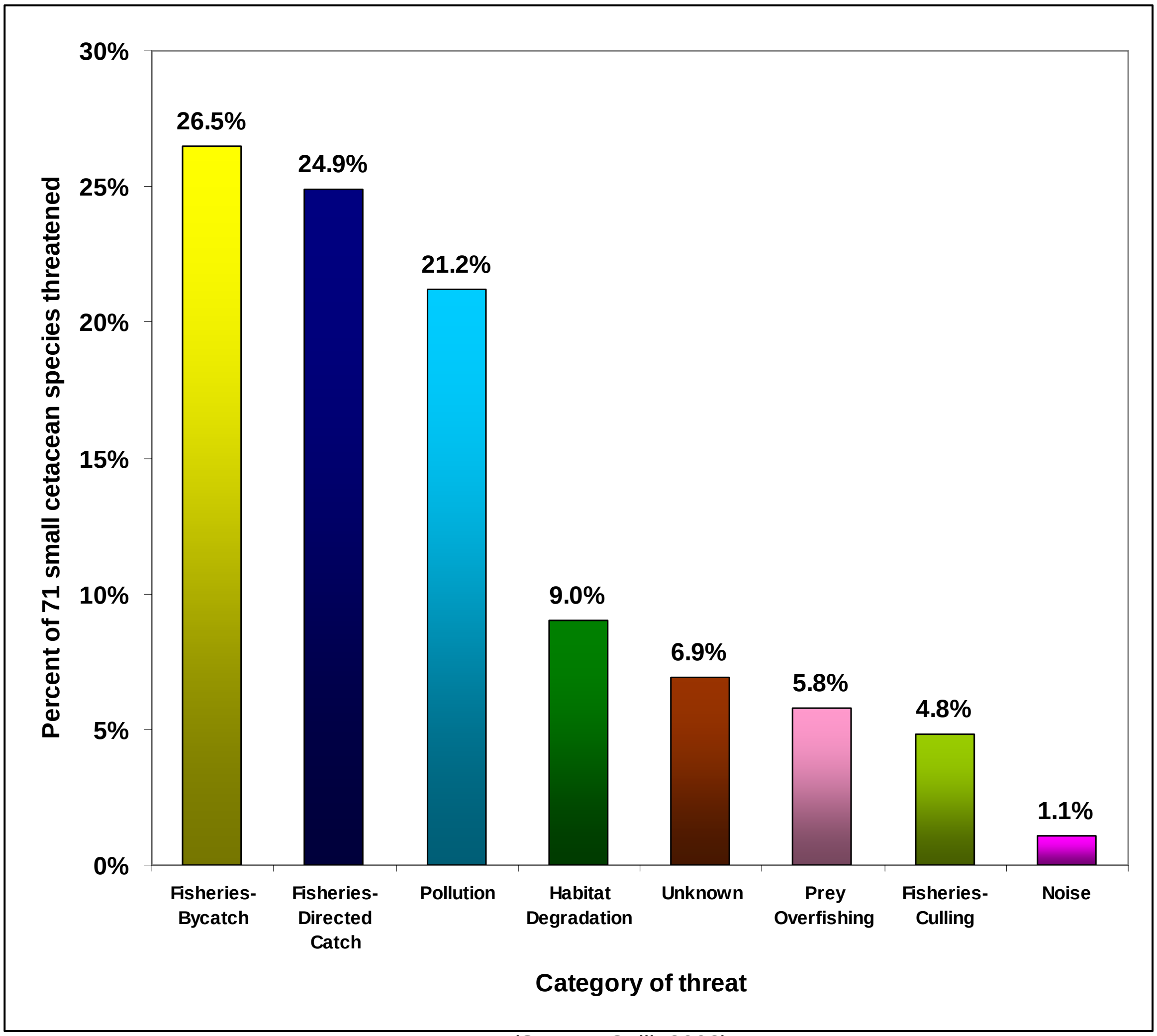
Echolocation Disruption in Shallow Water- Some researchers believe stranding may result from reductions in the effectiveness of echolocation within shallow water, especially with the pelagic species of odontocetes who may be less familiar with coastline (Dudok van Heel 1966; Chambers and James 2005). For an odontocete, echoes from echolocation signals contain important information on the location and identity of underwater objects and the shoreline. The authors postulate that the gradual slope of a beach may present difficulties to the navigational systems of some cetaceans, since it is common for live strandings to occur along beaches with shallow, sandy gradients (Brabyn and McLean 1992; Mazzuca et al. 1999; Maldini et al. 2005; Walker et al. 2005). A contributing factor to echolocation interference in turbulent, shallow water is the presence of microbubbles from the interaction of wind, breaking waves, and currents. Additionally, ocean water near the shoreline can have an increased turbidity (e.g., floating sand or silt, particulate plant matter, etc.) due to the run-off of fresh water into the ocean, either from rainfall or from freshwater outflows (e.g., rivers and creeks). Collectively, these factors can reduce and scatter the sound energy within echolocation signals and reduce the perceptibility of returning echoes of interest.

Social Cohesion

Many pelagic species such as sperm whale, pilot whales, melon-head whales, and false killer whales, and some dolphins occur in large groups with strong social bonds between individuals. When one or more animals strand due to any number of causative events, then the entire pod may follow suit out of social cohesion (Geraci et al. 1999; Conner 2000; Perrin and Geraci 2002; NMFS 2007).

A.1.2.2 Anthropogenic Stranding Causes and Potential Risks

With the exception of historic whaling in the 19th and early part of the 20th century, over the past few decades there has been an increase in marine mammal mortalities associated with a variety of human activities (Geraci et al. 1999; NMFS 2007). These include fisheries interactions (bycatch and directed catch), pollution (marine debris, toxic compounds), habitat modification (degradation, prey reduction), direct trauma (vessel strikes, gunshots), and noise. Figure A-2 shows potential worldwide risk to small toothed cetaceans by source.



(Source: Culik 2002)

Figure A-2. Human Threats to World Wide Small Cetacean Populations

Fisheries Interaction: By-Catch, Directed Catch, and Entanglement

The incidental catch of marine mammals in commercial fisheries is a significant threat to the survival and recovery of many populations of marine mammals (Geraci et al. 1999; Baird 2002; Culik 2002; Carretta et al. 2004; Geraci and Lounsbury 2005; NMFS 2007). Interactions with fisheries and entanglement in discarded or lost gear continue to be a major factor in marine mammal deaths worldwide (Geraci et al. 1999; Nieri et al. 1999; Geraci and Lounsbury 2005; Read et al. 2006; Zeeber et al. 2006). For instance, baleen whales and pinnipeds have been found entangled in nets, ropes, monofilament line, and other fishing gear that has been discarded out at sea (Geraci et al. 1999; Campagna et al. 2007).

Bycatch- Bycatch is the catching of non-target species within a given fishing operation and can include non-commercially used invertebrates, fish, sea turtles, birds, and marine mammals (NRC 2006). Read et al. (2006) attempted to estimate the magnitude of marine mammal bycatch in U.S. and global fisheries. Data on marine mammal bycatch within the United States was obtained from fisheries observer programs, reports of entangled stranded animals, and fishery logbooks, and was then extrapolated to estimate global bycatch by using the ratio of U.S. fishing vessels to the total number of vessels within the world's fleet (Read et al. 2006). Within U.S. fisheries, between 1990 and 1999 the mean annual bycatch of marine mammals was 6,215 animals, with a standard error of +/- 448 (Read et al. 2006). Eight-four percent of cetacean bycatch occurred in gill-net fisheries, with dolphins and porpoises constituting most of the cetacean bycatch (Read et al. 2006). Over the decade there was a 40 percent decline in marine mammal bycatch, which was significantly lower from 1995-1999 than it was from 1990-1994 (Read et al. 2006). Read et al. (2006) suggests that this is primarily due to effective conservation measures that were implemented during this time period.

Read et al. (2006) then extrapolated this data for the same time period and calculated an annual estimate of 653,365 of marine mammals globally, with most of the world's bycatch occurring in gill-net fisheries. With global marine mammal bycatch likely to be in the hundreds of thousands every year, bycatch in fisheries will be the single greatest threat to many marine mammal populations around the world (Read et al. 2006).

Entanglement- Entanglement in active fishing gear is a major cause of death or severe injury among the endangered whales in the action area. Entangled marine mammals may die as a result of drowning, escape with pieces of gear still attached to their bodies, or manage to be set free either of their own accord or by fishermen. Many large whales carry off gear after becoming entangled (Read et al. 2006). Many times when a marine mammal swims off with gear attached, the end result can be fatal. The gear may be become too cumbersome for the animal, or it can be wrapped around a crucial body part and tighten over time. Stranded marine mammals frequently exhibit signs of previous fishery interaction, such as scarring or gear attached to their bodies, and the cause of death for many stranded marine mammals is often attributed to such interactions (Baird and Gorgone 2005). Because marine mammals that die or are injured in fisheries may not wash ashore and not all animals that do wash ashore exhibit clear signs of interactions, stranding data probably underestimate fishery-related mortality and serious injury (NMFS 2005a)

From 1993 through 2003, 1,105 harbor porpoises were reported stranded from Maine to North Carolina, many of which had cuts and body damage suggestive of net entanglement (NMFS 2005e). In 1999 it was possible to determine that the cause of death for 38 of the stranded porpoises was from fishery interactions, with one additional animal having been mutilated (right flipper and fluke cut off) (NMFS 2005e). In 2000, one stranded porpoise was found with monofilament line wrapped around its body (NMFS 2005e). In 2003, nine stranded harbor porpoises were attributed to fishery interactions, with an additional three mutilated animals (NMFS 2005e). An estimated 78 baleen whales were killed annually in the offshore southern California/Oregon drift gillnet fishery during the 1980s (Heyning and Lewis 1990). From 1998-2005, based on observer records, five fin whales (CA/OR/WA stock), 12 humpback whales (ENP stock), and six sperm whales (CA/OR/WA stock) were either seriously injured or killed in fisheries off the mainland west coast of the U.S. (California Marine Mammal Stranding Network Database 2006).

Ship Strike

Vessel strikes to marine mammals are another cause of mortality and stranding (Laist et al. 2001; Geraci and Lounsbury 2005; de Stephanis and Urquiola, 2006). An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007).

An examination of all known ship strikes from all shipping sources (civilian and military) indicates vessel speed is a principal factor in whether a vessel strike results in death (Knowlton and Kraus 2001; Laist et al. 2001, Jensen and Silber 2003; Vanderlaan and Taggart 2007). In assessing records in which vessel speed was known, Laist et al. (2001) found a direct relationship between the occurrence of a whale strike and the speed of the vessel involved in the collision. The authors concluded that most deaths occurred when a vessel was traveling in excess of 13 knots although most vessels do travel greater than 15 kts. Jensen and Silber (2003) detailed 292 records of known or probable ship strikes of all large whale species from 1975 to 2002. Of these, vessel speed at the time of collision was reported for 58 cases. Of these cases, 39 (or 67%) resulted in serious injury or death (19 or 33% resulted in serious injury as determined by blood in the water, propeller gashes or severed tailstock, and fractured skull, jaw, vertebrae, hemorrhaging, massive bruising or other injuries noted during necropsy and 20 or 35% resulted in death). Operating speeds of vessels that struck various species of large whales ranged from 2 to 51 knots. The majority (79%) of these strikes occurred at speeds of 13 knots or greater. The average speed that resulted in serious injury or death was 18.6 knots. Pace and Silber (2005) found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45 percent to 75 % as vessel speed increased from 10 to 14 knots, and exceeded 90% at 17 knots. Higher speeds during collisions result in greater force of impact, but higher speeds also appear to increase the chance of severe injuries or death by pulling whales toward the vessel. Computer simulation modeling showed that hydrodynamic forces pulling whales toward the vessel hull increase with increasing speed (Clyne 1999, Knowlton et al. 1995).

The growth in civilian commercial ports and associated commercial vessel traffic is a result in the globalization of trade. The Final Report of the NOAA International Symposium on “Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology” stated that the worldwide commercial fleet has grown from approximately 30,000 vessels in 1950 to over 85,000 vessels in 1998 (NRC, 2003; Southall, 2005). Between 1950 and 1998, the U.S. flagged fleet declined from approximately 25,000 to less than 15,000 and currently represents only a small portion of the world fleet. From 1985 to 1999, world seaborne trade doubled to 5 billion tons and currently includes 90 percent of the total world trade, with container shipping movements representing the largest volume of seaborne trade. It is unknown how international shipping volumes and densities will continue to grow. However, current statistics support the prediction that the international shipping fleet will continue to grow at the current rate or at greater rates in the future. Shipping densities in specific areas and trends in routing and vessel design are as, or more, significant than the total number of vessels. Densities along existing coastal routes are expected to increase both domestically and internationally. New routes are also expected to develop as new ports are opened and existing ports are expanded. Vessel propulsion systems are also advancing toward faster ships operating in higher sea states for lower operating costs; and container ships are expected to become larger along certain routes (Southall 2005).

While there are reports and statistics of whales struck by vessels in U.S. waters, the magnitude of the risks of commercial ship traffic poses to marine mammal populations is difficult to quantify or estimate. In addition, there is limited information on vessel strike interactions between ships and marine mammals outside of U.S. waters (de Stephanis and Urquiola 2006). Laist et al. (2001) concluded that ship collisions may have a negligible effect on most marine mammal populations in general, except for regional based small populations where the significance of low numbers of collisions would be greater given smaller populations or populations segments.

U.S. Navy vessel traffic is a small fraction of the overall U.S. commercial and fishing vessel traffic. While U.S. Navy vessel movements may contribute to the ship strike threat, given the lookout and mitigation measures adopted by the U.S. Navy, probability of vessel strikes is greatly reduced. Furthermore, actions to avoid close interaction of U.S. Navy ships and marine mammals and sea turtles, such as maneuvering to keep away from any observed marine mammal and sea turtle are part of existing at-sea protocols and standard operating procedures. Navy ships have up to three or more dedicated and trained lookouts as well as two to three bridge watchstanders during at-sea movements who would be searching for any whales, sea turtles, or other obstacles on the water surface. Such lookouts are expected to further reduce the chances of a collision.

Commercial and Private Marine Mammal Viewing

In addition to vessel operations, private and commercial vessels engaged in marine mammal watching also have the potential to impact marine mammals in Southern California. NMFS has promulgated regulations at 50 CFR 224.103, which provide specific prohibitions regarding wildlife viewing activities. In addition, NMFS launched an education and outreach campaign to provide commercial operators and the general public with responsible marine mammal viewing guidelines. In January 2002, NMFS also published an official policy on human interactions with wild marine mammals which states that: "NOAA Fisheries cannot support, condone, approve or authorize activities that involve closely approaching, interacting or attempting to interact with whales, dolphins, porpoises, seals, or sea lions in the wild. This includes attempting to swim, pet, touch or elicit a reaction from the animals."

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational, and scientific benefits, marine mammal watching is not without potential negative impacts. One concern is that animals become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995). Another concern is that preferred habitats may become abandoned if disturbance levels are too high. A whale's behavioral response to whale watching vessels depends on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels (Amaral and Carlson 2005; Au and Green 2000; Cockeron 1995; Erbe 2002; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Schedat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002). The whale's responses changed with these different variables and, in some circumstances, the whales did not respond to the vessels, but in other circumstances, whales changed their vocalizations surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. In addition to the information on whale watching, there is also direct evidence of pinniped haul out site (Pacific harbor seals) abandonment because of human disturbance at Strawberry Spit in San Francisco Bay (Allen 1991).

Ingestion of Plastic Objects and Other Marine Debris and Toxic Pollution Exposure

For many marine mammals, debris in the marine environment is a great hazard and can be harmful to wildlife. Not only is debris a hazard because of possible entanglement, animals may mistake plastics and other debris for food (NMFS 2007g). There are certain species of cetaceans, along with Florida manatees, that are more likely to eat trash, especially plastics, which is usually fatal for the animal (Geraci et al. 1999).

Between 1990 through October 1998, 215 pygmy sperm whales stranded along the U.S. Atlantic coast from New York through the Florida Keys (NMFS 2005a). Remains of plastic bags and other debris were found in the stomachs of 13 of these animals (NMFS 2005a). During the same time period, 46 dwarf sperm whale strandings occurred along the U.S. Atlantic coastline between Massachusetts and the Florida Keys (NMFS 2005d). In 1987 a pair of latex examination gloves was retrieved from the stomach of a stranded dwarf sperm whale (NMFS 2005d). 125 pygmy sperm whales were reported stranded from 1999 – 2003 between Maine and Puerto Rico; in one pygmy sperm whale found stranded in 2002, red plastic debris was found in the stomach along with squid beaks (NMFS 2005a).

Sperm whales have been known to ingest plastic debris, such as plastic bags (Evans et al. 2003; Whitehead 2003). While this has led to mortality, the scale to which this is affecting sperm whale populations is unknown, but Whitehead (2003) suspects it is not substantial at this time.

High concentrations of potentially toxic substances within marine mammals along with an increase in new diseases have been documented in recent years. Scientists have begun to consider the possibility of a link between pollutants and marine mammal mortality events. NMFS takes part in a marine mammal bio-monitoring program not only to help assess the health and contaminant loads of marine mammals, but also to assist in determining anthropogenic impacts on marine mammals, marine food chains and marine ecosystem health. Using strandings and bycatch animals, the program provides tissue/serum archiving, samples for analyses, disease monitoring and reporting, and additional response during disease investigations (NMFS 2007).

The impacts of these activities are difficult to measure. However, some researchers have correlated contaminant exposure to possible adverse health effects in marine mammals. Contaminants such as organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in planktivorous mysticetes have been reported to be one to two orders of magnitude lower compared to piscivorous odontocetes (Borell 1993; O'Shea and Brownell 1994; O'Hara and Rice 1996; O'Hara et al. 1999).

The manmade chemical PCB (polychlorinated biphenyl), and the pesticide DDT (dichlorodiphyenyltrichloroethane), are both considered persistent organic pollutants that are currently banned in the United States for their harmful effects in wildlife and humans (NMFS, 2007c). Despite having been banned for decades, the levels of these compounds are still high in marine mammal tissue samples taken along U.S. coasts (NMFS, 2007c). Both compounds are long-lasting, reside in marine mammal fat tissues (especially in the blubber), and can be toxic causing effects such as reproductive impairment and immunosuppression (NMFS, 2007c).

Both long-finned and short-finned pilot whales have a tendency to mass strand throughout their range. Short-finned pilot whales have been reported as stranded as far north as Rhode Island, and long-finned pilot whales as far south as South Carolina (NMFS 2005b). For U.S. east coast stranding records, both species are lumped together and there is rarely a distinction between the two because of uncertainty in species identification (NMFS 2005b). Since 1980 within the Northeast region alone, between 2 and 120 pilot whales have stranded annually either individually or in groups (NMFS 2005b). Between 1999 and 2003 from Maine to Florida, 126 pilot whales were reported to be stranded, including a mass stranding of 11 animals in 2000 and another mass stranding of 57 animals in 2002, both along the Massachusetts coast (NMFS 2005b).

It is unclear how much of a role human activities play in these pilot whale strandings, and toxic poisoning may be a potential human-caused source of mortality for pilot whales (NMFS 2005b). Moderate levels of PCBs and chlorinated pesticides (such as DDT, DDE, and dieldrin) have been found in pilot whale blubber (NMFS 2005b). Bioaccumulation levels have been found to be more similar in whales from the same stranding event than from animals of the same age or sex (NMFS 2005b). Numerous studies have measured high levels of toxic metals (mercury, lead, and cadmium), selenium, and PCBs in pilot whales in the Faroe Islands (NMFS 2005b). Population effects resulting from such high contamination levels are currently unknown (NMFS 2005b).

Habitat contamination and degradation may also play a role in marine mammal mortality and strandings. Some events caused by man have direct and obvious effects on marine mammals, such as oil spills (Geraci et al. 1999). But in most cases, effects of contamination will more than likely be indirect in nature, such as effects on prey species availability, or by increasing disease susceptibility (Geraci et al. 1999).

U.S. Navy vessel operation between ports and exercise locations has the potential for release of small amounts of pollutant discharges into the water column. U.S. Navy vessels are not a typical source, however, of either pathogens or other contaminants with bioaccumulation potential such as pesticides and PCBs. Furthermore, any vessel discharges such as bilgewater and deck runoff associated with the vessels would be in accordance with international and U.S. requirements for eliminating or minimizing discharges of oil, garbage, and other substances, and not likely to contribute significant changes to ocean water quality.

For many marine mammals, debris in the marine environment is a great hazard and can be harmful to wildlife. Not only is debris a hazard because of possible entanglement, animals may mistake plastics and other debris for food (NMFS 2007g). There are certain species of cetaceans, along with Florida manatees, that are more likely to eat trash, especially plastics, which is usually fatal for the animal (Geraci et al. 1999).

Between 1990 through October 1998, 215 pygmy sperm whales stranded along the U.S. Atlantic coast from New York through the Florida Keys (NMFS 2005a). Remains of plastic bags and other debris were found in the stomachs of 13 of these animals (NMFS 2005a). During the same time period, 46 dwarf sperm whale strandings occurred along the U.S. Atlantic coastline between Massachusetts and the Florida Keys (NMFS 2005d). In 1987 a pair of latex examination gloves was retrieved from the stomach of a stranded dwarf sperm whale (NMFS 2005d). 125 pygmy sperm whales were reported stranded from 1999 – 2003 between Maine and Puerto Rico; in one pygmy sperm whale found stranded in 2002, red plastic debris was found in the stomach along with squid beaks (NMFS 2005a).

Sperm whales have been known to ingest plastic debris, such as plastic bags (Evans et al. 2003; Whitehead 2003). While this has led to mortality, the scale to which this is affecting sperm whale populations is unknown, but Whitehead (2003) suspects it is not substantial at this time.

High concentrations of potentially toxic substances within marine mammals along with an increase in new diseases have been documented in recent years. Scientists have begun to consider the possibility of a link between pollutants and marine mammal mortality events. NMFS takes part in a marine mammal bio-monitoring program not only to help assess the health and contaminant loads of marine mammals, but also to assist in determining anthropogenic impacts on marine mammals, marine food chains and marine ecosystem health. Using strandings and bycatch animals, the program provides tissue/serum archiving, samples for analyses, disease monitoring and reporting, and additional response during disease investigations (NMFS 2007).

The impacts of these activities are difficult to measure. However, some researchers have correlated contaminant exposure to possible adverse health effects in marine mammals. Contaminants such as organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in planktivorous mysticetes have been reported to be one to two orders of magnitude lower compared to piscivorous odontocetes (Borell 1993; O'Shea and Brownell 1994; O'Hara and Rice 1996; O'Hara et al. 1999).

The manmade chemical PCB (polychlorinated biphenyl), and the pesticide DDT (dichlorodiphyenyltrichloroethane), are both considered persistent organic pollutants that are currently banned in the United States for their harmful effects in wildlife and humans (NMFS 2007c). Despite having been banned for decades, the levels of these compounds are still high in marine mammal tissue samples taken along U.S. coasts (NMFS 2007c). Both compounds are long-lasting, reside in marine mammal fat tissues (especially in the blubber), and can be toxic causing effects such as reproductive impairment and immunosuppression (NMFS 2007c).

Both long-finned and short-finned pilot whales have a tendency to mass strand throughout their range. Short-finned pilot whales have been reported as stranded as far north as Rhode Island, and long-finned pilot whales as far south as South Carolina (NMFS 2005b). For U.S. east coast stranding records, both species are lumped together and there is rarely a distinction between the two because of uncertainty in species identification (NMFS, 2005b). Since 1980 within the Northeast region alone, between 2 and 120 pilot whales have stranded annually either individually or in groups (NMFS, 2005b). Between 1999 and 2003 from Maine to Florida, 126 pilot whales were reported to be stranded, including a mass stranding of 11 animals in 2000 and another mass stranding of 57 animals in 2002, both along the Massachusetts coast (NMFS, 2005b).

It is unclear how much of a role human activities play in these pilot whale strandings, and toxic poisoning may be a potential human-caused source of mortality for pilot whales (NMFS 2005b). Moderate levels of PCBs and chlorinated pesticides (such as DDT, DDE, and dieldrin) have been found in pilot whale blubber (NMFS 2005b). Bioaccumulation levels have been found to be more similar in whales from the same stranding event than from animals of the same age or sex (NMFS 2005b). Numerous studies have measured high levels of toxic metals (mercury, lead, and cadmium), selenium, and PCBs in pilot whales in the Faroe Islands (NMFS 2005b). Population effects resulting from such high contamination levels are currently unknown (NMFS 2005b).

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Deep Water Ambient Noise

Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather, are the primary causes of deep-water ambient noise. The ambient noise frequency spectrum can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983). For example, for frequencies between 100 and 500 Hz, Urick (1983) estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas.

Shallow Water Ambient Noise

In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, marine animals (Urick 1983). At any give time and place, the ambient noise is a mixture of all of these noise variables. In addition, sound propagation is also affected by the variable shallow water conditions, including the depth, bottom slope, and type of bottom. Where the bottom is reflective, the sounds levels tend to be higher, then when the bottom is absorptive.

Noise from Aircraft and Vessel Movement

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans and may contribute to over 75% of all human sound in the sea (Simmonds and Hutchinson 1996, ICES 2005b). Ross (1976) has estimated that between 1950 and 1975, shipping had caused a rise in ambient noise levels of 10 dB. He predicted that this would increase by another 5 dB by the beginning of the 21st century. The National Resource Council (1997) estimated that the background ocean noise level at 100 Hz has been increasing by about 1.5 dB per decade since the advent of propeller-driven ships. Michel et al. (2001) suggested an association between long-term exposure to low frequency sounds from shipping and an increased incidence of marine mammal mortalities caused by collisions with ships.

Airborne sound from a low-flying helicopter or airplane may be heard by marine mammals and turtles while at the surface or underwater. Due to the transient nature of sounds from aircraft involved in at-sea operations, such sounds would not likely cause physical effects but have the potential to affect behaviors. Responses by mammals and turtles could include hasty dives or turns, or decreased foraging (Soto et al. 2006). Whales may also slap the water with flukes or flippers, swim away from the aircraft track.

Sound emitted from large vessels, particularly in the course of transit, is the principal source of noise in the ocean today, primarily due to the properties of sound emitted by civilian cargo vessels (Richardson et al. 1995; Arveson and Vendittis 2000). Ship propulsion and electricity generation engines, engine gearing, compressors, bilge and ballast pumps, as well as hydrodynamic flow surrounding a ship's hull and any hull protrusions contribute to a large vessels' noise emission into the marine environment. Prop-driven vessels also generate noise through cavitation, which accounts much of the noise emitted by a large vessel depending on its travel speed. Military vessels underway or involved in naval operations or exercises, also introduce anthropogenic noise into the marine environment. Noise emitted by large vessels can be characterized as low-frequency, continuous, and tonal. The sound pressure levels at the vessel will vary according to speed, burden, capacity and length (Richardson et al. 1995; Arveson and Vendittis 2000). Vessels ranging from 135 to 337 m generate peak source sound levels from 169- 200 dB between 8 Hz and 430 Hz, although Arveson and Vendittis (2000) documented components of higher frequencies (10-30 kHz) as a function of newer merchant ship engines and faster transit speeds.

Whales have variable responses to vessel presence or approaches, ranging from apparent tolerance to diving away from a vessel. Unfortunately, it is not always possible to determine whether the whales are responding to the vessel itself or the noise generated by the engine and cavitation around the propeller. Apart from some disruption of behavior, an animal may be unable to hear other sounds in the environment due to masking by the noise from the vessel. Any masking of environmental sounds or conspecific sounds is expected to be temporary, as noise dissipates with a vessel transit through an area. Any masking of environmental sounds or conspecific sounds is expected to be temporary, as noise dissipates with a vessel transit through an area.

Vessel noise primarily raises concerns for masking of environmental and conspecific cues. However, exposure to vessel noise of sufficient intensity and/or duration can also result in temporary or permanent loss of sensitivity at a given frequency range, referred to as temporary or permanent threshold shifts (TTS or PTS). Threshold shifts are assumed to be possible in marine mammal species as a result of prolonged exposure to large vessel traffic noise due to its intensity, broad geographic range of effectiveness, and constancy.

Collectively, significant cumulative exposure to individuals, groups, or populations can occur if they exhibit site fidelity to a particular area; for example, whales that seasonally travel to a regular area to forage or breed may be more vulnerable to noise from large vessels compared to transiting whales. Any permanent threshold shift in a marine animal's hearing capability, especially at particular frequencies for which it can normally hear best, can impair its ability to perceive threats, including ships. Whales have variable responses to vessel presence or approaches, ranging from apparent tolerance to diving away from a vessel. It is not possible to determine whether the whales are responding to the vessel itself or the noise generated by the engine and cavitation around the propeller. Apart from some disruption of behavior, an animal may be unable to hear other sounds in the environment due to masking by the noise from the vessel.

Most observations of behavioral responses of marine mammals to human generated sounds have been limited to short-term behavioral responses, which included the cessation of feeding, resting, or social interactions. Nowacek et al. (2007) provide a detailed summary of cetacean response to underwater noise.

Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 87 to 288 mi (139-463 km) away (Ross 1976 in Polefka 2004). U.S. Navy vessels, however, have incorporated significant underwater ship quieting technology to reduce their acoustic signature (as compared to a similarly-sized vessel) in order to reduce their vulnerability to detection by enemy passive acoustics (Southall 2005). Therefore, the potential for TTS or PTS from U.S. Navy vessel and aircraft movement is extremely low given that the exercises and training events are transitory in time, with vessels moving over large area of the ocean. A marine mammal or sea turtle is unlikely to be exposed long enough at high levels for TTS or PTS to occur. Any masking of environmental sounds or conspecific sounds is expected to be temporary, as noise dissipates with a U.S. Navy vessel transiting through an area. If behavioral disruptions result from the presence of aircraft or vessels, it is expected to be temporary. Animals are expected to resume their migration, feeding, or other behaviors without any threat to their survival or reproduction. However, if an animal is aware of a vessel and dives or swims away, it may successfully avoid being struck.

A.1.3 Stranding Events Associated with Navy Sonar

There are two classes of sonars employed by the U.S. Navy: active sonars and passive sonars. Most active military sonars operate in a limited number of areas, and are most likely not a significant contributor to a comprehensive global ocean noise budget (ICES 2005b).

The effects of mid-frequency active naval sonar on marine wildlife have not been studied as extensively as the effects of air-guns used in seismic surveys (Madsen et al. 2006; Stone and Tasker 2006; Wilson et al. 2006; Palka and Johnson 2007; Parente et al. 2007). Maybaum (1989, 1993) observed changes in behavior of humpbacks during playback tapes of the M-1002 system (using 203 dB re 1 µPa-m for study); specifically, a decrease in respiration, submergence, and aerial behavior rates; and an increase in speed of travel and track linearity. Direct comparison of Maybaum's results, however, with U.S Navy mid-frequency active sonar are difficult to make. Maybaum's signal source, the commercial M-1002, is not similar to how naval mid-frequency sonar operates. In addition, behavioral responses were observed during playbacks of a control tape, (i.e. a tape with no sound signal) so interpretation of Maybaum's results are inconclusive.

Research by Nowacek, et al. (2004) on North Atlantic right whales using a whale alerting signal designed to alert whales to human presence suggests that received sound levels of only 133 to 148 pressure level (decibel [dB] re 1 microPascals [µPa]) for the duration of the sound exposure may disrupt feeding behavior. The authors did note, however, that within minutes of cessation of the source, a return to normal behavior would be expected. Direct comparison of the Nowacek et al. (2004) sound source to MFA sonar, however, is not possible given the radically different nature of the two sources. Nowacek et al.'s source was a series of non-sonar like sounds designed to purposely alert the whale, lasting several minutes, and covering a broad frequency band. Direct differences between Nowacek et al. (2004) and MFA sonar is summarized below from Nowacek et al. (2004) and Nowacek et al. (2007):

(1) Signal duration: Time difference between the two signals is significant, 18-minute signal used by Nowacek et al. verses < 1-sec for MFA sonar.

(2) Frequency modulation: Nowacek et al. contained three distinct signals containing frequency modulated sounds:

1st - alternating 1-sec pure tone at 500 and 850 Hz

2nd - 2-sec logarithmic down-sweep from 4500 to 500 Hz

3rd - pair of low-high (1500 and 2000 Hz) sine wave tones amplitude modulated at 120 Hz

(3) Signal to noise ratio: Nowacek et al.'s signal maximized signal to noise ratio so that it would be distinct from ambient noise and resist masking.

(4) Signal acoustic characteristics: Nowacek et al.'s signal comprised of disharmonic signals spanning North Pacific right whales' estimated hearing range.

Given these differences, therefore, the exact cause of apparent right whale behavior noted by the authors can not be attributed to any one component since the source was such a mix of signal types.

The effects of naval sonars on marine wildlife have not been studied as extensively as have the effects of airguns used in seismic surveys (Nowacek et al. 2007). In the Caribbean, sperm whales were observed to interrupt their activities by stopping echolocation and leaving the area in the presence of underwater sounds surmised to have originated from submarine sonar signals (Watkins and Schevill 1975; Watkins et al. 1985). The authors did not report receive levels from these exposures, and also got a similar reaction from artificial noise they generated by banging on their boat hull. It was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general. Madsen et al. (2006) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys. Sound sources were from approximately 2 to 7 nm (4 to 13 km) away from the whales and based on multipath propagation RLs were as high as 162 dB re 1 uPa with energy content greatest between 0.3 to 3.0 kHz. Sperm whales engaged in foraging dives continued the foraging dives throughout exposures to these seismic pulses. In the Caribbean Sea, sperm whales avoided exposure to mid-frequency submarine sonar pulses, in the range 1,000 Hz to 10,000 Hz (IWC 2005). Sperm whales have also moved out of areas after the start of air gun seismic testing (Davis et al. 1995). In contrast, during playback experiments off the Canary Islands, André et al. (1997) reported that foraging sperm whales exposed to a 10 kHz pulsed signal did not exhibit any general avoidance reactions.

The Navy sponsored tests of the effects of low-frequency active (LFA) sonar source, between 100 Hz and 1,000 Hz, on blue, fin, and humpback whales. The tests demonstrated that whales exposed to sound levels up to 155 dB did not exhibit significant disturbance reactions, though there was evidence that humpback whales altered their vocalization patterns in reaction to the noise. Given that the source level of the Navy's LFA is reported to be in excess of 215 dB, the possibility exists that animals in the wild may be exposed to sound levels much higher than 155 dB.

Acoustic exposures have been demonstrated to kill marine mammals, result in physical trauma, and injury (Ketten 2005). Animals in or near an intense noise source can die from profound injuries related to shock wave or blast effects. Acoustic exposures can also result in noise induced hearing loss that is a function of the interactions of three factors: sensitivity, intensity, and frequency. Loss of sensitivity is referred to as a threshold shift; the extent and duration of a threshold shift depends on a combination of several acoustic features and is specific to particular species (TTS or PTS, depending on how the frequency, intensity and duration of the exposure combine to produce damage). In addition to direct physiological effects, noise exposures can impair an animal's sensory abilities (masking) or result in behavioral responses such as aversion or attraction (see Section 3.19).

Acoustic exposures can also result in the death of an animal by impairing its foraging, ability to detect predators or communicate, or by increasing stress, and disrupting important physiological events. Whales have moved away from their feeding and mating grounds (Bryant et al. 1984; Morton and Symnods 2002; Weller et al. 2002), moved away from their migration route (Richardson et al. 1995), and have changed their calls due to noise (Miller et al. 2000). Acoustic exposures such as MFA sonar tend to be infrequent and short in duration, and therefore effects are likely indirect and to be short lived. In situations such as the alteration of gray whale migration routes in response to shipping and whale watching boats, those acoustic exposures were chronic over several years (Moore and Clarke 2002). This was also true of the effect of seismic survey airguns (daily for 39 days) on the use of feeding areas by gray whales in the western North Pacific although whales began returning to the feeding area witin one day of the end of the exposure (Weller et al. 2002).

Below are evaluations of the general information available on the variety of ways in which cetaceans and pinnipeds have been reported to respond to sound, generally, and mid-frequency sonar, in particular.

The Navy is very concerned and thoroughly investigates each marine mammal stranding to better understand the events surrounding strandings (Norman 2006). Strandings can be a single animal or several to hundreds. An event where animals are found out of their normal habitat is considered a stranding even though animals do not necessarily end up beaching (such as the July 2004 Hanalei Mass

Stranding Event; Southall et al. 2006). Several hypotheses have been given for the mass strandings which include the impact of shallow beach slopes on odontocete sonar, disease or parasites, geomagnetic anomalies that affect navigation, following a food source in close to shore, avoiding predators, social interactions that cause other cetaceans to come to the aid of stranded animals, and human actions. Generally, inshore species do not strand in large numbers but generally just as a single animal. This may be due to their familiarity with the coastal area whereas pelagic species that are unfamiliar with obstructions or sea bottom tend to strand more often in larger numbers (Woodings 1995). The Navy has studied several stranding events in detail that may have occurred in association with Navy sonar activities. To better understand the causal factors in stranding events that may be associated with Navy sonar activities, the main factors, including bathymetry (i.e. steep drop offs), narrow channels (less than 35 nm [65 km]), environmental conditions (e.g. surface ducting), and multiple sonar ships were compared between the different stranding events.

When a marine mammal swims or floats onto shore and becomes “beached” or stuck in shallow water, it is considered a “stranding” (MMPA section 410 (16 USC section 1421g;NMFS, 2007a). NMFS explains that “a cetacean is considered stranded when it is on the beach, dead or alive, or in need of medical attention while free-swimming in U.S. waters. A pinniped is considered to be stranded either when dead or when in distress on the beach and not displaying normal haul-out behavior” (NMFS 2007b).

Over the past three decades, several “mass stranding” events [strandings involving two or more individuals of the same species (excluding a single cow-calf pair) and at times, individuals from different species] that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduce sound into the marine environment (Canary Islands, Greece, Vieques, U.S. Virgin Islands, Madeira Islands, Haro Strait, Washington State, Alaska, Hawaii, North Carolina).

Information was collected on mass stranding events (events in which two or more cetaceans stranded) that have occurred and for which reports are available, from the past 40 years. Any causal agents that have been associated with those stranding events were also identified (Table 2-5). Major range events undergo name changes over the years, however, the equivalent of COMPTUEX and JTFEX have been conducted in southern California since 1934. Training involving sonar has been conducted since World War II and sonar systems described in the SOCAL EIS/OEIS since the 1970's (Jane’s 2005).

A.1.4 Stranding Analysis

Over the past two decades, several mass stranding events involving beaked whales have been documented. While beaked whale strandings have been reported since the 1800s (Geraci and Lounsbury 1993; Cox et al. 2006; Podesta et al. 2006), several mass strandings since have been associated with naval operations that may have included mid-frequency sonar (Simmonds and Lopez-Jurado 1991; Frantzis 1998; Jepson et al. 2003; Cox et al. 2006). As Cox et al. (2006) concludes, the state of science can not yet determine if a sound source such as mid-frequency sonar alone causes beaked whale strandings, or if other factors (acoustic, biological, or environmental) must co-occur in conjunction with a sound source.

A review of historical data (mostly anecdotal) maintained by the Marine Mammal Program in the National Museum of Natural History, Smithsonian Institution reports 49 beaked whale mass stranding events between 1838 and 1999. The largest beaked whale mass stranding occurred in the 1870s in New Zealand when 28 Gray’s beaked whales (*Mesoplodon grayi*) stranded. Blainsville’s beaked whale (*Mesoplodon densirostris*) strandings are rare, and records show that they were involved in one mass stranding in 1989 in the Canary Islands. Cuvier’s beaked whales (*Ziphius cavirostris*) are the most frequently reported beaked whale to strand, with at least 19 stranding events from 1804 through 2000 (DoC and DoN 2001; Smithsonian Institution 2000).

The discussion below centers on those worldwide stranding events that may have some association with naval operations, and global strandings that the U.S. Navy feels are either inconclusive or can not be associated with naval operations.

A.1.4.1 Naval Association

In the following sections, specific stranding events that have been putatively linked to potential sonar operations are discussed. Of note, these events represent a small overall number of animals over an 11 year period (40 animals) and not all worldwide beaked whale strandings can be linked to naval activity (ICES 2005a; 2005b; Podesta et al. 2006). Four of the five events occurred during NATO exercises or events where U.S. Navy presence was limited (Greece, Portugal, Spain). One of the five events involved only U.S. Navy ships (Bahamas).

Beaked whale stranding events associated with potential naval operations.

1996 May	Greece (NATO)
2000 March	Bahamas (US)
2000 May	Portugal, Madeira Islands (NATO/US)
2002 September	Spain, Canary Islands (NATO/US)
2006 January	Spain, Mediterranean Sea coast (NATO/US)

Case Studies of Stranding Events (coincidental with or implicated with naval sonar)

1996 Greece Beaked Whale Mass Stranding (May 12 – 13, 1996)

Description: Twelve Cuvier's beaked whales (*Ziphius cavirostris*) stranded along a 24-mi (38-km) strand of the coast of the Kyparissiakos Gulf on May 12 and 13, 1996 (Frantzis, 1998). From May 11 through May 15, the NATO research vessel Alliance was conducting sonar tests with signals of 600 Hz and 3 kHz and root-mean-squared (rms) sound pressure levels (SPL) of 228 and 226 dB re: 1μPa, respectively (D'Amico and Verboom 1998; D'Spain et al. 2006). The timing and the location of the testing encompassed the time and location of the whale strandings (Frantzis 1998).

Findings: Partial necropsies of eight of the animals were performed, including external assessments and the sampling of stomach contents. No abnormalities attributable to acoustic exposure were observed, but the stomach contents indicated that the whales were feeding on cephalods soon before the stranding event. No unusual environmental events before or during the stranding event could be identified (Frantzis 1998).

Conclusions: The timing and spatial characteristics of this stranding event were atypical of stranding in Cuvier's beaked whale, particularly in this region of the world. No natural phenomenon that might contribute to the stranding event coincided in time with the mass stranding. Because of the rarity of mass strandings in the Greek Ionian Sea, the probability that the sonar tests and stranding coincided in time and location, while being independent of each other, was estimated as being extremely low (Frantzis 1998). However, because information for the necropsies was incomplete and inconclusive, the cause of the stranding cannot be precisely determined.

2000 Bahamas Marine Mammal Mass Stranding (March 15-16, 2000)

Description: Seventeen marine mammals comprised of Cuvier's beaked whales, Blainville's beaked whales (*Mesoplodon densirostris*), minke whale (*Balaenoptera acutorostrata*), and one spotted dolphin (*Stenella frontalis*), stranded along the Northeast and Northwest Providence Channels of the Bahamas Islands on March 15-16, 2000 (Evans and England 2001). The strandings occurred over a 36-hour period and coincided with U.S. Navy use of mid-frequency active sonar within the channel. Navy ships were involved in tactical sonar exercises for approximately 16 hours on March 15. The ships, which operated the AN/SQS-53C and AN/SQS-56, moved through the channel while emitting sonar pings approximately every 24 seconds. The timing of pings was staggered between ships and average source levels of pings varied from a nominal 235 dB SPL (AN/SQS-53C) to 223 dB SPL (AN/SQS-56). The center frequency of pings was 3.3 kHz and 6.8 to 8.2 kHz, respectively.

Seven of the animals that stranded died, while ten animals were returned to the water alive. The animals known to have died included five Cuvier's beaked whales, one Blainville's beaked whale, and the single spotted dolphin. Six necropsies were performed and three of the six necropsied whales (one Cuvier's beaked whale, one Blainville's beaked whale, and the spotted dolphin) were fresh enough to permit identification of pathologies by computerized tomography (CT). Tissues from the remaining three animals were in a state of advanced decomposition at the time of inspection.

Findings: The spotted dolphin demonstrated poor body condition and evidence of a systemic debilitating disease. In addition, since the dolphin stranding site was isolated from the acoustic activities of Navy ships, it was determined that the dolphin stranding was unrelated to the presence of Navy active sonar.

All five necropsied beaked whales were in good body condition and did not show any signs of external trauma or disease. In the two best preserved whale specimens, hemorrhage was associated with the brain and hearing structures. Specifically, subarachnoid hemorrhage within the temporal region of the brain and intracochlear hemorrhages were noted. Similar findings of bloody effusions around the ears of two other moderately decomposed whales were consistent with the same observations in the freshest animals. In addition, three of the whales had small hemorrhages in their acoustic fats, which are fat bodies used in sound production and reception (i.e., fats of the lower jaw and the melon). The best-preserved whale demonstrated acute hemorrhage within the kidney, inflammation of the lung and lymph nodes, and congestion and mild hemorrhage in multiple other organs. Other findings were consistent with stresses and injuries associated with the stranding process. These consisted of external scrapes, pulmonary edema and congestion.

Conclusions: The post-mortem analyses of stranded beaked whales lead to the conclusion that the immediate cause of death resulted from overheating, cardiovascular collapse and stresses associated with being stranded on land. However, the presence of subarachnoid and intracochlear hemorrhages were believed to have occurred prior to stranding and were hypothesized as being related to an acoustic event. Passive acoustic monitoring records demonstrated that no large scale acoustic activity besides the Navy sonar exercise occurred in the times surrounding the stranding event. The mechanism by which sonar could have caused the observed traumas or caused the animals to strand was undetermined. The spotted dolphin was in overall poor condition for examination, but showed indications of long-term disease. No analysis of baleen whales (minke whale) was conducted. Baleen whale stranding events have not been associated with either low-frequency or mid-frequency sonar use (ICES 2005a, 2005b).

2000 Madeira Island, Portugal Beaked Whale Strandings (May 10 – 14, 2000)

Description: Three Cuvier's beaked whales stranded on two islands in the Madeira Archipelago, Portugal, from May 10 – 14, 2000 (Cox et al. 2006). A joint NATO amphibious training exercise, named "Linked Seas 2000," which involved participants from 17 countries, took place in Portugal during May 2 – 15, 2000. The timing and location of the exercises overlapped with that of the stranding incident.

Findings: Two of the three whales were necropsied. Two heads were taken to be examined. One head was intact and examined grossly and by CT; the other was only grossly examined because it was partially flensed and had been seared from an attempt to dispose of the whale by fire (Ketten 2005).

No blunt trauma was observed in any of the whales. Consistent with prior CT scans of beaked whales stranded in the Bahamas 2000 incident, one whale demonstrated subarachnoid and peribullar hemorrhage and blood within one of the brain ventricles. Post-cranially, the freshest whale demonstrated renal congestion and hemorrhage, which was also consistent with findings in the freshest specimens in the Bahamas incident.

Conclusions: The pattern of injury to the brain and auditory system were similar to those observed in the Bahamas strandings, as were the kidney lesions and hemorrhage and congestion in the lungs (Ketten 2005). The similarities in pathology and stranding patterns between these two events suggested a similar causative mechanism. Although the details about whether or how sonar was used during "Linked Seas 2000" is unknown, the presence of naval activity within the region at the time of the strandings suggested a possible relationship to Navy activity.

2002 Canary Islands Beaked Whale Mass Stranding (24 September 2002)

Description: On September 24, 2002, 14 beaked whales stranded on Fuerteventura and Lanzaote Islands in the Canary Islands (Jepson et al. 2003). Seven of the 14 whales died on the beach and the 7 were returned to the ocean. Four beaked whales were found stranded dead over the next three days either on the coast or floating offshore (Fernández et al. 2005). At the time of the strandings, an international naval exercise (Neo-Tapon 2002) that involved numerous surface warships and several submarines was being conducted off the coast of the Canary Islands. Tactical mid-frequency active sonar was utilized during the exercises, and strandings began within hours of the onset of the use of mid-frequency sonar (Fernández et al. 2005).

Findings: Eight Cuvier's beaked whales, one Blainville's beaked whale, and on Gervais' beaked whale were necropsied; six of them within 12 hours of stranding (Fernández et al. 2005). The stomachs of the whales contained fresh and undigested prey contents. No pathogenic bacteria were isolated from the whales, although parasites were found in the kidneys of all of the animals. The head and neck lymph nodes were congested and hemorrhages were noted in multiple tissues and organs, including the kidney, brain, ears, and jaws. Widespread fat emboli were found throughout the carcasses, but no evidence of blunt trauma was observed in the whales. In addition, the parenchyma of several organs contained macroscopic intravascular bubbles and lesions, putatively associated with nitrogen off-gassing.

Conclusions: The association of NATO mid-frequency sonar use close in space and time to the beaked whale strandings, and the similarity between this stranding event and previous beaked whale mass strandings coincident with sonar use, suggests that a similar scenario and causative mechanism of stranding may be shared between the events. Beaked whales stranded in this event demonstrated brain and auditory system injuries, hemorrhages, and congestion in multiple organs, similar to the pathological findings of the Bahamas and Madeira stranding events. In addition, the necropsy results of Canary Islands stranding event lead to the hypothesis that the presence of disseminated and widespread gas bubbles and fat emboli were indicative of nitrogen bubble formation, similar to what might be expected in decompression sickness (Jepson et al. 2003; Fernández et al. 2005). Whereas gas emboli would develop from the nitrogen gas, fat emboli would enter the blood stream from ruptured fat cells (presumably where nitrogen bubble formation occurs) or through the coalescence of lipid bodies within the blood stream.

The possibility that the gas and fat emboli found by Fernández et al. (2005) was due to nitrogen bubble formation has been hypothesized to be related to either direct activation of the bubble by sonar signals or to a behavioral response in which the beaked whales flee to the surface following sonar exposure. The first hypothesis is related to rectified diffusion (Crum and Mao 1996), the process of increasing the size of a bubble by exposing it to a sound field. This process is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard 1979). Deeper and longer dives of some marine mammals, such as those conducted by beaked whales, are theoretically predicted to induce greater levels of supersaturation (Houser et al. 2001). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness. It is unlikely that the short duration of sonar pings would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable bubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of the tissues. In such a scenario the marine mammal would need to be in a gas-supersaturated state for a long enough period of time for bubbles to become of a problematic size. The second hypothesis speculates that rapid ascent to the surface following exposure to a startling sound might produce tissue gas saturation sufficient for the evolution of nitrogen bubbles (Jepson et al. 2003; Fernández et al. 2005). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation. Tyack et al. (2006) showed that beaked whales often make rapid ascents from deep dives suggesting that it is unlikely that beaked whales would suffer from decompression sickness. Zimmer and Tyack (2007) speculated that if repetitive shallow dives that are used by beaked whales to avoid a predator or a sound source, they could accumulate high levels of nitrogen because they would be above the depth of lung collapse (above about 210 ft) and could lead to decompression sickness. There is no evidence that beaked whales dive in this manner in response to predators or sound sources and other marine mammals such as Antarctic and Galapagos fur seals, and pantropical spotted dolphins make repetitive shallow dives with no apparent decompression sickness (Kooyman and Trillmich 1984; Kooyman et al. 1984; Baird et al. 2001).

Although theoretical predictions suggest the possibility for acoustically mediated bubble growth, there is considerable disagreement among scientists as to its likelihood (Piantadosi and Thalmann 2004). Sound exposure levels predicted to cause in vivo bubble formation within diving cetaceans have not been evaluated and are suspected as needing to be very high (Evans 2002; Crum et al. 2005). Moore and Early (2004) reported that in analysis of sperm whale bones spanning 111 years, gas embolism symptoms were observed indicating that sperm whales may be susceptible to decompression sickness due to natural diving behavior. Further, although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Jepson et al. 2003), there is no conclusive evidence supporting this hypothesis and there is concern that at least some of the pathological findings (e.g., bubble emboli) are artifacts of the necropsy. Currently, stranding networks in the United States have agreed to adopt a set of necropsy guidelines to determine, in part, the possibility and frequency with which bubble emboli can be introduced into marine mammals during necropsy procedures (Arruda et al. 2007).

2006 Spain, Gulf of Vera Beaked Whale Mass Stranding (26-27 January 2006)

Description: The Spanish Cetacean Society reported an atypical mass stranding of four beaked whales that occurred January 26 to 28, 2006, on the southeast coast of Spain near Mojacar (Gulf of Vera) in the Western Mediterranean Sea. According to the report, two of the whales were discovered the evening of January 26 and were found to be still alive. Two other whales were discovered during the day on January 27, but had already died. A following report stated that the first three animals were located near the town of Mojacar and were examined by a team from the University of Las Palmas de Gran Canarias, with the help of the stranding network of Ecologistas en Acción Almería-PROMAR and others from the Spanish Cetacean Society. The fourth animal was found dead on the afternoon of May 27, a few kilometers north of the first three animals.

From January 25-26, 2006, a NATO surface ship group (seven ships including one U.S. ship under NATO operational command) conducted active sonar training against a Spanish submarine within 50 nm [93 km]of the stranding site.

Findings: Veterinary pathologists necropsied the two male and two female beaked whales (*Z. cavirostris*).

Conclusions: According to the pathologists, a likely cause of this type of beaked whale mass stranding event may have been anthropogenic acoustic activities. However, no detailed pathological results confirming this supposition have been published to date, and no positive acoustic link was established as a direct cause of the stranding.

Even though no causal link can be made between the stranding event and naval exercises, certain conditions may have existed in the exercise area that, in their aggregate, may have contributed to the marine mammal strandings (Freitas 2004):

- Operations were conducted in areas of at least 1,000 meters in depth near a shoreline where there is a rapid change in bathymetry on the order of 1,000 – 6,000 meters occurring a cross a relatively short horizontal distance (Freitas 2004).

- Multiple ships, in this instance, five MFA sonar equipped vessels, were operating in the same area over extended periods of time (20 hours) in close proximity.

- Exercises took place in an area surrounded by landmasses, or in an embayment. Operations involving multiple ships employing mid-frequency active sonar near land may produce sound directed towards a channel or embayment that may cut off the lines of egress for marine mammals (Freitas 2004)

A.1.4.2 Other Global Stranding Discussions

In the following sections, stranding events that have been linked to U.S. Navy activity in popular press are presented. As detailed in the individual case study conclusions, the U.S. Navy believes there is enough evidence available to refute allegations of impacts from mid-frequency sonar, or at least indicate that a substantial degree of uncertainty in time and space that preclude a meaningful scientific conclusion.

Case Studies of Stranding Events

2003 Washington State Harbor Porpoise Strandings (May 2 – June 2 2003)

Description: At 1040 hours on May 5, 2003, the USS SHOUP began the use of mid-frequency tactical active sonar as part of a naval exercise. At 1420, the USS SHOUP entered the Haro Strait and terminated active sonar use at 1438, thus limiting active sonar use within the strait to less than 20 minutes. Between May 2 and June 2, 2003, approximately 16 strandings involving 15 harbor porpoises (*Phocoena phocoena*) and one Dall's porpoise (*Phocoenoides dalli*) were reported to the Northwest Marine Mammal Stranding Network. A comprehensive review of all strandings and the events involving USS SHOUP on 5 May 2003 were presented in U.S. Department of Navy (2004). Given that the USS SHOUP was known to have operated sonar in the strait on May 5, and that supposed behavioral reactions of killer whales (*Orcinus orca*) had been putatively linked to these sonar operations (NMFS Office of Protected Resources, 2005), the NMFS undertook an analysis of whether sonar caused the strandings of the harbor porpoises.

Whole carcasses of ten of harbor porpoises and the head of an additional porpoise were collected for analysis. Necropsies were performed on ten of the harbor porpoises and six whole carcasses and two heads were selected for CT imaging. Gross examination, histopathology, age determination, blubber analysis, and various other analyses were conducted on each of the carcasses (Norman et al. 2004).

Findings: Post-mortem findings and analysis details are found in Norman et al. (2004). All of the carcasses suffered from some degree of freeze-thaw artifact that hampered gross and histological evaluations. At the time of necropsy, three of the porpoises were moderately fresh, whereas the remainder of the carcasses was considered to have moderate to advanced decomposition. None of the 11 harbor porpoises demonstrated signs of acoustic trauma. In contrast, a putative cause of death was determined for 5 of the porpoises; 2 animals had blunt trauma injuries and 3 animals had indication of disease processes (fibrous peritonitis, salmonellosis, and necrotizing pneumonia). A cause of death could not be determined in the remaining animals, which is consistent with expected percentage of marine mammal necropsies conducted within the northwest region. It is important to note, however, that these determinations were based only on the evidence from the necropsy so as not to be biased with regard to determinations of the potential presence or absence of acoustic trauma. The result was that other potential causal factors, such as one animal (Specimen 33NWR05005) found tangled in a fishing net, was unknown to the investigators in their determination regarding the likely cause of death.

Conclusions: The NMFS concluded from a retrospective analysis of stranding events that the number of harbor porpoise stranding events in the approximate month surrounding the USS SHOUP use of sonar was higher than expected based on annual strandings of harbor porpoises (Norman et al. 2004). In this regard, it is important to note that the number of strandings in the May-June timeframe in 2003 was also higher for the outer coast indicating a much wider phenemona than use of sonar by USS SHOUP in Puget Sound for one day in May. The conclusion by NMFS that the number of strandings in 2003 was higher is also different from that of The Whale Museum, which has documented and responded to harbor porpoise strandings since 1980 (Osborne 2003). According to The Whale Museum, the number of strandings as of May 15, 2003, was consistent with what was expected based on historical stranding records and was less than that occurring in certain years. For example, since 1992 the San Juan Stranding Network has documented an average of 5.8 porpoise strandings per year. In 1997 there were 12 strandings in the San Juan Islands with more than 30 strandings throughout the general Puget Sound area. Disregarding the discrepancy in the historical rate of porpoise strandings and its relation to the USS SHOUP, NMFS acknowledged that the intense level of media attention focused on the strandings likely resulted in an increased reporting effort by the public over that which is normally observed (Norman et al. 2004). NMFS also noted in its report that the "sample size is too small and biased to infer a specific relationship with respect to sonar usage and subsequent strandings."

Seven of the porpoises collected and analyzed died prior to SHOUP departing to sea on May 5, 2003. Of these seven, one, discovered on May 5, 2003, was in a state of moderate decomposition, indicating it died before May 5; the cause of death was determined to be due, most likely, to salmonella septicemia. Another porpoise, discovered at Port Angeles on May 6, 2003, was in a state of moderate decomposition, indicating that this porpoise also died prior to May 5. One stranded harbor porpoise discovered fresh on May 6 is the only animal that could potentially be linked in time to the USS SHOUP's May 5 active sonar use. Necropsy results for this porpoise found no evidence of acoustic trauma. The remaining eight strandings were discovered one to three weeks after the USS SHOUP's May 5 transit of the Haro Strait, making it difficult to causally link the sonar activities of the USS SHOUP to the timing of the strandings. Two of the eight porpoises died from blunt trauma injury and a third suffered from parasitic infestation, which possibly contributed to its death (Norman et al. 2004). For the remaining five porpoises, NMFS was unable to identify the causes of death.

The speculative association of the harbor porpoise strandings to the use of sonar by the USS SHOUP is inconsistent with prior stranding events linked to the use of mid-frequency sonar. Specifically, in prior events, the stranding of whales occurred over a short period of time (less than 36 hours), stranded individuals were spatially co-located, traumas in stranded animals were consistent between events, and active sonar was known or suspected to be in use. Although mid-frequency active sonar was used by the USS SHOUP, the distribution of harbor porpoise strandings by location and with respect to time surrounding the event do not support the suggestion that mid-frequency active sonar was a cause of harbor porpoise strandings. Rather, a complete lack of evidence of any acoustic trauma within the harbor porpoises, and the identification of probable causes of stranding or death in several animals, further supports the conclusion that harbor porpoise strandings were unrelated to the sonar activities of the USS SHOUP.

Additional allegations regarding USS SHOUP use of sonar having caused behavioral effects to Dall's porpoise, orca, and a minke whale also arose in association with this event (see U.S. Department of Navy 2004 for a complete discussion).

Dall's porpoise: Information regarding the observation of Dall's porpoise on 5 May 2003 came from the operator of a whale watch boat at an unspecified location. This operator reported the Dall's porpose were seen "going north" when the SHOUP was estimated by him to be 10 mi (16 km) away. Potential reasons for the Dall's movement include the pursuit of prey, the presence of harassing resident orca or predatory transient orca, vessel disturbance from one of many whale watch vessels, or multiple other unknowable reasons including the use of sonar by USS SHOUP. In short, there was nothing unusual in the observed behavior of the Dall's porpoise on 5 May 2003 and no way to assess if the otherwise normal behavior was in reaction to the use of sonar by USS SHOUP, any other potential causal factor, or a combination of factors.

Orca: Observer opinions regarding orca J-Pod behaviors on 5 May 2003 were inconsistent, ranging from the orca being "at ease with the sound" or "resting" to their being "annoyed." One witness reported observing "low rates of surface active behavior" on behalf of the orca J-Pod, which is in conflict with that of another observer who reported variable surface activity, tail slapping and spyhopping. Witnesses also expressed the opinion that the behaviors displayed by the orca on 5 May 2003 were "extremely unusual," although those same behaviors are observed and reported regularly on the Orca Network Website, are behaviors listed in general references as being part of the normal repertoire of orca behaviors. Given the contradictory nature of the reports on the observed behavior of the J-Pod orca, it is impossible to determine if any unusual behaviors were present. In short, there is no way to assess if any unusual behaviors were present or if present they were in reaction to vessel disturbance from one of many nearby whale watch vessels, use of sonar by USS SHOUP, any other potential causal factor, or a combination of factors.

Minke whale: A minke whale was reported porpoising in Haro Strait on 5 May 2003, which is a rarely observed behavior. The cause of this behavior is indeterminate given multiple potential causal factors including but not limited to the presence of predatory Transient orca, possible interaction with whale watch boats, other vessels, or SHOUP's use of sonar. The behavior of the minke whale was the only unusual behavior clearly present on 5 May 2003, however, no way to given the existing information if the unusual behavior observed was in reaction to the use of sonar by USS SHOUP, any other potential causal factor, or a combination of factors.

2004 Hawai'i Melon-Headed Whale Mass Stranding (July 3-4 2004)

Description: The majority of the following information is taken from the NMFS report on the stranding event (Southall et al. 2006) but is inclusive of additional and new information not presented in the NMFS report. On the morning of July 3, 2004, between 150-200 melon-headed whales (*Peponocephala electra*) entered Hanalei Bay, Kauai. Individuals attending a canoe blessing ceremony observed the animals entering the bay at approximately 7:00 a.m. The whales were reported entering the bay in a "wave as if they were chasing fish" (Braun 2006). At 6:45 a.m. on July 3, 2004, approximately 25 nm (46 km) north of Hanalei Bay, active sonar was tested briefly prior to the start of an anti-submarine warfare exercise.

The whales stopped in the southwest portion of the bay, grouping tightly, and displayed spy-hopping and tail-slapping behavior. As people went into the water among the whales, the pod separated into as many as four groups, with individual animals moving among the clusters. This continued through most of the day, with the animals slowly moving south and then southeast within the bay. By about 3 p.m., police arrived and kept people from interacting with the animals. The Navy believes that the abnormal behavior by the whales during this time is likely the result of people and boats in the water with the whales rather than the result of sonar activities taking place 25 mi or more (40 km or more) off the coast. At 4:45 p.m. on July 3, 2004, the RIMPAC Battle Watch Captain received a call from a National Marine Fisheries representative in Honolulu, Hawaii, reporting the sighting of as many as 200 melon-headed whales in Hanalei Bay. At 4:47 p.m. the Battle Watch Captain directed all ships in the area to cease active sonar transmissions.

At 7:20 p.m. on July 3, 2004, the whales were observed in a tight single pod 75 yards (69 m) from the southeast side of the bay. The pod was circling in a group and displayed frequent tail slapping and whistle vocalizations and some spy hopping. No predators were observed in the bay and no animals were reported as having fresh injuries. The pod stayed in the bay through the night of July 3, 2004. On the morning of July 4, 2004, the whales were observed to still be in the bay and collected in a tight group. A decision was made at that time to attempt to herd the animals out of the bay. A 700-to-800-foot (214- to 244-m) rope was constructed by weaving together beach morning glory vines. This vine rope was tied between two canoes and with the assistance of 30 to 40 kayaks, was used to herd the animals out of the bay. By approximately 11:30 a.m. on July 4, 2004, the pod was coaxed out of the bay.

A single neonate melon-headed whale was observed in the bay on the afternoon of July 4, after the whale pod had left the bay. The following morning on July 5, 2004, the neonate was found stranded on Lumahai Beach. It was pushed back into the water but was found stranded dead between 9 and 10 a.m. near the Hanalei pier. NMFS collected the carcass and had it shipped to California for necropsy, tissue collection, and diagnostic imaging.

Following the stranding event, NMFS undertook an investigation of possible causative factors of the stranding. This analysis included available information on environmental factors, biological factors, and an analysis of the potential for sonar involvement. The latter analysis included vessels that utilized mid-frequency active sonar on the afternoon and evening of July 2. These vessels were to the southeast of Kauai, on the opposite side of the island from Hanalei Bay.

Findings: NMFS concluded from the acoustic analysis that the melon-headed whales would have had to have been on the southeast side of Kauai on July 2 to have been exposed to sonar from naval vessels on that day (Southall et al. 2006). There was no indication whether the animals were in that region or whether they were elsewhere on July 2. NMFS concluded that the animals would have had to swim from 1.4-4.0 m/s for 6.5 to 17.5 hours after sonar transmissions ceased to reach Hanalei Bay by 7:00 a.m. on July 3. Sound transmissions by ships to the north of Hanalei Bay on July 3 were produced as part of exercises between 6:45 a.m. and 4:47 p.m. Propagation analysis conducted by the 3rd Fleet estimated that the level of sound from these transmissions at the mouth of Hanalei Bay could have ranged from 138-149 dB re: 1 μPa.

NMFS was unable to determine any environmental factors (e.g., harmful algal blooms, weather conditions) that may have contributed to the stranding. However, additional analysis by Navy investigators found that a full moon occurred the evening before the stranding and was coupled with a squid run (Mobley 2007). One of the first observations of the whales entering the bay reported the pod came into the bay in a line "as if chasing fish" (Braun 2005). In addition, a group of 500-700 melon-headed whales were observed to come close to shore and interact with humans in Sasanhaya Bay, Rota, on the same morning as the whales entered Hanalei Bay (Jefferson et al. 2006). Previous records further indicated that, though the entrance of melon-headed whales into the shallows is rare, it is not unprecedented. A pod of melon-headed whales entered Hilo Bay in the 1870s in a manner similar to that which occurred at Hanalei Bay in 2004.

The necropsy of the melon-headed whale calf suggested that the animal died from a lack of nutrition, possibly following separation from its mother. The calf was estimated to be approximately one week old. Although the calf appeared not to have eaten for some time, it was not possible to determine whether the calf had ever nursed after it was born. The calf showed no signs of blunt trauma or viral disease and had no indications of acoustic injury.

Conclusions: Although it is not impossible, it is unlikely that the sound level from the sonar caused the melon-headed whales to enter Hanalei Bay. This conclusion is based on a number of factors:

1. The speculation that the whales may have been exposed to sonar the day before and then fled to the Hanalei Bay is not supported by reasonable expectation of animal behavior and swim speeds. The flight response of the animals would have had to persist for many hours following the cessation of sonar transmissions. Such responses have not been observed in marine mammals and no documentation of such persistent flight response after the cessation of a frightening stimulus has been observed in other mammals. The swim speeds, though feasible for the species, are highly unlikely to be maintained for the durations proposed, particularly since the pod was a mixed group containing both adults and neonates. Whereas adults may maintain a swim speed of 4.0 m/s for some time, it is improbable that a neonate could achieve the same for a period of many hours.

2. The area between the islands of Oahu and Kauai and the PMRF training range have been used in RIMPAC exercises for more than 20 years, and are used year-round for ASW training using mid frequency active sonar. Melon-headed whales inhabiting the waters around Kauai are likely not naive to the sound of sonar and there has never been another stranding event associated in time with ASW training at Kauai or in the Hawaiian Islands. Similarly, the waters surrounding Hawaii contain an abundance of marine mammals, many of which would have been exposed to the same sonar operations that were speculated to have affected the melon-headed whales. No other strandings were reported coincident with the RIMPAC exercises. This leaves it uncertain as to why melon-headed whales, and no other species of marine mammal, would respond to the sonar exposure by stranding.

3. At the nominal swim speed for melon-headed whales, the whales had to be within 1.5 to 2 nm (2.8 to 4 km) of Hanalei Bay before sonar was activated on July 3. The whales were not in their open ocean habitat but had to be close to shore at 6:45 a.m. when the sonar was activated to have been observed inside Hanalei Bay from the beach by 7:00 a.m (Hanalei Bay is very large area). This observation suggests that other potential factors could be causative of the stranding event (see below).

4. The simultaneous movement of 500-700 melon-headed whales and Risso's dolphins into Sasanhaya Bay, Rota, in the Northern Marianas Islands on the same morning as the 2004 Hanalei stranding (Jefferson et al. 2006) suggests that there may be a common factor which prompted the melon-headed whales to approach the shoreline. A full moon occurred the evening before the stranding and a run of squid was reported concomitant with the lunar activity (Mobley et al. 2007). Thus, it is possible that the melon-headed whales were capitalizing on a lunar event that provided an opportunity for relatively easy prey capture (Mobley et al. 2007). A report of a pod entering Hilo Bay in the 1870s indicates that on at least one other occasion, melon-headed whales entered a bay in a manner similar to the occurrence at Hanalei Bay in July 2004. Thus, although melon-headed whales entering shallow embayments may be an infrequent event, and every such event might be considered anomalous, there is precedent for the occurrence.

5. The received noise sound levels at the bay were estimated to range from roughly 95 – 149 dB re: 1 μPa. Received levels as a function of time of day have not been reported, so it is not possible to determine when the presumed highest levels would have occurred and for how long. However, received levels in the upper range would have been audible by human participants in the bay. The statement by one interviewee that he heard "pings" that lasted an hour and that they were loud enough to hurt his ears is unreliable. Received levels necessary to cause pain over the duration stated would have been observed by most individuals in the water with the animals. No other such reports were obtained from people interacting with the animals in the water.

Although NMFS concluded that sonar use was a "plausible, if not likely, contributing factor in what may have been a confluence of events (Southall et al. 2006)," this conclusion was based primarily on the basis that there was an absence of any other compelling explanation. The authors of the NMFS report on the incident were unaware, at the time of publication, of the simultaneous event in Rota. In light of the simultaneous Rota event, the Hanalei stranding does not appear as anomalous as initially presented and the speculation that sonar was a causative factor is weakened. The Hanalei Bay incident does not share the characteristics observed with other mass strandings of whales coincident with sonar activity (e.g., specific traumas, species composition, etc.). In addition, the inability to conclusively link or exclude the impact of other environmental factors makes a causal link between sonar and the melon-headed whale strandings highly speculative at best.

1980- 2004 Beaked Whale Strandings in Japan (Brownell et al. 2004)

Description: Brownell et al. (2004) compare the historical occurrence of beaked whale strandings in Japan (where there are U.S. Naval bases), with strandings in New Zealand (which lacks a U.S. Naval base) and concluded the higher number of strandings in Japan may be related to the presence of the US. Navy vessels using mid-frequency sonar. While the dates for the strandings were well documented, the authors of the study did not attempt to correlate the dates of any navy activities or exercises with the dates of the strandings.

To fully investigate the allegation made by Brownell et al. (2004), the Center for Naval Analysis (CNA) in an internal Navy report, looked at the past U.S. Naval exercise schedules from 1980 to 2004 for the water around Japan in comparison to the dates for the strandings provided by Brownell et al. (2004). None of the strandings occurred during or soon (within weeks) after any U.S. Navy exercises. While the CNA analysis began by investigating the probabilistic nature of any co-occurrences, the strandings and sonar use were not correlated by time. Given there there there was no instance of co-occurrence in over 20 years of stranding data, it can be reasonably postulated that sonar use in Japan waters by U.S. Navy vessels did not lead to any of the strandings documented by Brownell et al. (2004).

2004 Alaska Beaked Whale Strandings (7-16 June 2004)

Description: In the timeframe between 17 June and 19 July 2004, five beaked whales were discovered at various locations along 1,600 mi (2,575 km) of the Alaskan coastline and one was found floating (dead) at sea. Because the Navy exercise Alaska Shield/Northern Edge 2004 occurred within the approximate timeframe of these strandings, it has been alleged that sonar may have been the probable cause of these strandings.

The Alaska Shield/Northern Edge 2004 exercise consisted of a vessel tracking event followed by a vessel boarding search and seizure event. There was no ASW component to the exercise, no use of mid-frequency sonar, and no use of explosives in the water. There were no events in the Alaska Shield/Northern Edge exercise that could have caused in any of the strandings over this 33-day period covering 1,600 mi (2,575 km) of coastline.

2005 North Carolina Marine Mammal Mass Stranding Event (January 15-16, 2005)

Description: On January 15 and 16, 2005, 36 marine mammals consisting of 33 short-finned pilot whales, 1 minke whale, and 2 dwarf sperm whales stranded alive on the beaches of North Carolina (Hohn et al., 2006a). The animals were scattered across a 60-nm (111-km) area from Cape Hatteras northward. Because of the live stranding of multiple species, the event was classified as a UME. It is the only stranding on record for the region in which multiple offshore species were observed to strand within a two- to three-day period

The U.S. Navy indicated that from January 12-14 some unit level training with mid-frequency active sonar was conducted by vessels that were 50 to 100 nm (93 to 185 km) from Oregon Inlet. An expeditionary strike group was also conducting exercises to the southeast, but the closest point of active sonar transmission to the inlet was351 nm (650 km) away. The unit level operations were not unusual for the area or time of year and the vessels were not involved in antisubmarine warfare exercises. Marine mammal observers on board the vessels did not detect any marine mammals during the period of unit level training. No sonar transmissions were made on January 15-16.

The National Weather Service reported that a severe weather event moved through North Carolina on January 13 and 14. The event was caused by an intense cold front that moved into an unusually warm and moist air mass that had been persisting across the eastern United States for about a week. The weather caused flooding in the western part of the state, considerable wind damage in central regions of the state, and at least three tornadoes that were reported in the north central part of the state. Severe, sustained (one to four days) winter storms are common for this region.

Over a two-day period (January 16-17), two dwarf sperm whales, 27 pilot whales, and the minke whale were necropsied and tissue samples collected. Twenty-five of the stranded cetacean heads were examined; two pilot whale heads and the heads of the dwarf sperm whales were analyzed by CT.

Findings: The pilot whales and dwarf sperm whale were not emaciated, but the minke whale, which was believed to be a dependent calf, was emaciated. Many of the animals were on the beach for an extended period of time prior to necropsy and sampling, and many of the biochemical abnormalities noted in the animals were suspected of being related to the stranding and prolonged time on land. Lesions were observed in all of the organs, but there was no consistency across species. Musculoskeletal disease was observed in two pilot whales and cardiovascular disease was observed in one dwarf sperm whale and one pilot whale. Parasites were a common finding in the pilot whales and dwarf sperm whales but were considered consistent with the expected parasite load for wild odontocetes. None of the animals exhibited traumas similar to those observed in prior stranding events associated with mid-frequency sonar activity. Specifically, there was an absence of auditory system trauma and no evidence of distributed and widespread bubble lesions or fat emboli, as was previously observed (Fernández et al. 2005).

Sonar transmissions prior to the strandings were limited in nature and did not share the concentration identified in previous events associated with mid-frequency active sonar use (Evans and England, 2001). The operational/environmental conditions were also dissimilar (e.g., no constrictive channel and a limited number of ships and sonar transmissions). NMFS noted that environmental conditions were favorable for a shift from up-welling to down-welling conditions, which could have contributed to the event. However, other severe storm conditions existed in the days surrounding the strandings and the impact of these weather conditions on at-sea conditions is unknown. No harmful algal blooms were noted along the coastline.

Conclusions: All of the species involved in this stranding event are known to occasionally strand in this region. Although the cause of the stranding could not be determined, several whales had preexisting conditions that could have contributed to the stranding. Cause of death for many of the whales was likely due to the physiological stresses associated with being stranded. A consistent suite of injuries across species, which was consistent with prior strandings where sonar exposure is expected to be a causative mechanism, was not observed.

NMFS was unable to determine any causative role that sonar may have played in the stranding event. The acoustic modeling performed, as in the Hanalei Bay incident, was hampered by uncertainty regarding the location of the animals at the time of sonar transmissions. However, as in the Hanalei Bay incident, the response of the animals following the cessation of transmissions would imply a flight response that persisted for many hours after the sound source was no longer operational. In contrast, the presence of a severe weather event passing through North Carolina during January 13 and 14 is a possible, if not likely, contributing factor to the North Carolina UME of January 15. Hurricanes may have been responsible for mass strandings of pygmy killer whales in the British Virgin Islands and Gervais' beaked whales in North Carolina (Mignucci-Giannoni et al. 2000; Norman and Mead 2001).

A.1.4.3 Causal Associations for Stranding Events

Several stranding events have been associated with Navy sonar activities but relatively few of the total stranding events that have been recorded occurred spatially or temporally with Navy sonar activities. While sonar may be a contributing factor under certain rare conditions, the presence of sonar it is not a necessary condition for stranding events to occur.

A review of past stranding events associated with sonar suggest that the potential factors that may contribute to a stranding event are steep bathymetry changes, narrow channels, multiple sonar ships, surface ducting and the presence of beaked whales that may be more susceptible to sonar exposures. The most important factors appear to be the presence of a narrow channel (e.g. Bahamas and Madeira Island, Portugal) that may prevent animals from avoiding sonar exposure and multiple sonar ships within that channel. There are no narrow channels (less than 35 nm [65 km] wide and 10 nm [19 km] in length) in the SOCAL Range Complex and the ships would be spread out over a wider area allowing animals to move away from sonar activities if they choose. In addition, beaked whales may not be more susceptible to sonar but may favor habitats that are more conducive to sonar effects.

There have been no mass strandings in Southern California waters are attributed to Navy sonar. Given the large military presence and private and commercial vessel traffic in the Southern California waters, it is likely that a mass stranding event would be detected. Therefore, it is unlikely that the conditions that may have contributed to past stranding events involving Navy sonar would be present in the SOCAL Range Complex.

A.1.5 Stranding Section Conclusions

Marine mammal strandings have been a historic and ongoing occurrence attributed to a variety of causes. Over the last fifty years, increased awareness and reporting has lead to more information about species effected and raised concerns about anthropogenic sources of stranding. While there has been some marine mammal mortalities potentially associated with mid-frequency sonar effects to a small number of species (primarily limited numbers of certain species of beaked whales), the significance and actual causative reason for any impacts is still subject to continued investigation.

By comparison and as described previously, potential impacts to all species of cetaceans worldwide from fishery related mortality can be orders of magnitude more significant (100,000s of animals vice 10s of animals) (Culik, 2002; ICES, 2005b; Read et al. 2006). This does not negate the influence of any mortality or additional stressor to small, regionalized sub-populations which may be at greater risk from human related mortalities (fishing, vessel strike, sound) than populations with larger oceanic level distribution or migrations. ICES (2005a) noted, however, that taken in context of marine mammal populations in general, sonar is not major threat, or significant portion of the overall ocean noise budget.

In conclusion, a constructive framework and continued research based on sound scientific principles is needed in order to avoid speculation as to stranding causes, and to further our understanding of potential effects or lack of effects from military mid-frequency sonar (Bradshaw et al. 2005; ICES 2005b; Barlow and Gisiner 2006; Cox et al. 2006).

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Appendix B Marine Mammals Impact Analysis Methods

B.1 OVERVIEW AND TECHNICAL APPROACH

The purpose of Appendix B is to describe the analytical methods used to model and interpret the effects of sonar emissions and underwater detonations to marine mammals for this biological evaluation (BE). Marine mammals modeled with these methods include six whale species (blue, fin, humpback, sei, sperm, and southern resident killer whale), one pinniped (Steller sea lion), and one mustelid (sea otter) species. Species-specific life history and other ecological information were presented previously in the biological evaluation.

When analyzing the results of the sonar and underwater detonation exposure modeling, it is important to understand there are limitations to the ecological data used in the model, and that model results must be interpreted within the context of a given species' ecology.

B.2 APPROACH TO ANALYSIS

This section describes the methods used to determine the potential environmental effects associated with conducting naval training activities in the NWTRC action area. Activities include active sonar emissions; surface vessel, submarine, and aircraft warfare training; weapons firing and non-explosives ordnance use; electronic combat; discharges of expendable materials; and mine countermeasure training. These operations are configured in various combinations to define specific warfare areas.

B.2.1 REGULATORY FRAMEWORK

The MMPA and ESA prohibit the unauthorized harassment of marine mammals and endangered species, and provide the regulatory processes for authorizing any such harassment that might occur incidental to an otherwise lawful activity. These two acts establish the context for determining potentially adverse impacts to marine mammals from military operations.

B.2.1.1 MARINE MAMMAL PROTECTION ACT

The Marine Mammal Protection Act (MMPA) of 1972 established, with limited exceptions, a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates "takes" of marine mammals in the global commons (that is, the high seas) by vessels or persons under U.S. jurisdiction. The term "take," as defined in Section 3 (16 USC 1362) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of harassment, Level A (potential injury) and Level B (potential disturbance).

The National Defense Authorization Act of Fiscal Year 2004 (Public Law 108-136) amended the definition of harassment as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government, consistent with Section 104(c)(3) [16 USC 1374 (c)(3)]. The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the Fiscal Year 2003 National Defense Authorization Act (Public Law 107-314). Military training activities within the NWTRC Study Area constitute military readiness activities as that term is defined in Public Law 107-314 because training activities constitute "training and operations of the Armed Forces that relate to combat" and constitute "adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use."

For military readiness activities, the relevant definition of harassment is any act that:

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment").
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing,

nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") [16 USC 1362 (18)(B)(i)(ii)].

Section 101(a)(5) of the MMPA directs the Secretary of the Department of Commerce to allow, upon request, the incidental (but not intentional) taking of marine mammals by U.S. citizens who engage in a specified activity (exclusive of commercial fishing), if certain findings are made and regulations are issued. Permission will be granted by the Secretary for the incidental take of marine mammals if the taking will have a negligible impact on the species or stock and will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses.

In support of the Proposed Action, the Navy is requesting a Letter of Authorization (LOA) pursuant to Section 101(a)(5)(A) of the MMPA. After the application is reviewed by NMFS, a Notice of Receipt of Application will be published in the Federal Register. Publication of the Notice of Receipt of Application will initiate the 30-day public comment period, during which time anyone can obtain a copy of the application by contacting NMFS. In addition, the MMPA requires NMFS to develop regulations governing the issuance of a LOA and to publish these regulations in the Federal Register. Specifically, the regulations for each allowed activity establish (1) permissible methods of taking, and other means of affecting the least practicable adverse impact on such species or stock and its habitat, and on the availability of such species or stock for subsistence, and (2) requirements for monitoring and reporting of such taking. For military readiness activities (as described in the National Defense Authorization Act), a determination of "least practicable adverse impacts" on a species or stock that includes consideration, in consultation with the DoD, of personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity.

Several species of marine mammals occur in the NWTRC Study Area. Accordingly, the Navy has initiated the MMPA compliance process with the NMFS.

B.2.1.2 ENDANGERED SPECIES ACT

The Endangered Species Act (ESA) of 1973 established protection over and conservation of threatened and endangered species and the ecosystems upon which they depend. An "endangered" species is a species that is in danger of extinction throughout all or a significant portion of its range, while a "threatened" species is one that is likely to become endangered within the foreseeable future throughout all or in a significant portion of its range. The USFWS and NMFS jointly administer the ESA and are also responsible for the listing of species (designating a species as either threatened or endangered). The USFWS has primary management responsibility for management of terrestrial and freshwater species, while the NMFS has primary responsibility for marine species and anadromous fish species (species that migrate from saltwater to freshwater to spawn). The ESA allows the designation of geographic areas as critical habitat for threatened or endangered species.

The ESA requires federal agencies to conserve listed species and consult with the USFWS and/or NMFS to ensure that proposed actions that may affect listed species or critical habitat are consistent with the requirements of the ESA. The ESA specifically requires agencies not to "take" or "jeopardize" the continued existence of any endangered or threatened species, or to destroy or adversely modify habitat critical to any endangered or threatened species. Under Section 9 of the ESA, "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect. Under Section 7 of the ESA, "jeopardize" means to engage in any action that would be expected to reduce appreciably the likelihood of the survival and recovery of a listed species by reducing its reproduction, numbers, or distribution.

Regulations implementing the ESA expand the consultation requirement to include those actions that "may affect" a listed species or adversely modify critical habitat. If an agency's proposed action would take a listed species, the agency must obtain an incidental take statement from the responsible wildlife agency. As part of the environmental documentation for this Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS), the Navy has entered into early consultation with NMFS

Consultation is complete once NMFS prepares a final Biological Opinion and issues an incidental take statement.

Nine marine mammal species listed as either endangered or threatened under the ESA could potentially occur in the Study Area. Accordingly, the Navy has initiated the ESA Section 7 consultation process with NMFS. Critical habitat for two listed marine mammal species has been designated under the ESA in the Study Area. Critical habitat for the southern resident killer whale stock is designated in Puget Sound and for specific Steller sea lion rookeries along the Oregon and California coasts.

B.2.2 STUDY AREA

The Study Area for marine mammals is analogous to the "action area," for purposes of analysis under Section 7 of the ESA.

B.2.3 DATA SOURCES

A comprehensive and systematic review of relevant literature and data was conducted to complete this analysis. Of the available scientific and technical literature (both published and unpublished), the following types of documents were utilized: journals, books, periodicals, bulletins, Department of Defense operations reports, theses, dissertations, endangered species recovery plans, species management plans, stock assessment reports, environmental impact statements, range complex management plans, and other technical reports published by government agencies, private businesses, or consulting firms. Scientific and technical literature was also consulted during the search for geographic location data (geographic coordinates) on the occurrence of marine resources within the Study Area.

Information was collected from the following sources to summarize the occurrence of and to evaluate the impacts to marine mammal species in the Study Area:

- Marine resource assessment (MRA) for the Pacific Northwest operating area and marine mammal density estimates for the Pacific Northwest Study Area;
- University on-line databases: Ingenta, Web of Science; Aquatic Sciences and Fisheries Abstracts, Science Direct, Synergy, BIOSIS previews;
- The Internet, including various databases and related websites: National Oceanic and Atmospheric Administration (NOAA)-Coastal Services Center, NMFS, Ocean Biogeographic Information System, U.S. Geological Survey, WhaleNet, Blackwell-Science, FishBase, Food and Agriculture Organization, Federal Register, Pacific and North Pacific Fishery Management Councils;
- Federal and state agencies: the Department of the Navy, Pacific Fishery Management Council, NMFS Highly Migratory Species Division, NMFS Northwest Fisheries Science Center, NMFS Southwest Fisheries Science Center, NMFS Alaska Fisheries Science Center, NMFS Northwest Regional Office, NMFS Office of Habitat Protection, NMFS Office of Protected Resources, NOAA: Marine Managed Areas Inventory, USFWS Ecological Services Field Offices, U.S. Environmental Protection Agency, U.S. Geological Survey: Sirenia Project, Bureau of Land Management, Minerals Management Service, California Department of Fish and Game, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife; and
- Marine resource experts and specialists.

B.2.4 MARINE MAMMAL DENSITY ESTIMATES

Estimates of marine mammal densities for the Study Area were obtained from the *Final Marine Mammal and Sea Turtle Density Estimates for the Pacific Northwest Study Area* (DoN 2007). The abundance of most cetaceans along the U.S. West Coast has been estimated since 1991 for waters off California and since 1996 for waters off Oregon and Washington (Barlow 1995; Barlow 2003; Barlow and Forney

2007). These estimates are based on shipboard surveys conducted by the Southwest Fisheries Science Center (SWFSC) during the summer and fall (late July to early December) in 1991, 1993, 1996, 2001, and 2005. These estimates are used to develop National Marine Fisheries Service (NMFS) Stock Assessment Reports; to interpret the impacts of human-caused mortality due to fishery bycatch, ship strikes, and other sources; and to evaluate the ecological role of cetaceans in the eastern north Pacific.

The *Marine Resource Assessment (MRA) for the Pacific Northwest Operating Area* provided detailed information on the marine species known to occur in the Study Area (Department of the Navy 2006). The MRA provided information on the physical description, life history, and general distribution patterns for marine mammals. Areas of occurrence for each species were depicted on maps indicating "primary," "secondary," or "rare" occurrence. Quantitative density estimates were not included.

For offshore areas, predictive species-habitat models were built for those species with sufficient numbers of sightings to estimate densities for the Study Area. The methods used for predictive species-habitat modeling were consistent with those used by Becker (2007), and followed a stepwise forward/backward variable selection approach developed by Ferguson et al. (2006). Detailed descriptions of the model building and selection process can be found in Becker (2007). For species with insufficient numbers of sightings, density estimates were obtained from Barlow and Forney (2007). They used multiple covariate line-transect methods based on the 1991-2005 SWFSC shipboard survey data to produce the most recent cetacean abundance estimates available. These estimates are not stratified according to the Navy's specific Study Areas, but they do provide representative numbers for the Study Area as a whole. Similar to the densities estimated from the models, they provide representative numbers for the "summer" season only (late July to early December).

For inland waters aerial line-transect surveys were conducted by the National Marine Mammal Laboratory (NMML) in 2002 and 2003 to estimate harbor porpoise abundance off the coasts of Oregon, Washington, and southern British Columbia, as well as the inland waters that include areas of interest to the Navy (Laake 2007). Harbor porpoise density estimates derived from these data were included in the report. Density estimates for other cetacean species known to occur in inland waters are not available. In order to roughly estimate the abundance of other cetacean species sighted during the surveys, data from the 2002-2003 surveys were prorated relative to harbor porpoise.

B.2.5 APPROACH TO ACOUSTIC ANALYSIS

The Proposed Action analyzed in this BE includes several warfare areas (for example, anti-surface warfare (ASUW) and anti-submarine warfare (ASW). Most warfare areas include multiple types of training activities (for example, ship sinking exercise (SINKEX) or anti-submarine warfare tracking exercise (TRACKEX). Likewise, many activities (for example, vessel movements, aircraft overflights, and weapons firing) are conducted for an operation, and those activities typically are common to many operations. For example, many of the operations involve Navy vessel movements and aircraft overflights. Accordingly, the marine mammals analysis is organized by specific activity and/or stressors associated with that activity, rather than warfare area or operations.

The following general steps were used to analyze the potential environmental consequences of the alternatives to marine mammals:

- Identify those aspects of the Proposed Action that are likely to act as stressors to marine mammals by having a direct or indirect effect on the physical, chemical, and biotic environment. As part of this step, the spatial extent of these stressors, including changes in that spatial extent over time, were identified. The results of this step identified those aspects of the Proposed Action that required detailed analysis in this EIS/OEIS.
- Identify marine mammal resources that may occur in the action area.

- Identify the marine mammal resources that are likely to co-occur with the stressors in space and time, and the nature of that co-occurrence (exposure analysis).
- Determine whether and how marine mammals are likely to respond given their exposure and available scientific knowledge of their responses (response analysis).
- Determine the risks those responses pose to marine mammals and the significance of those risks.
- Estimate the effectiveness of proposed mitigation measures in avoiding, offsetting, and reducing the intensity of any potential adverse impacts to marine mammals.
- Determine implications of the estimated risks under the ESA and MMPA.

B.2.5.1 WARFARE AREAS AND ASSOCIATED ENVIRONMENTAL STRESSORS

The Navy used a screening process to identify aspects of the Proposed Action that could act as stressors to marine mammals. Navy subject matter experts analyzed the warfare areas and operations included in the Proposed Action to identify specific activities that could act as stressors. Public and agency scoping comments, previous environmental analyses, previous agency consultations, laws, regulations, executive orders, and resource-specific information were also evaluated. This process was used to organize the information presented and analyzed in the affected environment and environmental consequences sections of this EIS/OEIS. Potential stressors and the type of effect to marine mammals include:

- Vessel movements (disturbance or collisions);
- Aircraft overflights (disturbance);
- Non-explosive practice munitions (disturbance and strikes);
- High-explosive ordnance (underwater detonations and explosive ordnance);
- Active sonar; and
- Expended materials (ordnance related materials, targets, self-protection flares, sonobuoys, and marine markers).

As discussed in Section 3.4 (Water Resources) and Section 3.2 (Air Quality) of this EIS, some water and air pollutants would be released into the environment as a result of the Proposed Action. Those sections indicated that any increases in water or air pollutant concentrations resulting from Navy training would be negligible and localized. Impacts to water and air quality would be less than significant. Thus, water and air quality changes would have no effect or negligible effects on marine mammals. Accordingly, the effects of water and air quality changes on marine mammals are not addressed further in this EIS/OEIS.

B.2.5.2 ASSESSING MARINE MAMMAL RESPONSES TO SOUND

Marine mammals respond to various types of man-made sounds introduced in the ocean environment. Responses are typically subtle and can include shorter surfacings, shorter dives, fewer blows per surfacing, longer intervals between blows (breaths), ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (National Research Council of the National Academies [NRC], 2005). However, it is not known how these responses relate to significant effects (for example, long-term effects or population consequences) (NRC, 2005). Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals. The Navy enlisted the expertise of the NMFS as the cooperating agency in the preparation of this EIS/OEIS.

In estimating the potential for marine mammals to be exposed to an acoustic source, the following actions were completed:

- Evaluated potential effects within the context of existing and current regulations, thresholds, and criteria.
- Identified all acoustic sources that will be used during active sonar activities.
- Identified the location, season, and duration of the action to determine which marine mammal species are likely to be present.
- Estimated the number of marine mammals (i.e., density) of each species that will likely be present in the respective OPAREAs during active sonar activities.
- Applied the applicable acoustic threshold criteria to the predicted sound exposures from the proposed activity. The results were then evaluated to determine whether the predicted sound exposures from the acoustic model might be considered harassment.
- Considered potential harassment within the context of the affected marine mammal population, stock, and species to assess potential population viability. Particular focus on recruitment and survival were provided to analyze whether the effects of the action can be considered to have negligible effects to species' populations.

Figure B-1 shows the general analytical framework used to apply the specific thresholds discussed in this section. The framework is organized from left to right and addresses the physics of sound propagation (Physics), the potential physiological processes associated with sound exposure (Physiology), the potential behavioral processes that might be affected as a function of sound exposure (Behavior), and the immediate effects these changes may have on functions the animal is engaged in at the time of exposure (Life Function – Proximate). These compartmentalized effects are extended to longer-term life functions (Life Function – Ultimate) and into population and species effects. Throughout the framework, dotted and solid lines are used to connect related events. Solid lines designate those effects that will happen; dotted lines designate those that might happen but must be considered (including those hypothesized to occur but for which there is no direct evidence).

Some boxes are colored according to how they relate to the definitions of harassment under the MMPA. Red boxes correspond to events that are injurious. By prior ruling and usage, these events would be considered as Level A harassment under the MMPA. Yellow boxes correspond to events that have the potential to qualify as Level B harassment under the MMPA. Based on prior ruling, the specific instance of Temporary Threshold Shift (TTS) is considered as Level B harassment. Boxes that are shaded from red to yellow have the potential for injury and behavioral disturbance.

B.2.5.2.1 PHYSICS

Sound emitted from a source, immediately begins to attenuate due to propagation loss. Uniform animal distribution was overlain onto the calculated sound fields to assess if animals were physically present at sufficient received sound levels to be considered "exposed" to the sound. If the animal was determined to be exposed, two possible scenarios were considered with respect to the animal's physiology– effects on the auditory system and effects on non-auditory system tissues. These are not independent pathways and both were considered since the same sound could affect both auditory and non-auditory tissues. Note that the model did not account for any animal response; rather the animals were considered stationary, accumulating energy until the threshold was tripped.

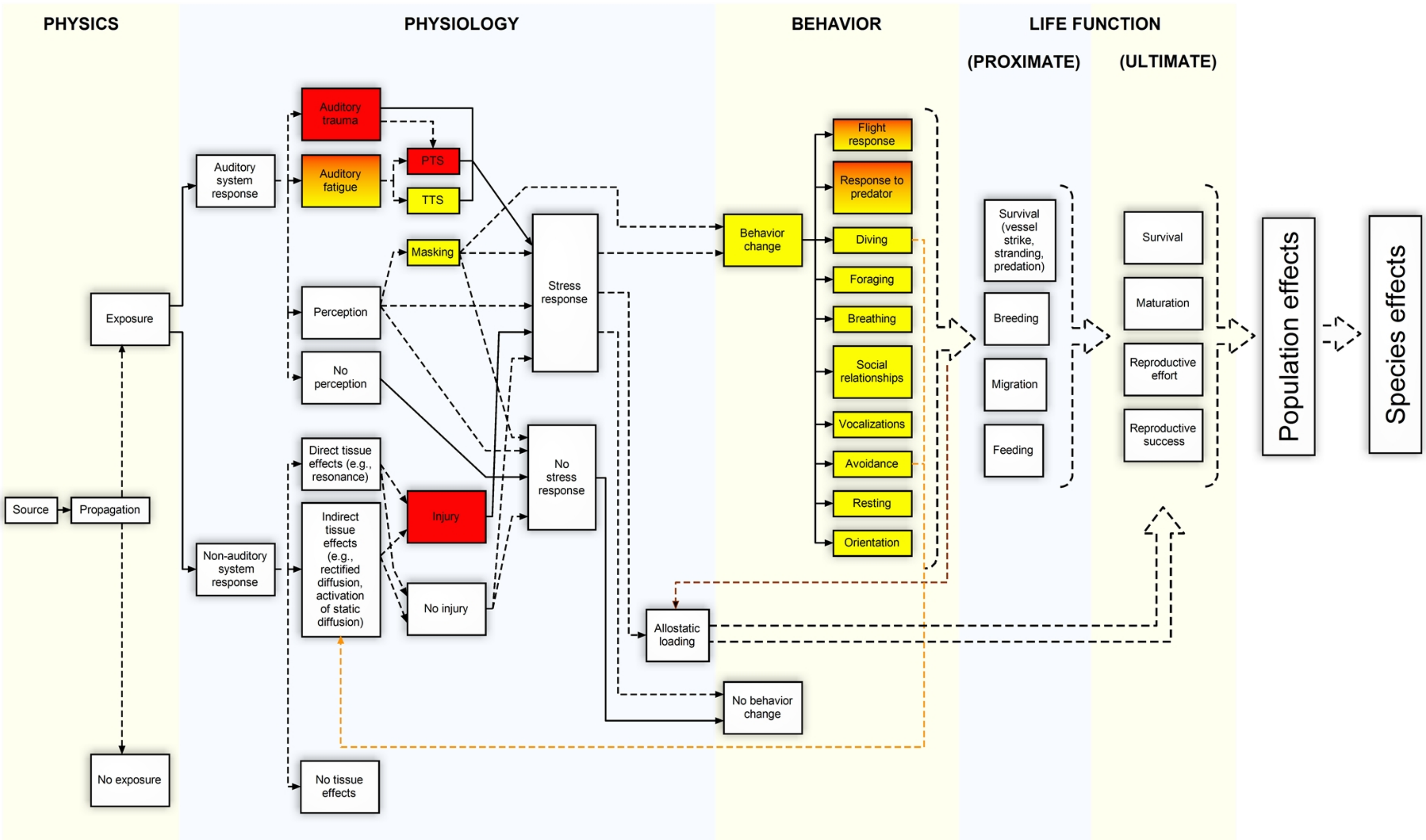

Figure B-1: Analytical Framework for Evaluating Sonar Effects to Marine Mammals

B.2.5.2.2 PHYSIOLOGY

Potential impacts to the auditory system were assessed by considering the characteristics of the received sound (that is the amplitude, frequency, and duration) and the sensitivity of the exposed animals. Some of these assessments were numerically based (e.g., TTS, permanent threshold shift [PTS], perception). Others were qualitative, due to lack of information, or were extrapolated from other species for which information exists. Potential physiological responses to the sound exposure were ranked in descending order, with the most severe impact (auditory trauma) occurring at the top and the least severe impact occurring at the bottom (the sound is not perceived).

- Auditory trauma represents direct mechanical injury to hearing related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and trauma to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory trauma is always injurious but could be temporary and not result in PTS. Auditory trauma is always assumed to result in a stress response.
- Auditory fatigue refers to a loss of hearing sensitivity after sound stimulation. The loss of sensitivity persists after the cessation of the sound. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic exhaustion of the hair cells and cochlear tissues. The features of the exposure (e.g., amplitude, frequency, duration, temporal pattern) and the individual animal's susceptibility would determine the severity of fatigue and whether the effects were temporary (TTS) or permanent (PTS). Auditory fatigue (PTS or TTS) is always assumed to result in a stress response.
- Sounds with sufficient amplitude and duration to be detected among the background ambient noise are considered to be perceived. This category includes sounds from the threshold of audibility through the normal dynamic range of hearing (i.e., not capable of producing fatigue). To determine whether an animal perceives the sound, the received level, frequency, and duration of the sound are compared to what is known of the species' hearing sensitivity.
- Since audible sounds may interfere with an animal's ability to detect other sounds at the same time, perceived sounds have the potential to result in auditory masking. Unlike auditory fatigue, which always results in a stress response because the sensory tissues are being stimulated beyond their normal physiological range, masking may or may not result in a stress response, depending on the degree and duration of the masking effect. Masking may also result in a unique circumstance where an animal's ability to detect other sounds is compromised without the animal's knowledge. This could conceivably result in sensory impairment and subsequent behavior change; in this case, the change in behavior is the lack of a response that would normally be made if sensory impairment did not occur. For this reason, masking also may lead directly to behavior change without first causing a stress response.
- The features of perceived sound are also used to judge whether the sound exposure is capable of producing a stress response. Factors to consider in this decision include the probability of the animal being naïve or experienced with the sound.
- The received level is not of sufficient amplitude, frequency, and duration to be perceptible by the animal. By extension, this does not result in a stress response (not perceived).

Potential impacts to tissues other than those related to the auditory system are assessed by considering the characteristics of the sound and the known or estimated response characteristics of nonauditory tissues. Some of these assessments can be numerically based (e.g., exposure required for rectified diffusion). Others will be necessarily qualitative, due to lack of information. Each of the potential responses may or may not result in a stress response.

- Direct tissue effects – Direct tissue responses to sound stimulation may range from tissue shearing (injury) to mechanical vibration with no resulting injury. Any tissue injury would produce a stress response, whereas noninjurious stimulation may or may not.
- Indirect tissue effects – Based on the amplitude, frequency, and duration of the sound, it must be assessed whether exposure is sufficient to indirectly affect tissues. For example, the hypothesis that rectified diffusion occurs is based on the idea that bubbles that naturally exist in biological tissues can be stimulated to grow by an acoustic field. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage occurs (injury); (2) bubbles develop to the extent that a complement immune response is triggered or nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury); or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based on what is known about the specific process involved.
- No tissue effects – The received sound is insufficient to cause either direct (mechanical) or indirect effects to tissues. No stress response occurs.

B.2.5.2.3 THE STRESS RESPONSE

The acoustic source is considered a potential stressor if, by its action on the animal, via auditory or nonauditory means, it may produce a stress response in the animal. The term "stress" has taken on an ambiguous meaning in the scientific literature, but with respect to Figure B-1 and the later discussions of allostasis and allostatic loading, the stress response will refer to an increase in energetic expenditure that results from exposure to the stressor and which is predominantly characterized by either the stimulation of the sympathetic nervous system (SNS) or the hypothalamic-pituitary-adrenal (HPA) axis (Reeder and Kramer, 2005).

The presence and magnitude of a stress response in an animal depends on a number of factors. These include the animal's life history stage, the environmental conditions, reproductive or developmental state, and experience with the stressor.

The stress response may or may not result in a behavioral change, depending on the characteristics of the exposed animal. However, provided a stress response occurs, it was assumed that some contribution is made to the animal's total stress load that could affect its life functions.

If the acoustic source did not produce tissue effects, was not perceived by the animal, or did not produce a stress response by any other means, it was assumed the exposure did not contribute to its stress load. Additionally, without a stress response or auditory masking, it was assumed that there would be no behavioral change. Conversely, any immediate effect of exposure that produced an injury was assumed to also produce a stress response and contribute to total stress load.

B.2.5.2.4 BEHAVIOR

Acute stress responses may or may not cause a behavioral reaction. However, all changes in behavior were expected to result from an acute stress response. This expectation was based on the idea that some sort of physiological trigger must exist to change any behavior. The exception to this rule is the case of masking. The presence of a masking sound may not produce a stress response, but may interfere with the animal's ability to detect and discriminate biologically relevant signals. The inability to detect and discriminate biologically relevant signals hinders the potential for normal behavioral responses to auditory cues and was thus considered a behavioral change.

Numerous behavioral changes could occur as a result of stress response, For each potential behavioral change, the magnitude in the change and the severity of the response was estimated. Certain conditions, such as stampeding (i.e., flight response) or a response to a predator, might have a probability of resulting in injury. For example, a flight response, if significant enough, could produce a stranding event. Under the MMPA, such an event would be considered a Level A harassment. Each altered behavior may also have the potential to disrupt biologically significant events (e.g., breeding or nursing) and may need to be qualified as Level B harassment. All behavioral disruptions have the potential to contribute to the total stress load.

Special considerations were given to the potential for avoidance and disrupted diving patterns. Due to past incidents of beaked whale strandings associated with sonar operations, feedback paths were provided between avoidance and diving and indirect tissue effects. This feedback accounted for the hypothesis that variations in diving behavior and/or avoidance responses could result in nitrogen tissue supersaturation and nitrogen off-gassing, possibly to the point of deleterious vascular bubble formation.

B.2.5.2.5 LIFE FUNCTIONS

Two types of life functions were considered in the modeling of acoustic exposure effects. There were proximate and ultimate life functions.

Proximate life history functions are the functions that the animal is engaged in at the time of acoustic exposure. The disruption of these functions, and the magnitude of the disruption, is something that must be considered in determining how the ultimate life history functions are affected.

The ultimate life functions are those that enable an animal to contribute to the population's (or stock, or species) long-term maintenance. The impact to ultimate life functions will depend on the nature and magnitude of the perturbation to proximate life history functions.

B.2.5.3 APPLICATION OF THE FRAMEWORK

For each species in the region of a Proposed Action, the density and occurrence of the species relative to the timing of the Proposed Action was determined. The probability of exposing an individual was based on the density of the animals at the time of the action and the acoustic propagation loss. Based upon the calculated exposure levels for the individuals, or proportions of the population, an assessment for auditory and nonauditory responses was made. Based on the available literature on the bioacoustics, physiology, dive behavior, and ecology of the species, the process outlined in Figure B-1 was used to assess the potential impact of the exposure to the population and species.

B.2.5.3.1 PHYSIOLOGICAL AND BEHAVIORAL EFFECTS

Sound exposure may affect multiple biological traits of a marine animal; however, the MMPA as amended directs which traits should be used when determining effects. Effects that address injury are considered Level A harassment. Effects that address behavioral disruption are considered Level B harassment.

The biological framework was structured according to potential physiological and behavioral effects resulting from sound exposure. The range of effects were then assessed to determine which qualify as injury or behavioral disturbance under MMPA regulations. Physiology and behavior are chosen over other biological traits because:

- They are consistent with regulatory statements defining harassment by injury and harassment by disturbance.
- They are components of other biological traits that may be relevant.
- They are a more sensitive and immediate indicator of effect.

A "physiological effect" was defined as one in which the "normal" physiological function of the animal was altered in response to sound exposure. Physiological function was any of a collection of processes ranging from biochemical reactions to mechanical interaction and operation of organs and tissues within an animal. Physiological effects ranged from the most significant of effects (i.e., mortality and serious injury) to lesser effects that defined the lower end of the physiological effects range, such as the noninjurious distortion of auditory tissues. This latter physiological effect was important to the integration of the biological and regulatory frameworks.

A "behavioral effect" is one in which the "normal" behavior or patterns of behavior of an animal were overtly disrupted in response to an acoustic exposure. Examples of behaviors of concern were derived from the harassment definitions in the MMPA and the ESA.

B.2.5.3.2 MMPA EXPOSURE ZONES

Two acoustic modeling approaches were used to account for both physiological and behavioral effects to marine mammals. The exposure zone modeled total energy. When using a threshold of accumulated energy, the areas of ocean in which Level A and Level B harassment would occur are called "exposure zones." As a conservative estimate, all marine mammals predicted to be in an exposure zone were considered exposed to accumulated sound levels within the applicable Level A or Level B harassment categories. Figure B-2 illustrates exposure zones extending from a hypothetical, directional sound source.

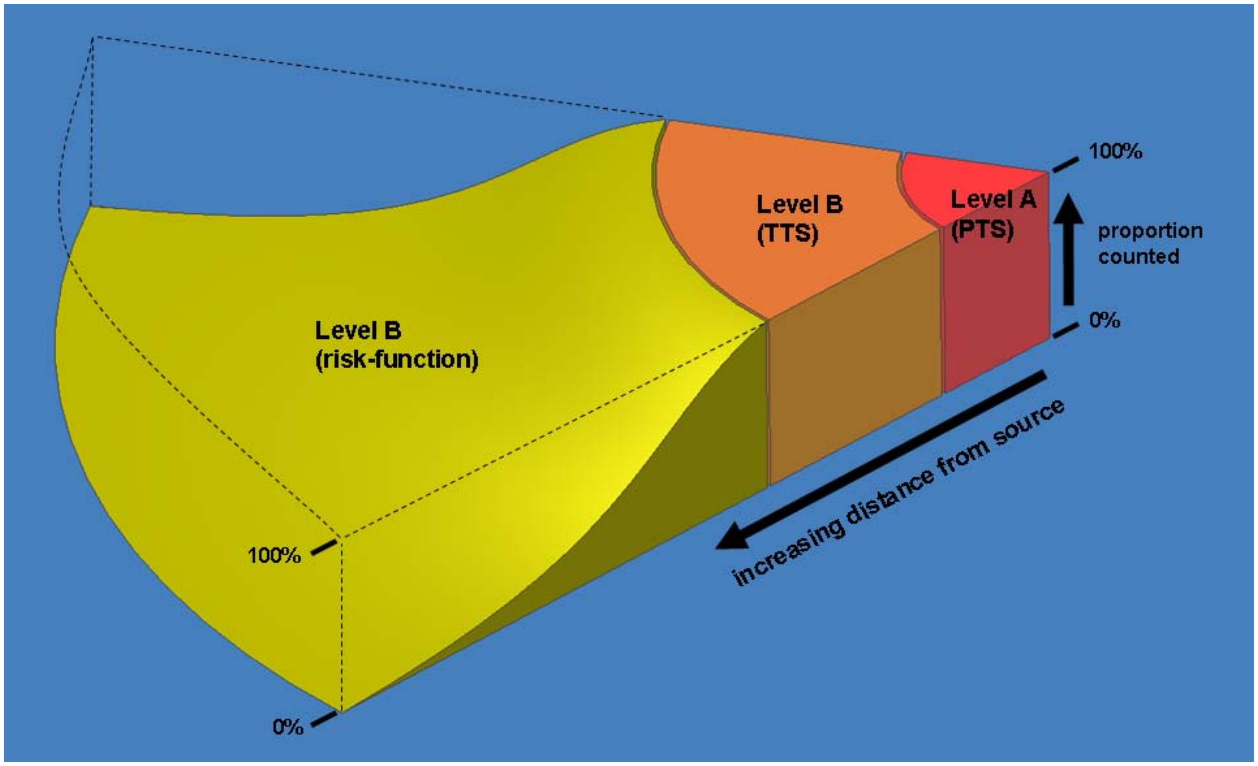

Figure B-2: Relationships of Physiological and Behavioral Effects to Level A and Level B Harassment Categories

The Level A exposure zone extended from the source out to the distance and exposure at which the slightest amount of injury is predicted to occur. The acoustic exposure that produced the slightest degree of injury is therefore the threshold of the Level A exposure zone. Use of the threshold associated with the onset of slight injury as the most distant point and least injurious exposure took into account all more serious injuries by inclusion within the Level A exposure zone. The Level B exposure zone began just beyond the point of slightest injury and extended outward from that point to include all animals that may possibly experience Level B harassment. Physiological effects extended beyond the range of slightest injury to a point where slight temporary distortion of the most sensitive tissue occurred but without destruction or loss of that tissue. The animals predicted to be in this exposure zone were assumed to experience Level B harassment due to temporary impairment of sensory function (i.e., altered physiological function) that could disrupt behavior.

Very high sound levels may rupture the eardrum or damage the small bones in the middle ear (Yost, 1994). Lower level exposures of sufficient duration may cause permanent or temporary hearing loss; such an effect is called a noise-induced threshold shift, or simply a threshold shift (TS) (Miller, 1974). A TS may be either temporary (TTS) or permanent (PTS). PTS does not equal permanent hearing loss; more correctly, it is a permanent loss of hearing sensitivity, usually over a subset of the animal's hearing range. Similarly, TTS is a temporary hearing sensitivity loss, usually over a subset of the animal's hearing range. Still lower levels of sound may result in auditory masking, which may interfere with an animal's ability to hear other concurrent sounds.

B.2.5.3.3 NOISE-INDUCED THRESHOLD SHIFTS

The amount of TS depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure. Threshold shifts generally increase with the amplitude and duration of sound exposure. For continuous sounds, exposures of equal energy lead to approximately equal effects (Ward, 1997). For intermittent sounds, less TS occurs than from a continuous exposure with the same energy because some recovery will occur between exposures (Kryter et al., 1966; Ward, 1997).

The magnitude of a TS normally decreases with the amount of time post-exposure (Miller, 1974). The amount of TS just after exposure is called the "initial TS." If the TS activity returns to zero (the threshold returns to the pre-exposure value), the TS is a TTS. Since the amount of TTS depends on the time postexposure, it is common to use a subscript to indicate the time in minutes after exposure (Quaranta et al., 1998). For example, TTS2 means a TTS measured 2 minutes after exposure. If the TS does not return to zero but leaves some finite amount of TS, then that remaining TS is a PTS. The distinction between PTS and TTS is based on whether there is a complete recovery of a TS following a sound exposure. Figure B-3 shows two hypothetical TSs: one that completely recovers (i.e., a TTS) and one that does not completely recover, leaving some PTS.

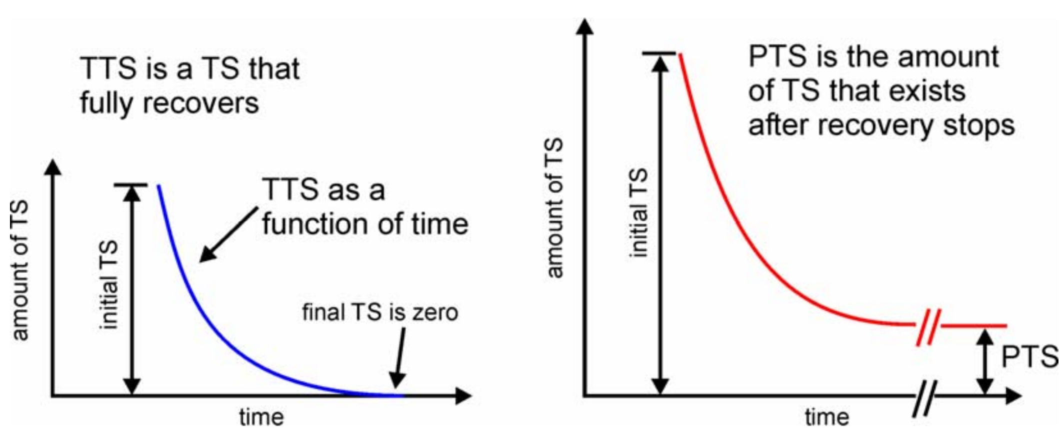

Figure B-3: Relationship of TTS and PTS Recovery Characteristics

B.2.5.3.4 PTS, TTS, AND EXPOSURE ZONES

PTS is nonrecoverable and therefore, qualifies as an injury and is classified as Level A harassment under the MMPA. The smallest amount of PTS (onset-PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset-PTS is used to define the outer limit of the Level A exposure zone.

TTS is recoverable and, as in recent rulings (NOAA, 2001; 2002a), is considered to result from the temporary, noninjurious distortion of hearing-related tissues. In the Study Area, the smallest measurable amount of TTS (onset-TTS) was taken as the best indicator for slight temporary sensory impairment. Because it is considered noninjurious, the acoustic exposure associated with onset-TTS was used to define the outer limit of the portion of the Level B exposure zone attributable to physiological effects. This follows from the concept that hearing loss potentially affects an animal's ability to react normally to the sounds around it. Therefore, in this BE, the potential for TTS was considered as a Level B harassment that is mediated by physiological effects upon the auditory system.

B.2.5.3.5 CRITERIA AND THRESHOLDS FOR PHYSIOLOGICAL EFFECTS

The most appropriate information from which to develop PTS/TTS criteria for marine mammals is experimental measurements of PTS and TTS from marine mammal species of interest. TTS data exist for several marine mammal species and may be used to develop meaningful TTS criteria and thresholds. PTS data do not exist for marine mammals and are unlikely to be obtained. Therefore, PTS criteria must be developed from TTS criteria and estimates of the relationship between TTS and PTS.

B.2.5.3.5.1 TTS IN MARINE MAMMALS

A number of investigators measured TTS in marine mammals. These studies measured hearing thresholds in trained marine mammals before and after exposure to intense sounds. Some of the more important data obtained from these studies are onset TTS levels - exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (e.g., Schlundt et al., 2000). The existing marine mammal TTS data are summarized below.

Schlundt et al. (2000) reported the results of TTS experiments conducted with bottlenose dolphins and white whales exposed to one second tones. This paper included a re-analysis of preliminary TTS data released in a technical report by Ridgway et al. (1997). At frequencies of 3, 10, and 20 kilohertz (kHz), sound pressure level (SPL) necessary to induce measurable amounts (6 dB or more) of TTS were between 192 and 201 dB dB re 1 μPa^2 (energy level (EL) = 192 to 201 dB re 1 μPa^2-s). EL is a measure of the sound energy flow per unit area expressed in dB. EL is stated in decibels (dB) referenced to 1 micro Pascal squared second (dB re 1 µPa2-s) for underwater sound.

The TTS threshold is primarily based on the cetacean TTS data from Schlundt et al. (2000). Since these tests used short-duration tones similar to sonar pings, they are the most directly relevant data. The mean exposure EL required to produce onset-TTS in these tests was 195 dB re 1 µPa2-s. This result was corroborated by the short-duration tone data of Finneran et al. (2000, and 2003) and the long-duration sound data from Nachtigall et al. (2003a, 2004). Together, these data demonstrated that TTS in cetaceans is correlated with the received EL and that onset- TTS exposures fit well by an equal-energy line passing through 195 dB re 1 µPa2-s.

Pinnipeds. For pinnipeds, the harassment thresholds for physiological effects are grouped by species indicated below.

California Sea Lions, Steller Sea Lions, and Northern Fur Seals:

- Level B (onset TTS) = 206 dB re 1 $\mu Pa^2 \cdot s$.
- Level A (onset PTS) = 226 dB re 1 $\mu Pa^2 \cdot s$.

Harbor Seals:

- Level B (onset TTS) = 183 dB re 1 $\mu Pa^2 \cdot s$.
- Level A (onset PTS) = 203 dB re 1 $\mu Pa^2 \cdot s$.

Northern Elephant Seals:

- Level B (onset TTS) = 204 dB re 1 $\mu Pa^2 \cdot s$.

- Level A (onset PTS) = 224 dB re 1 μPa^2·s.

The thresholds for pinnipeds are based on the analysis conducted by Kastak et al (1999, 2005), which determined TTS criteria for three different species. The rationale for the 20-dB offset between onset-TTS and assumed onset-PTS is the same as for cetaceans.

B.2.5.4 ANALYTICAL METHODOLOGY – MMPA BEHAVIORAL HARASSMENT FOR MID-FREQUENCY ACTIVE/HIGH-FREQUENCY ACTIVE SOURCES

Based on available evidence, marine animals are likely to exhibit any of a suite of potential behavioral responses or combinations of behavioral responses upon exposure to sonar transmissions. Potential behavioral responses include, but are not limited to: avoiding exposure or continued exposure; behavioral disturbance (including distress or disruption of social or foraging activity); habituation to the sound; becoming sensitized to the sound; or not responding to the sound.

Existing studies of behavioral effects of human-made sounds in marine environments remain inconclusive, partly because many of those studies have lacked adequate controls, applied only to certain kinds of exposures (which are often different from the exposures being analyzed in the study), and had limited ability to detect behavioral changes that may be significant to the biology of the animals that were being observed. These studies are further complicated by the wide variety of behavioral responses marine mammals exhibit and the fact that those responses can vary substantially by species, individuals, and the context of an exposure. In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al., 1995a; Wartzok et al., 2003; Southall et al., 2007). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict.

It is possible that some marine mammal behavioral reactions to anthropogenic sound may result in strandings. Several "mass stranding" events—strandings that involve two or more individuals of the same species (excluding a single cow–calf pair)—that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. Sonar exposure has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Advisory Committee Report on Acoustic Impacts on Marine Mammals, 2006).

In these circumstances, exposure to acoustic energy has been considered a potential indirect cause of the death of marine mammals (Cox et al., 2006). A popular hypothesis regarding a potential cause of the strandings is that tissue damage results from a "gas and fat embolic syndrome" (Fernandez et al., 2005; Jepson et al., 2003; 2005). Models of nitrogen saturation in diving marine mammals have been used to suggest that altered dive behavior might result in the accumulation of nitrogen gas such that the potential for nitrogen bubble formation is increased (Houser et al., 2001 ; Zimmer and Tyack, 2007). If so, this mechanism might explain the findings of gas and bubble emboli in stranded beaked whales. It is also possible that stranding is a behavioral response to a sound under certain contextual conditions and that the subsequently observed physiological effects of the strandings (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding and not the direct result of exposure to sonar (Cox et al., 2006).

B.2.5.4.1 RISK FUNCTION ADAPTED FROM FELLER (1968)

The particular acoustic risk function developed by the Navy and NMFS estimates the probability of behavioral responses that NMFS would classify as harassment for the purposes of the MMPA given exposure to specific received levels of MFA sonar. The mathematical function is derived from a solution in Feller (1968) for the probability as defined in the SURTASS LFA Sonar Final OEIS/EIS (U.S.

Department of the Navy, 2001c), and relied on in the Supplemental SURTASS LFA Sonar EIS (U.S. Department of the Navy, 2007d) for the probability of MFA sonar risk for MMPA Level B behavioral harassment with input parameters modified by NMFS for MFA sonar for mysticetes, odontocetes, and pinnipeds.

In order to represent a probability of risk, the function should have a value near zero at very low exposures, and a value near one for very high exposures. One class of functions that satisfies this criterion is cumulative probability distributions, a type of cumulative distribution function. In selecting a particular functional expression for risk, several criteria were identified:

- The function must use parameters to focus discussion on areas of uncertainty;
- The function should contain a limited number of parameters;
- The function should be capable of accurately fitting experimental data; and
- The function should be reasonably convenient for algebraic manipulations.

As described in U.S. Department of the Navy (2001c), the mathematical function below is adapted from a solution in Feller (1968).

Where:

R = risk (0 – 1.0);

L = received Level (RL) in dB;

B = basement RL in dB; (120 dB);

K = the RL increment above basement in dB at which there is 50 percent risk;

A = risk transition sharpness parameter (A=10 odontocetes (except harbor porpoises)/pinnipeds; A = 8 mysticetes) (explained in Section 2.5.4.4.3).

In order to use this function, the values of the three parameters (B, K, and A) need to be established. As further explained in Section 2.5.4.2 , the values used in this analysis are based on three sources of data: TTS experiments conducted at SSC and documented in Finneran, et al. (2001, 2003, and 2005); Finneran and Schlundt, (2004); reconstruction of sound fields produced by the USS SHOUP associated with the behavioral responses of killer whales observed in Haro Strait and documented in Department of Commerce National Marine Fisheries Service, (2005a); U.S. Department of the Navy (2004b); and Fromm (2004a, 2004b); and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components documented in Nowacek et al. (2004). The input parameters, as defined by NMFS, are based on very limited data that represent the best available science at this time.

B.2.5.4.2 DATA SOURCES USED FOR RISK FUNCTION

There is widespread consensus that cetacean response to MFA sound signals needs to be better defined using controlled experiments (Cox et al. 2006; Southall et al. 2007). The Navy is contributing to an ongoing behavioral response study in the Bahamas that is anticipated to provide some initial information on beaked whales, the species identified as the most sensitive to MFA sonar. NMFS is leading this international effort with scientists from various academic institutions and research organizations to conduct studies on how marine mammals respond to underwater sound exposures.

Until additional data is available, NMFS and the Navy have determined that the following three data sets are most applicable for the direct use in developing risk function parameters for MFA sonar. These data sets represent the only known data that specifically relate altered behavioral responses to exposure to MFA sound sources. Until applicable data sets are evaluated to better qualify harassment from HFA sources, the risk function derived for MFA sources will apply to HFA.

B.2.5.4.2.2 DATA FROM SSC'S CONTROLLED EXPERIMENTS

Most of the observations of the behavioral responses of toothed whales resulted from a series of controlled experiments on bottlenose dolphins and beluga whales conducted by researchers at SSC's facility in San Diego, California (Finneran et al. 2001, 2003, 2005; Finneran and Schlundt 2004; Schlundt et al., 2000). In experimental trials with marine mammals trained to perform tasks when prompted, scientists evaluated whether the marine mammals performed these tasks when exposed to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests. (Schlundt et al., 2000, Finneran et al., 2002a) Bottlenose dolphins exposed to 1-second (sec) intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 □Pa root mean square (rms), and beluga whales did so at received levels of 180 to 196 dB and above. Test animals sometimes vocalized after an exposure to impulsive sound from a seismic watergun (Finneran et al., 2002a). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al., 1997; Schlundt et al. 2000).

Finneran and Schlundt (2004) examined behavioral observations recorded by the trainers or test coordinators during the Schlundt et al. (2000) and Finneran et al. (2001, 2003, 2005) experiments featuring 1-sec tones. These included observations from 193 exposure sessions (fatiguing stimulus level > 141 dB re 1µPa) conducted by Schlundt et al. (2000) and 21 exposure sessions conducted by Finneran et al. (2001, 2003, 2005). The observations were made during exposures to sound sources at 0.4 kHz, 3 kHz, 10 kHz, 20 kHz, and 75 kHz. The TTS experiments that supported Finneran and Schlundt (2004) are further explained below:

Schlundt et al. (2000) provided a detailed summary of the behavioral responses of trained marine mammals during TTS tests conducted at SSC San Diego with 1-sec tones. Schlundt et al. (2000) reported eight individual TTS experiments. Fatiguing stimuli durations were 1-sec; exposure frequencies were 0.4 kHz, 3 kHz, 10 kHz, 20 kHz and 75 kHz. The experiments were conducted in San Diego Bay. Because of the variable ambient noise in the bay, low-level broadband masking noise was used to keep hearing thresholds consistent despite fluctuations in the ambient noise. Schlundt et al. (2000) reported that "behavioral alterations," or deviations from the behaviors the animals being tested had been trained to exhibit, occurred as the animals were exposed to increasing fatiguing stimulus levels.

Finneran et al. (2001, 2003, 2005) conducted TTS experiments using tones at 3 kHz. The test method was similar to that of Schlundt et al. (2000) except the tests were conducted in a pool with very low ambient noise level (below 50 dB re 1 µPa2/hertz [Hz]), and no masking noise was used. Two separate experiments were conducted using 1-sec tones. In the first, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB SPL were randomly presented.

B.2.5.4.2.3 DATA FROM STUDIES OF BALEEN (MYSTICETES) WHALE RESPONSES

The only mysticete data available resulted from a field experiments in which baleen whales (mysticetes) were exposed to sounds ranging in frequency from 50 Hz (ship noise playback) to 4500 Hz (alert stimulus) (Nowacek et al., 2004). Behavioral reactions to an alert stimulus, consisting of a combination of tones and frequency and amplitude modulated signals ranging in frequency from 500 Hz to 4500 Hz, was the only portion of the study used to support the risk function input parameters.

Nowacek et al. (2004; 2007) documented observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components. To assess risk factors involved in ship strikes, a multi-sensor acoustic tag was used to measure the responses of whales to passing ships and experimentally tested their responses to controlled sound exposures, which included recordings of ship noise, the social sounds of conspecifics and a signal designed to alert the whales. The alert signal was 18 minutes of exposure consisting of three 2-minute signals played sequentially three times over. The three signals had a 60 percent duty cycle and consisted of: (1) alternating 1-sec pure tones at 500 Hz and 850 Hz; (2) a 2-sec logarithmic down-sweep from 4,500 Hz to 500 Hz; and (3) a pair of low (1,500 Hz)-high (2,000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. The purposes of the alert signal were (a) to provoke an action from the whales via the auditory system with disharmonic signals that cover the whales' estimated hearing range; (b) to maximize the signal to noise ratio (obtain the largest difference between background noise) and c) to provide localization cues for the whale. Five out of six whales reacted to the signal designed to elicit such behavior. Maximum received levels ranged from 133 to 148 dB re 1μPa/√Hz.

B.2.5.4.2.4 OBSERVATIONS OF KILLER WHALES IN HARO STRAIT IN THE WILD

In May 2003, killer whales (*Orcinus orca*) were observed exhibiting behavioral responses while USS SHOUP was engaged in MFA sonar operations in the Haro Strait in the vicinity of Puget Sound, Washington. Although these observations were made in an uncontrolled environment, the sound field associated with the sonar operations had to be estimated, and the behavioral observations were reported for groups of whales, not individual whales, the observations associated with the USS SHOUP provide the only data set available of the behavioral responses of wild, non-captive animal upon exposure to the AN/SQS-53 MFA sonar.

U.S. Department of Commerce (National Marine Fisheries, 2005a); U.S. Department of the Navy (2004b); Fromm (2004a, 2004b) documented reconstruction of sound fields produced by USS SHOUP associated with the behavioral response of killer whales observed in Haro Strait. Observations from this reconstruction included an estimate of 169.3 dB SPL which represents the mean received level at a point of closest approach within a 500 m wide area in which the animals were exposed. Within that area, the estimated received levels varied from approximately 150 to 180 dB SPL.

B.2.5.4.3 LIMITATIONS OF THE RISK FUNCTION DATA SOURCES

There are substantial limitations and challenges to any risk function derived to estimate the probability of marine mammal behavioral responses; these are largely attributable to sparse data. Ultimately there should be multiple functions for different marine mammal taxonomic groups, but the current data are insufficient to support them. The goal is unquestionably that risk functions be based on empirical measurement.

The risk function presented here is based on three data sets that NMFS and Navy have determined are the best available science at this time. The Navy and NMFS acknowledge each of these data sets has limitations.

While NMFS considers all data sets as being weighted equally in the development of the risk function, the Navy believes the SSC San Diego data is the most rigorous and applicable for the following reasons:

- The data represents the only source of information where the researchers had complete control over and ability to quantify the noise exposure conditions.
- The altered behaviors were identifiable due to long term observations of the animals.
- The fatiguing noise consisted of tonal exposures with limited frequencies contained in the MFA sonar bandwidth.

However, the Navy and NMFS do agree that the following are limitations associated with the three data sets used as the basis of the risk function:

- The three data sets represent the responses of only four species: trained bottlenose dolphins and beluga whales, North Atlantic right whales in the wild and killer whales in the wild.

- None of the three data sets represent experiments designed for behavioral observations of animals exposed to MFA sonar.
- The behavioral responses of marine mammals that were observed in the wild are based solely on an estimated received level of sound exposure; they do not take into consideration (due to minimal or no supporting data):
- Potential relationships between acoustic exposures and specific behavioral activities (e.g., feeding, reproduction, changes in diving behavior, etc.), variables such as bathymetry, or acoustic waveguides; or
- Differences in individuals, populations, or species, or the prior experiences, reproductive state, hearing sensitivity, or age of the marine mammal.

B.2.5.4.3.5 SSC San Diego Trained Bottlenose Dolphins and Beluga Data Set:

- The animals were trained animals in captivity; therefore, they may be more or less sensitive than cetaceans found in the wild (Domjan, 1998).
- The tests were designed to measure TTS, not behavior.
- Because the tests were designed to measure TTS, the animals were exposed to much higher levels of sound than the baseline risk function (only two of the total 193 observations were at levels below 160 dB re 1 μPa^2-s).
- The animals were not exposed in the open ocean but in a shallow bay or pool.
- The tones used in the tests were 1-second pure tones similar to MFA sonar.

B.2.5.4.3.6 North Atlantic Right Whales in the Wild Data Set

- The observations of behavioral response were from exposure to alert stimuli that contained mid-frequency components but was not similar to an MFA sonar ping. The alert signal was 18 minutes of exposure consisting of three 2-minute signals played sequentially three times over. The three signals had a 60 percent duty cycle and consisted of: (1) alternating 1-sec pure tones at 500 Hz and 850 Hz; (2) a 2-sec logarithmic down-sweep from 4,500 Hz to 500 Hz; and (3) a pair of low (1,500 Hz)-high (2,000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. This 18-minute alert stimuli is in contrast to the average 1-sec ping every 30 sec in a comparatively very narrow frequency band used by military sonar.
- The purpose of the alert signal was, in part, to provoke an action from the whales through an auditory stimulus.

B.2.5.4.3.7 Killer Whales in the Wild Data Set

- The observations of behavioral harassment were complicated by the fact that there were other sources of harassment in the vicinity (other vessels and their interaction with the animals during the observation).
- The observations were anecdotal and inconsistent. There were no controls during the observation period, with no way to assess the relative magnitude of the any observed response as opposed to baseline conditions.

B.2.5.5 Input Parameters for the Feller-Adapted Risk Function

The values of <u>B</u>, <u>K,</u> and <u>A</u> need to be specified in order to utilize the risk function defined in Section 2.5.4.1. The risk continuum function approximates the dose-response function in a manner analogous to pharmacological risk assessment (U.S. Department of Navy, 2001c, Appendix A). In this case, the risk function is combined with the distribution of sound exposure levels to estimate aggregate impact on an exposed population.

B.2.5.5.1 BASEMENT VALUE FOR RISK – THE B PARAMETER

The B parameter defines the basement value for risk, below which the risk is so low that calculations are impractical. This 120 dB level is taken as the estimated received level (RL) below which the risk of significant change in a biologically important behavior approaches zero for the MFA sonar risk assessment. This level is based on a broad overview of the levels at which multiple species have been reported responding to a variety of sound sources, both mid-frequency and other, was recommended by the scientists, and has been used in other publications. The Navy recognizes that for actual risk of changes in behavior to be zero, the signal-to-noise ratio of the animal must also be zero.

B.2.5.5.2 THE K PARAMETER

NMFS and the Navy used the mean of the following values to define the midpoint of the function: (1) the mean of the lowest received levels (185.3 dB) at which individuals responded with altered behavior to 3 kHz tones in the SSC data set; (2) the estimated mean received level value of 169.3 dB produced by the reconstruction of the USS SHOUP incident in which killer whales exposed to MFA sonar (range modeled possible received levels: 150 to 180 dB); and (3) the mean of the 5 maximum received levels at which Nowacek et al. (2004) observed significantly altered responses of right whales to the alert stimuli than to the control (no input signal) is 139.2 dB SPL. The arithmetic mean of these three mean values is 165 dB SPL. The value of K is the difference between the value of B (120 dB SPL) and the 50 percent value of 165 dB SPL; therefore, K=45.

B.2.5.5.3 RISK TRANSITION – THE A PARAMETER

The A parameter controls how rapidly risk transitions from low to high values with increasing received level. As A increases, the slope of the risk function increases. For very large values of A, the risk function can approximate a threshold response or step function. NMFS has recommended that Navy use A = 10 as the value for odontocetes (except harbor porpoises), and pinnipeds (Figure B-4) and A = 8 for mysticetes (Figure B-5) (National Marine Fisheries Service, 2008).

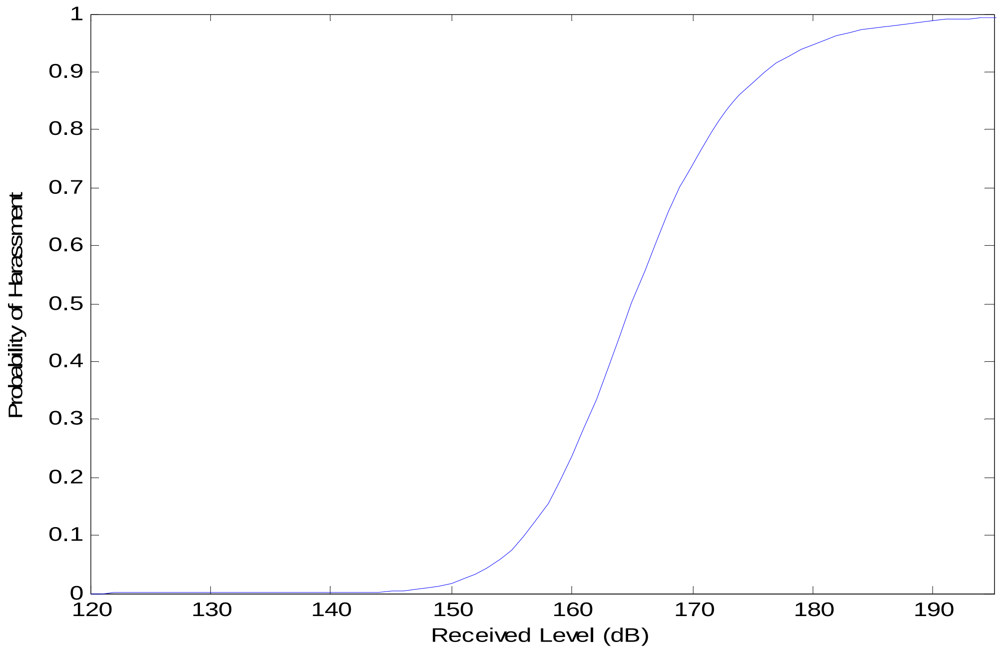

Figure B-4: Risk Function Curve for Odontocetes (except harbor porpoises) (toothed whales) and Pinnipeds

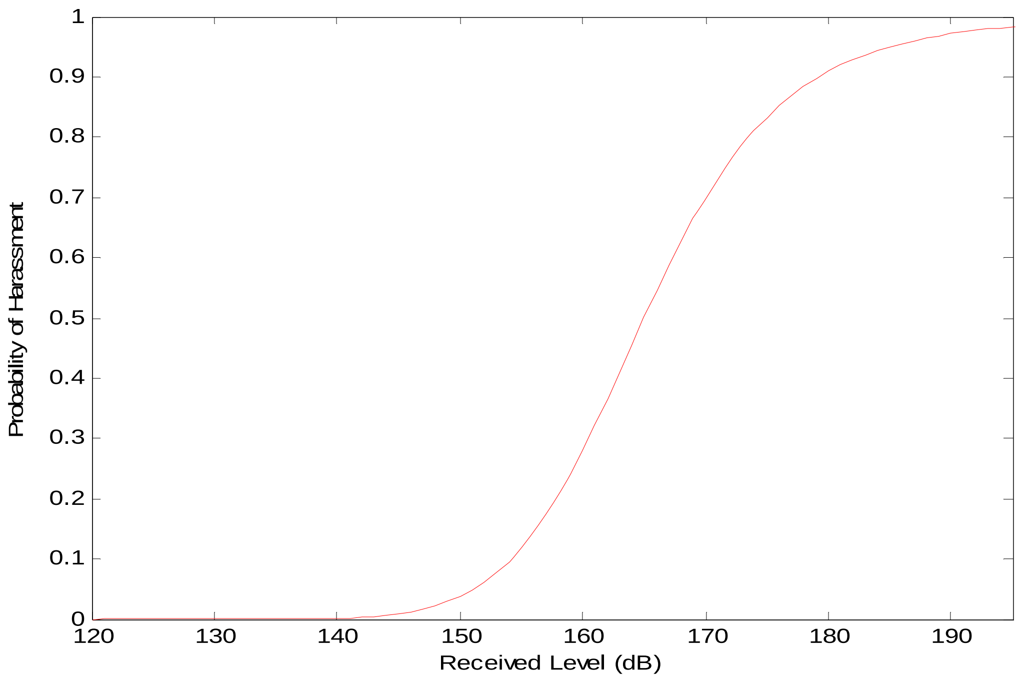

Figure B-5: Risk Function Curve for Mysticetes (Baleen Whales)

B.2.5.5.4 JUSTIFICATION FOR THE STEEPNESS PARAMETER OF A = 10 FOR THE ODONTOCETE CURVE

The NMFS independent review process described in Section 4.1.2.4.9 of the Hawaii Range Complex Final EIS/OEIS (U.S. Department of Navy, 2008) provided the impetus for the selection of the parameters for the risk function curves. One scientist recommended staying close to the risk continuum concept as used in the SURTASS LFA sonar EIS. This scientist opined that both the basement and slope values; B=120 dB and A=10 respectively, from the SURTASS LFA sonar risk continuum concept are logical solutions in the absence of compelling data to select alternate values supporting the Feller-adapted risk function for MFA sonar. Another scientist indicated a steepness parameter needed to be selected, but did not recommend a value. Four scientists did not specifically address selection of a slope value. After reviewing the six scientists' recommendations, the two NMFS scientists recommended selection of A=10. Direction was provided by NMFS to use the A=10 curve for odontocetes based on the scientific review of potential risk functions explained in Section 4.1.2.4.9.2 of U.S. Department of Navy (2008).

As background, a sensitivity analysis of the A=10 parameter was undertaken and presented in Appendix D of the SURTASS/LFA FEIS (U.S. Department of the Navy, 2001c). The analysis was performed to support the A=10 parameter for mysticete whales responding to a low-frequency sound source, a frequency range to which the mysticete whales are believed to be most sensitive to. The sensitivity analysis results confirmed the increased risk estimate for animals exposed to sound levels below 165 dB. Results from the Low Frequency Sound Scientific Research Program (LFS SRP) phase II research showed that whales (specifically gray whales in their case) did scale their responses with received level as supported by the A=10 parameter (Buck and Tyack, 2000). In the second phase of the LFS SRP research, migrating gray whales showed responses similar to those observed in earlier research (Malme et al., 1983, 1984) when the LF source was moored in the migration corridor (2 km [1.1 nm] from shore). The study extended those results with confirmation that a louder SL elicited a larger scale avoidance response. However, when the source was placed offshore (4 km [2.2 nm] from shore) of the migration corridor, the avoidance response was not evident. This implies that the inshore avoidance model – in which 50 percent of the whales avoid exposure to levels of 141 + 3 dB – may not be valid for whales in proximity to an offshore source (U.S. Department of Navy, 2001c). As concluded in the SURTASS LFA Sonar Final OEIS/EIS (U.S. Department of the Navy, 2001c), the value of A=10 produces a curve that has a more gradual transition than the curves developed by the analyses of migratory gray whale studies (Malme et al., 1984; Buck and Tyack, 2000; and SURTASS LFA Sonar EIS, Subchapters 1.43, 4.2.4.3 and Appendix D, and NMFS, 2008).

B.2.5.5.5 JUSTIFICATION FOR THE STEEPNESS PARAMETER4 OF A = 8 FOR THE MYSTICETE CURVE

The Nowacek et al. (2004) study provides the only available data source for a mysticete species behaviorally responding to a sound source (i.e., alert stimuli) with frequencies in the range of tactical mid-frequency sonar (1-10 kHz), including empirical measurements of received levels (RLs). While there are fundamental differences in the stimulus used by Nowacek et al. (2004) and tactical mid-frequency sonar (e.g., source level, waveform, duration, directionality, likely range from source to receiver), they are generally similar in frequency band and the presence of modulation patterns. Thus, while they must be considered with caution in interpreting behavioral responses of mysticetes to mid-frequency sonar, they seemingly cannot be excluded from this consideration given the overwhelming lack of other information. The Nowacek et al. (2004) data indicate that five out the six North Atlantic right whales exposed to an alert stimuli "significantly altered their regular behavior and did so in identical fashion" (i.e., ceasing feeding and swimming to just under the surface). For these five whales, maximum RLs associated with this response ranged from root- mean-square sound (rms) pressure levels of 133-148 dB (re: 1 μPa).

When six scientists (one of them being Nowacek) were asked to independently evaluate available data for constructing a dose response curve based on a solution adapted from Feller (1968), the majority of them (4 out of 6; one being Nowacek) indicated that the Nowacek et al. (2004) data were not only appropriate but also necessary to consider in the analysis. While other parameters associated with the solution adapted from Feller (1968) were provided by many of the scientists (i.e., basement parameter [B], increment above basement where there is 50 percent risk [K]), only one scientist provided a suggestion for the risk transition parameter, A.

A single curve may provide the simplest quantitative solution to estimating behavioral harassment. However, the policy decision, by NMFS-OPR, to adjust the risk transition parameter from A=10 to A=8 for mysticetes and create a separate curve was based on the fact the use of this shallower slope better reflected the increased risk of behavioral response at relatively low RLs suggested by the Nowacek et al. (2004) data. In other words, by reducing the risk transition parameter from 10 to 8, the slope of the curve for mysticetes is reduced. This results in an increase the proportion of the population being classified as behaviorally harassed at lower RLs. It also slightly reduces the estimate of behavioral response probability at quite high RLs, though this is expected to have quite little practical result owing to the very limited probability of exposures well above the mid-point of the function. This adjustment allows for a slightly more conservative approach in estimating behavioral harassment at relatively low RLs for mysticetes compared to the odontocete curve and is supported by the only dataset currently available. It should be noted that the current approach (with A=8) still yields an extremely low probability for behavioral responses at RLs between 133-148 dB, where the Nowacek data indicated significant responses in a majority of whales studied. (Note: Creating an entire curve based strictly on the Nowacek et al. [2004] data alone for mysticetes was advocated by several of the reviewers and considered inappropriate, by NMFS-OPR, since the sound source used in this study was not identical to tactical mid-frequency sonar, and there were only 5 data points available). The policy adjustment made by NMFS-OPR was also intended to capture some of the additional recommendations and considerations provided by the scientific panel (i.e., the curve should be more data driven and that a greater probability of risk at lower RLs be associated with direct application of the Nowacek et al. 2004 data).

B.2.5.6 BASIC APPLICATION OF THE RISK FUNCTION AND RELATION TO THE CURRENT REGULATORY SCHEME

The risk function is used to estimate the percentage of an exposed population that is likely to exhibit behaviors that would qualify as harassment (as that term is defined by the MMPA applicable to military readiness activities, such as the Navy's testing and training with MFA sonar) at a given received level of sound. For example, at 165 dB SPL (dB re: 1µPa rms), the risk (or probability) of harassment is defined according to this function as 50 percent, and Navy/NMFS applies that by estimating that 50 percent of the individuals exposed at that received level are likely to respond by exhibiting behavior that NMFS would classify as behavioral harassment. The risk function is not applied to individual animals, only to exposed populations.

The data used to produce the risk function were compiled from four species that had been exposed to sound sources in a variety of different circumstances. As a result, the risk function represents a general relationship between acoustic exposures and behavioral responses that is then applied to specific circumstances. That is, the risk function represents a relationship that is deemed to be generally true, based on the limited, best-available science, but may not be true in specific circumstances. In particular, the risk function, as currently derived, treats the received level as the only variable that is relevant to a marine mammal's behavioral response. However, we know that many other variables—the marine mammal's gender, age, and prior experience; the activity it is engaged in during an exposure event, its distance from a sound source, the number of sound sources, and whether the sound sources are approaching or moving away from the animal—can be critically important in determining whether and how a marine mammal will respond to a sound source (Southall et al., 2007). The data that are currently available do not allow for incorporation of these other variables in the current risk functions; however, the risk function represents the best use of the data that are available.

NMFS and Navy made the decision to apply the MFA risk function curve to HFA sources due to lack of available and complete information regarding HFA sources. As more specific and applicable data become available for MFA/HFA sources, NMFS can use these data to modify the outputs generated by the risk function to make them more realistic. Ultimately, data may exist to justify the use of additional, alternate, or multi-variate functions. As mentioned above, it is known that the distance from the sound source and whether it is perceived as approaching or moving away can affect the way an animal responds to a sound (Wartzok et al., 2003). In the HRC example, animals exposed to received levels between 120 and 130 dB may be more than 65 nautical miles (131,651 yards) from a sound source; those distances would influence whether those animals might perceive the sound source as a potential threat, and their behavioral responses to that threat. Though there are data showing marine mammal responses to sound sources at that received level, NMFS does not currently have any data that describe the response of marine mammals to sounds at that distance (or to other contextual aspects of the exposure, such as the presence of higher frequency harmonics), much less data that compare responses to similar sound levels at varying distances. However, if data were to become available that suggested animals were less likely to respond (in a manner NMFS would classify as harassment) to certain levels beyond certain distances, or that they were more likely to respond at certain closer distances, the Navy will re-evaluate the risk function to try to incorporate any additional variables into the "take" estimates.

Last, pursuant to the MMPA, an applicant is required to estimate the number of animals that will be "taken" by their activities. This estimate informs the analysis that NMFS must perform to determine whether the activity will have a "negligible impact" on the species or stock. Level B (behavioral) harassment occurs at the level of the individual(s) and does not assume any resulting population-level consequences, though there are known avenues through which behavioral disturbance of individuals can result in population-level effects. Alternately, a negligible impact finding is based on the lack of likely adverse effects on annual rates of recruitment or survival (i.e., population-level effects). An estimate of the number of Level B harassment takes, alone, is not enough information on which to base an impact determination. In addition to considering estimates of the number of marine mammals that might be "taken" through harassment, NMFS must consider other factors, such as the nature of any responses (their intensity, duration, etc.), the context of any responses (critical reproductive time or location, migration, etc.), or any of the other variables mentioned in the first paragraph (if known), as well as the number and nature of estimated Level A takes, the number of estimated mortalities, and effects on habitat. Generally speaking, the Navy and NMFS anticipate more severe effects from takes resulting from exposure to higher received levels (though this is in no way a strictly linear relationship throughout species, individuals, or circumstances) and less severe effects from takes resulting from exposure to lower received levels.

Table B-1. Behavioral Harassments at Each Received Level Band from the 53C Sonar

Received Level (dB SPL)	Distance at which Levels Occur in NWTRC	Percent of Behavioral Harassments Occurring at Given Levels
Below 140	51 km - 130 km	< 1%
140<Level<150	25 km – 51 km	2%
150<Level<160	10 km – 25 km	18%
160<Level<170	3 km – 10 km	43%
170<Level<180	560 m – 3 km	28%
Above 180 dB	0 m – 560 m	< 9%

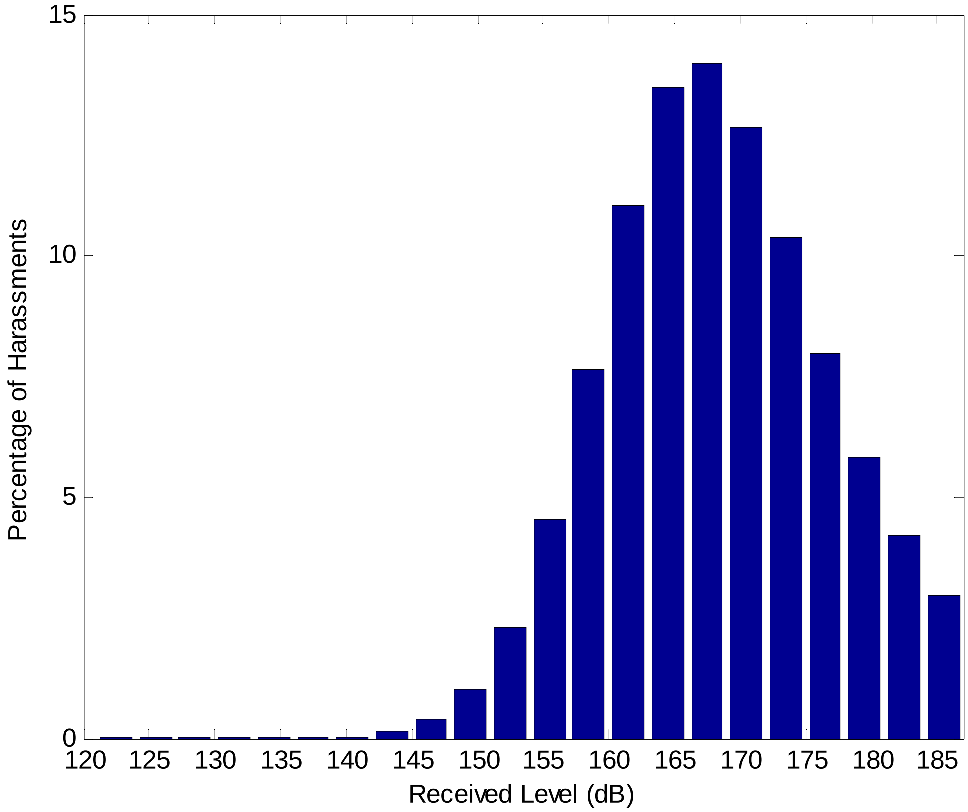

Figure B-6: Approximate Percentage of Behavioral Harassments for Every 5 Degree Band of Received Level from the 53C

B.2.5.6.1 SPECIFIC CONSIDERATION FOR HARBOR PORPOISES

The information currently available regarding these inshore species that inhabit shallow and coastal waters suggests a very low threshold level of response for both captive and wild animals. Threshold levels at which both captive (e.g. Kastelein *et al*., 2000, 2005, 2006) and wild harbor porpoises (e.g. Johnston, 2002) responded to sound (e.g. acoustic harassment devices (ADHs), acoustic deterrent devices (ADDs), or other non-pulsed sound sources) is very low (e.g. ~120 dB SPL), although the biological significance of the disturbance is uncertain. Therefore, Navy will not use the risk function curve as presented but will apply a step function threshold of 120 dB SPL estimate take of harbor porpoises (i.e., assumes that all harbor porpoises exposed to 120 dB or higher MFAS/HFAS will respond in a way NMFS considers behavioral harassment).

B.2.5.7 NAVY POST ACOUSTIC MODELING ANALYSIS

The quantification of the acoustic modeling results includes additional analysis to increase the accuracy of the number of marine mammals affected. Table B-2 provides a summary of the modeling protocols used in this analysis. Post modeling analysis includes reducing acoustic footprints where they encounter land masses, accounting for acoustic footprints for sonar sources that overlap to accurately sum the total area when multiple ships are operating together, and to better account for the maximum number of individuals of a species that could potentially be exposed to sonar within the course of one day or a discreet continuous sonar event.

Table B-2. Navy Protocols Providing for Accurate Modeling Quantification of Marine Mammal Exposures

Historical Data	Sonar Positional Reporting System (SPORTS)	Annual active sonar usage data is obtained from the SPORTS database to determine the number of active sonar hours and the geographic location of those hours for modeling purposes.
Acoustic Parameters	AN/SQS-53 and AN/SQS-56	The AN/SQS-53 and the AN/SQS-56 active sonar sources separately to account for the differences in source level, frequency, and exposure effects.
	Submarine Sonar	Submarine active sonar use is included in effects analysis calculations using the SPORTS database.
Post Modeling Analysis	Land Shadow	For sound sources within the acoustic footprint of land, subtract the land area from the marine mammal exposure calculation.
	Multiple Ships	Correction factors are used to address the maximum potential of exposures to marine mammals resulting from multiple counting based on the acoustic footprint when there are occasions for more than one ship operating within approximately 130 nm of one another.
	Multiple Exposures	Accurate accounting for NWTRC training events within the course of one day or a discreet continuous sonar event:

B.2.6 APPROACH TO EXPLOSIVES MODELING AND ANALYSIS

The effects of an underwater explosion on a marine mammal depends on many factors, including the size, type, and depth of both the animal and the explosive charge; the depth of the water column; the standoff distance between the charge and the animal; and the sound propagation properties of the environment. Potential impacts can range from brief acoustic effects (such as behavioral disturbance), tactile perception, physical discomfort, slight injury of the internal organs and the auditory system, to death of the animal (Yelverton et al. 1973; O'Keeffe and Young 1984; DoN 2001). Non-lethal injury includes slight injury to internal organs and the auditory system; however, delayed lethality can be a result of individual or cumulative sublethal injuries (DoN 2001). Short-term or immediate lethal injury would result from massive combined trauma to internal organs as a direct result of proximity to the point of detonation (DoN 2001).

The exercises that use underwater explosives include Surface-to-Surface Gunnery Exercise (S-S GUNEX), Air-to-Surface Bombing Exercise, Sink Exercise (SINKEX), Missile Exercises (MISSILEX), Bombing Exercises (BOMBEX), and Mine Countermeasures Exercises (MINEX). Table B-3 summarizes the number of events per year and specific areas where each occurs for each type of ordnance used.

Table B-3: Number of Explosive Events in the NWTRC

Warfare Area	Ordnance	Number of Events per Year		
		No Action	Alternative 1	Alternative 2
S-S GUNEX	5 in / 54 cal INERT Naval Shells	540	600	1080
	76 mm Naval Shells	360	400	720
A-S BOMBEX	MK-82 Live HE (500 lb)	8	10	10
ASW TRACKEX	SSQ-110A Sonobuoy	124	136	149
SINKEX	AGM-88 HARM	2	4	4
	SLAM-ER	1	2	2
	AGM-84 Harpoon	3	6	6
	5" Naval Gunfire	500	1000	1000
	76 mm Rounds	200	400	400
	AGM-114 HELLFIRE	1	2	2
	AGM-65F MAVERICK	3	6	6
	GBU-10	4	8	8
	GBU-12	4	8	8
	GBU-16	4	8	8
	MK-48	1	2	2
Mine Countermeasures Exercises (MINEX)	2.5 lb Demo charge	51	4	4
	20.0 lb Demo charge	65	0	0

B.2.6.1 ANALYTICAL FRAMEWORK FOR ASSESSING MARINE MAMMAL RESPONSE TO UNDERWATER DETONATIONS

Criteria and thresholds for estimating the exposures from a single explosive activity on marine mammals were established for the Seawolf Submarine Shock Test Final Environmental Impact Statement (FEIS) ("Seawolf") and subsequently used in the USS Winston S. Churchill (DDG-81) Ship Shock FEIS ("Churchill") (DON, 1998 and 2001). NMFS adopted these criteria and thresholds in its final rule on unintentional taking of marine animals occurring incidental to the shock testing (NOAA, 1998). In addition, this section reflects a revised acoustic criterion for small underwater explosions (that is, 23 pounds per square inch [1.6 kg/cm^2] instead of previous acoustic criteria of 12 pounds per square inch [0.8 kg/cm^2] for peak pressure over all exposures), which is based on an incidental harassment authorization (IHA) issued to the Air Force (NOAA, 2006b). Figure B-1 depicts the acoustic impact framework used in this assessment.

Although the thresholds and criteria used to determine effects resulting from impulsive sound were originally developed to assess impacts under the MMPA (Level A and Level B harassment), these thresholds and criteria are also used to assess impacts under the ESA (Harm and Harassment). Table B-4 summarizes the effects, criteria, and thresholds used in the assessment for impulsive sounds.

For single explosion injury, two criteria were used: eardrum rupture (that is tympanic-membrane [TM] rupture) and onset of slight lung injury. These criteria are considered indicative of the onset of injury. The criterion for mortality for marine mammals used in the CHURCHILL Final EIS (DoN 2001) is "onset of severe lung injury." This is a conservative approach because it corresponds to a 1 percent chance of mortal injury, and yet any animal experiencing onset severe lung injury is counted as a lethal exposure.

- The threshold is stated in terms of the Goertner (1982) modified positive impulse with value "indexed to 31 psi-ms." Because the Goertner approach depends on propagation, source/animal depths, and animal mass in a complex way, the actual impulse value corresponding to the 31-psi-ms index is a complicated calculation. Again, to be conservative, CHURCHILL used the mass of a calf dolphin (at 27 lb. [12.2 kg]), so that the threshold index is 30.5 psi-ms (Table B-4).

Two criteria are used for injury: onset of slight lung hemorrhage and 50 percent eardrum rupture (tympanic membrane [TM] rupture). These criteria are considered indicative of the onset of injury (Table B-4).

- The threshold for onset of slight lung injury is calculated for a small animal (a dolphin calf weighing 27 lb [12.2 kg.]), and is given in terms of the "Goertner modified positive impulse," indexed to 13 psi-ms (DoN 2001a). This threshold is conservative because the positive impulse needed to cause injury is proportional to animal mass, and therefore, Larger animals require a higher impulse to cause the onset of injury.

- The threshold for TM rupture corresponds to a 50 percent rate of rupture (i.e., 50 percent of animals exposed to the level are expected to suffer TM rupture); this threshold is stated in terms of an EL value of 205 dB re 1 μPa2-s. The criterion reflects that TM rupture is not necessarily a serious or life-threatening injury, but is a useful index of possible injury that is well correlated with measures of permanent hearing impairment (e.g., Ketten, 1998 indicates a 30 percent incidence of permanent threshold shift [PTS] at the same threshold).

The following criteria is used for non-injurious harassment temporary threshold shift (TTS), which is a temporary, recoverable, loss of hearing sensitivity (NMFS 2001; DoN 2001a).

- A threshold of 12 pounds per square inch (0.8 kg/cm^2) peak pressure was developed for 10,000 pound (4,535.9 kg) charges as part of the CHURCHILL Final EIS (DoN 2001a, [FR70/160, 19 Aug 05; FR 71/226, 24 Nov 06]). It was introduced to provide a more conservative safety zone for TTS when the explosive or the animal approaches the sea surface (for which case the explosive energy is reduced but the peak pressure is not). Navy policy is to use a 23 pounds per square inch (1.6 kg/cm^2) criterion for explosive charges less than 2,000 lb (907.2 kg) and the 12 psi (0.8 kg/cm^2) criterion for explosive charges larger than 2,000 lb (907.2 kg). This is below the level of onset of TTS for an odontocete (Finneran et al., 2002). All explosives modeled for the NWTRC are less than 1,500 lbs.

Table B-4: Effects Analysis Criteria and Thresholds for Impulsive Sounds

	Criterion	Metric	Threshold	Comments	Source
Mortality & Injury	**Mortality** Onset of extensive lung hemorrhage	**Shock Wave** Goertner modified positive impulse	**30.5 psi-msec***	All marine mammals (dolphin calf)	Goertner 1982
	Slight Injury Onset of slight lung hemorrhage	**Shock Wave** Goertner modified positive impulse	**13.0 psi-msec***	All marine mammals (dolphin calf)	Goertner 1982
	Slight Injury 50% TM Rupture	**Shock Wave** Energy Flux Density (EFD) for *any single exposure*	**205 dB re:1µPa²-sec**	All marine mammals	DoN 2001
Harassment	**Temporary Auditory Effects** TTS	**Noise Exposure** greatest EFD in any 1/3-octave band *over all exposures*	**182 dB re:1µPa²-sec**	Odontocetes greatest EFD for frequencies ≥100 Hz and mysticetes ≥10 Hz	NMFS 2005, NMFS 2006a
	Temporary Auditory Effects TTS	**Noise Exposure** Peak Pressure for *any single exposure*	**23 psi**	All marine mammals	DoN 2001
	Behavioral Modification	**Noise Exposure** greatest EFD in any 1/3-octave band *over all exposures*	**177 dB re:1µPa²-sec**	For odontocetes greatest EFD for frequencies ≥100 Hz and for mysticetes ≥10 Hz	NMFS

Notes:

Goertner, J.F. 1982. Predictions of underwater explosion safe ranges for sea mammals. Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, MD. NSWC/WOL TR-82-188. 25 pp.

DON. 2001. USS Churchill Shock Trail FEIS. February 2001.

NMFS. 2005. Notice of Issuance of an Incidental Harassment Authorization, Incidental to Conducting the Precisions Strike Weapon (PSW) Testing and training by Elgin Air Force base in the Gulf of Mexico. Federal register 70:48675-48591.

NMFS. 2006. Incidental Takes of Marine Mammals Incidental to Specified Activities: Naval Explosive Ordnance Disposal School Training Operations at Eglin Air Force Base, Florida. NMFS Federal Register 71(199):60693-60697.

NMFS. Briefed NMFS for VAST-IMPASS, U.S. Air Force uses 176 dB for permit applications at Eglin Gulf Test and Training Range (EGTTR)

B.2.6.1.1 VERY SHALLOW WATER UNDERWATER DETONATIONS

Measurements of pressure-wave propagation are available for detonations in deep and shallow water, but only fragmentary data exist for propagation in Very Shallow Water (VSW) near shorelines between the shoreline and 50-foot (15.2 m) depth. The lack of data is due to the complicated nature of the VSW environment as well as to substantial differences between different VSW sites. In VSW, surface- and bottom-boundary effects have more influence on propagation than in deeper water. At the point of detonation, the geometry of the short water column dictates that a charge must be close to one or both of these boundaries. More likely surface blowout can dissipate energy and diminish bubble formation with its attendant oscillation effects while detonations closer to the bottom may have considerable energy absorbed by the bottom as well.

Further, as pressure waves propagate laterally through the VSW column, they reflect off surface and bottom boundaries more often over a given distance than in deeper waters and thus, VSW boundaries exert their influence relatively more frequently over that distance. Refraction of the pressure waves, determined by differences in sound velocity at different depths – i.e., the sound velocity profile (SVP) - acts as it does in deeper water, but thermal layering and mixing of layers that determine the SVP may be more complicated and dynamic in VSW. In summary, reliable prediction of pressure wave propagation in all situations requires knowledge of the charge size, type, and position as well as boundary and water column conditions, but in VSW, the relative contributions of these variables may differ considerably from those in deeper waters.

The best mathematical models of underwater explosive-pressure propagation take into account the variables just described. However, the lack of empirical validation data for VSW has allowed the use of less complete models with untested assumptions as well as more complete models with untested assumptions and extreme values of those variables. Occasionally, these practices produced extreme over- and underestimation of propagation and consequent effects on marine mammals, neither of which facilitate realistic, practical regulatory compliance policy. To address the variables of concern and garner an understanding of the affects of underwater detonations, the Navy collected and analyzed empirical data from underwater detonations conducted during training events. Because bottom conditions factor heavily into the amount energy propagating through the water column, explosive tests were conducted at actual ordnance training sites so that, in addition to providing basic data to test theoretical issues, the tests would also provide applied knowledge about the acoustic properties of specific beach approaches in which explosive training and tests are conducted.

The principle objectives of the tests reported in the main body of this report were to measure the pressure waves at various distances seaward of single-charge underwater explosions in VSW and, subsequently evaluate the predictions of existing underwater explosion-propagation models. A model of particular interest is the Reflection and Refraction in Multi-Layered Ocean/Ocean Bottoms with Shear Wave Effects (REFMS), but the test results may be used to evaluate other models of underwater explosive propagation as well. A second objective was to record waveform propagation information for specific single-charge sizes on the specific beach approaches where underwater ordnance training is conducted by Navy Special Warfare (NSW) and Explosive Ordinance Disposal (EOD) personnel in routine underwater ordinance training. This report deals with single charges of up to 15 lbs on those beach approaches.

B.2.6.1.2 THRESHOLDS AND CRITERIA FOR NON-INJURIOUS PHYSIOLOGICAL EFFECTS

The criterion for non-injurious harassment is TTS — a slight, recoverable loss of hearing sensitivity (DoN, 2001). In this case, there are two thresholds: Level B Harassment (with TTS) and peak pressure thresholds. Exposure is assumed to occur if either of the thresholds are exceeded.

B.2.6.1.2.8 TTS-ENERGY THRESHOLD

The first threshold is a 182 dB re 1 μPa^2-s maximum energy flux density level in any 1/3-octave band. For large explosives frequency range cutoffs at 10 and 100 Hz make a difference in the range estimates.

For small explosives, as what was modeled for this analysis, the spectrum of the shot arrival was broad, and there was essentially no difference in impact ranges for toothed whales or baleen whales.

The TTS energy threshold for explosives was derived from the Space and Naval Warfare Systems Center (SSC) pure-tone tests for TTS. The pure-tone threshold (192 dB as the lowest value) was modified for explosives by (a) interpreting it as an energy metric, (b) reducing it by 10 dB to account for the time constant of the mammal ear, and (c) measuring the energy in 1/3-octave bands, the natural filter band of the ear. The resulting threshold was 182 dB re 1 μPa^{2}-s in any 1/3-octave band. The energy threshold usually dominates and was used in the analysis to determine potential Level B Harassment exposures for single explosion ordnance.

B.2.6.1.2.9 TTS-PEAK PRESSURE THRESHOLD

The second threshold was stated in terms of peak pressure at 23 psi (about 225 dB re 1 μPa). This threshold was derived from the Churchill shock trial threshold. However, peak pressure and energy scale at different rates with charge weight, so that ranges based on the peak-pressure threshold are much greater than those for the energy metric when charge weights are small-even when source and animal are away from the surface. To more accurately estimate TTS for smaller shots while preserving the safety feature provided by the peak pressure threshold, the peak pressure threshold was appropriately scaled for small shot detonations. This scaling was based on the similitude formulas (Urick, 1983) used in virtually all compliance documents for short ranges. Further, the peak-pressure threshold for marine mammal TTS for explosives offers a safety margin for a source or an animal near the ocean surface.

B.2.6.1.3 THRESHOLDS AND CRITERIA FOR BEHAVIORAL EFFECTS

For a single explosion, TTS was the criterion for Level B Harassment. In other words, because behavioral disturbance for a single explosion is likely to be limited to a short-lived startle reaction, use of the TTS criterion was considered sufficient protection and therefore behavioral effects (without TTS) are not considered for single explosions.

B.2.6.2 ACOUSTIC EFFECTS ANALYSIS

The impacts on marine mammals from underwater detonations are based on a modeling approach that considers several fators to ensure an accurate estimation of effects by species.

Impact areas of underwater detonations are derived from mathematical calculations and models that predict the distances to which threshold noise levels would travel. The equations for the models consider the amount of net explosive, the properties of detonations under water, and environmental factors such as depth of the explosion, overall water depth, water temperature, and bottom type.

The result of the analysis is an area known as the Zone of Influence (ZOI). A ZOI is based on an outward radial distance from the point of detonation, extending to the limit of a particular threshold level in a 360-degree area. Thus, there are separate ZOIs for mortality, injury (hearing-related injury and slight, non-fatal lung injury), and harassment (temporary threshold shift, or TTS, and behavioral). The ZOIs are also influenced by the body size and species of marine mammal exposed. Given the radius, and assuming noise spreads outward in a spherical manner, the entire area ensonified (i.e., exposed to the specific noise level being analyzed) is estimated.

The radius of each threshold is shown for each detonation system in Table B-5. The radius is assumed to extend from the point of detonation in all directions, allowing calculation of the affected area.

The number of marine mammal takes is estimated by applying marine mammal density to the ZOI (area) for each detonation type. Abundance estimates for cetaceans were obtained from the *Marine Mammal and Sea Turtle Density Estimates for the Pacific Northwest Study Area* (ManTech-SRS Technologies 2007). The abundance of most cetaceans was derived from shipboard surveys conducted by the Southwest Fisheries Science Center in 1991, 1993, 1996, 2001, and 2005 (Barlow 1995; Barlow 2003; Barlow and

Forney 2007). These estimates are used to develop National Marine Fisheries Service (NMFS) Stock Assessment Reports; interpret the impacts of human-caused mortality associated with fishery bycatch, ship strikes, and other sources; and evaluate the ecological role of cetaceans in the eastern North Pacific (ManTech-SRS Technologies 2007). In the marine mammal density study, predictive species-habitat models were built for species with sufficient numbers of sightings to estimate densities for the NWTRC Study Area. For species with insufficient numbers of sightings, density estimates were obtained from Barlow and Forney (2007) (ManTech-SRS Technologies 2007).

Table B-5: Distances to Explosive Thresholds (in Meters)

	Behavioral	Level B		Level A	Mortality	
Source	**177 dB Energy**	**182 dB Energy**	**23 psi**	**205 dB Energy**	**13 psi-ms**	**31 psi-ms**
Demo 20 lbs	909 m	511 m	350 m	125 m	222 m	107 m
Demo 2.5 lbs	317 m	179 m	175 m	35 m	74 m	31 m

Explosives detonated underwater introduce loud, impulsive, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: the weight of the explosive warhead, the type of explosive material, and the detonation depth. The net explosive weight (or NEW) accounts for the first two parameters. The NEW of an explosive is the weight of only the explosive material in a given round, referenced to the explosive power of TNT.

The detonation depth of an explosive is particularly important due to a propagation effect known as surface-image interference increasingly. For sources located near the sea surface, a distinct interference pattern arises from the coherent sum of the two paths that differ only by a single reflection from the pressure-release surface. As the source depth and/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).

For the NWTRC there are two types of explosive sources: demolition charges and munitions (MK-48 torpedo; HARM, Maverick, Hellfire and Harpoon missiles; MK-82, MK-83 and MK-84 bombs; and 5-inch rounds and 76 mm rounds). Demolition charges are typically modeled as detonating near the middle of the water column. The MK-48 torpedo detonates immediately below the hull of its target (nominally 50 ft [15.2 m]). A source depth of 6.6 ft (2.0 m) is used for bombs and missiles that do not strike their target. For the gunnery rounds, a source depth of 1 foot (0.3 m) is used. The NEW for these sources are as follows:

- Demolition charge – 20 pounds (9.1 kg),
- MK-48 – 851 pounds (386.0 kg),
- Maverick – 78.5 pounds (35.6 kg),
- Harpoon – 448 pounds (203.2 kg),
- MK-82 – 238 pounds (108.0 kg),
- MK-83 – 574 pounds (260.4 kg),
- 5-inch rounds – 9.54 pounds (4.3 kg), and
- 76-mm rounds – 1.6 pounds (0.7 kg)

The exposures expected to result from these sources are computed on a per in-water explosive basis. The cumulative effect of a series of explosives can often be derived by simple addition if the detonations are spaced widely in time or space, allowing for sufficient animal movements to ensure a different population of animals is considered for each detonation.

B.2.6.2.1 GUNEX

Modeling was completed for 340 annual GUNEX activities in which 720 explosive rounds were fired.

B.2.6.2.2 BOMBEX

Modeling was completed for three explosive weights involved in BOMBEX, each assumed detonation at 3.3-foot (1-meter) depth. The NEW used in simulations of the MK82, MK83 and MK84 explosives are 192.2 lb (87.2 kg), 415.8 lb (188.6 kg), 944.7 lb (428.5 kg), respectively. The ZOI, when multiplied by the estimated animal densities and total number of events, provides exposure estimates for that animal species for the given bomb source.

B.2.6.2.3 SINKEX

The cases in which simple addition of the exposures estimates may not be appropriate are addressed by the modeling of a "representative" sinking exercise (SINKEX). In a SINKEX, a decommissioned surface ship is towed to a specified deep-water location and there used as a target for a variety of weapons. Although no two SINKEXs are ever the same, a representative case derived from past exercises is described in the Programmatic SINKEX Overseas Environmental Assessment (March 2006) for the Western North Atlantic.

In a SINKEX, weapons are typically fired in order of decreasing range from the source with weapons fired until the target is sunk. A torpedo is used after all munitions have been expended if the target is still afloat. Because the target may sink at any time during the exercise, the actual number of weapons used can vary widely. In the representative case, however, all of the ordnances are assumed expended; this represents the worst case of maximum exposure.

The sequence of weapons firing for the representative SINKEX is described in Table B-6. Guided weapons are nearly 100 percent accurate and are modeled as hitting the target (that is, no underwater acoustic effect) in all but two cases: (1) the Maverick is modeled as a miss to represent the occasional miss, and (2) the MK-48 torpedo intentionally detonates in the water column immediately below the hull of the target. Unguided weapons are more frequently off-target and are modeled according to the statistical hit/miss ratios. Note that these hit/miss ratios are artificially low in order to demonstrate a worst-case scenario; they should not be taken as indicative of weapon or platform reliability.

B.2.6.2.4 MINEX

The Comprehensive Acoustic System Simulation/Gaussian Ray Bundle (CASS/GRAB) (OAML, 2002) model, modified to account for impulse response, shock-wave waveform, and nonlinear shock-wave effects, was run for acoustic-environmental conditions derived from the Oceanographic and Atmospheric Master Library (OAML) standard databases. The explosive source was modeled with standard similitude formulas. Because all the sites were shallow (less than 164.0 ft [50.0 m]), propagation model runs were made for bathymetry in the range from 32.8 ft (10 m) to 132.1 ft (40 m).

Table B-6. Representative SINKEX Weapons Firing Sequence

Time (Local)	Event Description
0900	Range Control Officer receives reports that the exercise area is clear of non-participant ship traffic, marine mammals, and sea turtles.
0909	Hellfire missle fired, hits target.
0915	2 HARM missles fired, both hit target (5 minutes apart).
0930	1 Penguin missle fired, hits target.
0940	3 Maverick missles fired, 2 hit target, 1 misses (5 minutes apart).
1145	1 SM-1 fired, hits target.
1147	1 SM-2 fired, hits target.
1205	5 harpoon missles fired, all hit target (1 minute apart).
1300-1335	7 live and 3 inert MK-82 bombs dropped – 7 hit target, 2 live and 1 inert miss target (4 minutes apart).
1355-1410	4 MK-83 bombs dropped – 3 hit target, 1 misses target (5 minutes apart).
1500	Surface gunfire commences – 400 5-inch rounds fired (1 every 6 seconds), 280 hit target, 120 miss target.
1700	MK-48 torpedo fired, hits, and sinks target.

B.2.6.2.5 IMPACT THRESHOLDS

In addition to the impact thresholds described previously, this BE analyzes potential effects to marine mammals in the context of the MMPA and ESA (listed species only). The factors used to assess the significance of effects vary under these Acts and are discussed below.

For purposes of compliance with the MMPA, effects of the action were analyzed to determine if an alternative would result in Level A or Level B harassment of marine mammals. For military readiness activities under the MMPA, the relevant definition of harassment is any act that:

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment). For active sonar activities this is equivalent to a sound exposure received by the marine mammals of 215 dB of received energy (EL, or energy level) or greater.
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered (Level B harassment) [16 USC 1362 (18)(B)(i)(ii)]. For active sonar activities this is equivalent to a sound exposure received by the marine mammals of greater than or equal to 190 dB EL but less than 195 dB of EL for behavioral disturbance and greater than or equal to 195 dB EL but less than 215 dB of EL for physiological disturbance or effects. The basement value for MFA/HFA sonar risk is 120 dB. This level is taken as the estimated received level below which the risk of significant change in a biologically important behavior approaches zero.

For purposes of ESA compliance, effects of the action were analyzed to make a determination of effect for listed species (for example, no effect or may affect). The definitions used in making the determination of effect under Section 7 of the ESA are based on the USFWS and NMFS *Endangered Species Consultation Handbook* (USFWS and NMFS, 1998).

- “No effect” is the appropriate conclusion when a listed species or its designated critical habitat will not be affected, either because the species will not be present or because the project does not have any elements with the potential to affect the species or modify designated critical habitat. “No effect” does not include a small effect or an effect that is unlikely to occur.
- If effects are insignificant (in size) or discountable (extremely unlikely), a “may affect” determination is appropriate. Insignificant effects relate to the magnitude or extent of the impact (for example, they must be small and would not rise to the level of a take of a species).
- Discountable effects are those extremely unlikely to occur and based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

For ESA compliance relative to designated critical habitats for listed species, effects of the action were analyzed to determine if destruction or adverse modification of critical habitats would occur. The factors used to determine effect are based on whether proposed Navy actions are likely to destroy or change the biological or physical primary constituent elements (PCEs) of the critical habitat that are considered essential for the conservation of the species. The species-specific PCEs are described in the Federal Register announcement listing the final critical habitat ruling for each species.

B.2.6.2.6 MITIGATION MEASURES

The Navy has implemented a comprehensive suite of mitigation measures that reduce impacts to marine mammals that might result from Navy training and testing activities in the NWTRC. No mitigation measures were considered in calculating acoustic modeling results. In order to make the findings necessary to issue a Letter of Authorization (LOA) under MMPA, it may be necessary for NMFS to require additional mitigation or monitoring measures beyond those addressed in this BE. These measures could include measures considered, but eliminated in this BE, or as yet undeveloped measures. The public will have an opportunity, through the MMPA process, both to provide information to NMFS in the comment period following NMFS' Notice of Receipt of the application for an LOA, and to review any additional mitigation or monitoring measures that NMFS might propose in the comment period at the proposed rule stage. The final suite of measures developed as a result of the MMPA process would be identified and analyzed in the Final BE.

Effective training and testing dictate that ship, submarine, and aircraft participants utilize their sensors and exercise weapons to their optimum capabilities as required by the mission. Standard operating procedures and mitigation measures are employed to avoid and minimize potential adverse effects of training. A comprehensive list of mitigation measures that would be utilized for training activities analyzed in the NWTRC BE in order to minimize potential for impacts on listed species, especially marine mammals is presented in Chapter 6 of the BE.